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Status and Forecast of Avionics Evolution

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Abstract

This document is the 2022 update of the Federal Aviation Administration (FAA) Status and Forecast of Avionics Evolution, covering aircraft operating in the United States (U.S.) National Airspace System. It is intended as a common, comprehensive summary of Next Generation Air Transportation System (NextGen) avionics enablers and operational capabilities. The coverage of U.S. aircraft fleet composition and avionics-enabled capabilities serves to inform FAA, operators, and industry on fleet evolution toward NextGen. It offers key findings, operator and industry feedback and plans, plus issues and challenges impacting NextGen fleet readiness. It includes current trends in equipage and forecasts of future aircraft avionics capabilities in the commercial Air Transport fleet that can be used to inform Air Traffic Infrastructure planning under the FAA's NextGen program. The data contained in this report was accumulated while aviation and other industries are still recovering from impacts from the Coronavirus Disease of 2019 (COVID-19) pandemic. The full extent of the impacts of COVID-19, along with other fleet impacts such as the current pilot shortages and geo-political instabilities on aviation, are not yet known. The MITRE Corporation's (MITRE) Center for Advanced Aviation System Development will continue to track changes that result from the pandemic and other significant impacts on the civil aircraft fleet, operators, and NextGen avionics equipage. Due to the diversity of and rate of change in the responses to the COVID-19 pandemic seen within the various fleets operating in the National Airspace System, MITRE's confidence in the forecasts and projections offered in this edition of the report is necessarily somewhat lower than for the pre-pandemic editions of this product, but these forecasts and projections remain both relevant and usable for planning and assessment purposes. MITRE maintains a wide range of additional information on fleet and avionics evolution that is outside the scope of this report but may be available upon request.

Executive Summary

The MITRE Corporation's (MITRE) Center for Advanced Aviation System Development (CAASD) has updated the Federal Aviation Administration (FAA) Status and Forecast of Avionics Evolution. This report covers aircraft operating in the United States (U.S.) National Airspace System (NAS) in 2022 with the equipage status and trends for key Next Generation Air Transportation System (NextGen) capability enablers.

The purpose of this report is to provide common, comprehensive summaries of avionics and aircraft capability evolution data that underpin a wide range of FAA and aviation community analyses. This update covers aircraft operated in the U.S. National Airspace System. Data sets utilized in producing this report include airplanes certificated under Operations Specifications, those filing Instrument Flight Rules (IFR) flight plans, and/or with a U.S. registration, conducting flight operations in the NAS within the following operator categories: Air Transport, Air Taxi, Foreign Carrier, Corporate/General Aviation (GA), and Helicopter.

Fleet and Capability Impacts

The coronavirus disease of 2019 (COVID-19) pandemic continues to have major impacts across the global aviation community. U.S. aviation has seen significant changes to all aspects of the industry, including original equipment manufacturers (OEMs), suppliers, service providers, Air Traffic Management (ATM) providers, and regulators. Operators of Air Transport, Air Taxi, GA, and Helicopter aircraft all experienced significant groundings of their fleets through the initial few months of the pandemic. The impacts of COVID-19 started to become measurable after March 1, 2020 and have steadily increased since then, with significant and wide-ranging effects. Additionally, other fleet impacts such as the current pilot shortages and geo-political instabilities are impacting fleet compositions and impacting operator and OEM fleet planning. As such, data used in generating this report on fleet makeup, capabilities, operational approvals, etc. can be considered a COVID-19 recovery phase, but the pandemic is still impacting aircraft and operations for reporting purposes. Due to the diversity of and rate of change in the responses to the COVID-19 pandemic seen within the various fleets operating in the NAS, MITRE's confidence in the forecasts and projections offered in this edition of the report is necessarily somewhat lower than for the pre-pandemic editions of this product, but these forecasts and projections remain both relevant and usable for planning and assessment purposes.

MITRE continues regular tracking of:

- **Aircraft fleets:** Aircraft added, removed, or parked by specific operators, including announcements regarding future-fleet makeup.
- **Capabilities:** NextGen-related aircraft capability changes due to fleet changes and known avionics forward-fit or retrofit changes.
- **Operations:** NAS-wide tracking of detailed aircraft operations for specific en route, terminal, and airport locations.
- **Other key metrics:** Manufacturer and supplier assessments of the potential range of futures for fleets and capabilities.

The data is constantly changing as all operators adjust to COVID-19, pilot shortages, and geo-political impacts while trying to forecast future-fleet requirements in an ever-changing environment. Global financial markets, mergers, and acquisitions are expected to result in fundamental changes to many companies.

During the COVID-19 pandemic, operators took many different actions: accelerated retirements of specific fleets, deferred delivery of new aircraft, and temporarily put some aircraft into short-term storage. In 2022, many operators are now through much, but not all, of their fleet restructuring efforts, and have begun to accept new aircraft deliveries at much higher rates. In particular, significant quantities of narrow-body and regional aircraft such as the Boeing 737 Max aircraft, Airbus A320 and A220 aircraft, and EMB 175 series have been delivered. New wide-body aircraft have also been delivered, but at much smaller rates with international travel still lagging the domestic travel rebound.

For the Air Taxi and Corporate/GA operator categories, significant demand has emerged over the past two years, contributing to increases in operations and fleet sizes. For these operator categories, a lack of new aircraft has compelled many companies to opt for acquiring used aircraft versus experiencing the often-lengthy waiting lists for new aircraft delivery slots. The resultant effect has been that - although fleet capabilities increase with new aircraft – the older and less NextGen-capable Air Taxi and Corporate/GA aircraft have been pressed into greater service, creating a delay in overall fleet NextGen capability in those fleet segments. In some cases, like Oceanic Operations, data are showing decreases in overall fleet capability simply because older or less equipped aircraft are being flown in Oceanic Airspace as operator demand for flights grows and newer, NextGen-enabled aircraft are not readily available.

While some Air Transport operators have reduced their operations, fleets, and schedules, others are expanding. It is important to realize that, although one airline may elect to retire a particular aircraft fleet, those aircraft are not necessarily leaving the NAS. Some U.S. operators have taken advantage of inexpensive used aircraft retired by another airline and are now putting them back into service, hoping to capitalize on inexpensive leasing or buying options.

Although overall air traffic is down as compared to pre-COVID-19 levels, there has been a significant increase in overall flight activity over similar time periods in 2021. With this continued resurgence in activity in mind, the pandemic's long-term impacts on specific carriers, airports, and routes remain unclear. Even if operations return in the coming years to pre-COVID-19 levels, it may be a different mix of operators or airports that create those operations.

Another potential factor that may significantly impact future NAS NextGen-related capabilities is the strong possibility that operators who are searching for ways to sustain their businesses may press for:

- Greater relief from scope clauses, allowing more and larger aircraft to be flown by regional partners.
- Using improved aircraft automation to justify reducing the required number of pilots onboard commercial aircraft while also further enabling remote piloted vehicles.
- Conversion of some carriers from established industry models (e.g., mainline network, low-cost, all-cargo, regional/feeder carriers) to hybrid operating models (e.g., leisure-focused low-cost passenger services/priority low-density cargo).
- Further diversification across the transportation service industry, including airline investments in Advanced Air Mobility (AAM)/Urban Air Mobility (UAM) and new supersonic aircraft.

- Increasing merger and acquisition strategies to overcome growth constraints from pilot shortages and lengthy backlogs for new aircraft orders.

The persistence of COVID-19 and the possibility of evolving variants leading to renewal or extension of travel bans to and from global pandemic hotspots, together with current pilot shortages and geo-political instability, make this year's report the most challenging in terms of forecasts and identification of trends since MITRE began delivering the product in 2009. Even as the U.S. and global commercial aviation industry appears on an observable path to recovery from the impacts of COVID-19, additional factors challenging U.S. and global aviation warrant MITRE's plans to continue to track NAS changes in hopes of identifying any reportable trends that emerge in the coming months. However, it is expected to take multiple years before fleets are rationalized and the resultant NAS operations and avionics capability is clear.

Fleets, Operators, and Enablers

Table ES-1 summarizes the NAS fleet composition by operator category and engine type, including aircraft operated by Foreign Carriers approved for U.S. operations in 2022. A total fleet of 241,323 aircraft are potential candidates for equipage and approval.

This report includes an assessment of the NAS fleet based on IFR operations. This focus is because aircraft flying IFR are considered the more likely candidates to equip with NextGen enablers as compared to those operated by Visual Flight Rules (VFR) only. This report excludes aircraft registered as Experimental due to the lack of available avionics data on these fleets. Table ES-1 below captures relevant fleet breakouts, with subtotals shown in italicized font and totals indicated with bold and italicized font.

Table ES-1. Total Fleet and IFR Fleets by Operator and Engine Type

Operator Category	Total Aircraft	File IFR	Percent IFR	Total Operations	Operations per IFR Aircraft
Air Transport	7,081	7,081	100%	10,151,364	1434
Air Taxi	8,504	7,418	87%	2,955,235	398
Corporate / GA	205,961	65,939	32%	3,210,375	49
U.S. Airplane Subtotal	*221,546*	*80,438*	*36%*	*16,316,974*	*203*
Helicopters	12,329	1,098	9%	54,769	50
Aircraft Subtotal	*233,875*	*81,536*	*35%*	*16,371,743*	*201*
Foreign Carrier	7,448	4,912	66%	792,859	161
Total	***241,323***	***86,448***	***36%***	***17,164,602***	***199***

Engine Type	Total Aircraft	Percent IFR	Total Operations	Operations per IFR Aircraft
Turbojet	31,252	84%	13,881,791	529
Turboprop	12,594	67%	1,795,174	214
Multi Engine Piston	15,374	54%	350,299	42
Single Engine Piston	169,774	25%	1,082,569	26
Airplane Subtotal	*228,994*	*37%*	*17,109,833*	*200*
Turbine Helicopter	8,048	11%	53,690	62
Piston Helicopter	4,281	6%	1,079	5
Helicopter Subtotal	*12,329*	*9%*	*54,769*	*50*
Total	***241,323***	***36%***	***17,164,602***	***199***

The equipage reported reflects mature and evolving NextGen avionics enablers as defined in the NextGen Segment Implementation Plan, including in the areas of: Performance Based Navigation (PBN), Automatic Dependent Surveillance-Broadcast (ADS-B), Data Communications (Data Comm), low-visibility operations, and other safety enhancements (see Table ES-2). For oceanic airspace enablers, only airplanes in the fleet identified as flying in ocean regions are considered in the analysis for equipage and approval. Additional emerging capabilities that leverage NextGen avionics enablers are also discussed throughout this report, such as: Established on Required Navigation Performance (EoR), Cockpit Display of Traffic Information (CDTI) Assisted Separation (CAS), Multiple Airport Route Separation (MARS), and Combined Vision Systems (CVS).

Table ES-2. NextGen Enablers

PBN	**Performance Based Navigation (PBN) Enablers**
RNP 4 w/Oceanic Comms	Required Navigation Performance (RNP) 4 with (w/) Oceanic Distance Communications
RNAV 1	Area Navigation (RNAV) 1
RNAV 2	RNAV 2
RNAV 1 & 2	RNAV 1 and 2
RNP 1 w/RF	RNP 1 with Radius to Fix (RF)
RNP 1 w/TF	RNP 1 with Track to Fix (TF)
VNAV Approach	Vertical Navigation (VNAV) Approach
LPV Approach	Localizer Performance with Vertical Guidance (LPV) Approach
RNP Approach	RNP Approach
RNP AR Approach	RNP Authorization Required (AR) Approach (RNAV/RNP)
GLS I	Ground Based Augmentation System (GBAS) 1 Landing System (GLS)
ADS-B	**Automatic Dependent Surveillance – Broadcast (ADS-B) Enablers**
ADS-B Out	ADS-B Out
ADS-B In - CAS/CAVS	ADS-B In Cockpit Display of Traffic Information (CDTI)-Assisted Separation (CAS) / CDTI-Assisted Visual Separation (CAVS)
ADS-B In - SA Apps	ADS-B In Cockpit Display of Traffic Information (CDTI) for Situational Awareness (SA) Airborne and Ground Applications
ADS-B In - Approach Apps	ADS-B In CDTI Assisted Visual Separation (CAVS) for Approach Applications
ADS-B In - ITP Apps	ADS-B In for In-trail Procedures (ITP) Applications
Data Comm	**Data Communications (Data Comm) Enablers**
FANS 1/A Domestic - Tower Services	Future Air Navigation Systems (FANS) 1/A over Very High Frequency (VHF) Data Link (VDL) Mode 0 or Mode 2 for Continental United States (U.S.)
FANS 1/A Domestic - En Route Services	FANS 1/A over VDL Mode 2 for Continental U.S.
FANS 1/A Oceanic	FANS 1/A over SATCOM for Controller-Pilot Datalink Communication (CPDLC) / Automatic Dependent Surveillance - Contract (ADS-C) for Oceanic
Low-Viz	**Low-Visibility (Low-Viz) Enablers**
HUD Approach	Head-Up Display (HUD) Approach for Manually Flown Landing Operations Other Than Categories II and III
EFVS	Enhanced Flight Vision System (EFVS)
Safety and Other	**Safety Enhancement and Other Enablers**
EFB	Electronic Flight Bag (EFB)
EFB w/Aircraft Integration	EFB with (w/) Aircraft Integration

Air Transport Equipage

The key findings from the fleet and equipage data are:

- The Air Transport fleet comprises 7,081 authorized airplanes, of which 1,226 (17%) are wide-body; 3,965 (56%) are narrow-body; 1,779 (25%) are regional jets (those with 90 seats or less in normal service configuration); and 111 (2%) are turboprops. The authorized fleet decreased by 316 airplanes from March 2021 to March 2022, with 351 entering service and 667 exiting.
- The Air Transport fleet already has high equipage and operational approval levels for PBN capabilities. It is forecasted to remain in this state because airplanes that retire with NextGen capability are replaced with equal or greater capability. For capabilities such as Area Navigation (RNAV) 2 or Advanced Required Navigation Performance (RNP), the equipage trend increases as new airplanes are delivered with these capabilities and older non-equipped airplanes are retired. These trends support new, evolving capabilities such as EoR and MARS. It is important to note that EoR, MARS, and other PBN procedures may in the future be able to leverage the higher equipage rates for Track to Fix (TF) and non-coupled Vertical Navigation (VNAV) found in the existing fleets, and thus many equipped capabilities may play a role in PBN procedure evolution. It is also important to note that some new regional jet and turboprop operators are still not investing in Inertial Reference Unit (IRU) equipage that provides additional levels of PBN resiliency and enables RNP Authorization Required (AR) approaches.
- The longer-term outlook for IRU equipage and PBN operational resiliency may be changing for two reasons. IRU trends on regional and turboprop airplanes may increase due to the Minimum Capability List (MCL) activity and industry changes from consolidation and business ventures, such as new planned regional jet offerings from Mitsubishi. At the time of the writing of this report, the MCL includes Resilient NextGen Operations as a key capability, with IRU and Distance Measuring Equipment (DME)/DME as key components in delivering resiliency, particularly in busy airport terminal and remote operations areas. In coordination with the NextGen Advisory Committee, the FAA has invested significantly in additional DME ground stations in key locations to guarantee airplanes without IRUs will be able to continue operations should any disruption to Global Positioning System (GPS) signals occur. Industry feedback indicates that some aircraft without IRU, but equipped with DME/DME, still may lack the appropriate approvals for use of those systems for RNAV terminal procedures and, therefore, would require conventional ground-based navigation aids and procedures in cases when GPS systems are not usable. Many of the airplanes without IRUs are also not capable of Radius-to-Fix (RF) legs or, in some cases, VNAV approaches utilizing lateral navigation (LNAV)/VNAV lines of minima. When these unequipped airplanes are eventually either equipped or retired from the fleet, the corresponding level of fleet capability would be expected to have a corresponding increase into the 90–99% range.
- There is continued interest in the potential of EoR procedures to create operational benefits at particular airports. At the time of the writing of this report, it is believed that EoR implementations could utilize a wide range of airplane equipage and capabilities, depending on the criteria applied for a given airport location and the benefits desired. All EoR implementations will likely utilize GPS equipage as a basic requirement, while some

implementations may also leverage DME/DME or IRU aircraft equipage. Individual implementations could utilize a range of NextGen operational capabilities found in this report; some examples include: RNP AR Approach, RNP Approach, Localizer Performance with Vertical Guidance (LPV) Approach, VNAV Approach, RNAV 1, and RNP 1 with RF.

- GBAS Landing System (GLS) capabilities using the Ground Based Augmentation System (GBAS) continue to increase as many new narrow-body and wide-body aircraft are coming equipped with Multi-mode Receivers (MMRs) that support GLS operations. Additional fleet equipage with GBAS-capable GPS receivers is projected to increase, as is the related uptake rate of GLS approach capability as operators leverage their GBAS receiver investments.
- ADS-B Out equipage increased rapidly as operators equipped with rule compliant transponders ahead of the 2020 ADS-B Out mandate. At industry's request, the FAA published Exemption 12555 that allows operators to defer upgrades to their GPS position sources (with conditions) until January 1, 2025. The exemption did not change the requirement for operators to install a rule compliant ADS-B Out transponder by January 1, 2020. Many Air Transport and Foreign Carrier operators applied for and received the Exemption 12555. This past year, the FAA made Exemption 12555 permanent and the 2025 date is no longer applicable; as a result, many Situational Awareness (SA)-Aware GPS position source systems that were anticipated to be replaced by 2025 are now not expected to be replaced until after 2025, when new GPS capabilities such as Dual Frequency Multi-Constellation are expected to come to market. It is anticipated that aircraft that are upgraded with new GPS position source systems will likely gain additional capabilities such as GLS and LPV, since GBAS and Wide Area Augmentation System (WAAS) sensors are expected to be standard in all new GPS units. Furthermore, aircraft manufacturers have indicated that they plan to broaden their range of LPV and GLS offerings in response to strong demand signals received from both U.S. and global customers, especially those operating in India.
- ADS-B In is projected to remain relatively flat for the next few years while those applications and capabilities are slowly fielded and business cases for operators are matured. Operators indicate they continue to investigate if there is a positive business case for further fleet investment in ADS-B In applications. The ADS-B In Retrofit Spacing Evaluation (AIRS Eval) project will demonstrate the operational feasibility and value of ADS-B In capabilities using a retrofit solution leveraging a plan for over 300 American Airlines Airbus A321 ADS-B In equipped aircraft. The AIRS Eval project plans to include the following potential ADS-B In applications: Basic Airborne (AIRB), CDTI Assisted Visual Separation (CAVS), CAS, and AIRS Interval Management (IM) in a limited same runway use case. Airplanes that equip with ADS-B In also gain safety benefits of improved traffic awareness and, in the case of oceanic in-trail procedures (ITP), reduced fuel use.
- Data Comm equipage for oceanic operations is high and will increase as additional satellite communications (SATCOM) equipment is installed on airplanes flying in RNP 4 oceanic airspace and in North Atlantic Track (NAT) High Level Airspace (HLA). Passenger data services continue to be a driving force in increased SATCOM connectivity on aircraft that also provides foundational equipment for RNP 4 and NAT HLA operations. New satellite connectivity options, such as Star Link, are giving operators more choice and access to satellite networks. Domestic-use Data Comm equipage is increasing as operators exercise available forward-fit options on narrow-body aircraft. Although there have been pandemic-related impacts on operator retrofit plans for all NextGen capabilities, Data Comm equipage continues to occur.

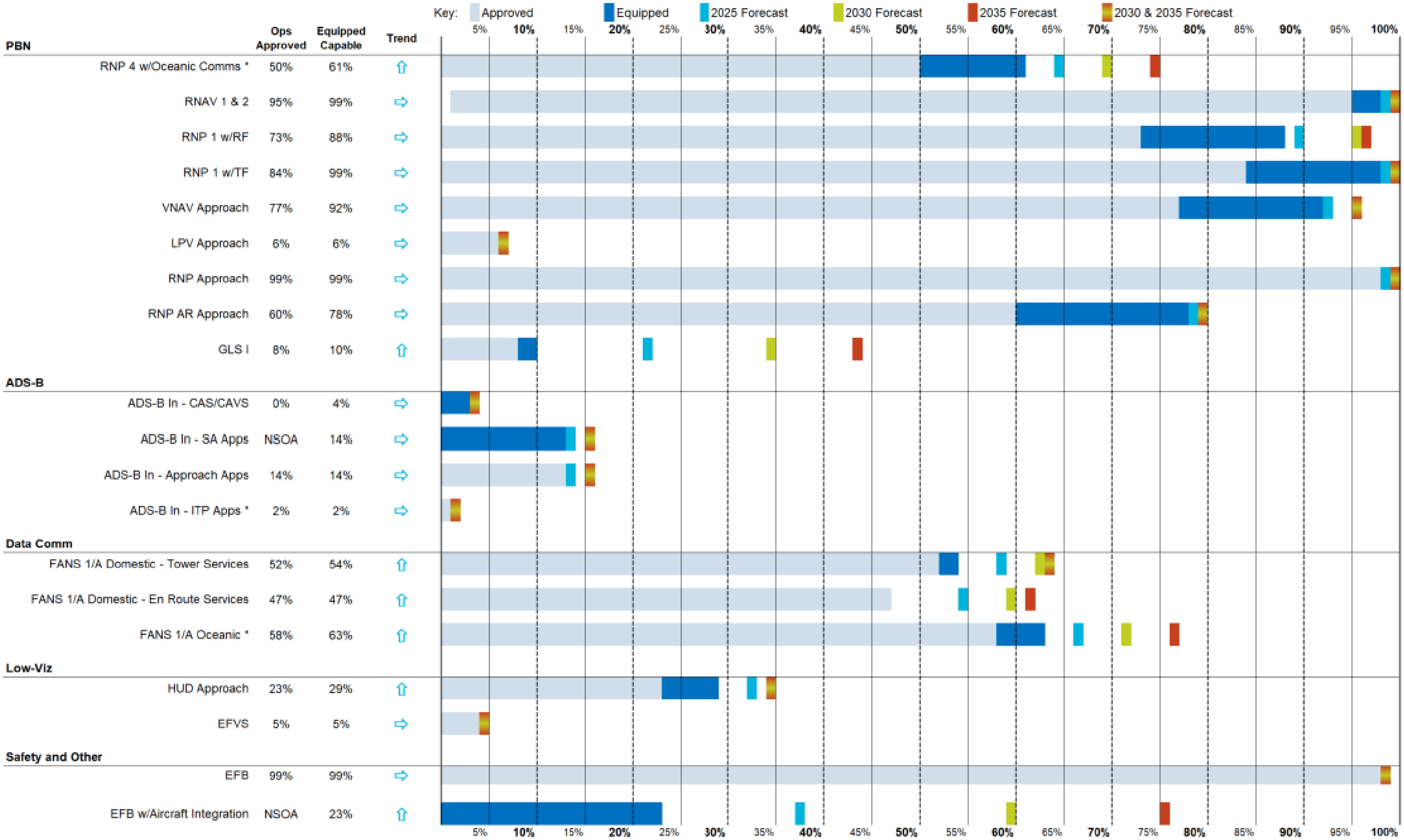
- Low-visibility enablers continue to be a niche capability due to high cost, but some operators have positive business cases to equip for all-weather operations and redundancy. As in the 2021 version of this report, it is worth noting the increased availability of Head Worn Displays (HWD) for use in supporting such capabilities as Head-Up Display (HUD) Approach (referred to in previous editions of this report as HUD/ILS) and Enhanced Flight Vision Systems (EFVS) type operations. New and pending certification efforts for HWDs, some with integration to the Flight Management System (FMS), have some Air Transport operators re-evaluating their business case for HUD and HWD. These HWDs are seen as potentially improving the business case for retrofit of these capabilities since they are expected to involve far less complicated and timely retrofit actions as compared to a traditional, fixed HUD system, thus creating significant savings and perhaps tipping the business case for some operators. As these technologies continue to evolve, they are becoming more capable, less costly, and smaller, which, when coupled with ever evolving operational benefits provided to operators, is positively impacting the business case.
- Electronic Flight Bags (EFBs) continue to be a key safety enabler in 2022. The fleet is already highly equipped, with most operators completing or planning programs with portable EFBs (not installed equipment) such as Apple iPads® or similar devices, but installed EFB system equipage rates are increasing. Systems for assisting pilots in runway awareness during takeoff, taxi, and/or landing operations are examples of solutions being made available to operators. EFBs with connectivity is a continuing trend in new aircraft being delivered forward-fit capable and existing aircraft accomplishing some retrofits. Aircraft with EFB connectivity fall into two general categories based on the level of aircraft integration and therefore the types of capabilities they can support. The first group is those with one way connectivity where the EFB can receive information from installed avionics systems only. The other category is those implementations where the EFB can both send and receive information from avionics systems. EFBs with aircraft integration, coupled with commercial network links, support emerging connected aircraft concepts by enabling the transfer. Some operators are electing to install Aircraft Interface Devices (AIDs) to accomplish improved EFB connectivity, security, and capability and, as a result, are enabling additional benefits to fielded EFB systems. The continued interest in increasing passenger connectivity results in many new aircraft entering service with onboard servers, commercial satellite communications, and other on aircraft networks that are the key enablers to EFBs with connectivity and future connected aircraft concepts.

Figure ES-1 shows the current Air Transport operator fleet equipage and approvals, the trend through 2025, and forecast equipage for 2025, 2030, and 2035. Forecast data presented should be interpreted as the lower bound, which assumes operators do not make additional investments in optional equipment over what is either already underway, or part of explicit operator plans provided to MITRE directly or through FAA/industry activities. Greater detail on the potential upper bound forecasts is provided throughout the main body of the report.

As mentioned previously, these forecasts are based on data in 2022, and represent a COVID-19 impacted environment. Typically, it is assumed that technologies, business entities, plans, and operating practices observed in the recent past continue in the future. Recent unforeseen events are an example of potential impacts from outside the industry purview. Potential additional impacts of COVID-19 both in the U.S. and globally, such as industry consolidation, bankruptcies, and operating route structure, can greatly affect future conditions but are difficult to predict. Other factors within the industry's purview, such as radar altimeter retrofits for potential 5G interference and equipage to improve GPS resiliency, could disrupt historical practices, but their magnitude and/or likelihood of adoption are difficult to predict and are also not included in the forecast.

This edition of the *Status and Forecast of Avionics Evolution* report includes a section first introduced in the FY2021 report detailing technologies and trends of interest that may merit more detailed treatment in future reporting. This updated watch list includes the following:

- Connected aircraft
- Evolving landscape of new entrants in Urban Air Mobility/Advanced Air Mobility and supersonic aircraft
- Evolving avionics designs for potential radio frequency interference and spectrum evolution
- Emerging effects on U.S. fleets from pilot shortages



Notes:
* Oceanic enabler percentages relative to active oceanic fleet
NSOA -No Specific OpSpec Applicable

Figure ES-1. Air Transport Enablers: Current, Trend, and Forecast Equipage Assessment

Other Operator Categories Equipage

For the other operator categories (Air Taxi, Foreign Carrier, Corporate/GA, and Helicopter), Table ES-3 tabulates the estimated current equipage. The key findings from the fleet and equipage data are:

- When comparing 2022 and 2021 MITRE-reported data, increases are evident in the helicopter and piston GA airplane IFR fleet counts. In the case of helicopters, a large reduction in IFR operations associated with offshore oil services in 2019–2020 appears to have stabilized in 2022. Increases in the number of piston GA aircraft can be attributed to better data analytics and broad use of International Civil Aviation Organization (ICAO) flight plans rather than an increase in traditionally VFR aircraft now flying IFR.
- Although forecast data are not provided for these operator categories, available information and historical trends indicate equipage and capability consistently increase over time. Operators who retire old airplanes often add capabilities to their replacement airplanes, particularly for PBN and ADS-B In capabilities.
- For these other operator categories, this report uses information provided on IFR flight plans or other pertinent sources (e.g., industry-provided estimates) to estimate equipage and approvals for a capability. In the case of flight plans, the derived equipage values are likely lower bounds as there are several reasons why operators may not file for a capability even if equipped and approved for IFR operational use.
- The international, oceanic, and turbojet fleets tend to have higher levels of equipage as compared to propeller and piston-powered airplanes. This higher equipage is driven by the greater need for operational redundancy when operating in far-ranging or remote operations. However, with the continued significant demand for Air Taxi and Corporate GA aircraft in a COVID-19 impacted environment, operators have been flying less equipped older aircraft in international and oceanic operations, resulting ultimately in a less capable fleet in these regions. It is believed that these aircraft will ultimately be replaced with newer and more capable aircraft or upgraded with improved avionics if they remain in the fleet. The result would be a continued and unchanged long-term trend toward greater equipage in these regions for NextGen capabilities.
- PBN equipage across all operator types is mostly high, and other MITRE data indicate it will remain so. For capabilities such as RNP Approach, RNP 1 with RF, and VNAV Approach through high levels of LPV equipage, the trends will be for equipage to increase as new airplanes are delivered with these capabilities. Investment by the FAA in additional DME ground systems will benefit some operators in these categories who are equipped for DME RNAV and/or RNP, but do not have IRU equipage. The potential to leverage modern FMS systems that use "All in View DME" in their RNAV systems will likely further result in benefits from the FAA investments in DME for resiliency.
- Data Comm equipage for oceanic operations is high and will increase as additional SATCOM equipment is installed on airplanes flying in RNP 4 oceanic airspace and NAT HLA operations. As mentioned earlier in this report, near-term equipage appears slightly lower in FY22 as compared to other years, but this is seen as a short-term impact due to COVID-19 impacts on international travel, and the longer term trend of high equipage is forecasted. These systems are expected to be leveraged for participation in U.S. domestic

Data Comm tower and en route services, particularly by long-range GA and Air Taxi Turbojet airplanes.

- ADS-B Out equipage increased rapidly as operators equipped with rule compliant systems ahead of the 2020 ADS-B Out mandate. Equipage continues in 2022 as some operators change their operations and identify a need to equip. The compliance total as of July 2022 is more than 150,000 U.S. registered aircraft, with over 80,000 of these in the U.S. registered IFR fleet. These operator categories continue equipping at very high rates with ADS-B In capable systems as they see benefit in safety enhancements, such as traffic and weather data in the cockpit. Total ADS-B In equipage is approximately 105,000 aircraft, with over 60,000 of these installations occurring in the IFR fleet. Some operators electing not to equip for ADS-B Out for the mandate are still installing ADS-B In systems to gain the benefits of improved situational awareness from limited traffic and weather information in the cockpit.
- Low-visibility enablers continue to be a niche capability due to high cost, but operators of turbojet airplanes in these groups equip at higher rates than Air Transport. These operators seek all-weather operations and redundancy offered by low-visibility systems, especially at smaller and more operationally challenging airports that are part of their operations. Feedback from operators and suppliers indicates that the continued evolution of vision system technologies and corresponding standards development is pointing toward improved business cases for these technologies.
- As in Air Transport, EFBs are a key safety enabler for the other operator categories. Portable EFBs continue to be a highly desired enabler, offering a variety of onboard uses. Long-range, turbojet airplanes have several available options for runway safety applications, and data suggest some operators continue to purchase these capabilities. Systems for assisting pilots in runway awareness during takeoff, taxi, and/or landing operations are examples of solutions being made available to operators. Similar to Air Transport, EFBs with connectivity is a continuing trend, with some new aircraft being delivered forward-fit capable and existing aircraft accomplishing some retrofits. Aircraft with EFB connectivity fall into two general categories based on the level of aircraft integration and therefore the types of capabilities they can support. The first group is those with one way connectivity where the EFB can receive information from installed avionics systems only. The other category is those implementations where the EFB can both send and receive information from avionics systems. EFBs with aircraft integration, coupled with commercial network links, support emerging connected aircraft concepts by enabling the transfer. Some operators are electing to install AIDs to accomplish improved EFB connectivity, security, and capability and, as a result, are enabling additional benefits to fielded EFB systems. The continued interest in increasing passenger connectivity results in many new aircraft entering service with onboard servers, commercial satellite communications, and other on aircraft networks that are the key enablers to EFBs with connectivity and future connected aircraft concepts. Also of note, for the Air Taxi and Corporate/GA fleets, other connectivity options such as Bluetooth and Wi-Fi are becoming more common, enabling both piston and turbojet powered airplanes to connect portable devices and avionics to improve safety and efficiency.

Table ES-3 tabulates the estimated current equipage for these other operator categories.

Table ES-3. Other Fleets: Current Equipage

		Air Taxi	Foreign Carrier	Corporate / GA	Helicopter
PBN	RNP 4 w/Oceanic Comms	51%	83%	70%	NOHO
	RNAV 1	99%	>>99%	94%	91%
	RNAV 2	99%	>>99%	95%	91%
	RNP 1 w/RF *	13%	34%	5%	2%
	RNP 1 w/TF	99%	>>99%	94%	91%
	VNAV Approach *	75%	88%	58%	42%
	LPV Approach *	69%	23%	56%	41%
	RNP Approach	99%	>>99%	94%	91%
	RNP AR Approach	5%	26%	1%	<<1%
	GLS I	9%	15%	4%	2%
ADS-B	ADS-B Out	>>99%	98%	99%	99%
	ADS-B In - SA Apps	54%	13%	83%	63%
	ADS-B In - Approach Apps	54%	13%	83%	63%
	ADS-B In - ITP Apps	AAR	AAR	AAR	NOHO
Data Comm	FANS 1/A Domestic - Tower Services	15%	64%	4%	<<1%
	FANS 1/A Domestic - En Route Services	13%	48%	4%	<<1%
	FANS 1/A Oceanic	51%	83%	70%	NOHO
Low-Viz	HUD Approach	AAR	AAR	AAR	AAR
	EFVS	AAR	AAR	AAR	AAR
Safety and Other	EFB	AAR	AAR	AAR	AAR

Key
AAR Additional Analysis Required
NOHO No Oceanic Helicopter Operations

*Equipage for these capabilies are lower due to constraints of IFR flight plan data. Actual equipage is higher - see relevant sections in remainder of report for additional detail.

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1 Avionics Evolution Overview

1.1 Introduction, Purpose, and Scope

The MITRE Corporation's (MITRE) Center for Advanced Aviation System Development (CAASD) has been tracking and reporting United States (U.S.) fleet and avionics capability information in support of the Next Generation Air Transportation System (NextGen) since 2009. This report provides the 2022 update of the Federal Aviation Administration (FAA) Status and Forecast of Avionics Evolution, covering aircraft operating in the U.S. National Airspace System (NAS). The data contained in this report has been accumulated during the Coronavirus Disease 2019 (COVID-19) pandemic. As a result, the report represents an in-pandemic analysis of fleet evolution influenced by pre-pandemic and in-pandemic data, coupled with a range of post-pandemic forecasts.

Due to the diversity of and rate of change in the responses to the COVID-19 pandemic seen within the various fleets operating in the NAS, MITRE's confidence in the forecasts and projections offered in this edition of the report is necessarily somewhat lower than for the pre-pandemic editions of this product, but these forecasts and projections remain both relevant and usable for planning and assessment purposes. MITRE maintains a wide range of additional information on fleet and avionics evolution that is outside the scope of this report but may be available upon request. The data in this report represents a COVID-19 impacted environment and can be considered a good estimate of the current state of NextGen capabilities for the U.S. fleet, while forecast projections are subject to expected, but still unclear, additional fleet rationalizations.

The purpose of this report is to provide a common, comprehensive summary and forecast of NextGen avionics enablers and operational capabilities. The coverage of the U.S. aircraft fleet composition and avionics-enabled capabilities serves to inform the FAA, operators, and industry on fleet evolution toward NextGen.

The report covers a wide range of operators and aircraft, including those certificated under Operations Specifications (OpSpecs), filing Instrument Flight Rules (IFR) flight plans, and/or with a U.S. registration, and conducting flight operations in the NAS in the categories of Air Transport, Air Taxi, Foreign Carrier, Corporate/General Aviation (GA), and Helicopter. It covers fleet composition, equipage, and approvals as well as forecasts of future NextGen capabilities in the commercial Air Transport fleet.

For aircraft in these categories, the report indicates the status of their equipage for mature NextGen avionics enablers as defined in the NextGen Segment Implementation Plan (NSIP), including in the areas of Performance Based Navigation (PBN), Automatic Dependent Surveillance-Broadcast (ADS-B), Data Communications (Data Comm), low-visibility operations, and other safety enhancements. It offers key findings and is inclusive of industry feedback and plans. Additionally, it identifies issues and challenges impacting NextGen fleet readiness.

1.2 Fleet and Equipage Overview

1.2.1 Operators, Aircraft, and Enablers Overview

This report includes information about the U.S. fleet of airplanes, international air carrier operators approved to fly to the U.S., and a separate breakout of helicopters. The aircraft flown by Air Transport operators are exclusively airplanes. Airplanes flown by Air Taxi, Foreign Carrier, and Corporate/GA operators are treated under those respective groupings, but the helicopters they operate are combined in the Helicopter category.

Airplanes in the Air Transport fleet are further characterized by body type and engine as narrow-body, wide-body, regional jet (those with 90 seats or less in normal service configuration), and turboprop. Non-Air Transport airplanes are characterized as single-engine piston, multi-engine piston, turbojet (inclusive of turbofans), or turboprop. Helicopters are characterized as piston or turbine.

The Air Transport fleet is dominated by turbine-powered models from four manufacturers (Boeing, Airbus, Embraer, and Bombardier) and is equipped with numerous NextGen enablers. This fleet's regional jets are generally less equipped for NextGen avionics enablers as compared to wide-body and narrow-body airplanes, though their capabilities continue increasing steadily each year. The Foreign Carrier fleet resembles the Air Transport fleet in terms of body type and equipage.

The other operator categories are more diverse in manufacturers and engine types represented and include many lower-cost, single-engine piston models. Their equipage status reflects this wider variety of aircraft types, greater spread in airframe age and time in service, a more diverse, larger set of possible missions and, often, less tolerance for equipage costs. Generally, avionics capabilities are highest in Air Taxi and Corporate/GA turbojet and turboprop aircraft and lowest in piston-engine GA aircraft.

A total fleet of 241,323 aircraft are potential candidates for equipage and approval (excludes aircraft registered as Experimental due to the lack of available avionics data on these fleets at this time). Aircraft that file IFR flight plans (just over 35% of the total U.S. operated fleet) are considered the more likely candidates to equip with NextGen enablers.

Table 1-1 summarizes the fleets of interest for this report, distinguished by operator category and the filing of IFR flight plans. Table 1-2 represents the same fleets of interest distinguished by the engine type (including Air Transport airplanes under turbojet or turboprop as appropriate). Tables 1-1 and 1-2 below capture relevant fleet breakouts, with subtotals shown in italicized font and totals indicated with bold and italicized font.

Table 1-1. Fleet Size and IFR Operations by Operator Category

Operator Category	Total Aircraft	File IFR	Percent IFR	Total Operations	Operations per IFR Aircraft
Air Transport	7,081	7,081	100%	10,151,364	1434
Air Taxi	8,504	7,418	87%	2,955,235	398
Corporate / GA	205,961	65,939	32%	3,210,375	49
U.S. Airplane Subtotal	*221,546*	*80,438*	*36%*	*16,316,974*	*203*
Helicopters	12,329	1,098	9%	54,769	50
Aircraft Subtotal	*233,875*	*81,536*	*35%*	*16,371,743*	*201*
Foreign Carrier	7,448	4,912	66%	792,859	161
Total	***241,323***	***86,448***	***36%***	***17,164,602***	***199***

Table 1-2. Fleet Size and IFR Flight-Plan Filings by Engine Type

Engine Type	Total Aircraft	File IFR	Percent IFR	Total Operations	Operations per IFR Aircraft
Turbojet	31,252	26,264	84%	13,881,791	529
Turboprop	12,594	8,401	67%	1,795,174	214
Multi Engine Piston	15,374	8,310	54%	350,299	42
Single Engine Piston	169,774	42,375	25%	1,082,569	26
Airplane Subtotal	*228,994*	*85,350*	*37%*	*17,109,833*	*200*
Turbine Helicopter	8,048	860	11%	53,690	62
Piston Helicopter	4,281	238	6%	1,079	5
Helicopter Subtotal	*12,329*	*1,098*	*9%*	*54,769*	*50*
Total	***241,323***	***86,448***	***36%***	***17,164,602***	***199***

This report generally identifies the equipage status against this IFR operating subset of the total fleet. For oceanic airspace enablers, only airplanes filed to fly in ocean regions are considered in the analysis for equipage and approval. This report uses the oceanic fleet (i.e., those airplanes that flew in oceanic airspace in the previous 18 months) when reporting Required Navigation Performance (RNP) 4 with Oceanic Comms, ADS-B In for in-trail procedures (ITP), and Future Air Navigation System (FANS) 1/A Oceanic.

Forecasts of Air Transport future-fleet size and composition by airplane make and model are used to generate equipage forecasts. For other operator categories, future-fleet forecasts are not readily available in formats needed for this report; however, available information and historical trends indicate fleet size, equipage, and capabilities are increasing over time. Operators who retire old airplanes replace them with new aircraft that also have the same capabilities and often add new capabilities as they take ownership of different airplanes.

For purposes of this report, IFR flight activity is determined by analyzing IFR flight plan data as well as flown altitude. MITRE defines IFR flight activity as at least one operation for a given aircraft registration number that filed an IFR flight plan over the last 18-month period, or at least one operation over the last 18-month period wherein the altitude exceeded 18,000 feet.[1] For Air Transport aircraft, six operations for a given aircraft registration number that filed an IFR flight plan over the last 18-month period is used to filter out maintenance and ferry flights of aircraft that are considered not to be in routine service or in long-term storage.

There are many NextGen enablers that span PBN, ADS-B, Data Comm, low-visibility operations, and other safety enhancements consistent with the NSIP. This report addresses 21 of the mature capabilities (engineering-complete or have been demonstrated in operation); see Table 1-3.

Most NextGen enablers can be associated with flight operations that require filing an IFR flight plan. While all Air Transport aircraft fly under IFR, many airplanes in the other operator categories fly under Visual Flight Rules (VFR). Many VFR-only operated airplanes are fitted with key avionics technologies, such as GPS with localizer performance, Vertical Guidance (LPV) Approach capability, and ADS-B In for cockpit weather and traffic. As a result, total U.S. fleet equipage is higher than as indicated in this report, which focuses on IFR equipage and operators only.

Certain capability definitions have been tailored to reflect finer-grained distinctions as they support FAA program and NSIP increment plans (e.g., PBN for Area Navigation [RNAV] 1 routing versus longer-term plans that will leverage Dynamic RNP route segments). MITRE maintains a wide range of additional information on fleet and avionics evolution that is outside the scope of this report that could be made available upon request.

1.2.2 Equipage and Capabilities Overview

Table 1-4 provides the current state of equipped capabilities and operational approvals for the five operator categories.

[1] Only IFR flights are permitted to fly in Class A airspace, which spans Flight Level (FL)180 through FL450; therefore, this altitude-based criterion was used as an additional mechanism of determining IFR status.

Table 1-3. NextGen Enablers

PBN	**Performance Based Navigation (PBN) Enablers**
RNP 4 w/Oceanic Comms	Required Navigation Performance (RNP) 4 with (w/) Oceanic Distance Communications
RNAV 1	Area Navigation (RNAV) 1
RNAV 2	RNAV 2
RNAV 1 & 2	RNAV 1 and 2
RNP 1 w/RF	RNP 1 with Radius to Fix (RF)
RNP 1 w/TF	RNP 1 with Track to Fix (TF)
VNAV Approach	Vertical Navigation (VNAV) Approach
LPV Approach	Localizer Performance with Vertical Guidance (LPV) Approach
RNP Approach	RNP Approach
RNP AR Approach	RNP Authorization Required (AR) Approach (RNAV/RNP)
GLS I	Ground Based Augmentation System (GBAS) 1 Landing System (GLS)
ADS-B	**Automatic Dependent Surveillance – Broadcast (ADS-B) Enablers**
ADS-B Out	ADS-B Out
ADS-B In - CAS/CAVS	ADS-B In Cockpit Display of Traffic Information (CDTI)-Assisted Separation (CAS) / CDTI-Assisted Visual Separation (CAVS)
ADS-B In - SA Apps	ADS-B In Cockpit Display of Traffic Information (CDTI) for Situational Awareness (SA) Airborne and Ground Applications
ADS-B In - Approach Apps	ADS-B In CDTI Assisted Visual Separation (CAVS) for Approach Applications
ADS-B In - ITP Apps	ADS-B In for In-trail Procedures (ITP) Applications
Data Comm	**Data Communications (Data Comm) Enablers**
FANS 1/A Domestic - Tower Services	Future Air Navigation Systems (FANS) 1/A over Very High Frequency (VHF) Data Link (VDL) Mode 0 or Mode 2 for Continental United States (U.S.)
FANS 1/A Domestic - En Route Services	FANS 1/A over VDL Mode 2 for Continental U.S.
FANS 1/A Oceanic	FANS 1/A over SATCOM for Controller-Pilot Datalink Communication (CPDLC) / Automatic Dependent Surveillance - Contract (ADS-C) for Oceanic
Low-Viz	**Low-Visibility (Low-Viz) Enablers**
HUD Approach	Head-Up Display (HUD) Approach for Manually Flown Landing Operations Other Than Categories II and III
EFVS	Enhanced Flight Vision System (EFVS)
Safety and Other	**Safety Enhancement and Other Enablers**
EFB	Electronic Flight Bag (EFB)
EFB w/Aircraft Integration	EFB with (w/) Aircraft Integration

Table 1-4. Current Equipage Capabilities by Operator Category

(PBN and Data Comm values for non-Air Transport fleets derived primarily from IFR flight plan filings)

		Air Transport	Air Taxi	Foreign Carrier	Corporate / GA	Helicopter
PBN	RNP 4 w/Oceanic Comms	61%	51%	83%	70%	NOHO
	RNAV 1	NR	99%	>>99%	94%	91%
	RNAV 2	NR	99%	>>99%	95%	91%
	RNAV 1 & 2	>>99%	NR	NR	NR	NR
	RNP 1 w/RF	88%	13%	34%	5%	2%
	RNP 1 w/TF	99%	99%	>>99%	94%	91%
	VNAV Approach	92%	75%	88%	58%	42%
	LPV Approach	6%	69%	23%	56%	41%
	RNP Approach	99%	99%	>>99%	94%	91%
	RNP AR Approach	78%	5%	26%	1%	<<1%
	GLS I	10%	9%	15%	4%	2%
ADS-B	ADS-B Out	NR	>>99%	98%	99%	99%
	ADS-B In - CAS/CAVS	4%	NR	NR	NR	NR
	ADS-B In - SA Apps	14%	54%	13%	83%	63%
	ADS-B In - Approach Apps	14%	54%	13%	83%	63%
	ADS-B In - ITP Apps	2%	AAR	AAR	AAR	NOHO
Data Comm	FANS 1/A Domestic - Tower Services	54%	15%	64%	4%	<<1%
	FANS 1/A Domestic - En Route Services	47%	13%	48%	4%	<<1%
	FANS 1/A Oceanic	63%	51%	83%	70%	NOHO
Low-Viz	HUD Approach	29%	AAR	AAR	AAR	AAR
	EFVS	5%	AAR	AAR	AAR	AAR
Safety and Other	EFB	99%	AAR	AAR	AAR	AAR
	EFB w/Aircraft Integration	23%	NR	NR	NR	NR

Key

AAR	Additional Analysis Required
NOHO	No Oceanic Helicopter Operations
NSOA	No Specific OpSpec Applies
NOAR	No Operational Approval Required
NR	Not Reported

Key findings for equipage include:

- PBN equipage and operational approvals in Air Transport are generally high. They are forecasted to remain high because airplanes that retire with a NextGen capability are replaced by new airplanes with equal or greater capability. Capabilities with lesser equipage rates, e.g., RNP Authorization Required (AR) Approach, will increase as newer, equipped airplanes are delivered and older, non-equipped airplanes are retired. PBN equipage across other operator categories is mostly high, and additional data indicate it will remain so. For capabilities like RNP AR Approach, Vertical Navigation (VNAV) Approach, RNP 1 with Radius-to-Fix (RF) and others, the trends will be for equipage to increase as new airplanes are delivered with these capabilities in support of evolving and new operations such as Established on RNP (EoR).
- ADS-B Out equipage has remained flat during the post-mandate period as most operators had accomplished equipping their fleets for the rule by January 1, 2020. While Air Transport operators successfully equipped nearly all airplanes with the required transponders in time

for rule implementation, many operators utilized FAA Exemption 12555 for additional position source modifications in the period after 2020, but before January 1, 2025. In the past year, Exemption 12555 has been made permanent and the 2025 date is no longer applicable. Some non-Air Transport operators, due to operational considerations and other factors, chose to wait to equip until after January 1, 2020, and as a result, equipage has continued even after rule implementation.

- ADS-B In equipage in the Air Transport fleet is projected to remain relatively flat for the next few years. Several Air Transport operators, particularly American Airlines, are actively assessing operational applications and resultant business cases to justify further equipage. As a result, those applications and capabilities are slowly fielded as business cases for operators are matured. For other operator categories, many operators are equipping with ADS-B In capable systems as part of their ADS-B Out compliant implementations because they see safety benefits in traffic and weather data in the cockpit.

- Data Comm equipage for oceanic Air Transport operations is high and will increase as additional satellite communication (SATCOM) equipment is installed on airplanes flying in RNP 4 oceanic airspace and to provide passenger data services. Data suggests these oceanic airplane implementations are also Required Communication Performance (RCP) 240 second and Required Surveillance Performance (RSP) 180 second compliant. Domestic-use Data Comm equipage is increasing as operators continue to exercise available options on new airplanes, while FAA financial assistance for avionics on new delivery narrow-body aircraft has ended, having had a positive influence on operators' rates of ordering Data Comm options on new delivery aircraft. Some Regional Aircraft are now being delivered forward-fit with Data Comm capability, and retrofit plans are still evolving due to COVID-19 impacts. Other operators flying oceanic routes, such as turbine-powered Corporate/GA, have similar motivations for equipping for Data Comm to take advantage of North Atlantic Track (NAT) High Level Airspace (HLA) routes and improved passenger data services.

- Low-visibility enablers continue to be a niche capability due to high cost, but new market offerings have significantly lowered the price points and physical size of some systems. Manufacturers are evolving their systems with additional capabilities such as runway overrun protection and extended runway centerline display that provide additional safety enhancements and may offer improved business cases. Overall, there is continued interest in all operator categories in various vision system technologies to improve safety and operational efficiencies. As manufacturers evolve the technology of available systems, the FAA continues to evolve operational approvals for these systems, strengthening the business case of using vision systems for improved safety. Operators of turbojet airplanes in Corporate/GA continue to equip at higher rates than Air Transport. These operators seek all-weather operations and redundancy offered by low-visibility systems, especially when access to smaller airports is impeded due to less ground infrastructure, resulting in higher minima.

- Electronic Flight Bags (EFBs) are a key safety enabler. Portable EFBs (not installed equipment) continue to be a highly desired enabler, with most Air Transport operators completing or planning programs. The fleet is already highly equipped and will only increase as operators adopt Apple iPads® and similar platforms for a variety of onboard uses. Industry engagement has revealed that Air Transport operators see the pairing of an EFB with an Aircraft Interface Device (AID) as a method to further extend the use of the EFB, thus increasing the pool of potential benefits. Interest is also high in other operator categories.

Regional airplanes, a subset of Air Transport, can represent up to 60% of operations at some metroplexes and Operational Evolution Plan 35 airports. MITRE has been working closely with the Regional Airline Association and regional carriers to better understand equipage expectations and trends affecting this sub-fleet. Regional aircraft are also a key fleet of aircraft included in the industry led Minimum Capability List (MCL) Activity group convened through the direction of the NextGen Advisory Committee. Of note for this 2022 update:

- Historically, some new regional airplanes entering service were capable of RNP approaches with RF leg capability, while other regional airplanes did not have RF leg capability due to lack of forward-fit offerings or challenging business cases for retrofitting unequipped airplanes. With Bombardier no longer producing regional aircraft and Mitsubishi having paused development of their new planned regional aircraft, regional aircraft from companies such as Embraer and ATR are being delivered standard with RNP and RF leg capability, resulting in improvements to the regional aircraft fleet's PBN footprint.
- MCL updates may result in more forward-fit and retrofit offerings and positively impact business cases for a range of PBN, Data Comm, and Resilient Navigation capabilities.
    - Regional airlines continue to have business challenges that prevent them from investing in non-essential operational capabilities, even if the business case for a NextGen capability may be positive. The NextGen Advisory Committee is updating their MCL business case materials to assist operators in development and refinement of business cases that may allow some operators to overcome their business case challenges.
    - Mainline partner interest and engagement on their regional partner fleet evolution plans is increasing, but the ultimate impact to equipage and capability is unclear.
- Regional airline challenges include:
    - Short-term aircraft lease agreements where benefits cannot be recouped in time to meet return on investment requirements.
    - Business arrangements with mainline operators where benefits of fuel or time saved may be attributed to the mainline partner, while cost of avionics equipment is often borne by the regional airline.
    - Short-term contracts for carriage between regional and mainline partners that can challenge longer-term fleet investments and evolution.
    - Other airline investments that are considered priorities over avionics and NextGen capability enhancements.

Emerging world-wide avionics requirements and implementation schedules add to an already complex decision environment, in which operators with finite resources need to satisfy regulatory mandates and can be caught between improving aircraft or enhancing customer experience. This investment environment is also balanced with the need to compete against aggressive startups without legacy fleets, facilities, and labor costs. In some cases, operators do not yet understand the use cases for certain NextGen avionics-related capabilities—particularly those related to more forward-leaning capabilities such as ADS-B In for Tactical and Strategic Advanced Interval Management (IM), or not fully defined separation standards that are still being researched, such as Multiple Airport Route Separation (MARS). Where avionics upgrades clearly warrant operator spending, the interrelated nature of PBN, Data Comm, and ADS-B In and Out technologies requires careful design and scheduling of upgrades to fully leverage their collective capabilities and resultant benefits. Establishing the business case and operational impacts of integrating multiple technologies (i.e., communications, navigation, surveillance, safety) is challenging and sometimes impedes implementation of the individual technologies considered beneficial or required. As a result, some operators are choosing to upgrade individual capabilities and deferring decisions regarding longer-term integrated architectural solutions, often relying on new aircraft purchases alone to evolve their fleets with multiple additional capabilities.

In the past year, significant new attention has been paid to aviation spectrum frequency bands and radio frequency interference (RFI). The potential for 5G interference with aircraft radar altimeters resulted in issuance of FAA Airworthiness Directives and resultant Alternative Means of Compliance (AMOCs). For operators experiencing significant operational impacts, many have chosen to retrofit their aircraft with improvements to their radar altimeter systems. In some cases, Air Transport and regional operators have had to delay potential NextGen capability improvements to accomplish radar altimeter upgrades. Current Radio Technical Commission for Aeronautics (RTCA) efforts to create new standards for radar altimeters are expected to be completed in 2023, which may result in additional fleet radar altimeter retrofits; the impact of these efforts on NextGen capability forecasts is not yet known.

Another focus area for potential interference is NAS operations that are dependent on GPS. Several interference events have been documented in recent years, impacting both large and small airports. Even though aviation has not generally been a planned target of GPS interference, as with 5G interference, it is the unintended consequences of real or potential interference that impact aviation. Operators flying to parts of the Middle East and other international locations have reported routine interruption and interference with GPS and other Global Navigation Satellite Systems (GNSS) signals. In these cases, although some aircraft and systems functioned as expected with the loss of GNSS signals, other aircraft had unexpected results where systems were rendered unusable, requiring pilots to fly using their backup procedures and systems. Although pilots and aircraft are appropriately trained and certified for these backup operations, it does present challenges for operators desiring to maintain high integrity in their planned schedules. Operators are beginning to take steps to identify GNSS dependencies and consider how to best equip their aircraft to leverage key FAA infrastructure such as Distance Measuring Equipment (DME), while exploring new technologies like Multi Frequency GNSS receivers to reduce their dependency on GPS and potential impacts to their flight schedules, should GNSS signals become unavailable.

New avionics that provide capabilities for PBN and other enablers (e.g., LPV Approach, Ground Based Augmentation System [GBAS] Landing System I [GLS I]) are likely to have a significant impact on fleet operational capabilities. The NextGen Advisory Committee and Equip 2020 activities, both government-industry partnerships, have offered stakeholders opportunities for enhanced information sharing and common forecasts that support both FAA and industry decision-making processes, particularly where mixed-equipage fleets are forecast for the foreseeable future. Recent focus has included the unique equipage challenges regional aircraft present while representing significant operations at many large airports, and the need to understand how and when to invest in appropriate air and ground supporting infrastructure. The initial MCL was completed in CY2020. An annual update has been initiated for FY22, as of the time of the writing of this report. Although airlines are voicing their support for the MCL, airline adoption rates and the resultant impact on equipage rates are not yet known.

Fleet turnover may provide opportunities for NextGen stakeholders to influence equipage on new airplanes and lease renewals, although discussions with operators have indicated that, in many cases, they have already defined their equipage and capabilities to be delivered on their newest airplanes. The impacts of COVID-19, supply chain issues, delays at Boeing in delivering aircraft, and ongoing rationalization of air carrier fleets to address changing market conditions have resulted in continued adjustment of deliveries in the 2022 to 2025 period. As a result of these many factors, the net effect on NextGen aircraft readiness is an expected shift to the right, but specific estimates cannot yet be made

Commercial aircraft are significant capital investments with long asset lives. As in other industries with analogous capital asset mixes, airlines have sought to move their airplane assets off their balance sheets through leasing arrangements. In previous years, estimates have reported that approximately 50% of the Air Transport fleet is leased. Although not supported with quantitative data in 2022, industry feedback and analysis of available data indicate the 50% value to be a reasonable overall estimate for 2022. Data analyzed shows that in 2022, larger airlines tend to have fewer leased aircraft than smaller airlines. While the percentage of owned vs. leased aircraft does fluctuate year-to-year due to local and global economic factors, the 50% range has been consistent over the past several years, resulting in leasing companies being large stakeholders in NextGen. The pool of leasable aircraft has been complicated by geo-political impacts and, separately, by the disruption to Boeing delivery schedules. It is too soon to tell whether new, unleased, or returned-from-lease older aircraft will remain in flyable storage or be converted to other use, but MITRE will continue to track this pool of aircraft.

Lease duration and expiration dates can provide insight into future-fleet turnover and potential opportunities for avionics upgrades. Lease durations have generally been getting shorter in recent years, particularly for regional aircraft, which complicates aircraft and capability forecasts. Short lease durations can make it harder to justify investment by a current lessee unsure of a reasonable return on investment, but this may also provide the opportunity for more capability to be added to the aircraft upon lease expiration.

Aircraft are leased using differing business models. So-called ‘wet’ leases include the aircraft, crew, maintenance, and insurance; operate on the lessor certificate; and are usually short-duration arrangements. ‘Dry’ leases include only the aircraft; operate on the lessee certificate; and are usually of longer duration. Wet lease aircraft are generally equipped consistent with the lessor business model. As such, current FAA engagements with the wet lessors should influence those decision makers. However, it is unlikely that advanced NextGen capabilities would be justified by their marginal return on investment. On the other hand, dry aircraft lessors are responsive to the needs of their airline customers and are motivated to equip their fleets consistently to lower unit acquisition prices. Likewise, the dry leasing market is global, and lessors seek to offer lowest-common-denominator avionics configurations consistent with global aircraft equipage and capability requirements. When the U.S. market seeks to drive enhanced aircraft avionics equipage, it challenges both these motivations. To effectively influence dry aircraft lessor decision makers to include greater NextGen capability offerings, consideration must be given to their affordability and interoperability market drivers. NextGen benefits alone may not be sufficient in a global market.

1.3 Analysis Overview

1.3.1 Data Sources

MITRE collects and analyzes data from multiple sources, including aircraft manufacturers, avionics suppliers, aircraft operators, and the FAA. Each source provides specific insights on aircraft status and evolution.

Manufacturers know valuable details about new aircraft: how aircraft are equipped, capability options offered, plus future orders and trends. Operators know their aircraft modification history, planned upgrades, and key drivers for their equipage business case. Avionics suppliers know avionics capabilities, future avionics offerings, and timelines for when new capabilities could be made available to operators and original equipment manufacturers. The FAA Web-based Operations Safety System (WebOPSS) database records FAA operational approvals and some equipage for commercial operators (those for hire). The FAA Aircraft Registry database records U.S. fleet registrations, aircraft makes/models, engine data, and other fleet information. The FAA fleet forecast estimates U.S. future Air Transport fleet composition.

Current Air Transport, Air Taxi, and Foreign Carrier fleet inventory is derived from the Operator Aircraft Viewer (OAV) data table on the FAA's WebOPSS database along with complementary IFR flight plan information as noted below. Fleet inventory for Corporate/GA and Helicopter is defined by the FAA Registry Master File. Only aircraft with valid registration status (or reported in the OAV with foreign registration) are included. The fleet inventory data consists of aircraft identifying metadata (e.g., operator name, aircraft registration, aircraft model/series, and year of manufacture).

The fleet inventory data is supplemented by observed IFR flight plan data that provide information regarding:

- IFR flight activity that is determined by analyzing IFR flight plan data and flown altitudes
- Number of operations filed in oceanic airspace over the same period
- Number of equipped capable operations for various PBN, Data Comm, and Other NextGen capabilities and, in some cases, the equipage utilized to conduct these operations

Often, IFR flight plan capability filings have a one-to-one mapping to the capabilities and equipages in Table 1-3. However, for those capabilities that do not have explicit filings, a combination of filings may be used together to infer equipped capability. The mappings used in this report are covered in Appendix B.

Operational approval for various capabilities in the Air Transport fleet is based on a detailed review of the associated OpSpecs and engagement with FAA Flight Standards. Specific approvals are noted at the operator level, make/model level, or by specific registration number as reported in the OpSpec. Additional details about OpSpec documents for other than Air Transport operators are available, but substantial additional analysis is required to derive data from this large document set. Hence, operational approvals for these other operator categories are equated to the filing for the capability in a flight plan, assuming the act of filing indicates the operator's belief they have the necessary approval to use the capability.

A common request to MITRE from industry and various working groups is to estimate future equipage levels in the Air Transport fleet. To accommodate this, MITRE leverages the FAA fleet forecast produced by the FAA Office of Aviation Policy and Plans to define future Air Transport fleets. It builds on the FAA Aerospace Forecast report, detailing the number and types of airplanes entering and departing the Air Transport fleet in each year, while remaining consistent with the total annual fleet counts in the Aerospace Forecast.

The summary trend data provides a high-level, conservative progress assessment of NextGen avionics enablers. Equipage rates shown are based on MITRE avionics assessments. Trends over the next five years (through calendar year 2027) are characterized as being flat (less than three percent) or increasing (three percent or greater). Forecasted equipage in future years reflects current equipage levels incremented with new delivery airplanes with standard capability offerings and known operator equipage plans, and an assumption that all current equipped airplanes that retire are replaced with airplanes of at least equal capability.

1.3.2 Presentation Formats

This section describes how to interpret the most common graphics contained within this report. Figure 1-1 shows the example Air Transport infographic that is the most complex in this report, comprising eleven individual elements that are described below.

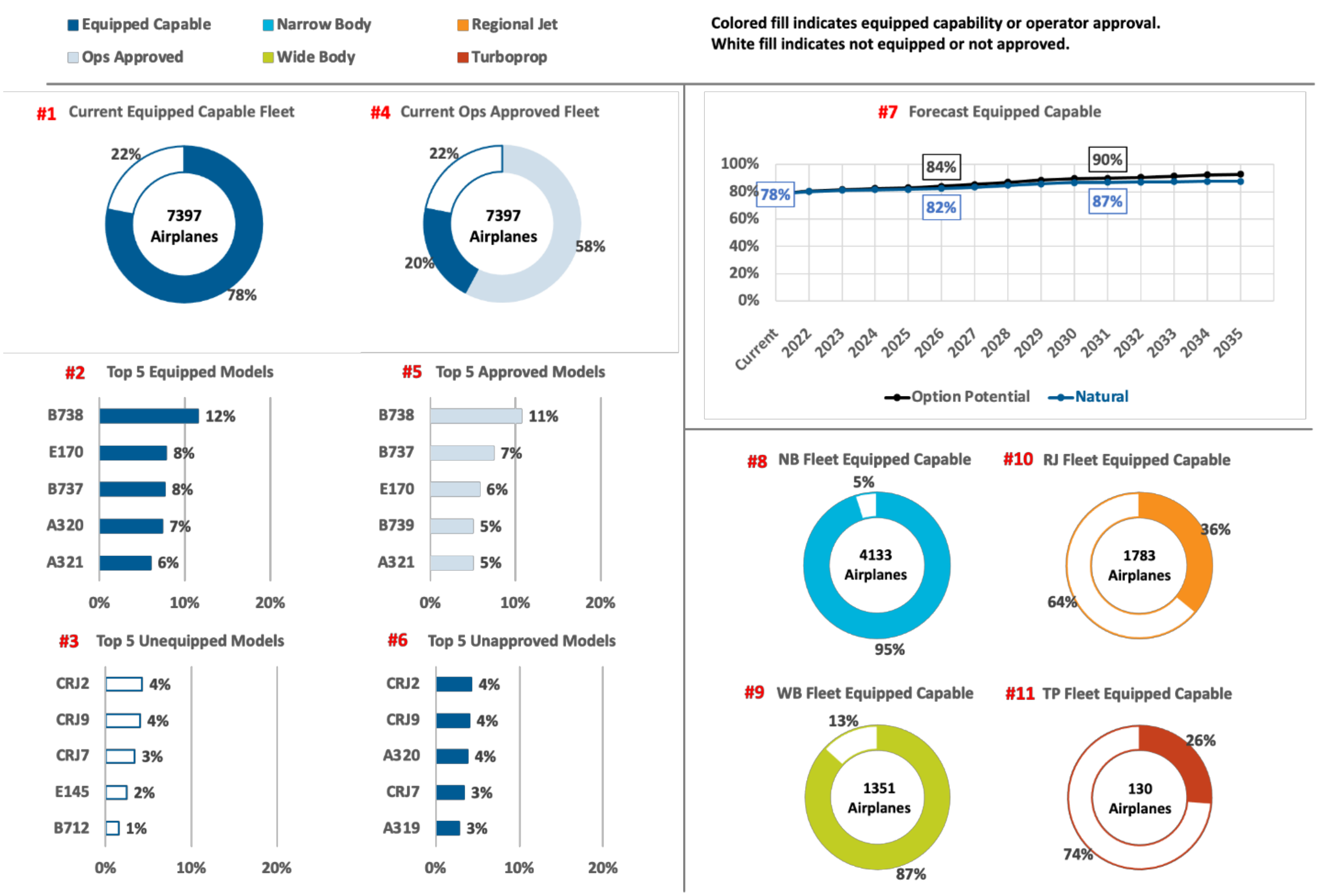


Figure 1-1. Example Infographic for Air Transport Operator Category

Current Equipped Capable Fleet: The doughnut chart represents the percentage of the total current fleet equipped capable (i.e., airplanes that are equipped but not necessarily operationally approved to use that capability) for the given NextGen enabler. The dark blue fill indicates airplanes equipped capable. The white fill indicates airplanes not equipped capable. The total Air Transport fleet is shown inside of the doughnut graph.

Top 5 Equipped Models: Up to the top five equipped capable airplane models are listed in this chart, in descending order based on the number of equipped airplanes. The percentage values shown are of the total Air Transport fleet. The color fill is dark blue to mirror the equipped capable portion of the Current Equipped Capable Fleet chart (#1). If there are no models known to be equipped for a given NextGen enabler, this chart will be labeled *No Equipped Models*. This may occur when a capability is conceptually and operationally immature and operators have not made fleet equipage decisions.

Top 5 Unequipped Models: Up to the top five unequipped airplane models are listed in this chart, in descending order based on the number of unequipped airplanes. The percentage values shown are of the total Air Transport fleet. The color fill is white to mirror the unequipped portion of the Current Equipped Capable Fleet chart (#1).

Current Operationally (Operations [Ops]) Approved Fleet: The doughnut chart represents the percentage of the total current fleet operationally approved via OpSpec for the given NextGen enabler. The silver fill indicates airplanes equipped capable and operationally approved. The dark blue fill indicates airplanes equipped capable, but that have not yet been approved for operational use. Note that the sum of the silver and dark blue fills equals the dark blue fill in the Current Equipped Capable Fleet chart (#1). This is because operational approval is a subset of equipped capable. The white fill represents the percentage of airplanes not equipped capable.

Top 5 Approved Models: Up to the top five operationally approved airplane models are listed in this chart, in descending order based on the number of airplanes that have been approved via OpSpec. The percentage values shown are of the total Air Transport fleet. The color fill is light blue to mirror the operationally approved portion of the Current Ops Approved Fleet chart (#4). For some NextGen enablers, this chart may be labeled *Additional Analysis Required*, which means there are multiple OpSpec documents that must be reconciled to result in a single approval number. Additionally, in the absence of a known or required guidance document for operational approval, this chart will be labeled *No Approved Models*.

Top 5 Unapproved Models: Up to the top five operationally unapproved airplane models are listed in this chart in descending order based on the number of airplanes that have not been approved via OpSpec. The percentage values shown are of the total Air Transport fleet. If there are airplanes equipped capable but not yet operationally approved for one reason or another, the color fill will be dark blue to follow the equipped capable but not operationally approved color scheme in the Current Ops Approved Fleet chart (#4). If all equipped capable airplanes are operationally unapproved, the color fill will be white with a dark blue outline to mirror the unequipped portion of the two doughnut charts above.

Forecast Equipped Capable: This chart presents an annual end-of-calendar-year summary of the percentage of the fleet equipped capable for the given NextGen enabler through 2040. Values are shown for today’s current equipage, and 2027, 2030, 2035, and 2040 snapshots of forecasted equipage percentage. New airplanes are delivered in a standard capability, optional capability, or capability not available configuration as indicated in the airframe manufacturer’s planned offerings and are added to the current equipage as growth.

The Natural curve in the chart starts with current equipped airplanes. It accounts for the retirement and replacement of existing airplanes over time. It includes operator equipage plans known at this time (e.g., ADS-B Out and FANS 1/A for domestic use are expected and new delivery airplanes will come with the capabilities offered as standard). It is expected operators will replace equipped airplanes that retire with new airplanes no less equipped, even if they will need to pay a fee for optional equipage.

The Option Potential curve in the chart indicates the upper bound of fleet equipage given that all new airplanes with option capability are exercised and equipped. The delta from the top of the Option Potential curve to 100% equipage represents the remaining opportunity space that could be addressed by retrofits.

Narrow-body (NB) Fleet Equipped Capable: The doughnut chart represents the percentage of the total current NB fleet equipped capable for the given NextGen enabler. The turquoise blue fill indicates airplanes equipped capable. The white fill indicates airplanes not equipped capable. The total current NB fleet is shown inside the doughnut chart.

Wide-body (WB) Fleet Equipped Capable: The doughnut chart represents the percentage of the total current WB fleet equipped capable for the given NextGen enabler. The green fill indicates airplanes equipped capable. The white fill indicates airplanes not equipped capable. The total current WB fleet is shown inside the doughnut chart.

Regional Jet (RJ) Fleet Equipped Capable: The doughnut chart represents the percentage of the total current RJ fleet, defined in this report as an aircraft in normal configuration with 90 or less seats, equipped capable for the given NextGen enabler. The orange fill indicates airplanes equipped capable. The white fill indicates airplanes not equipped capable. The total current RJ fleet is shown inside the doughnut chart.

Turboprop (TP) Fleet Equipped Capable: The doughnut chart represents the percentage of the total current TP fleet equipped capable for the given NextGen enabler. The red fill indicates airplanes equipped capable. The white fill indicates airplanes not equipped capable. The total current TP fleet is shown inside the doughnut chart.

The Air Taxi, Foreign Carrier, and Corporate/GA infographics are a variant of the Air Transport infographic. The largest difference is that there is no forecast readily available for Air Taxi, Foreign Carrier, and Corporate/GA because the FAA's fleet forecasting application, APO *fleet*Forecaster, is tailored to the Air Transport fleet. Figure 1-2 provides the infographic for VNAV Approach on the Air Taxi fleet as an example. The following four statements apply across all Air Taxi, Foreign Carrier, and Corporate/GA infographics.

Equipped Capable Fleet: The doughnut chart represents the percentage of the total current fleet (for the appropriate operator category) equipped capable for the given NextGen enabler. The dark blue fill indicates airplanes equipped capable. The white fill indicates airplanes not equipped capable. The total current fleet is shown inside the doughnut chart.

Top 5 Equipped Capable Models: Based on flight plan filings indicating an equipped capability, the five most commonly reported aircraft models as represented in the aircraft type field, coded according to FAA Order 7360.1E, "Aircraft Type Designators."

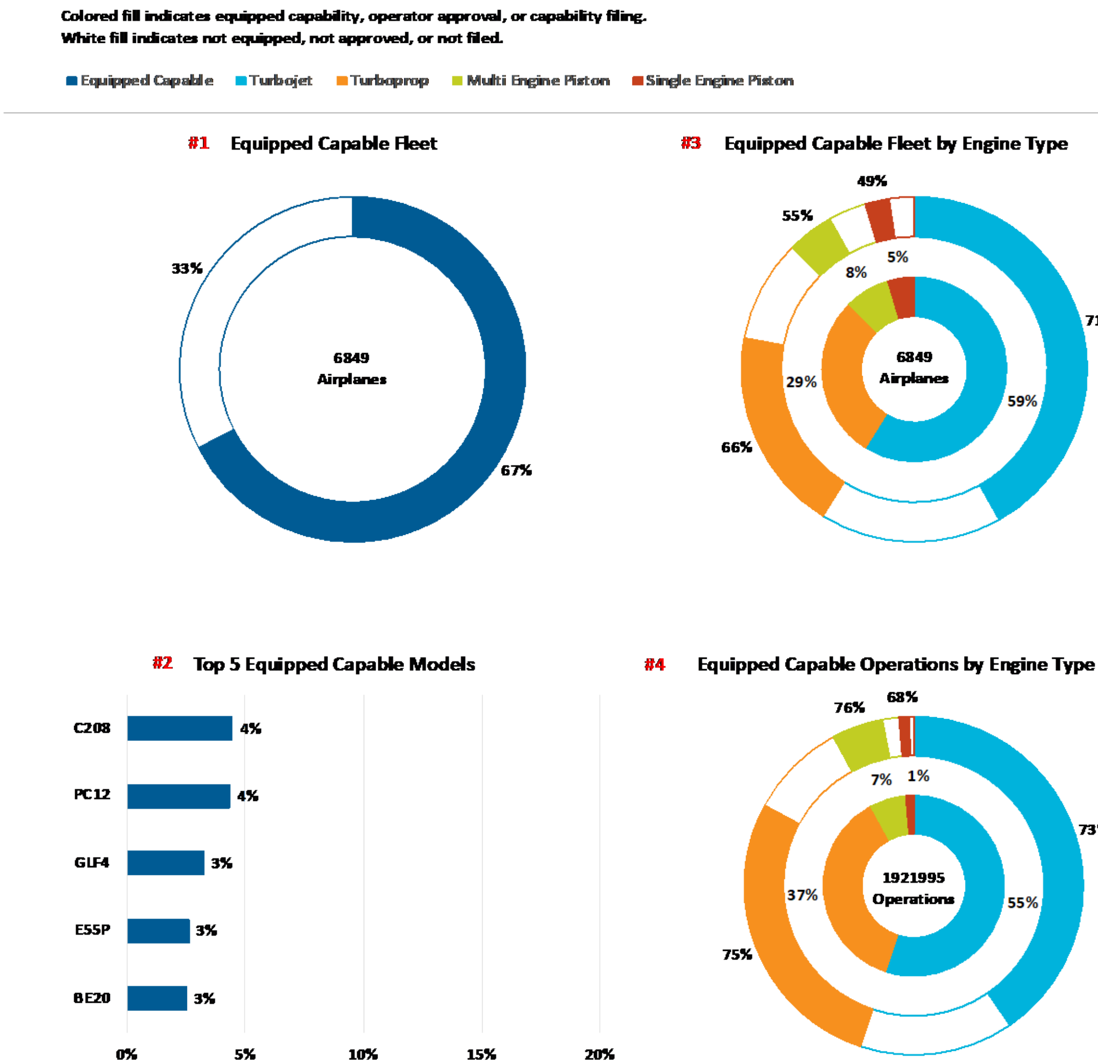


Figure 1-2. Example Infographic for Other Operator Categories

Equipped Capable Fleet by Engine Type: The doughnut chart represents the percentage of the total current fleet (for the appropriate operator category) equipped capable for the given NextGen enabler. Airplane models in the non-Air Transport fleet do not fit neatly into the body type groupings (i.e., NB, WB, RJ, and TP). There are many piston airplane models flown by the Air Taxi and Corporate/GA operators. Because of this, an engine type parsing of the airplane models results in more informative groupings.

Turbojet airplanes are indicated by a turquoise blue fill and outline; turboprop airplanes are indicated by an orange fill and outline; multi-engine piston airplanes are indicated by a green fill and outline; and single-engine piston airplanes are indicated by a red fill and outline.

The inner ring of the doughnut chart will always equal the total number of airplanes in the fleet. These are broken out by the different engine type groupings. Their respective percentage shares are listed adjacent to the inner ring. The total number of airplanes is shown in the center of the doughnut chart.

The outer ring represents the equipped capability as determined in one of three ways: from explicit IFR flight plan filings, imputed from multiple filing mappings when explicit filings are not available, or from operator-provided data (e.g., ADS-B Out) for Equip 2020. The colored fills represent the percentage of airplanes in their respective engine type groupings that are equipped capable.

To interpret the example graphic in words, 59% of the 6,849 IFR airplanes in this example fleet are turbojet. Of that 59%, 71% of turbojet airplanes are equipped capable for the NextGen enabler the graphic represents; 5% of the 6,849 IFR airplanes in this example fleet are single-engine piston. Of that 5%, 49% are equipped capable for the NextGen enabler the graphic represents.

Equipped Capable Operations by Engine Type: The doughnut chart represents the percentage of the total current operations (for the appropriate operator category) equipped capable for the given NextGen enabler.

Turbojet operations are indicated by a turquoise blue fill and outline; turboprop operations are indicated by an orange fill and outline; multi-engine piston operations are indicated by a green fill and outline; and single-engine piston operations are indicated by a red fill and outline.

The inner ring of the doughnut chart will always equal the total number of operations. These are broken out by the different engine type groupings. Their respective percentage shares are listed adjacent to the inner ring. The total number of operations in the assessed 12-month time period is shown in the center of the doughnut chart.

The outer ring represents the equipped capability as determined in one of three ways: from explicit IFR flight plan filings, imputed from multiple filing mappings when explicit filings are not available, or from operator-provided data (e.g., ADS-B Out) for Equip 2020. The colored fills represent the percentage of operations in the respective engine type groupings that are equipped capable.

To interpret the example graphic in words, 55% of the example fleet's 1,921,995 IFR operations are flown by turbojet aircraft. Of that 55%, 73% of turbojet operations are equipped capable for the NextGen enabler the graphic represents; 1% of the example fleet's 1,921,995 IFR operations are flown by single-engine piston aircraft. Of that 1%, 68% are equipped capable for the NextGen enabler the graphic represents.

The Helicopter infographic is interpreted identically to the Air Taxi, Foreign Carrier, and Corporate/GA infographics. However, the engine type breakout is limited to turbine-powered (colored turquoise blue) and piston-powered (colored red) helicopters.

1.4 Document Organization

Section 2 discusses commercial Air Transport carriers with detail charts for each enabler and the forecasted levels of equipped capabilities through 2040. Sections 3, 4, and 5 characterize fleet and equipage for Air Taxi, Foreign Carrier, and Corporate/GA operators, focusing on fixed-wing airplanes authorized and filing flight plans for IFR operations. Section 6 covers fleet and equipage for helicopters, with a focus on helicopters filing IFR flight plans. Section 7 is new for the 2022 version of this report and is a concise summary of a larger list of trends and technology data tracked and maintained by MITRE related to avionics evolution for NextGen and the future NAS. Appendix A includes a detailed list of reference documents that relate to the listed capabilities. Appendix B provides a mapping of capabilities to flight plan data fields.

2 Air Transport Fleet and Enablers

2.1 Air Transport Fleet and Operator Overview

The Air Transport fleet comprises 7,081 IFR filing airplanes, of which 1,226 (17%) are wide-body; 3,965 (56%) are narrow-body; 1,779 (25%) are regional jets (those with 90 seats or less in normal service configuration); and 111 (2%) are turboprop (see Figure 2-1). It is an IFR fleet by regulatory requirement. The proportions of narrow-body and turbojet aircraft match the operational proportions, e.g., 56% of the fleet is narrow-body and 57% of the total operations are flown by narrow-body. Conversely, regional jets fly more operations per aircraft and wide-bodies fly fewer operations per aircraft.

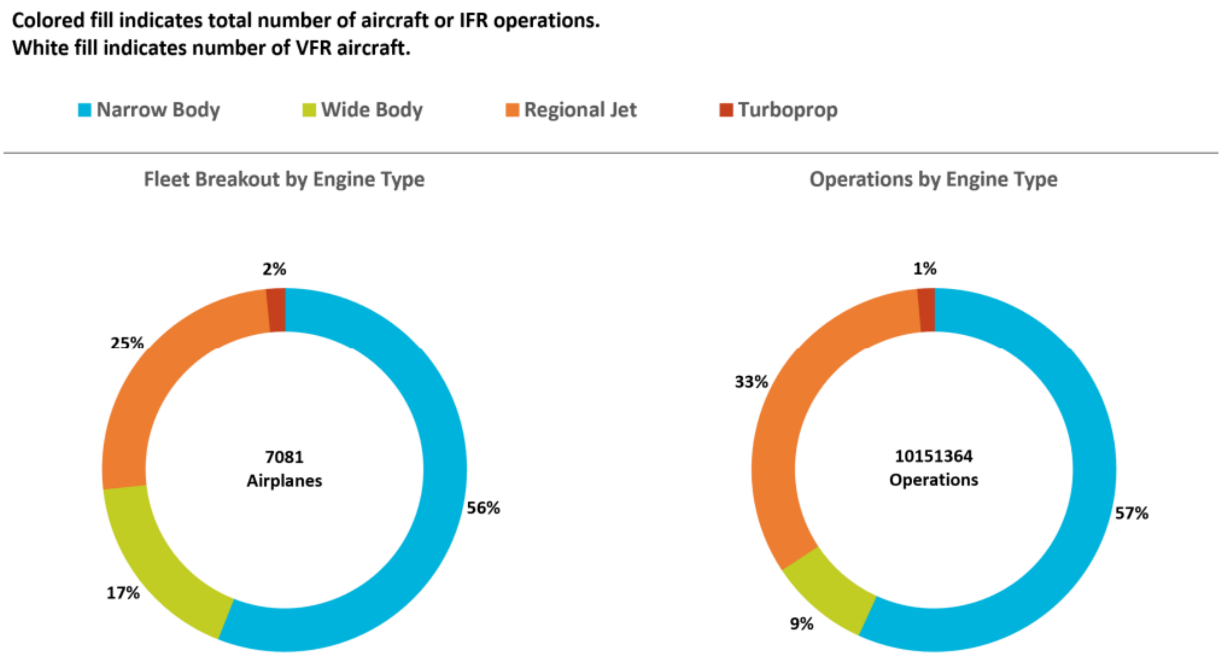


Figure 2-1. Air Transport Fleet: Engine Type and Operations Distribution

The Air Transport fleet comprises both larger carriers, some with more than 700 or more airplanes, and smaller carriers with fewer airplanes. Business consolidations have resulted in the largest 13 airlines representing more than 80% of the Air Transport fleet (see Figure 2-2).

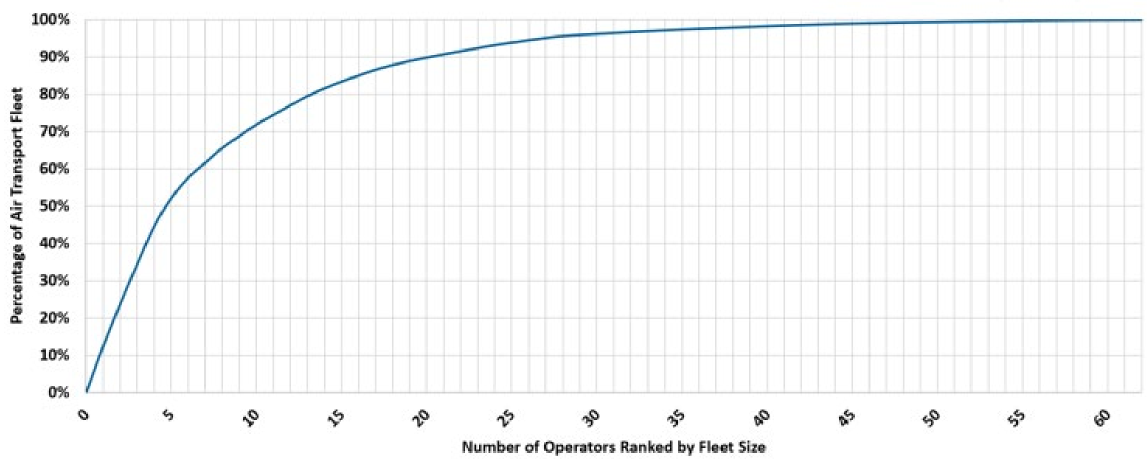


Figure 2-2. Distribution of Air Transport Fleet by Number of Operators

The average age of all Air Transport airplanes is 15 years. The fleet average is generally unchanged from last year's report. The turboprop fleet and wide-body fleet averages have slightly increased in the past year but are offset by some new deliveries in the narrow-body and regional jet categories. Operators have continued to increase new aircraft deliveries, but some have not yet permanently removed older aircraft that are in storage but not routinely flown in operations. The regional jet fleet has the youngest average age, while turboprops have the oldest average age (see Figure 2-3).

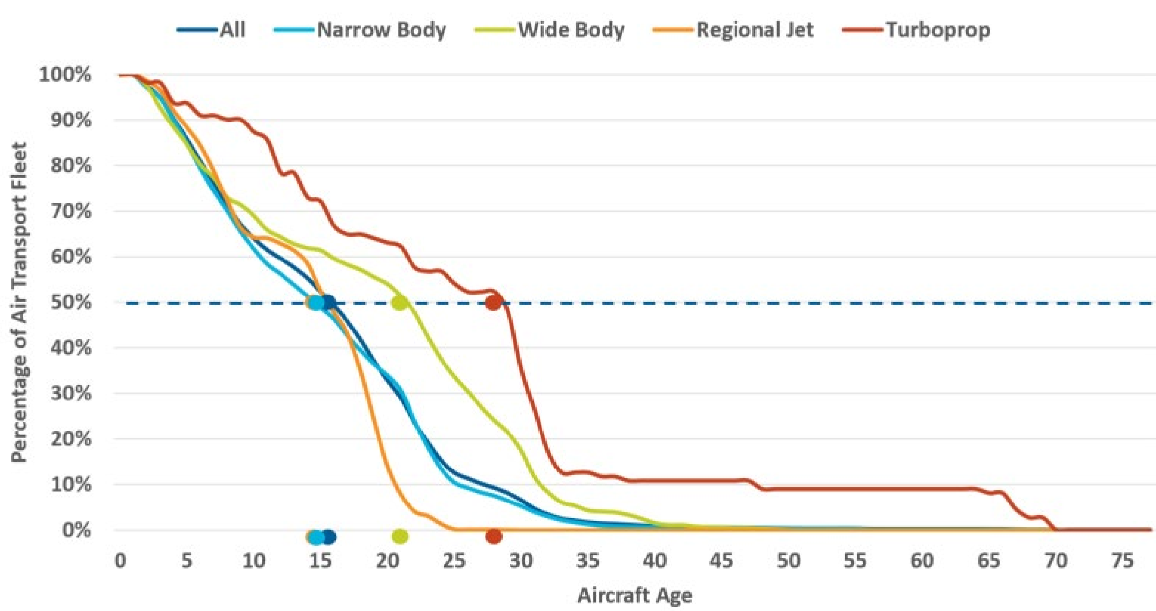


Figure 2-3. Air Transport Fleet: Airplane Age

Large deliveries of narrow-body and regional jet airplanes between 1996 and 2006 mean technologies widely available at that time (e.g., GPS and flight management systems) have significant influence on current fleet equipage and capability. After a decline in total fleet count by 59 aircraft in 2020, fleet counts increased by 127 as of March 2022.

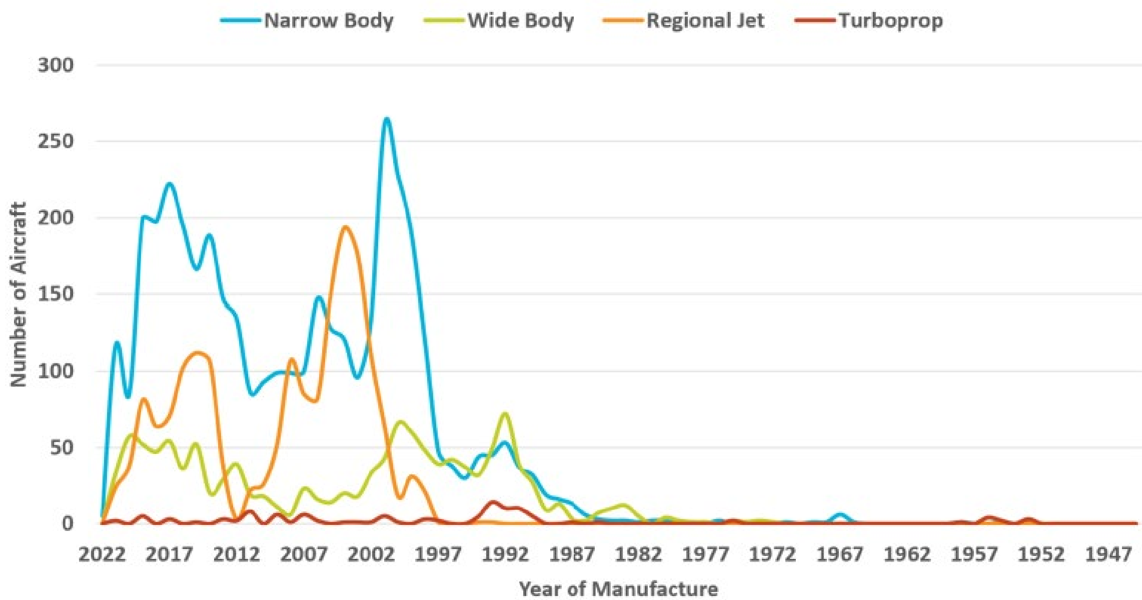


Figure 2-4. Air Transport Fleet: Year of Manufacture Update to Fiscal Year 2021 (FY21)

The top-ten operators, measured by fleet size and by total IFR operations (see Figure 2-5), have not changed in the past year as industry growth and consolidation slowed. Five airlines have fleets of greater than 500 airplanes and had more than 750,000 operations each in the 18-month period (September 2020 – February 2022). A top-five airline, SkyWest, operates only regional jets. FedEx and United Parcel Service (UPS) are the largest cargo operators and, although smaller than some of the passenger carrying airlines, have significant operations counts at their hub airports.

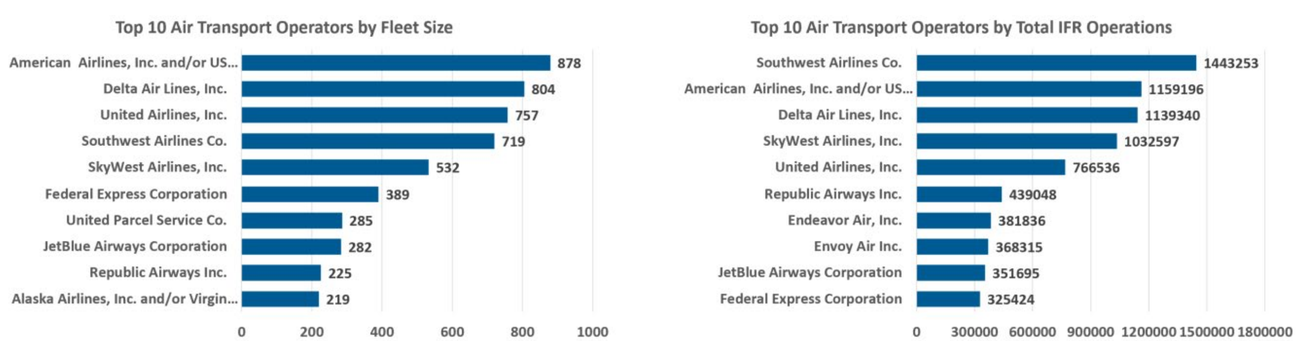


Figure 2-5. Air Transport Fleet: Top Operators

The top-ten airplane models, measured by fleet size and by total IFR operations, are shown in Figure 2-6. Narrow-body and regional jets fly significantly more operations as compared to wide-body airplanes. Smaller wide-body operations counts have been a historical norm, but are further amplified from continued COVID-19 impacts on international travel.

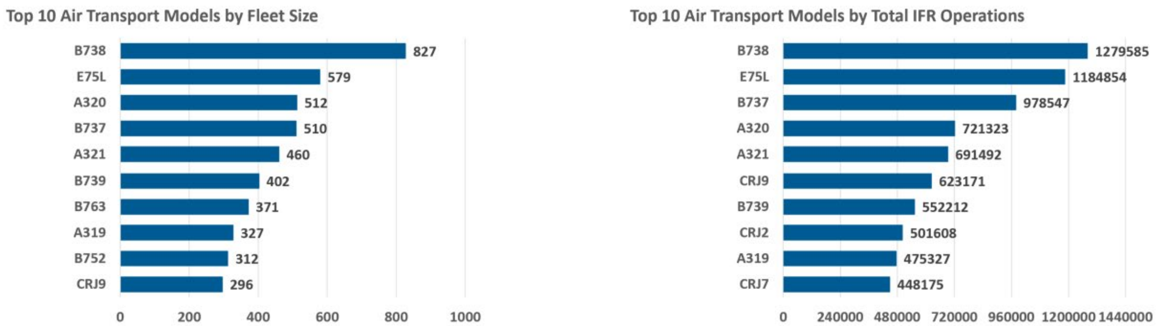


Figure 2-6. Air Transport Fleet: Top Models

2.1.1 Terminal Area Navigation and Required Navigation Performance Equipage

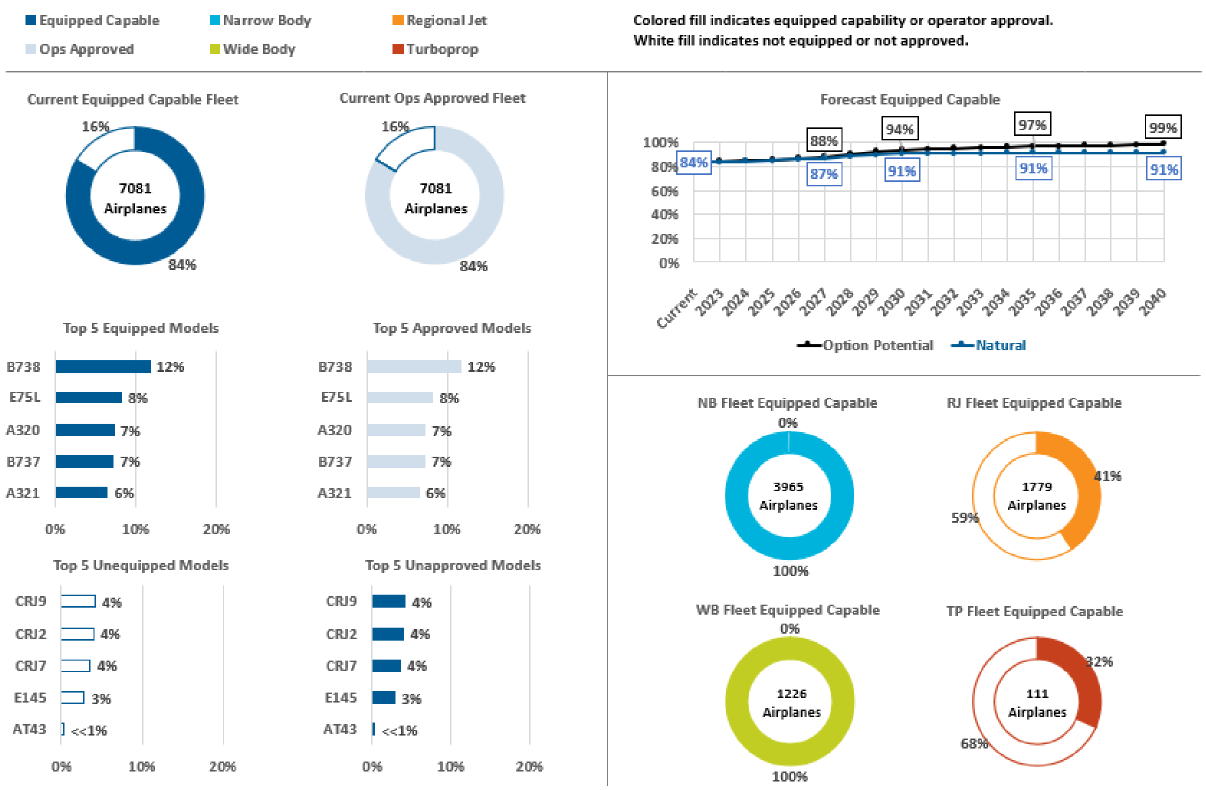
The FAA has made a considerable investment in additional DME ground stations to provide non-Inertial Reference Unit (IRU) equipped airplanes flying in busy terminal airspace the opportunity to continue PBN terminal operations in the event GPS signals are not available. Satellite outages, solar flares, and other issues can impact GPS signals. It is important that airplanes flying in busy terminal areas be able to continue operations despite the loss of GPS signals.

Although Air Transport airplanes are the primary operators in these terminal areas, some Air Taxi and GA operators also would be impacted to the degree they also fly in these areas. Many Air Transport airplanes, along with some Air Taxi and GA, can rely on their onboard DME with IRU systems to continue operations without GPS. Some regional and mid-size jets, although equipped with GPS and multi-channel DME systems to allow for continued RNAV use in terminal areas without GPS, appear to lack the proper certification and approvals to use these systems for RNAV when GPS signals are not available.

A portion of the fleet, particularly certain makes and models of regional jets and turboprops, are not equipped with IRU components due to the expense of retrofit or forward-fit option selection. Many of the airplanes without IRU are also not capable of RF legs and, in some cases, VNAV approaches. When these airplanes are either equipped or retired, the corresponding level of fleet capability will increase into the 90–99% range.

The forward-fit trends of the fleet toward RNP AR Approaches, RNP 1 with RF, and VNAV approaches result in high future rates of the avionics that will support potential EoR operations in the future and are beneficial as described in the FAA PBN Navigation Strategy document. The investment by the FAA in additional DME ground stations allows these airplanes without IRU to continue operations using DME sensors and is a key underlying airplane equipage characteristic that influences RNAV 1, RNP 1 with Track to Fix (TF), and RNP 1 with RF capabilities in this report.

2.1.2 DME/DME/IRU on Air Transport Fleet



Current State

- Most narrow-body and wide-body fleets are equipped for DME/DME/IRU, with regional jets and turboprops accounting for the majority of unequipped airplanes.
- In cases where GPS is not available/suitable for navigation, airplanes not equipped with IRU must rely on sufficient DME signal availability to maintain RNAV and/or RNP capability and continuity of operations in busy terminal areas. Note that some regional jet airplanes that lack IRU are equipped with DME/DME systems that could enable RNAV when GPS is not available, yet appear to lack the appropriate certifications and approvals according to industry feedback.
- Capabilities enabled by this equipage can include RNAV 1, RNP 1 with TF, and RNP 1 with RF.

Forecast

- Trend is increasing.
- Most new airplanes are delivered with IRUs as a standard capability, except for some turboprops for which IRU is an available option.
- Most non-equipped airplanes will retire by 2030.

Significant Factors

- The inclusion of IRU in the MCL could lead to all new delivery Air Transport airplanes being equipped with IRU; however, COVID-19 impacts are unknown. The inclusion of RNP and RF leg capability in the MCL could lead to additional aircraft being equipped through retrofits with DME/DME IRU.
- Enhancements are underway to DME ground stations and aircraft avionics that may enable aircraft to better utilize DME signals and improve aircraft RNP and RNAV capabilities.

2.2 Air Transport Current Capabilities and Forecasts

Figure 2-7 shows the assessment of current equipage and operational approvals for the Air Transport fleet. The detailed pages that follow include forecasts of equipage for years 2022 through 2040, based on a combination of the FAA fleet forecast and manufacturer-planned offerings of standard equipment. Additional information is provided for significant factors influencing current state, key trend drivers, and potential factors that may impact the reported trend. Potential factors include program plans, draft policies, and draft standards not yet fully matured but which, upon completion, would be expected to impact NextGen enabler equipage.

The progress "Trend" assessment is a conservative assessment of equipage expected between now and 2027 based on current equipage, operator feedback, FAA program plans, FAA rules, and manufacturer-planned offerings of standard equipment. These trends are based on current and forecasted MITRE assessments, characterized as flat (less than 3%), or increasing (at or above 3%). These trends represent natural equipage (i.e., known equipage plans and forward-fit standard delivery). They do not include retrofits not known to be in progress at the time of the development of this report.

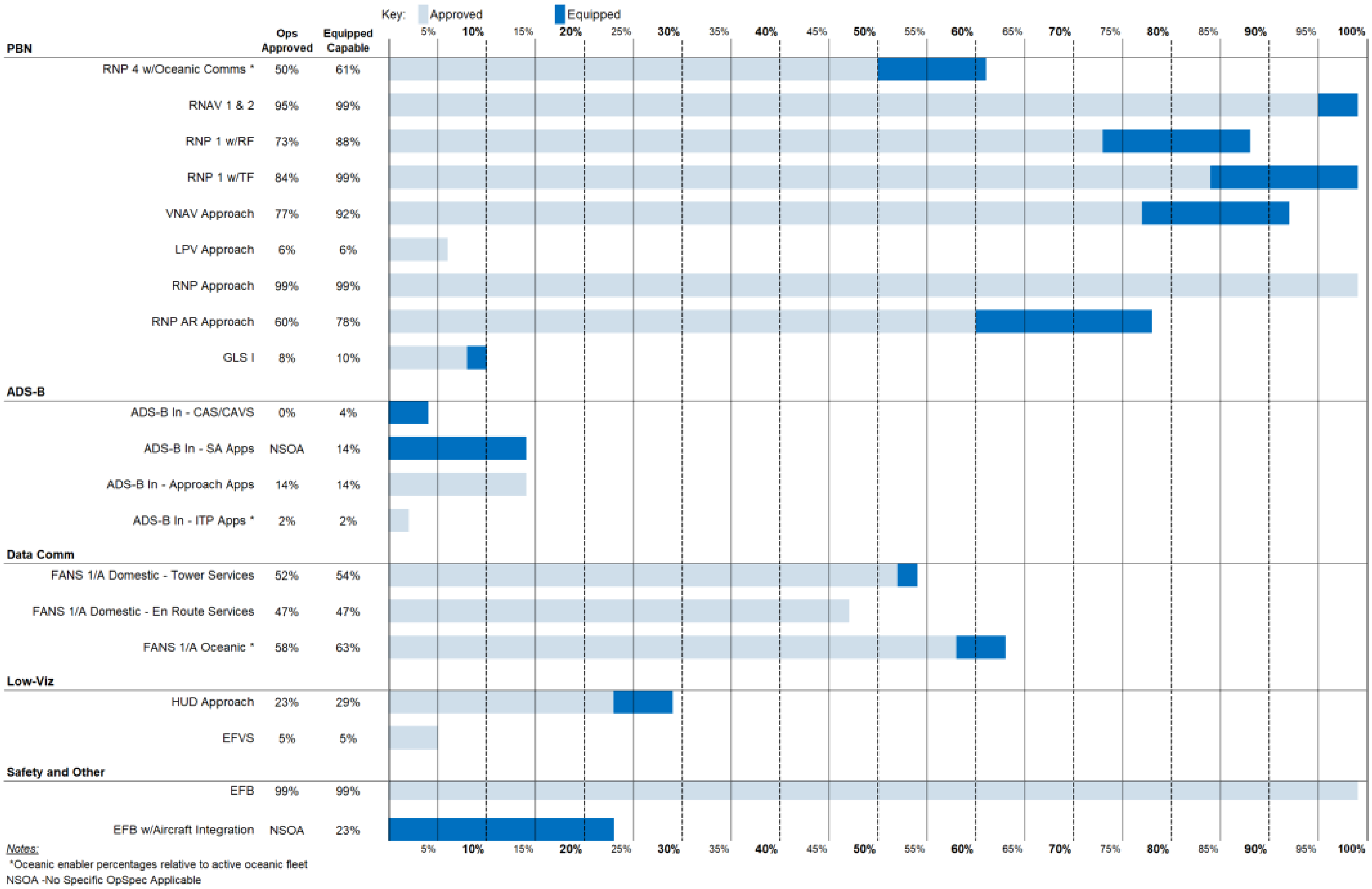
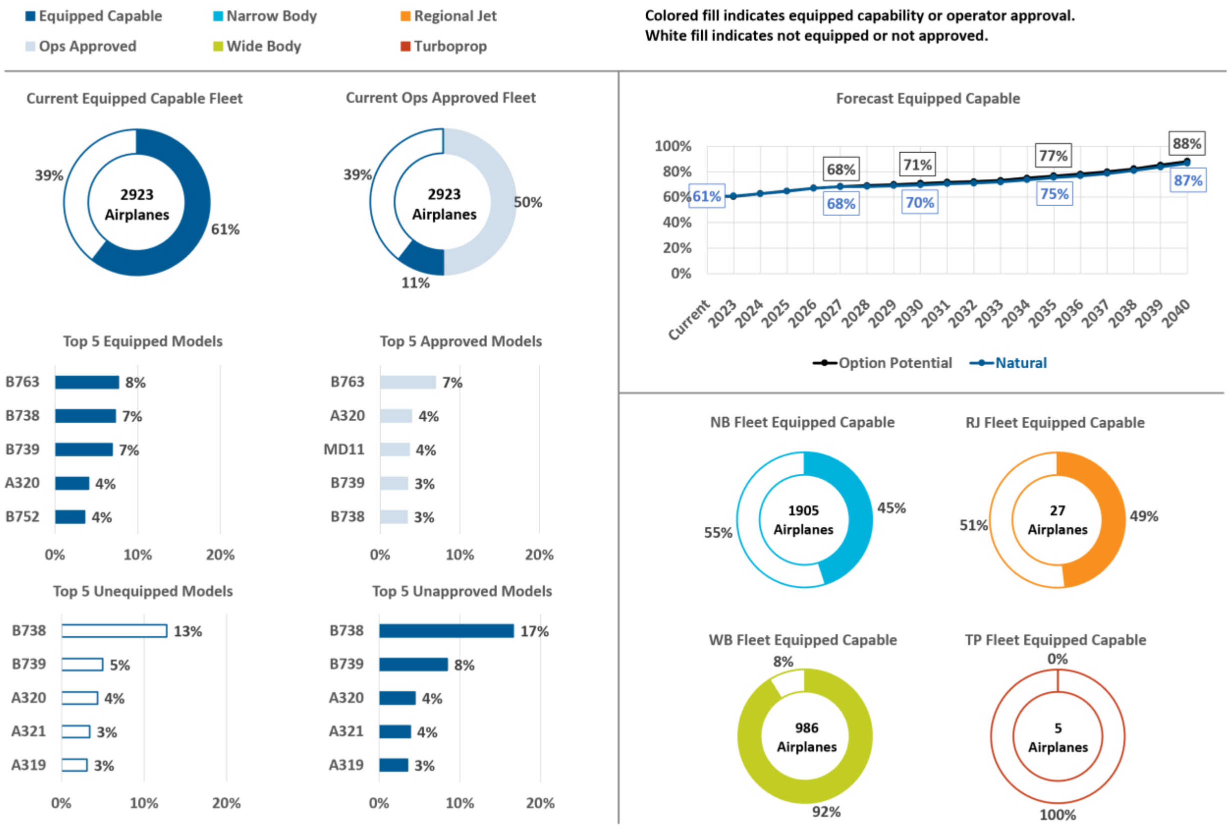


Figure 2-7. Air Transport Enablers: Current Equipage and Approvals Assessment

2.2.1 Performance Based Navigation Enablers for Air Transport

RNP 4 with Oceanic Comms on Oceanic Air Transport Fleet



Current State

- This capability is applicable to and reported against the oceanic fleet of airplanes.
- RNP 4 operations require RNP 4 navigation coupled with SATCOM; the presence of the two capabilities is reported for the oceanic fleet of airplanes.
- RNP 4 requires RSP 180 and RCP 240. Analysis of operational approvals indicates aircraft approved for RNP 4 operations meet these requirements.
- RNP 4 navigation equipage is greater than 50%, while lower SATCOM equipage constrains higher fleet capability levels.
- Wide-body airplanes typically are RNP 4 capable; narrow-body and regional aircraft typically are not.

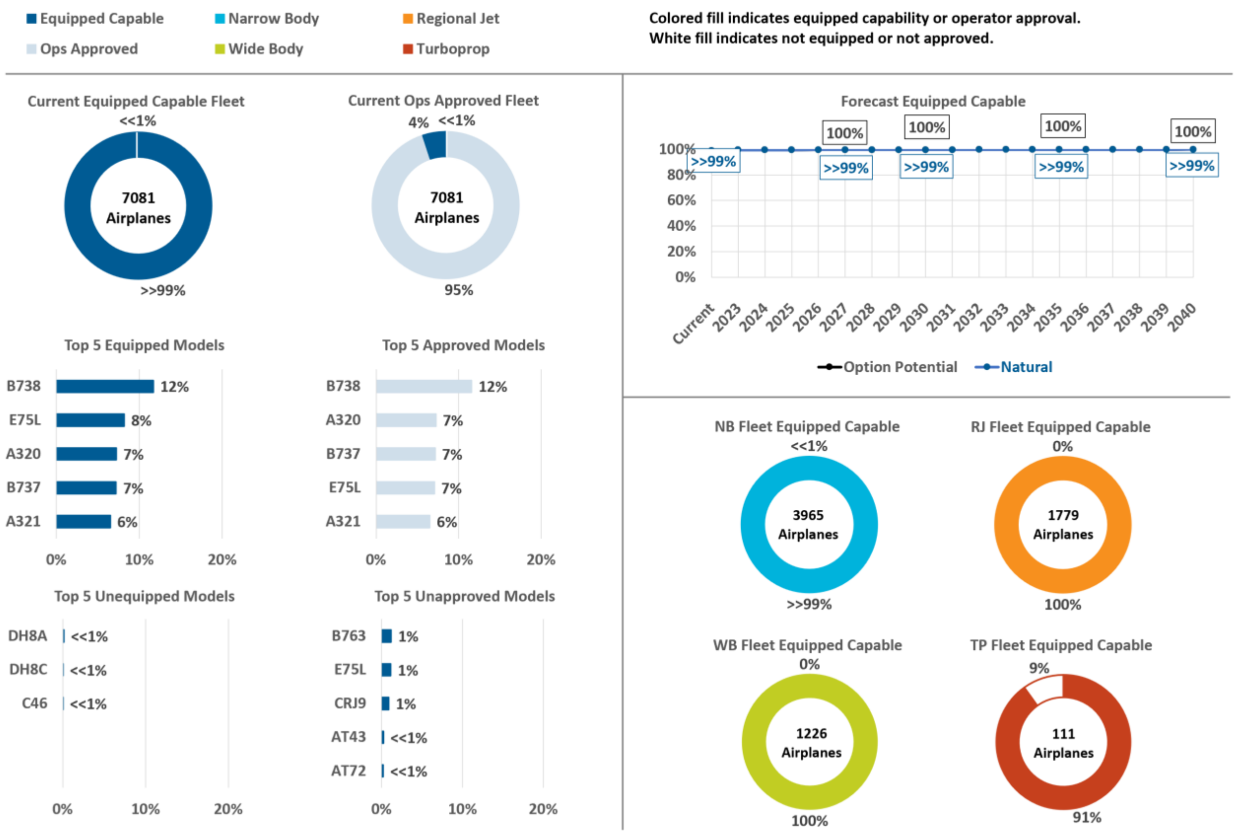
Forecast

- Trend is increasing.
- Standard capability for new wide-body airplanes.
- Narrow-body airplanes are growing in use in oceanic airspace and appear to be leveraging their RNP 4 standard capability and exercising SATCOM options to enable oceanic operations.

Significant Factors

- Impacts from COVID-19 and international travel constraints have drastically changed the makeup and operational pace of Oceanic Aircraft in the past year, resulting in significant equipage and capability variations in data sets over the past year.
- Operators are interested in improving passenger inflight connectivity. SATCOM is a key piece to many of these systems and continues to influence equipage rates.

RNAV 1 and 2 on Air Transport Fleet



Current State

- Equipage is already high with almost all airplanes currently capable.
- Retirements are replaced with airplanes delivered with standard capability.

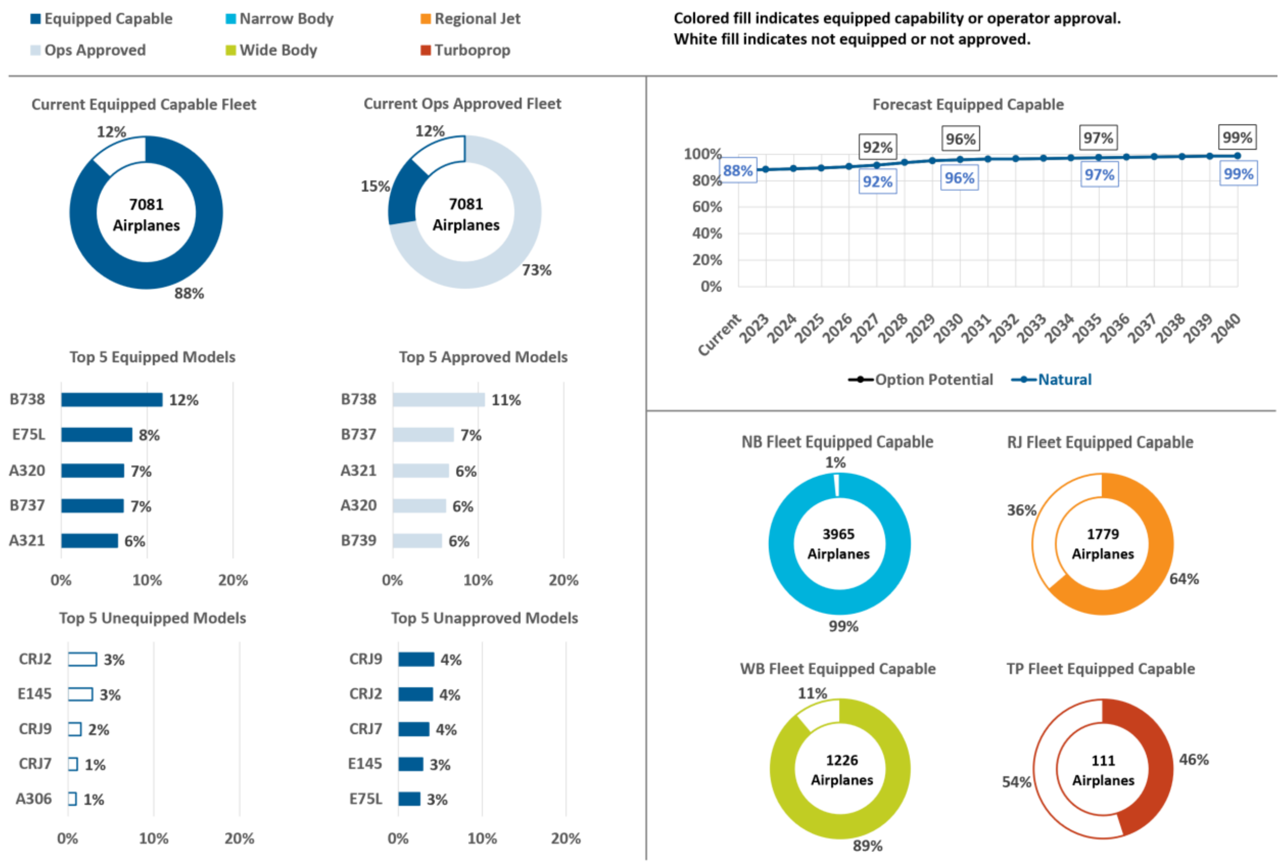
Forecast

- Trend is flat.
- Standard capability for all new airplanes.

Significant Factors

- All airplanes have retrofit potential through GPS avionics that are affordable and widely available.
- Some operators do not have a business case for investing in retrofit solutions and/or operational approvals, often because of unknown future-fleet plans or operational needs. Investing for equipage and/or approvals on these airplanes risks a negative return.
- Some aircraft, such as Bombardier CRJ aircraft, are dependent upon GPS to provide RNAV 1 capability, and when GPS signals are not available, these aircraft are not capable of RNAV 1.
- The inclusion of DME/DME/IRU in the MCL for resilient operational capability, if adopted by airlines, would result in all new aircraft delivered with RNAV 1 capability without reliance on GPS signals.
- Evolving avionics and enhancements to DME stations may result in improved availability for RNAV 1 operations when GPS signals are not available, particularly for aircraft not equipped with IRU.

RNP 1 with RF on Air Transport Fleet



Current State

- RF leg capability does not require a specific operational approval when used with RNP 1, although OpSpec C063 does allow for operators to indicate these individual capabilities.
- Displays capable of showing a curved path have been the significant limiter to higher levels of equipped capability.

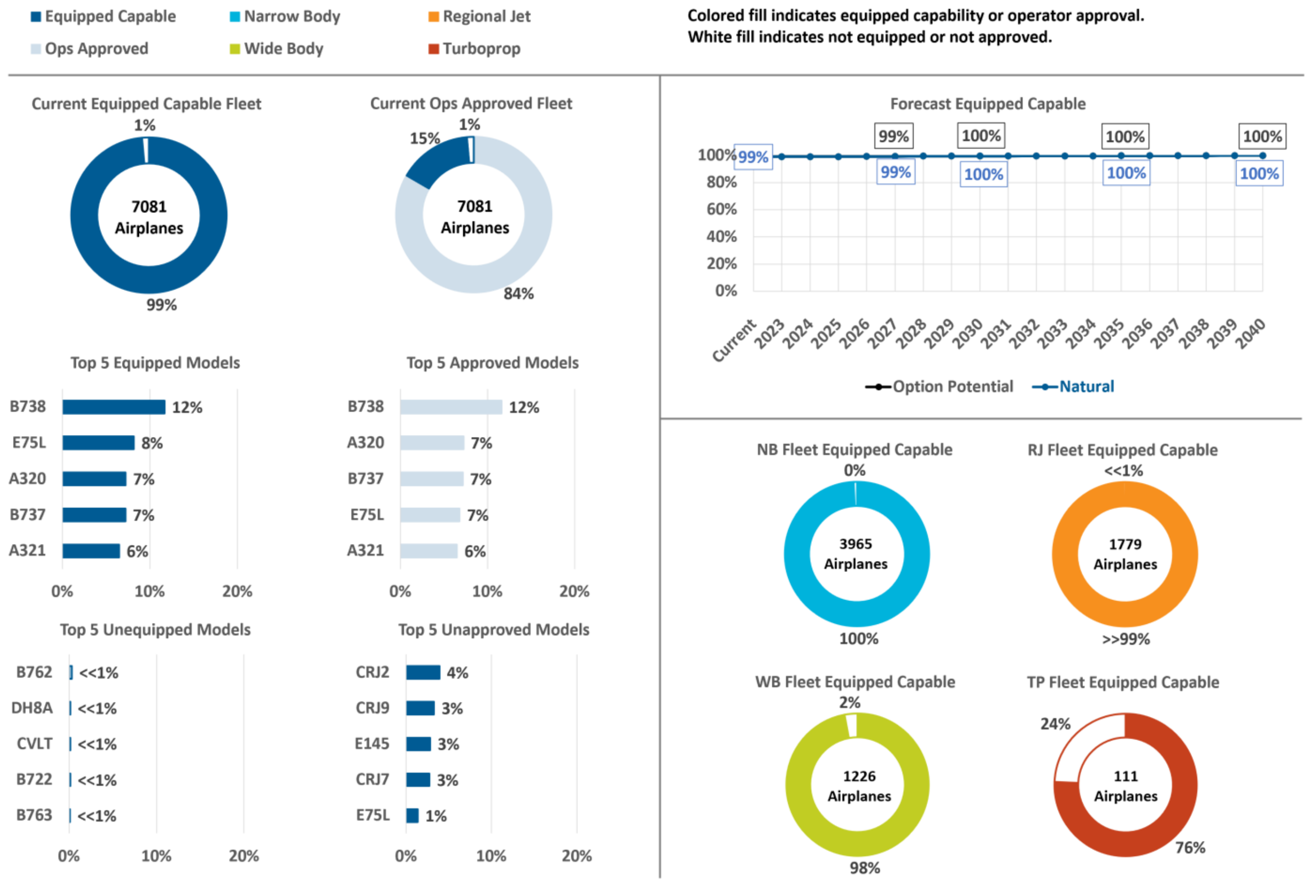
Forecast

- Trend is increasing.
- Standard capability for all new airplanes, while some mixed equipage will persist.
- Most non-equipped airplanes are forecast to retire by 2030.

Significant Factors

- The inclusion of RNP and RF leg capability in the MCL could lead to additional aircraft being equipped through retrofits with RNP 1 and RF leg.
- Some NextGen operations such as Advanced RNP, EoR, RNP AR Approach, and GLS may apply RF leg capability to specific operations. This could lead to an improved business case for unequipped operators to request forward-fit and retrofit options for RF leg capability, resulting in higher future equipage rates.

RNP 1 with TF on Air Transport Fleet



Current State

- Equipage is already high with almost all airplanes currently capable.
- Retirements are replaced with airplanes delivered with standard capability.

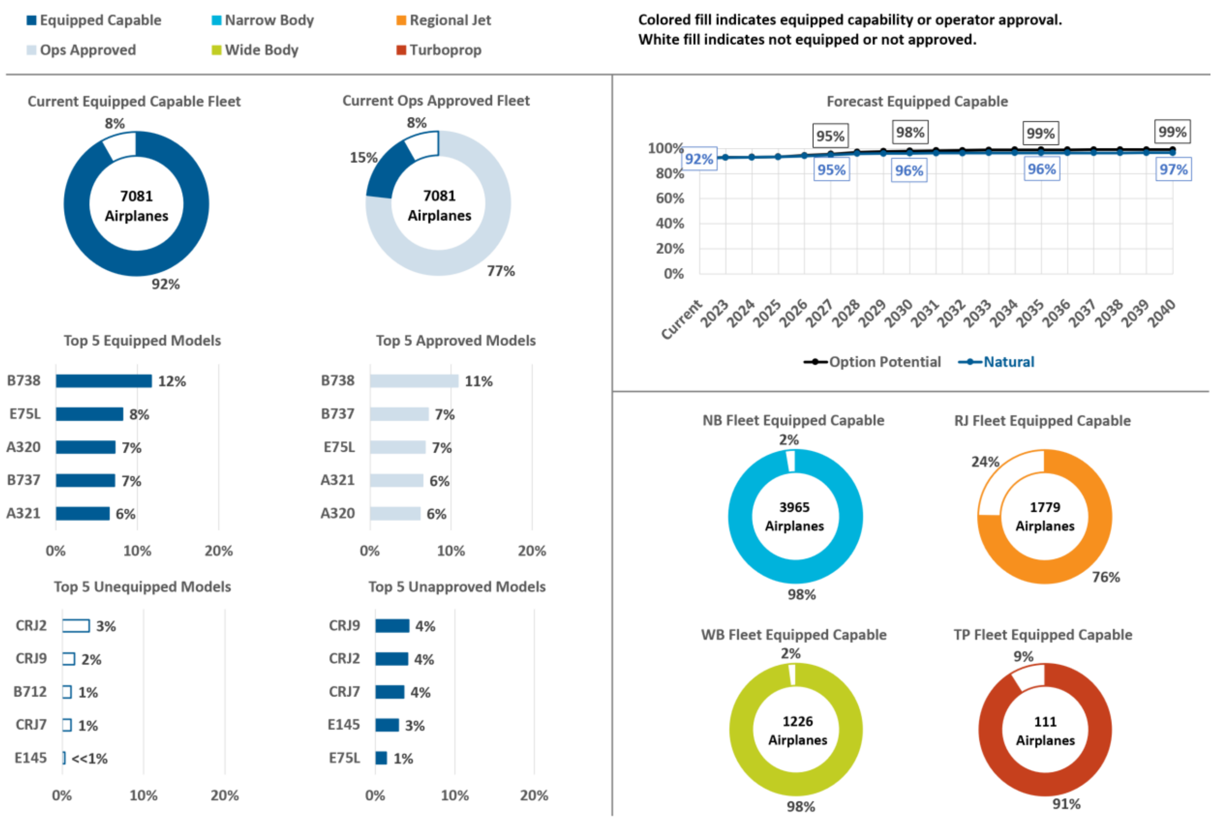
Forecast

- Trend is flat.
- Standard capability for all new airplanes.

Significant Factors

- All airplanes have retrofit potential through GPS avionics that are affordable and widely available.
- Some operators do not have a business case for investing in retrofit solutions and/or operational approvals, often because of unknown future-fleet plans or operational needs. Investing for equipage and/or approvals on these airplanes risks a negative return.

Vertical Navigation (VNAV) Approach on Air Transport Fleet



Current State

- VNAV Approach is defined in this report as an aircraft that can fly to lateral navigation (LNAV)/VNAV line of minima on an instrument approach chart.
- VNAV Approach can have different curved path leg types, TF and RF. This infographic covers VNAV Approach for TF legs.
- VNAV Approach with TF leg equipage rates are higher than VNAV Approach with RF leg equipage, which is estimated at 82%.

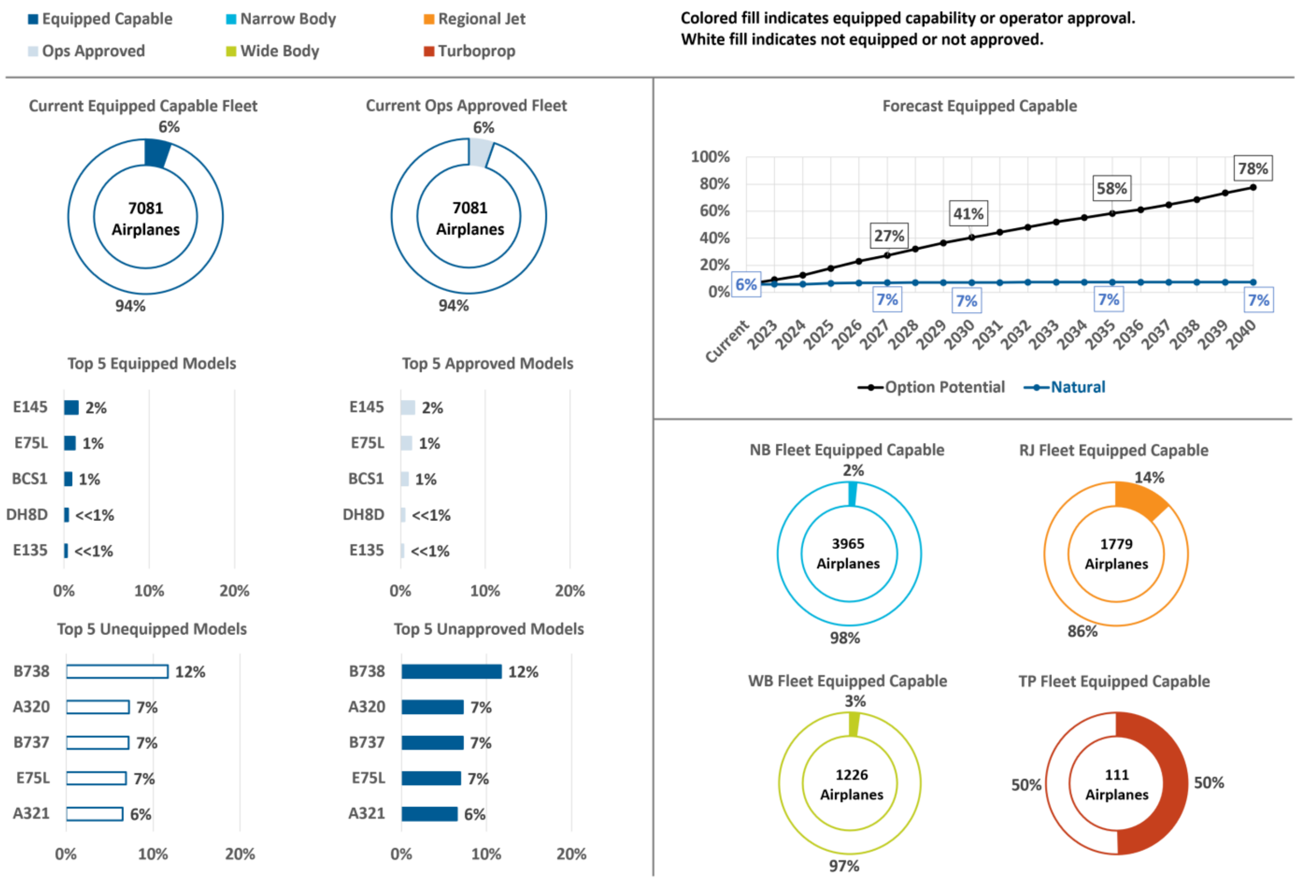
Forecast

- Trend is increasing.
- Standard capability for all new airplanes, apart from Bombardier CRJ and turboprop airplanes, for which it is an available option.
- Most new production airplanes will come standard with coupled barometric (BARO) VNAV, GPS, and an option for GLS I and/or LPV Approach.
- Some mixed equipage will still exist.

Significant Factors

- The inclusion of VNAV in the MCL could lead to all new delivery Air Transport airplanes being equipped with VNAV Approach.
- The inclusion of VNAV capability in the MCL could lead to additional aircraft being equipped through retrofits with VNAV.
- Continued operator interest in GLS I, LPV Approach, and RNP AR Approach capabilities may result in higher future VNAV Approach equipage rates.

LPV Approach on Air Transport Fleet

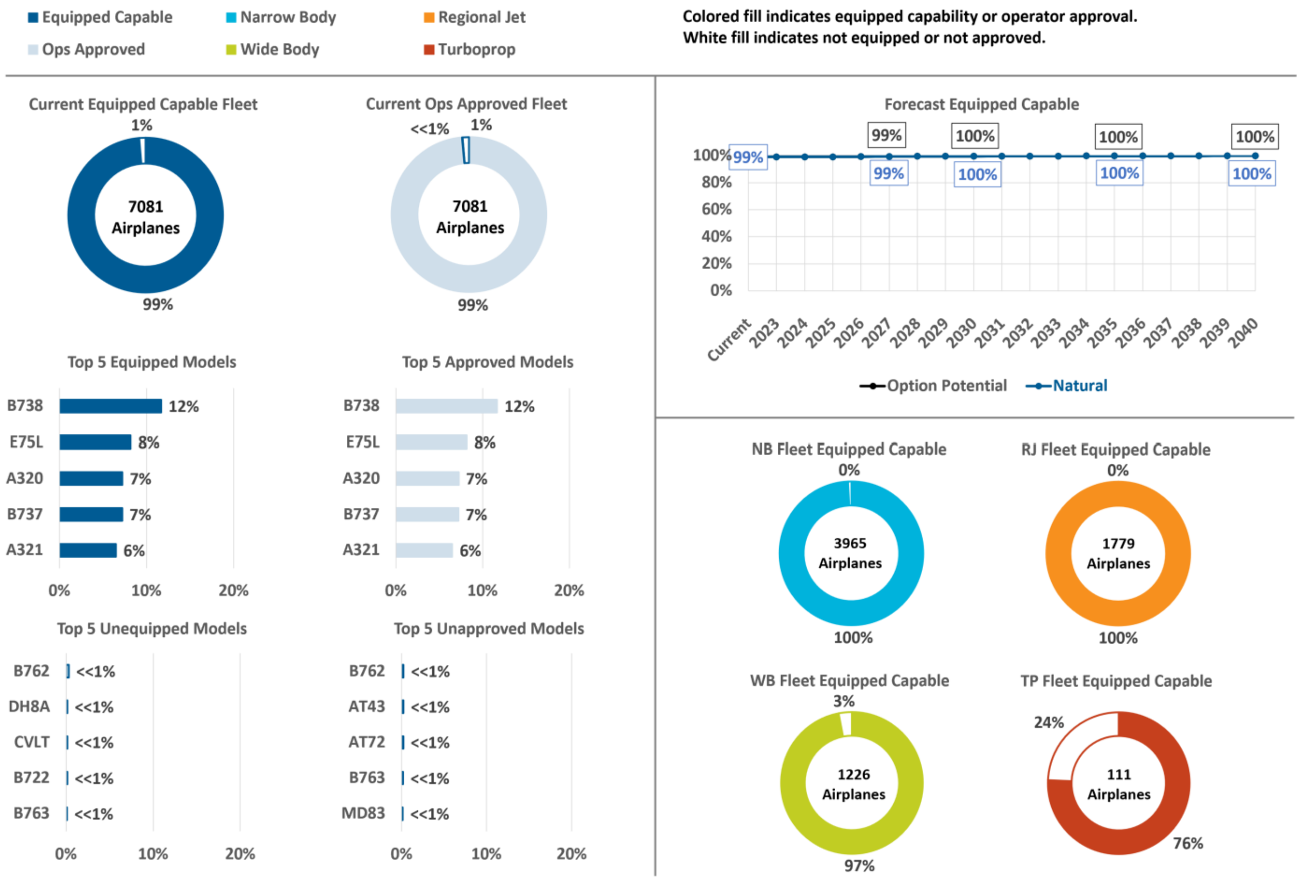


Current State
- Equipped airplanes consist of forward-fit and retrofits of wide-body, narrow-body, and regional aircraft

Forecast
- Trend is flat.
- Airbus A350 and A220 airplanes are delivered standard with this capability; other airplanes have options.
- As more airplanes come standard with Satellite Based Augmentation System (SBAS) Multi-mode Receivers (MMRs) to support ADS-B Out, it is expected more operators will develop a positive business case for LPV Approach capability.

Significant Factors
- The inclusion of LPV Approach in the MCL Supplemental List could lead to higher rates of new delivery Air Transport aircraft being equipped with LPV Approach.
- The inclusion of VNAV capability in the MCL could lead to additional aircraft being equipped through retrofits with LPV.
- Airlines continue to up gauge from regional airplanes to narrow-body airplanes in secondary airports where LPV approaches offer improved access.
- Expanding global implementations of SBAS, such as India, are driving widespread manufacturer offerings for LPV-type approach capability.

RNP Approach on Air Transport Fleet



Current State

- Equipage is already high with almost all airplanes currently capable.
- Retirements are replaced with airplanes delivered with standard capability.
- Enabling equipage is GPS with RNP 0.3 approach capability.
- GPS and MMR equipage to support ADS-B Out mandate have positively impacted fleet equipage for RNP Approach capability.

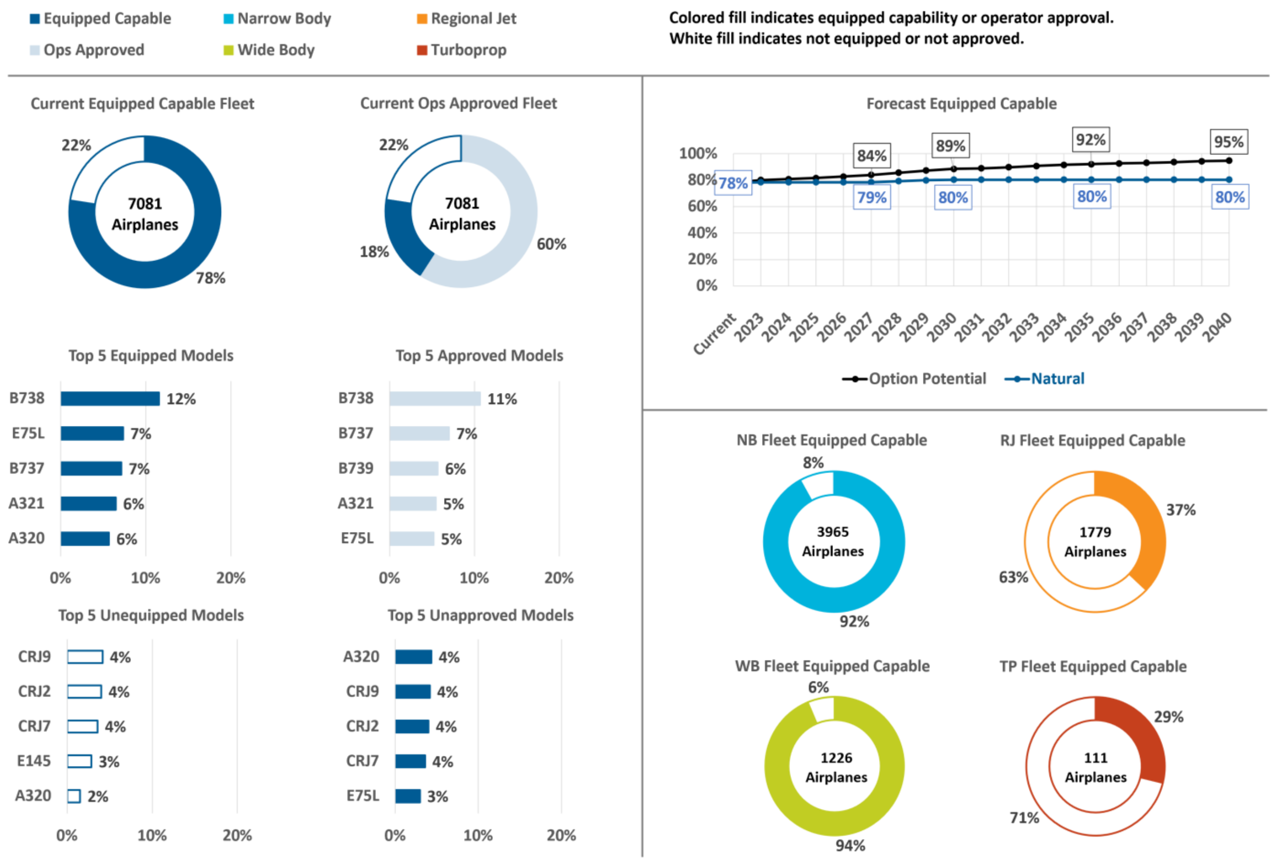
Forecast

- Trend is flat.
- Standard capability for all new airplanes.

Significant Factors

- All airplanes have retrofit potential through GPS avionics that are affordable and widely available.
- Some operators do not have a business case for investing in retrofit solutions and/or operational approvals, often because of unknown future-fleet plans or operational needs. Investing for equipage and/or approvals on these airplanes risks a negative return.

RNP AR Approach on Air Transport Fleet



Current State

- Current equipage includes wide-body, narrow-body, regional jet, and turboprop airplanes.
- Current equipped capable exceeds operational approvals because some operators do not have operational need for RNP AR Approach. However, the gap continues to close each year as more operators intend operational use.

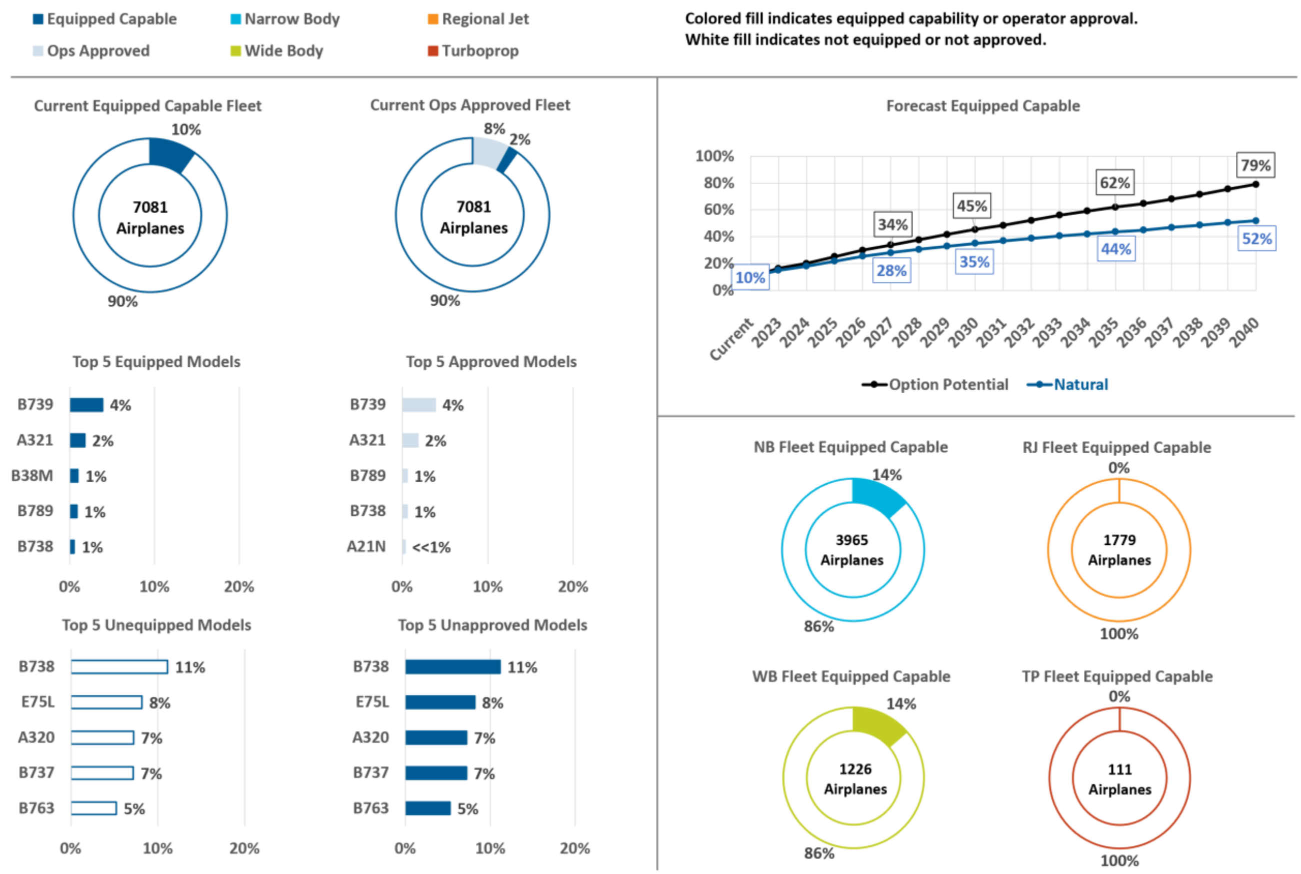
Forecast

- Trend is flat.
- Standard capability on wide-body airplanes, and the majority of narrow-body airplanes and Embraer 170/190s come with exercised options.
- RNP AR Approach will continue to grow steadily as older unequipped airplanes will be replaced by new deliveries with options exercised for this capability.

Significant Factors

- The inclusion of RNP AR Approach in the MCL Supplemental List could lead to higher new delivery Air Transport equipage.
- U.S. and global demand for all-weather operations, environmental impact reductions, and predictable and repeatable paths may lead to higher rates of equipage offerings, standard equipage with RNP AR Approach, and/or additional options.

GLS I on Air Transport Fleet



Current State

- Current equipage is primarily on new delivery aircraft, with the majority of equipage coming from a small set of operators.

Forecast

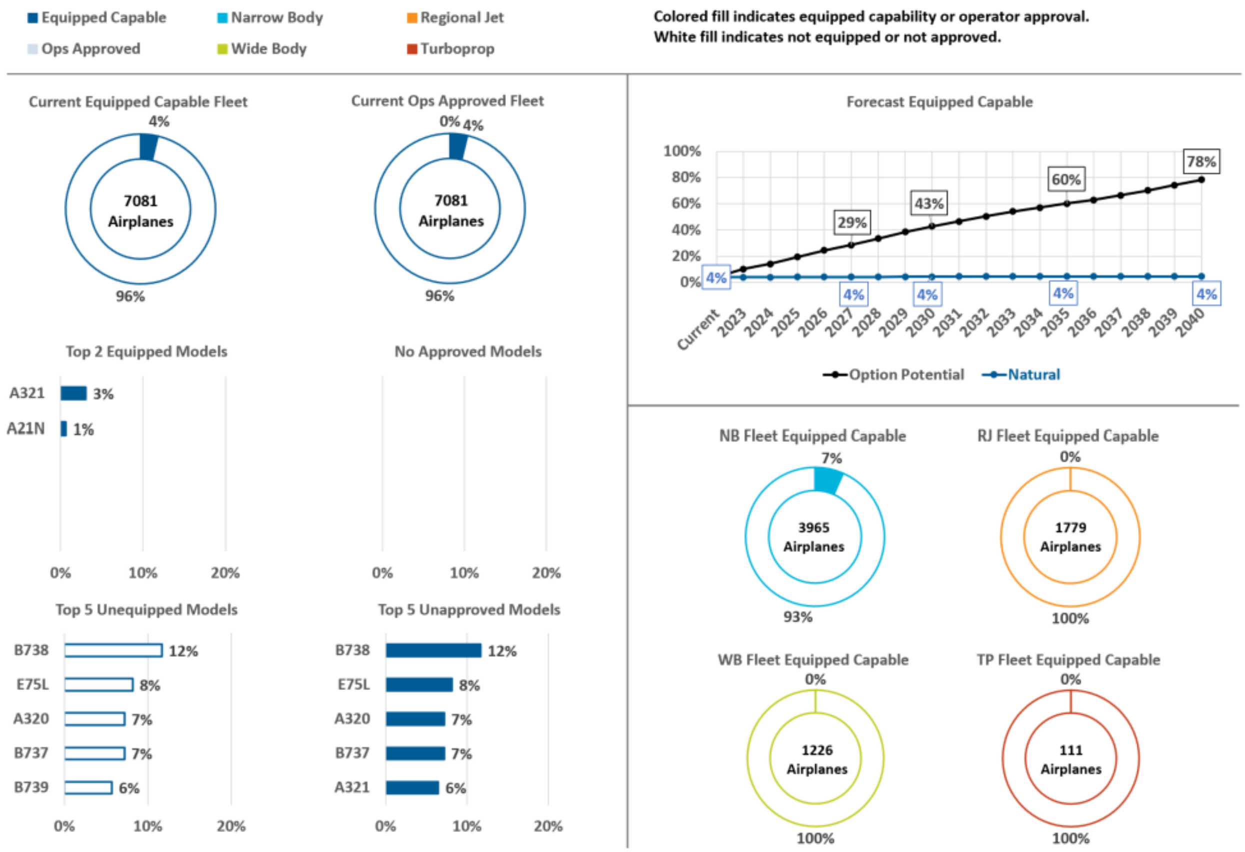
- Trend is increasing.
- Standard capability for wide-body Boeings and option capability on narrow-body Boeings and all Airbuses.
- Some regional airplanes such as Embraer 170/190 are expected to have an available option in the near term.

Significant Factors

- Trend is increasing as more narrow-bodies and wide-bodies are delivered and retrofitted with new MMR to meet ADS-B position source requirements.
- The inclusion of GLS I, II, and III in the MCL Supplemental List could lead to higher new delivery Air Transport equipage.
- If airports or other entities were to begin fielding more GLS ground systems, it is likely more operators would equip with GLS I as a backup to Instrument Landing System (ILS). This will be particularly true when GLS Category (CAT) III (GBAS Approach Service Type D [GAST D]) standards are complete and the business case for equipping is even stronger.
- International interest in GLS I could result in more oceanic narrow-body GLS I options being taken by operators and by lessors considering the global market.

2.2.2 Automatic Dependent Surveillance-Broadcast Enablers for Air Transport

ADS-B In – CAS/CAVS



Current State

- American Airlines is the only Air Transport operator equipped with this capability on their A321 fleets.
- Retrofit solutions exist for several wide-body and narrow-body airplanes.
- Forward-fit solutions are not available.

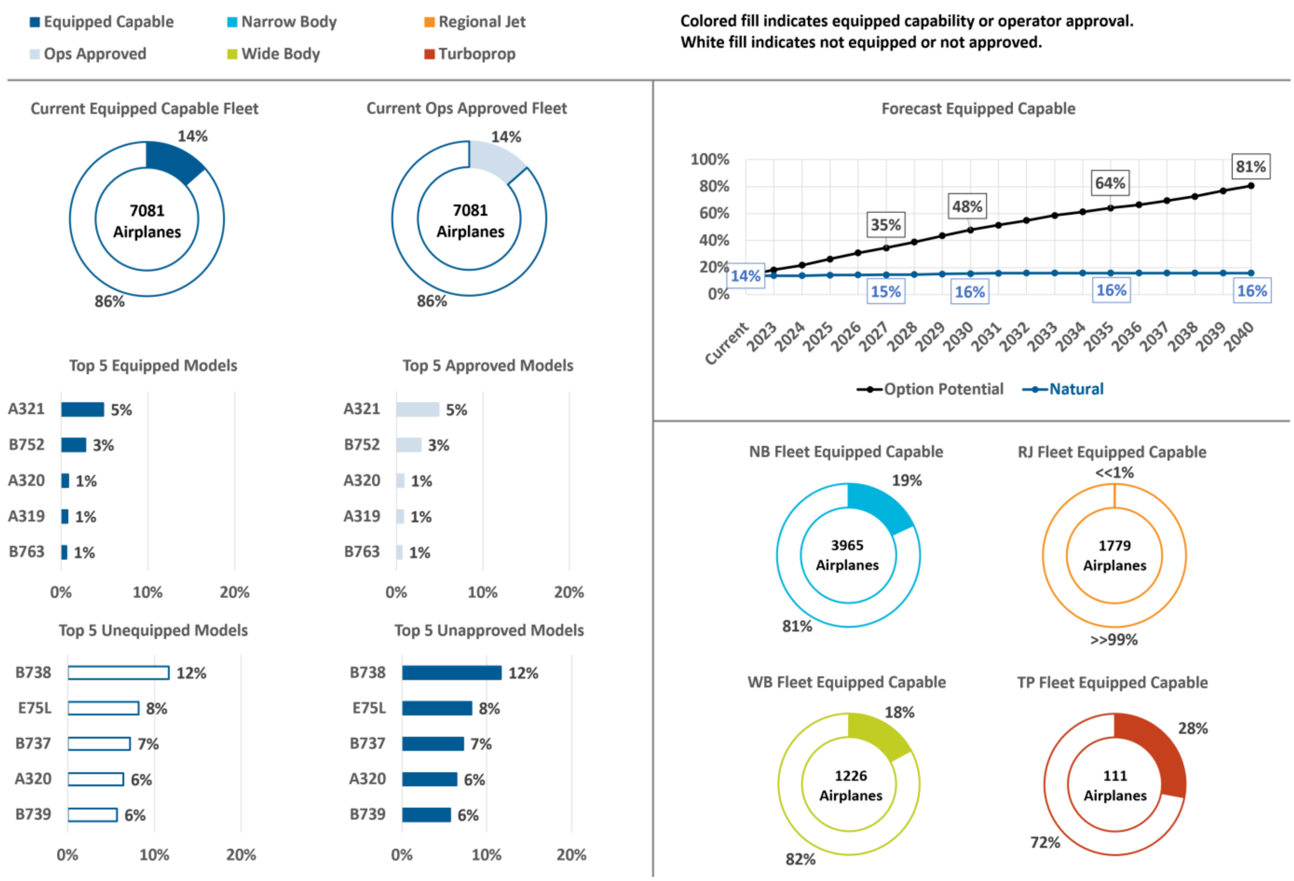
Forecast

- Trend is flat.
- Forward-fit options are anticipated to be available in the next five to ten years.

Significant Factors

- Trend is flat, but several airlines have indicated significant interest in this capability.
- The inclusion of ADS-B Cockpit Display of Traffic Information (CDTI) Assisted Separation (CAS) and CDTI Assisted Visual Separation (CAVS) in the MCL Supplemental List could lead to higher retrofits and future forward-fits for Air Transport fleets.
- Airlines and manufacturers are actively researching potential business cases for additional investment. It is believed that as CAVS, CAS, IM, and other ADS-B In applications mature, more offerings will exist and airlines will increase their equipage rates in the 2025–2035 timeframe with potential for some aircraft standard offerings.

ADS-B In – Situational Awareness (SA) Applications (Apps) on Air Transport Fleet



Current State

- ADS-B Out equipage does not contribute to ADS-B In capability.
- Forward-fit and retrofit solutions exist.
- Basic CDTI offerings support airborne situational awareness, but additional display modifications on some aircraft may be necessary to support basic surface awareness.
- Current equipage, with ADS-B In, although relatively low, is primarily in support of oceanic ITP and SA applications.

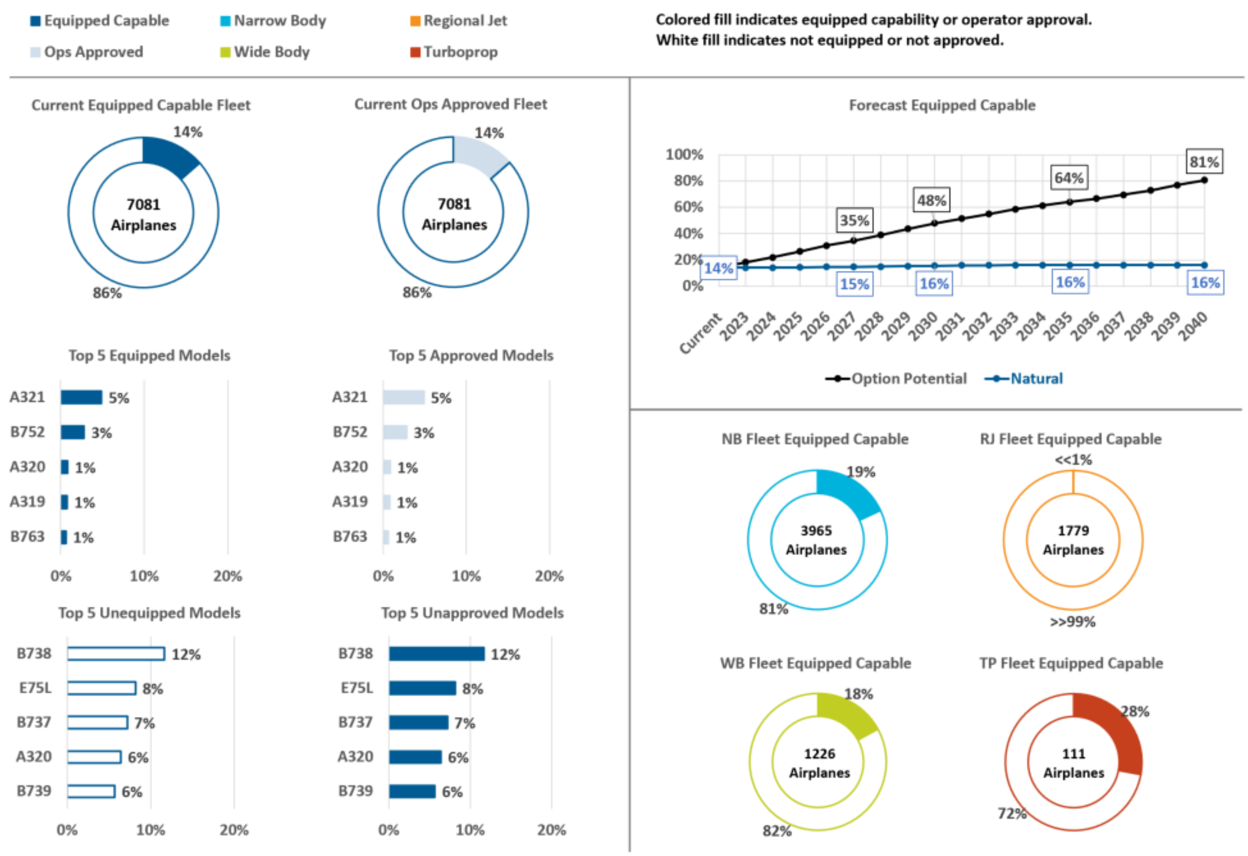
Forecast

- Trend is flat.
- CDTI will continue to be offered as optional equipment on new airplanes.

Significant Factors

- Trend is flat, but industry feedback indicates continued interest in ADS-B In applications to improve operations.
- Airlines and manufacturers are actively researching potential business cases for additional investment. It is believed that as CAVS, IM, and other ADS-B In applications mature, more offerings will exist and airlines will increase their equipage rates in the 2025–2035 timeframe with potential for some aircraft standard offerings.
- Less expensive retrofit solutions are coming to market and recent airline investments in ADS-B In equipage for safety and research purposes may result in positive business cases and higher future equipage rates.

ADS-B In – Approach Apps on Air Transport Fleet

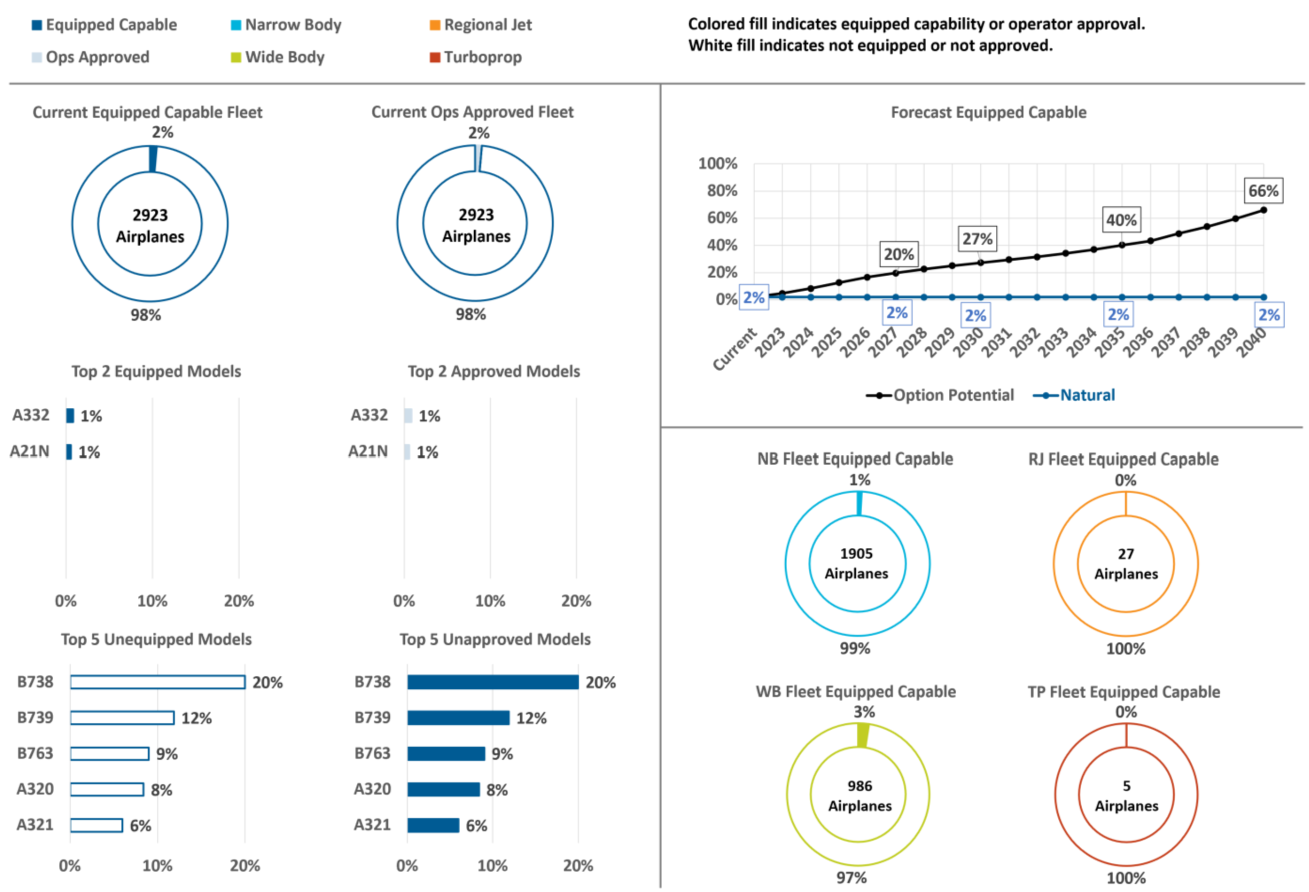


Current State
- ADS-B Out equipage does not contribute to ADS-B In capability.
- CAVS approach applications are available and usable throughout the NAS.
- Forward-fit and retrofit solutions exist.

Forecast
- Trend is flat.
- CAVS will be an option only and not standard on new airplanes.

Significant Factors
- Trend is flat, but industry feedback indicates continued interest in ADS-B In applications to improve operations.
- Airlines and manufacturers are actively researching potential business cases for additional investment. It is believed that as CAVS, CAS, and other ADS-B In applications mature, more offerings will exist, and airlines will increase their equipage rates in the 2025–2035 timeframe.
- Less expensive retrofit solutions are coming to market and recent airline investments in ADS-B In equipage for safety and research purposes may result in positive business cases and higher future equipage rates.

ADS-B In – ITP Apps on Oceanic Air Transport Fleet



Current State

- This capability is applicable to and reported against the oceanic fleet of airplanes.
- ADS-B Out equipage does not contribute to ADS-B In capability.
- Current equipage comprised of two trial operators.

Forecast

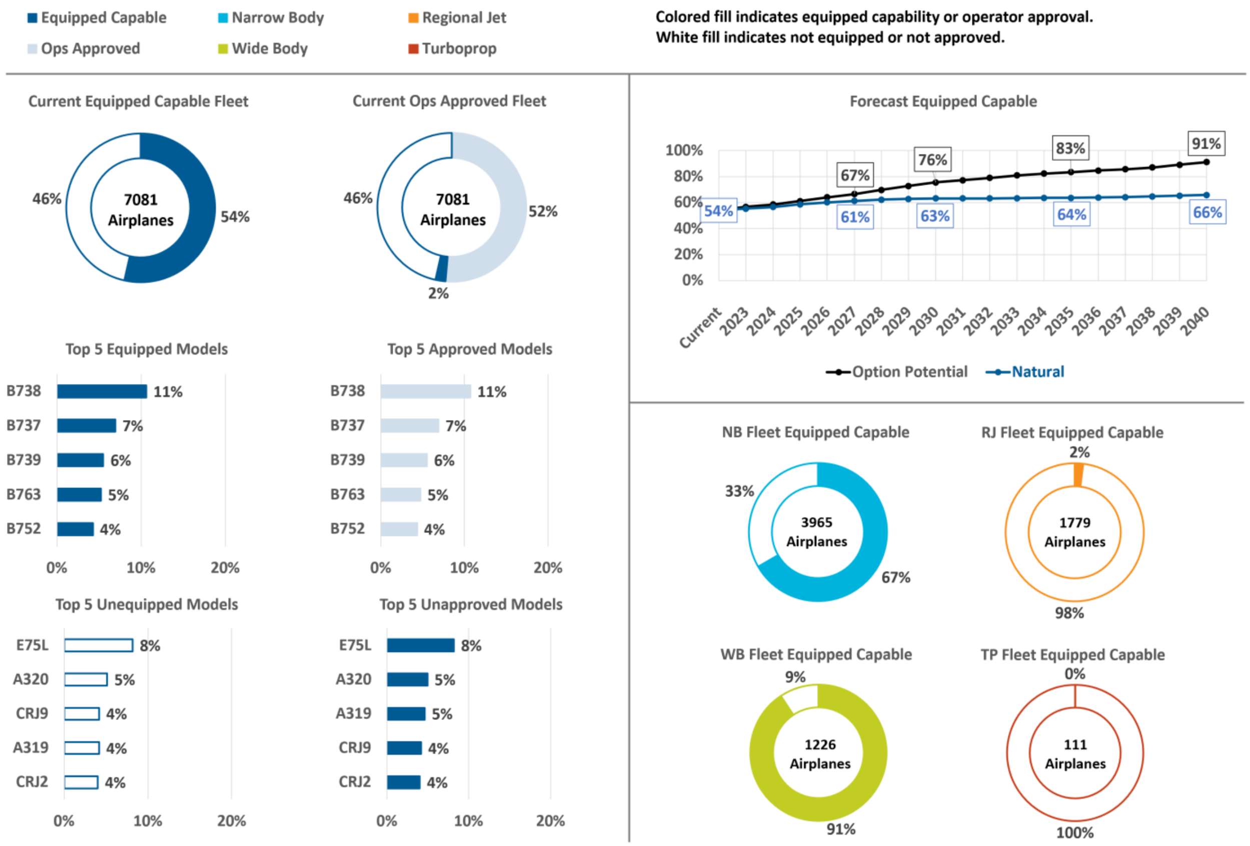
- Trend is flat.
- ITP will continue to be offered as optional equipment on new airplanes.

Significant Factors

- Impacts from COVID-19 and international travel constraints have drastically changed the makeup and operational pace of Oceanic Aircraft in the past year resulting in significant equipage and capability variations in data sets over the past year.
- Airlines and manufacturers are actively researching potential business cases for additional investment.
- It is believed that as CAVS, CAS, IM, and other ADS-B In applications mature, more offerings will exist, and airlines will increase their equipage rates in the 2025–2035 timeframe.
- Less expensive retrofit solutions are coming to market and recent airline investments in ADS-B In equipage for safety and research purposes may result in positive business cases and higher future equipage rates.

2.2.3 Data Communications for Air Transport

FANS 1/A Domestic – Tower Services on Air Transport Fleet



Current State

- FANS 1/A Domestic – Tower Services includes aircraft that are equipped with Very High Frequency (VHF) Data Link (VDL) Mode 0 or Mode 2.
- Equipage is increasing as most of the largest Air Transport operators are ordering their aircraft capable of domestic Data Comm Tower and En Route Services.
- The FAA Domestic Data Communications Program equipage is complete.

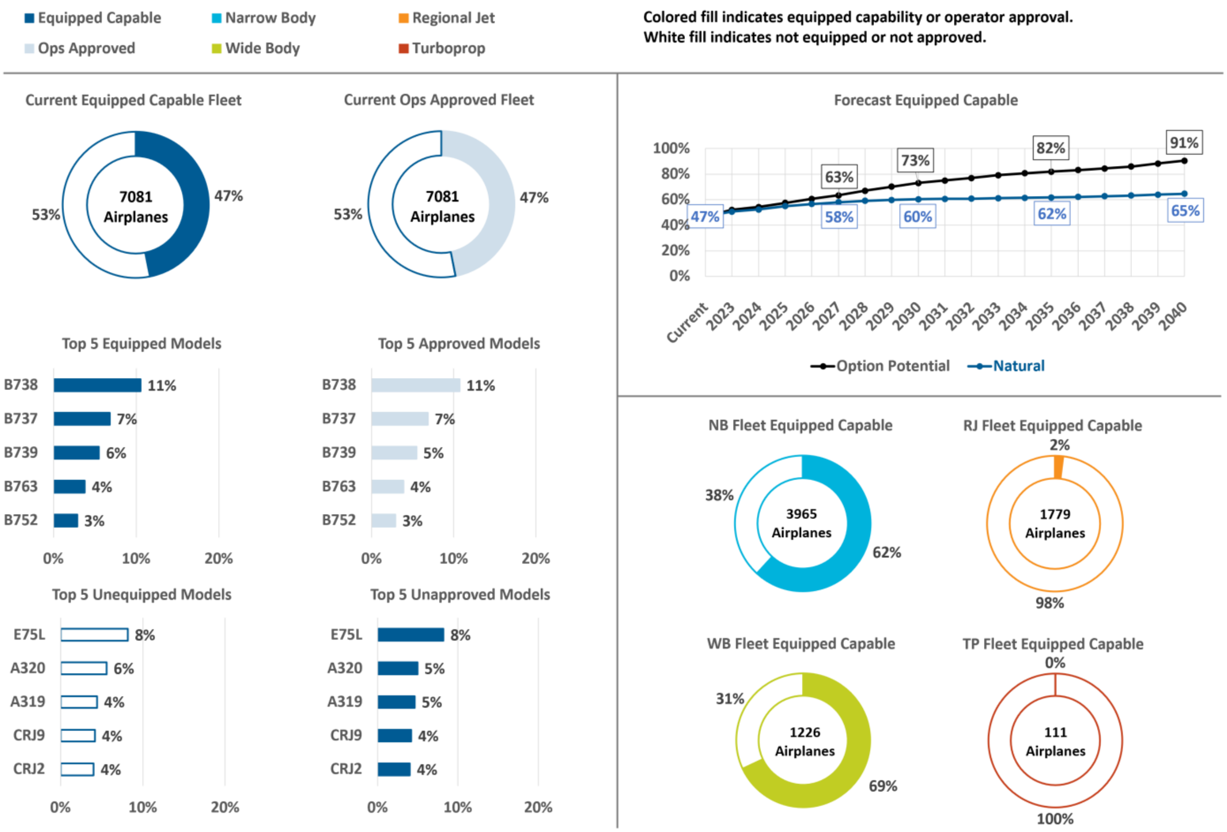
Forecast

- Trend is increasing.
- All new wide-body airplanes are assumed standard with this capability, while narrow-body and regional airplanes have available forward-fit or retrofit options.
- Major airline operators indicate plans to exercise many new delivery narrow-body options after 2020, while some regional operators are exercising forward-fit options and conducting retrofits.

Significant Factors

- The trend is expected to continue to increase as COVID-19 impacts wane.
- Impacts from COVID-19 and international travel constraints have drastically changed the makeup and operational pace of Oceanic Aircraft in the past year, resulting in significant equipage and capability variations in data sets over the past year.
- The inclusion of Data Comm in the MCL could lead to additional forward-fit and retrofits.
- Success of initial Data Comm services will impact further equipage, but trends indicate a continued increase in equipage as operators see the value of tower and en route services.

FANS 1/A Domestic – En Route Services on Air Transport Fleet



Current State

- FANS 1/A Domestic – En Route Services includes aircraft that are equipped with VHF VDL Mode 2.
- Equipage is flat, but most of the largest Air Transport operators are ordering their aircraft capable of domestic Data Comm Tower and En Route Services.
- The FAA Domestic Data Communications Program equipage is complete.

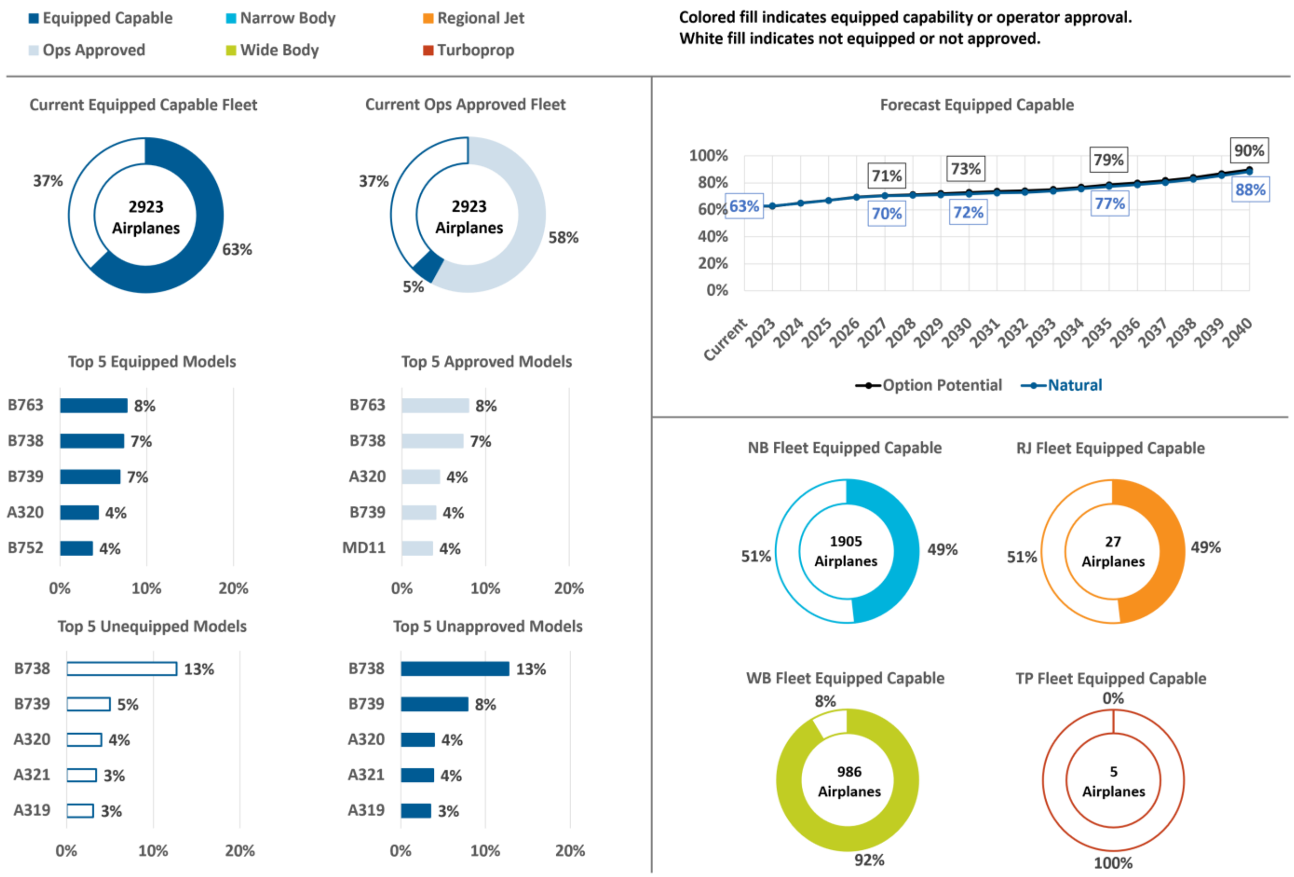
Forecast

- Trend is increasing.
- All new wide-body airplanes are assumed standard with this capability, while narrow-body and regional airplanes have available forward-fit or retrofit options.
- Major airline operators indicate plans to exercise many new delivery narrow-body options after 2020, while one large regional airline has committed to forward-fit and retrofit of over 220 Embraer 175 aircraft in support of U.S. tower and en route services.

Significant Factors

- Impacts from COVID-19 and international travel constraints have drastically changed the makeup and operational pace of Oceanic Aircraft in the past year, resulting in significant equipage and capability variations in data sets over the past year.
- The inclusion of Data Comm in the MCL could lead to additional forward-fit and retrofits.
- Success of initial Data Comm services will impact further equipage, but trends indicate a continued increase in equipage as operators see the value of tower and en route services.

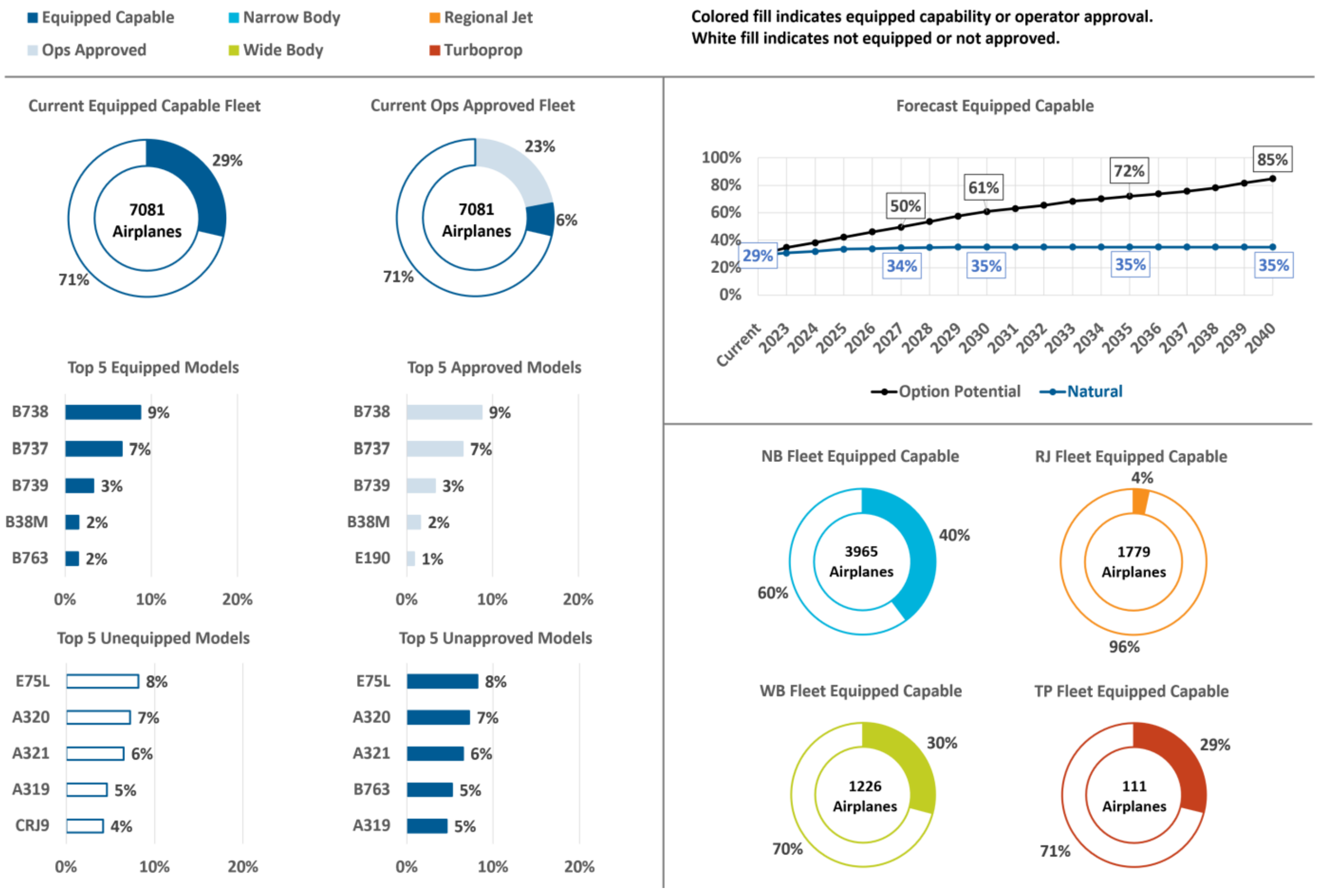
FANS 1/A Oceanic on Oceanic Air Transport Fleet



Current State	• This capability is applicable to and reported against the oceanic fleet of airplanes. • Wide-body airplanes typically are SATCOM capable; narrow-body and regional aircraft typically are not.
Forecast	• Trend is increasing. • This capability is a standard forward-fit offering on new production, wide-body airplanes. Although narrow body aircraft comprise a small percentage of the oceanic fleet, options remain available for these aircraft. • Narrow-body airplanes are growing in use in oceanic airspace and appear to be leveraging their RNP 4 standard capability and exercising SATCOM options to enable oceanic operations.
Significant Factors	• Many operators are equipping with FANS for the FAA Domestic Data Communications Program, which could result in increased SATCOM for Oceanic FANS 1/A capability. • Impacts from COVID-19 and international travel constraints have drastically changed the makeup and operational pace of Oceanic Aircraft in the past year, resulting in significant equipage and capability variations in data sets over the past year. • Operators are interested in improving passenger inflight connectivity. SATCOM is a key piece to many of these systems and continues to influence equipage rates.

2.2.4 Low-Visibility Enablers for Air Transport

Head-up Display (HUD) Approach on Air Transport Fleet



Current State

- Equipage is influenced by CAT III ILS capability where HUD can be used to manually fly the airplanes without the need for an operational auto-land capability.
- Equipage is predominantly observed on major airlines, particularly Boeing 737 operators, but there is also regional airplanes equipage.

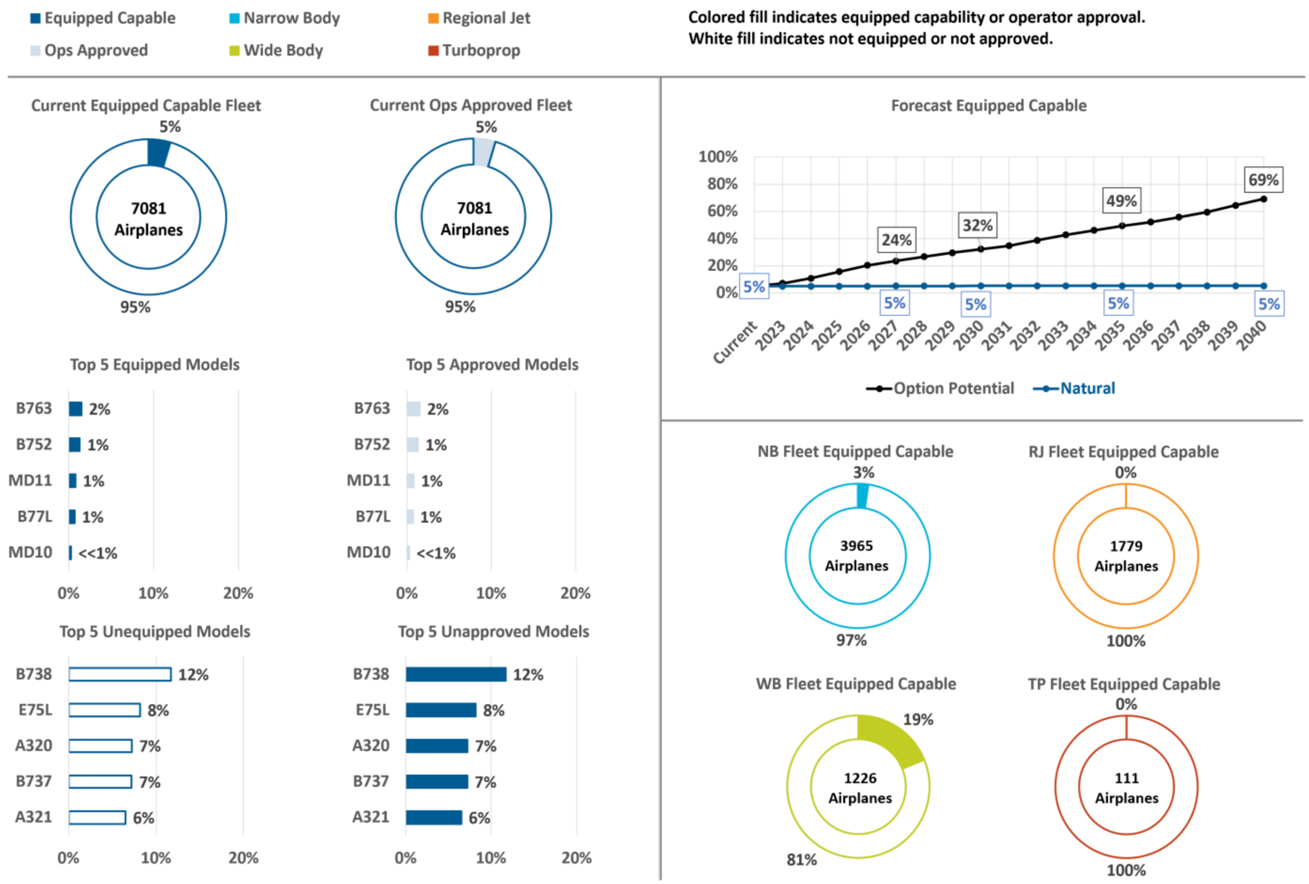
Forecast

- Trend is increasing.
- Most airplanes, including narrow-body and regional airplanes, have available options. Some, such as the Airbus A220, Airbus A350, and Boeing 787, come standard with this capability.

Significant Factors

- The inclusion of HUD in the MCL Supplemental List could lead to higher Air Transport equipage, while aircraft original equipment manufacturers (OEMs) continue to pursue new HUD certifications.
- Solutions coming to market without an IRU, along with smaller and lighter-weight systems, and in some cases Head Worn Displays (HWD), make for an improved potential business case across a wider range of airplanes and operators.
- Operational benefits in low-visibility conditions combining HUD with Enhanced Flight Vision Systems (EFVS), runway safety systems, and other sensors/systems may provide a positive business case for some operators to equip with HUD/ILS.

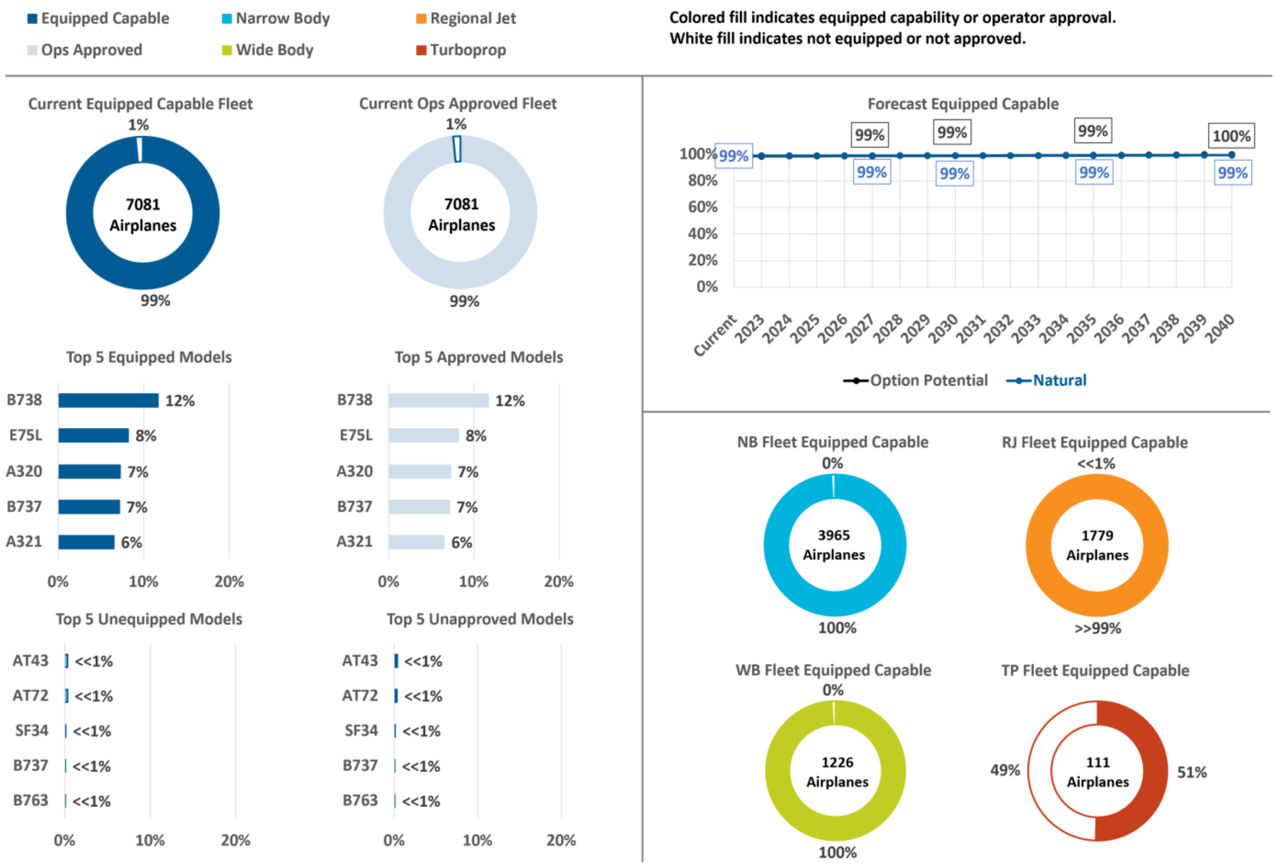
EFVS on Air Transport Fleet



Current State	• FedEx is the only Air Transport operator equipped with this capability.
Forecast	• Trend is flat. • Standard forward-fit offerings on new production airplanes are not available. • Operators with EFVS are expected to continue equipping new replacement airplanes.
Significant Factors	• Trend is expected to increase slowly as system prices and physical size are expected to decrease, while industry activities continue to pursue additional credit for EFVS and Combined Vision Systems (CVS), resulting in a more favorable business case. • New head-worn devices that are less expensive and easier to install on a wider range of smaller aircraft may result in greater equipage rates. • Operators indicate high interest in EFVS in support of all-weather operational capability, but the business case is currently challenging for many operators. • FedEx is still the only airline to significantly commit to the technology. • Airlines have indicated that the approach credit authorization, lower takeoff and landing minimums mitigation for unavailable ground infrastructures has increased interest in this technology and that business case assessments are still underway.

2.2.5 Avionics Safety and Other Enablers for Air Transport

EFB on Air Transport Fleet

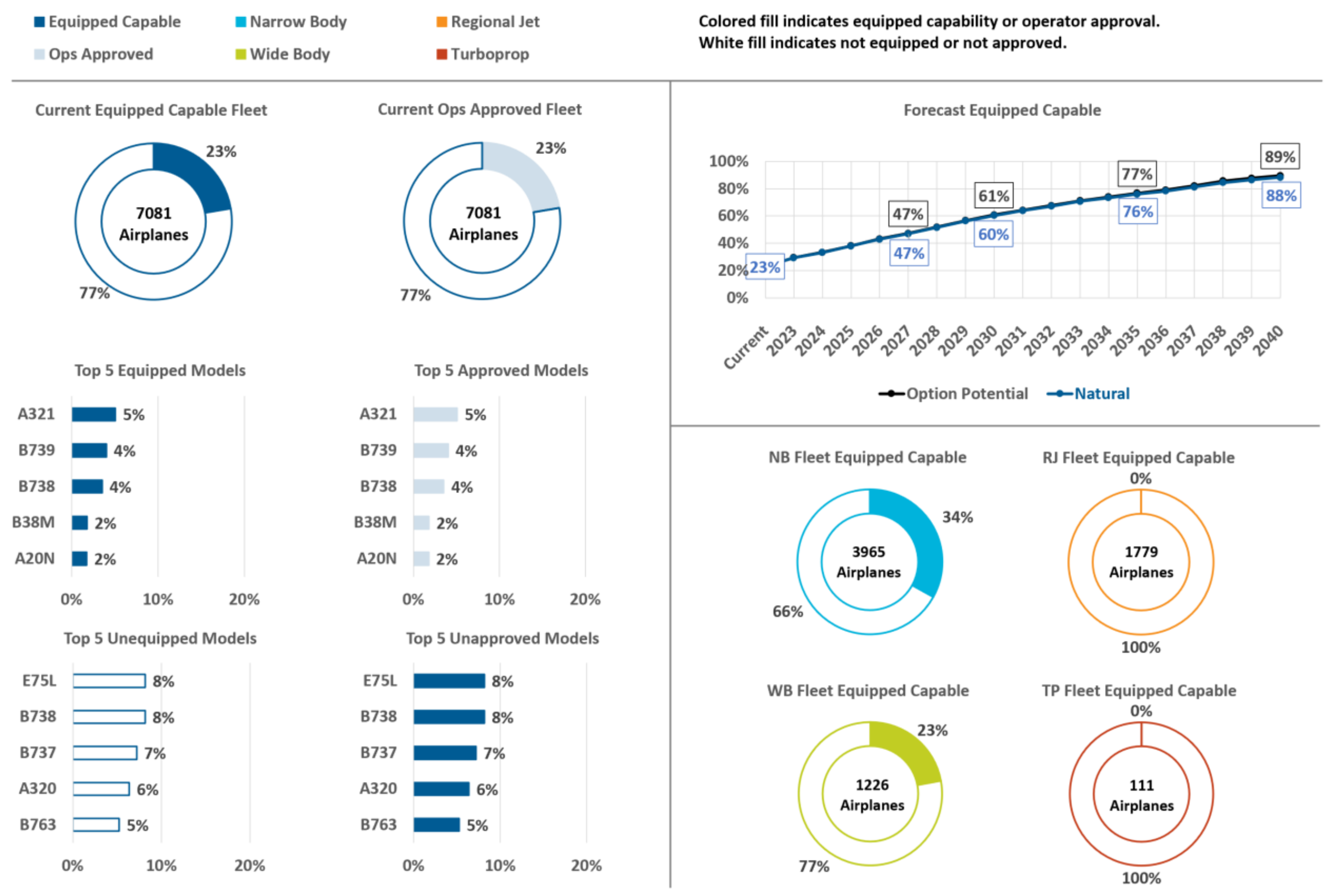


Current State
- Equipage is already high with almost all airplanes currently capable.
- Retirements are replaced with airplanes delivered with option capability.
- Available solutions exist for all airplanes.

Forecast
- Trend is flat.
- Equipage will occur as new airplanes are delivered with exercised option capability, while some mixed equipage will persist.

Significant Factors
- AIDs and new market offerings support emerging connected aircraft concepts and will likely result in new operational use cases for EFB and/or new hardware and software market options. These systems feature improved pairings (both one way and bi-directional) and connectivity of EFB with onboard avionics.
- Aircraft Access to System Wide Information Management (SWIM) (AAtS), live weather, CDTI, and potential for supplemental Data Comm-type applications may leverage the low cost of EFBs as a computing device or display, resulting in higher equipage rates for EFBs and these other capabilities.

EFB with Aircraft Integration on Air Transport Fleet



Current State

- Operators indicate high interest in integrated EFB in support of airline-specific and planned NextGen operational improvements.
- Some Boeing and Airbus aircraft have been delivered standard with this capability for several years.
- Forward-fit and retrofit solutions are available for wide-body, narrow-body and regional aircraft.

Forecast

- Trend is increasing.
- Equipage will occur as new airplanes are delivered standard and with exercised option capability, while some retrofits are forecast.

Significant Factors

- AIDs and new market offerings allowing improved pairings (both one way and bi-directional), and connectivity of EFB with onboard avionics supporting emerging connected aircraft concepts, and will likely result in new operational use cases for EFB and/or new hardware and software market options.
- AAtS, live weather, CDTI, and potential for supplemental Data Comm-type applications may leverage the low cost of EFBs as a computing device or display, resulting in higher equipage rates for EFBs and these other capabilities.

3 Air Taxi Fleet and Enablers

3.1 Air Taxi Fleet and Operators Overview

Figure 3-1 provides information about the Air Taxi operators and airplanes (helicopter analysis is included in Section 6 of this report). The fleet comprises 8,504 airplanes, of which 7,418 (87%) are designated for IFR, with 1,861 operating in oceanic airspace. Turbojet airplanes comprise 53% of the overall fleet but a larger proportion (60%) of the total operations. Single-engine piston airplanes are 13% of the fleet (one-quarter IFR and three-quarters VFR) but account for only 1% of the total IFR operations.

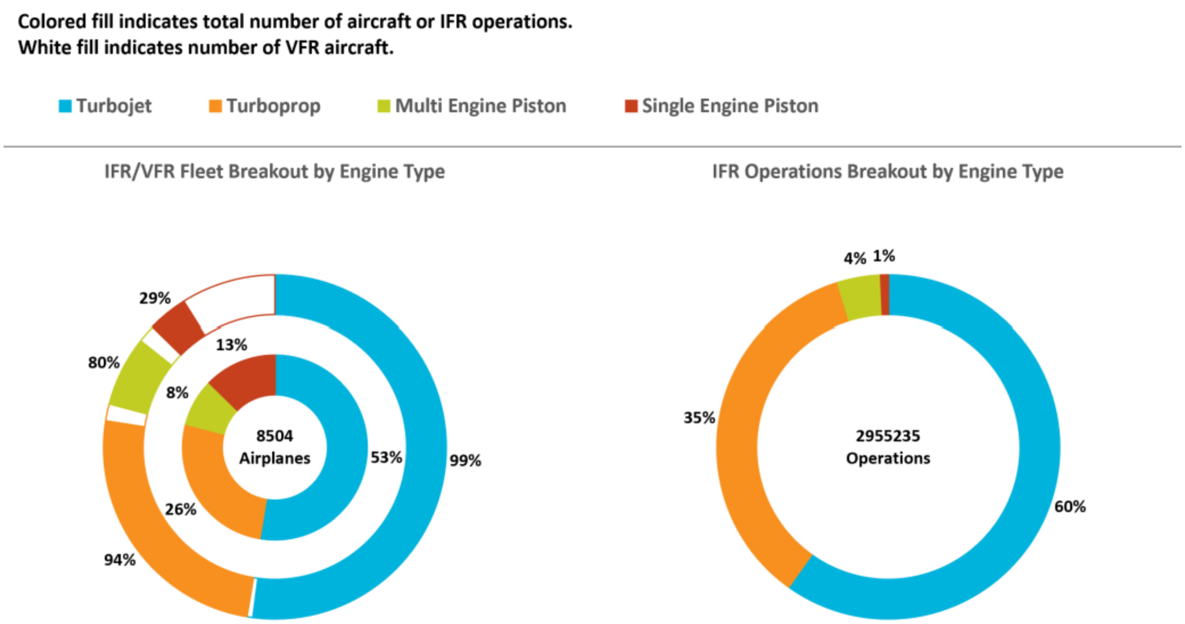


Figure 3-1. Air Taxi Fleet: IFR/VFR Fleet and Operations Breakout by Engine Type

The Air Taxi fleet comprises many operators and a wide variety of airplanes, operational profiles, and capabilities. Figure 3-2 shows the top-ten operators, measured by fleet size and by total IFR operations. There are 1,496 operators in the Air Taxi category; 1,162 operate IFR airplanes. The top-ten IFR operators account for 21% of the Air Taxi IFR fleet and 30% of the Air Taxi IFR operations. NetJets also owns Executive Jet Management, and the combined companies are more than three times the size of the next largest Air Taxi operator.

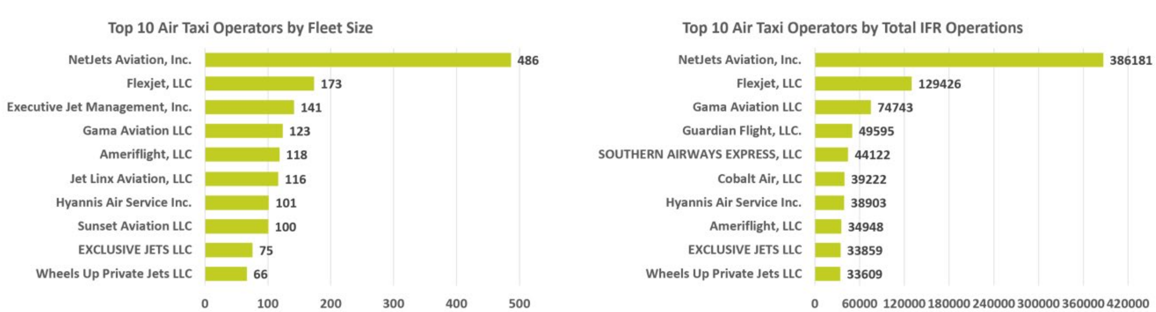


Figure 3-2. Air Taxi Fleet: Largest Ten Operators

Figure 3-3 shows the top-ten airplane models, measured by fleet size and total IFR operations. These top-ten models account for 38% of the Air Taxi IFR fleet and 50% of the Air Taxi IFR operations. The top-ten models include all engine type groupings (i.e., turbojet, turboprop, multi-engine piston, and single-engine piston).

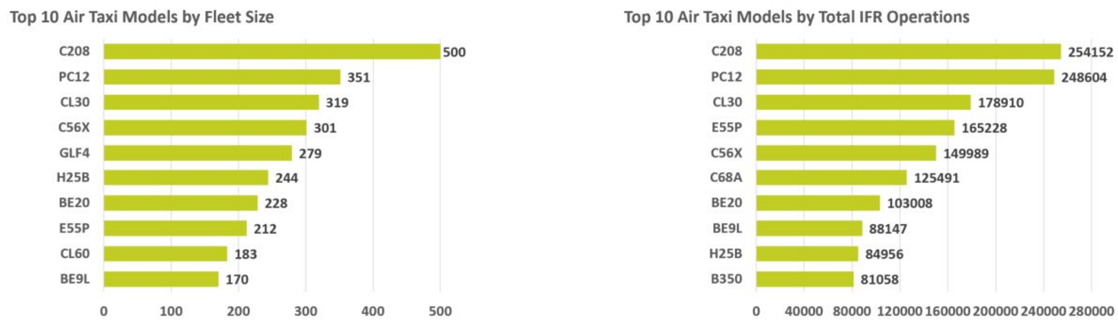


Figure 3-3. Air Taxi Fleet: Top-Ten Models

3.2 Air Taxi Current Capabilities

Figure 3-4 shows the assessment of current equipage for the Air Taxi fleet as derived from IFR flight plan filings (except for ADS-B equipage). The detailed pages that follow include additional information regarding significant factors influencing current state, key trend drivers, and potential factors that may impact the reported trend. Additionally, a review of available information indicates the majority of RNP 4 capable aircraft reported RSP 180 and RCP 240.

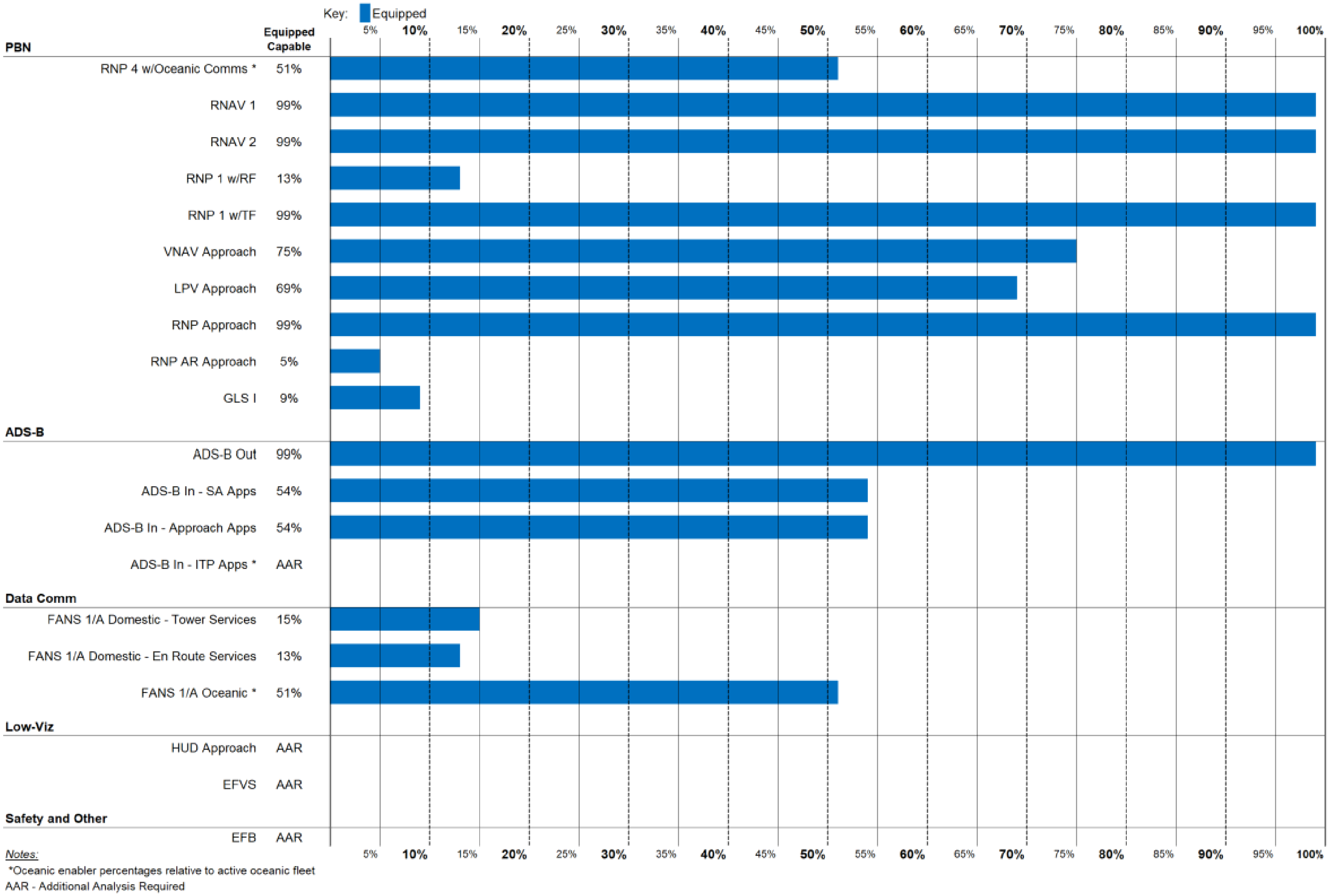
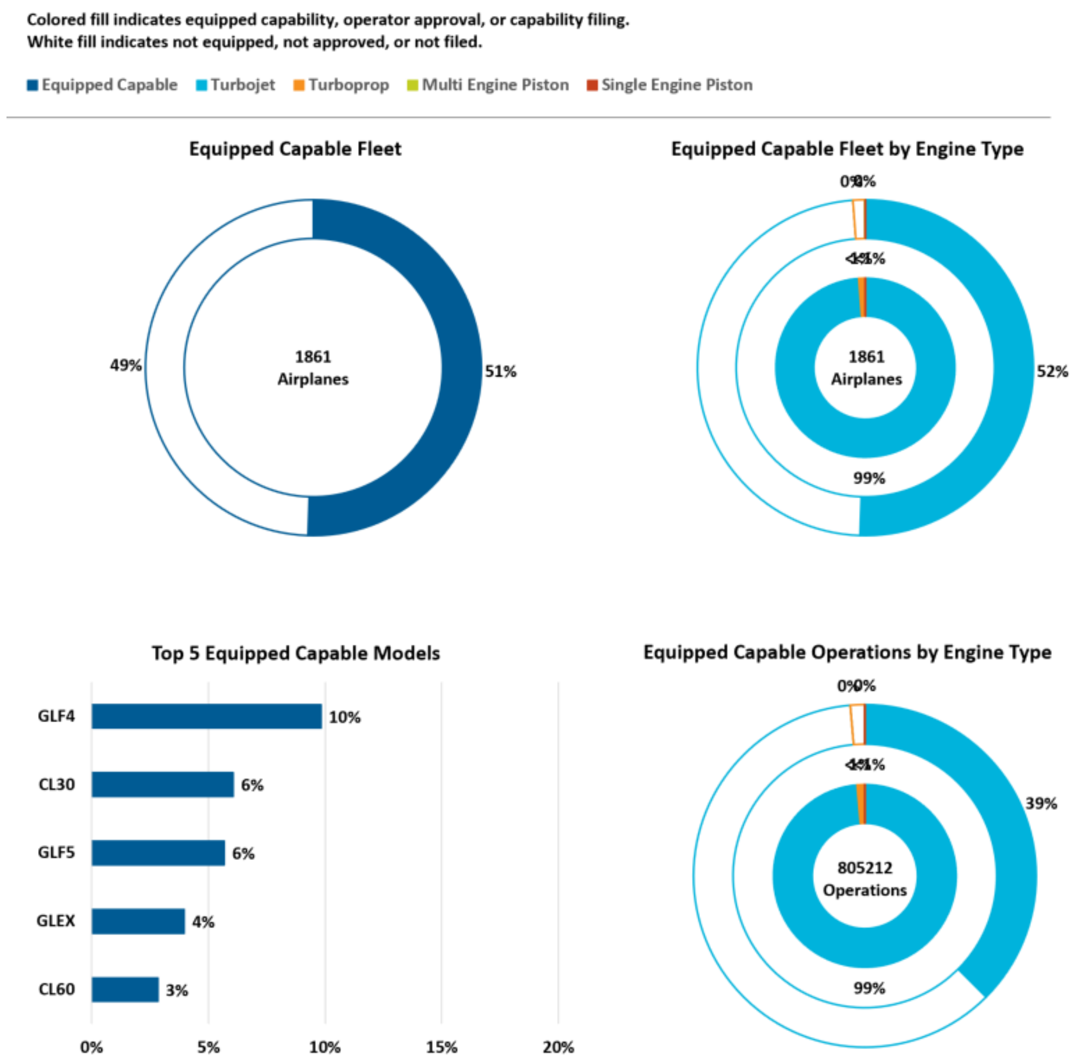


Figure 3-4. Air Taxi Enablers: Current Equipage Assessment

3.2.1 Performance Based Navigation Enablers for Air Taxi

RNP 4 with Oceanic Comms on Oceanic Air Taxi Fleet



Current State

- This capability is applicable to and reported against the oceanic fleet of airplanes.
- RNP 4 operations require RNP 4 navigation coupled with SATCOM; the presence of the two capabilities is reported for the oceanic fleet of airplanes.
- RNP 4 NAT HLA operations require RSP 180 and RCP 240.
- Many new long-range turbojet deliveries are equipped with RNP 4, but SATCOM equipage rates are lower on shorter range and smaller non-oceanic airplanes.

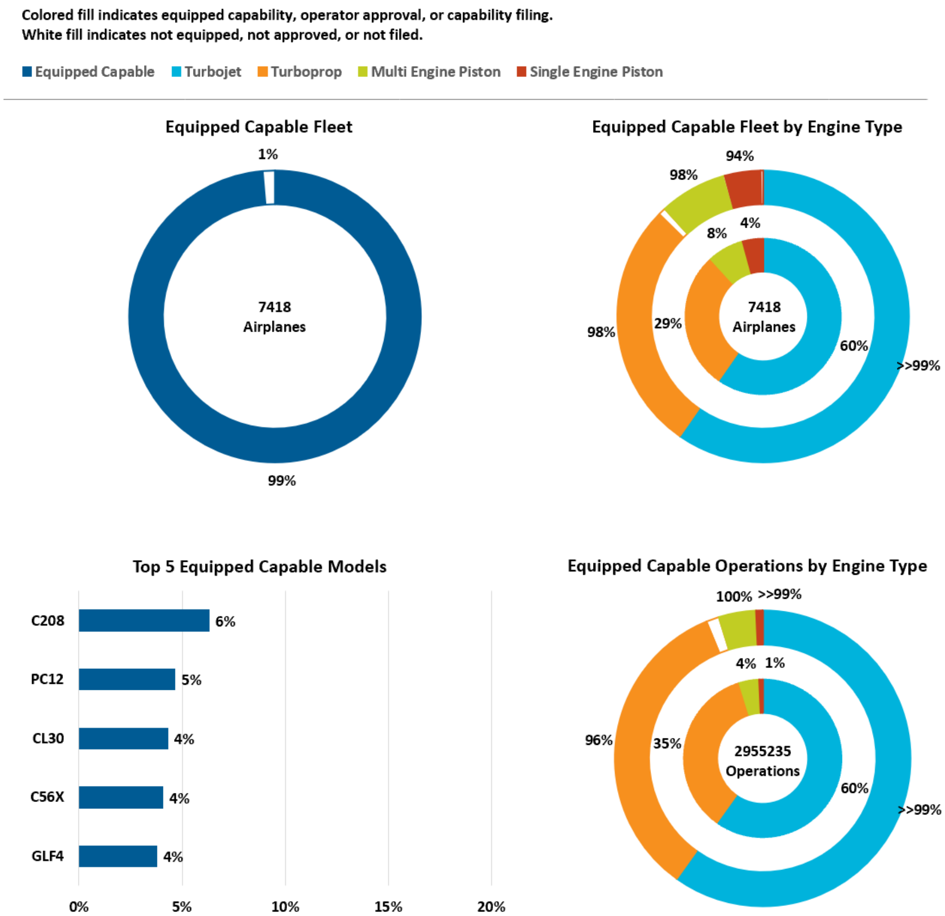
Forecast

- Trend is estimated to be flat.
- Operators select this capability for oceanic flight and inflight connectivity on their new, large, long-range airplanes.

Significant Factors

- Impacts from COVID-19 and international travel constraints have drastically changed the makeup and operational pace of Oceanic Aircraft in the past year, resulting in significant equipage and capability variations in data sets over the past year.

RNAV 1 on Air Taxi Fleet



Current State

- Equipage is already high and has increased as operators upgrading for ADS-B Out added additional GPS and WAAS with LPV Approach capabilities.
- New airplanes are delivered standard with significant level of PBN capability from GPS and WAAS with LPV Approach capability.

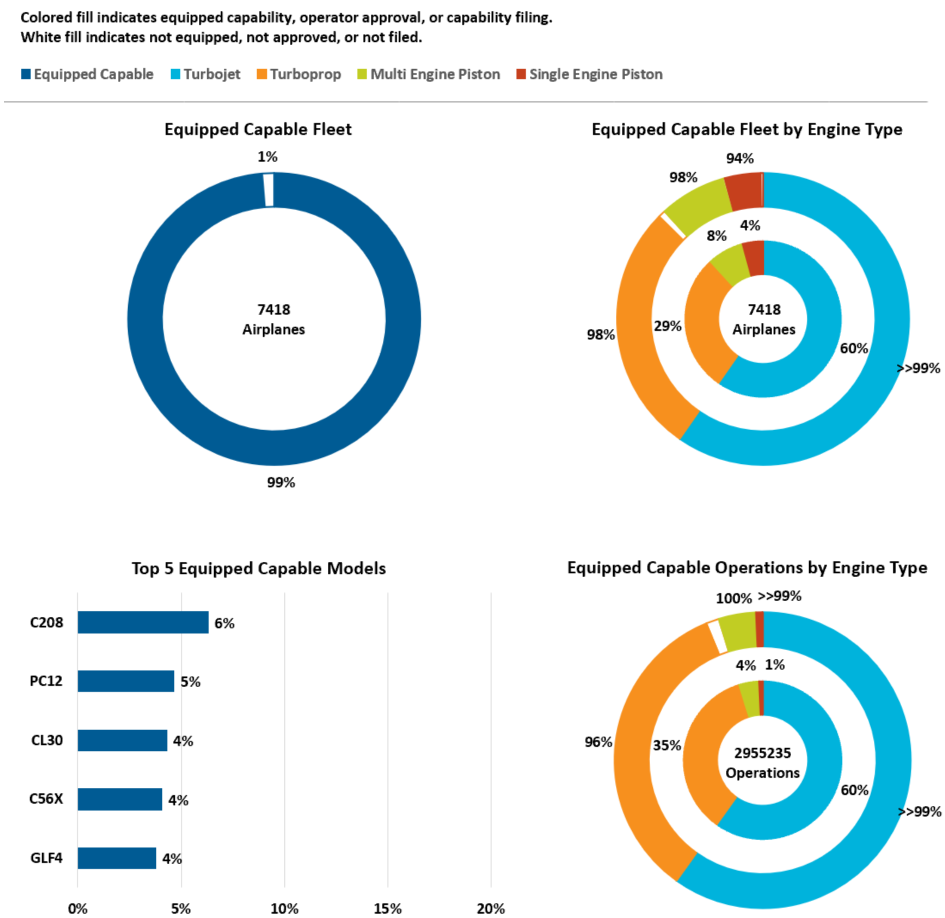
Forecast

- Trend is estimated to be flat.
- Standard capability for all new airplanes.

Significant Factors

- All airplanes have retrofit potential through GPS avionics that are affordable and widely available.
- Some operators do not have a business case for investing in retrofit solutions and/or operational approvals, often because of unknown future-fleet plans or operational needs. Investing for equipage and/or approvals on these airplanes risks a negative return.
- Some airplanes are dependent upon GPS to provide RNAV 1 capability and when GPS signals are not available, these airplanes are not capable of RNAV 1.

RNAV 2 on Air Taxi Fleet



Current State

- Equipage is already high and has increased as operators upgrading for ADS-B Out added additional GPS and WAAS with LPV Approach capabilities.
- New airplanes are delivered standard with significant level of PBN capability from GPS and WAAS with LPV Approach capability.

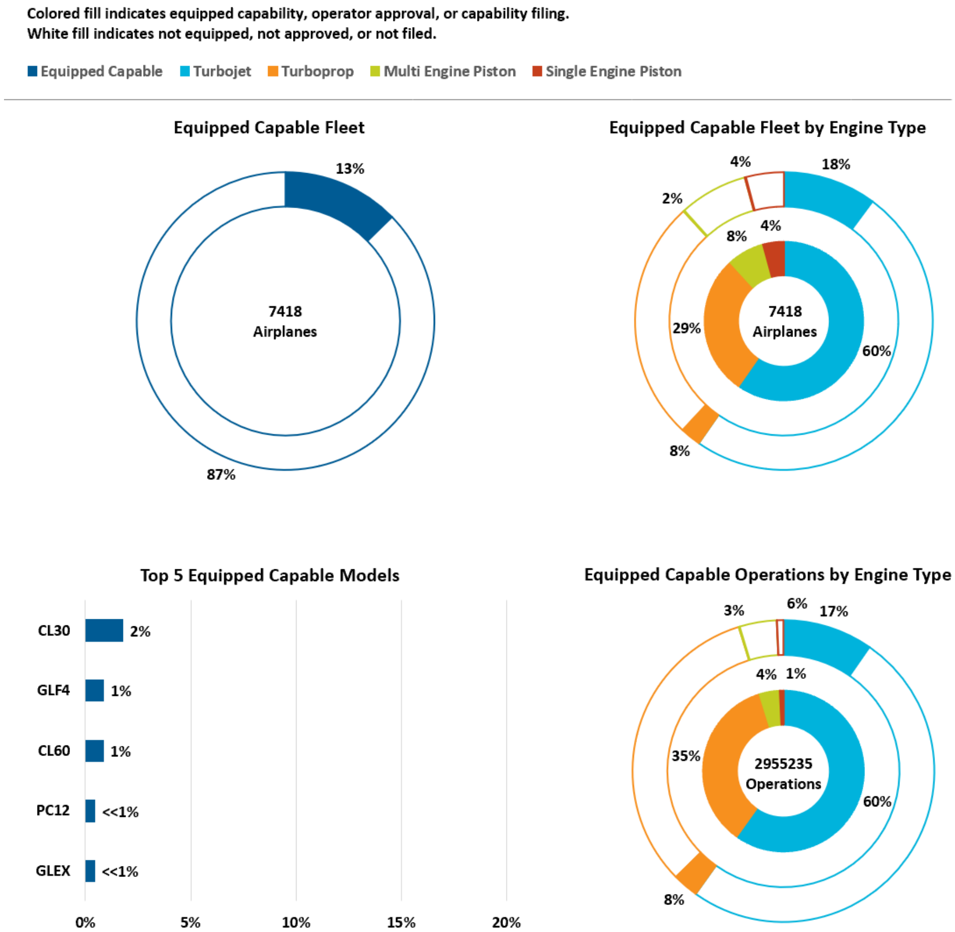
Forecast

- Trend is estimated to be flat.
- Standard capability for all new airplanes.

Significant Factors

- All airplanes have retrofit potential through GPS avionics that are affordable and widely available.
- Some operators do not have a business case for investing in retrofit solutions and/or operational approvals, often because of unknown future-fleet plans or operational needs. Investing for equipage and/or approvals on these airplanes risks a negative return.

RNP 1 with RF on Air Taxi Fleet



Current State

- RF leg capability does not require a specific operational approval when used with RNP 1, although OpSpec C063 does allow for operators to indicate these individual capabilities.
- Current estimates may be lower than actual equipage in cases where operators do not file flight plans that reflect all their airplane's capabilities.
- Displays capable of showing a curved path have been the significant limiter to higher levels of equipped capability.

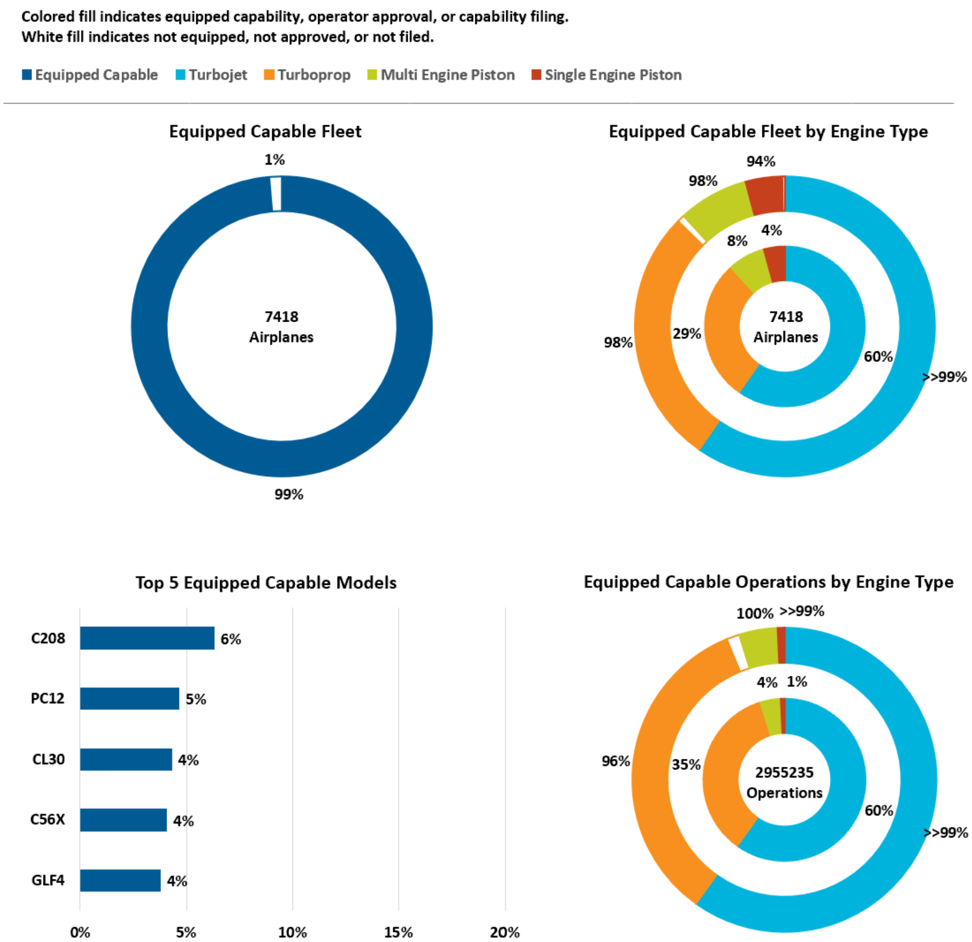
Forecast

- Trend is estimated to be increasing.
- Standard capability for most new airplanes, while some mixed equipage will persist.

Significant Factors

- Some NextGen operations, such as Advanced RNP, EoR, RNP AR Approach, and GLS I, may apply RF leg capability to specific operations. This could lead to an improved business case for unequipped operators to request forward-fit and retrofit options for RF leg capability, resulting in higher future equipage rates.

RNP 1 with TF on Air Taxi Fleet



Current State

- Equipage is already high and has increased as operators upgrading for ADS-B Out added additional GPS and WAAS with LPV Approach capabilities.
- New airplanes are delivered standard with significant level of PBN capability from GPS and WAAS with LPV Approach capability.

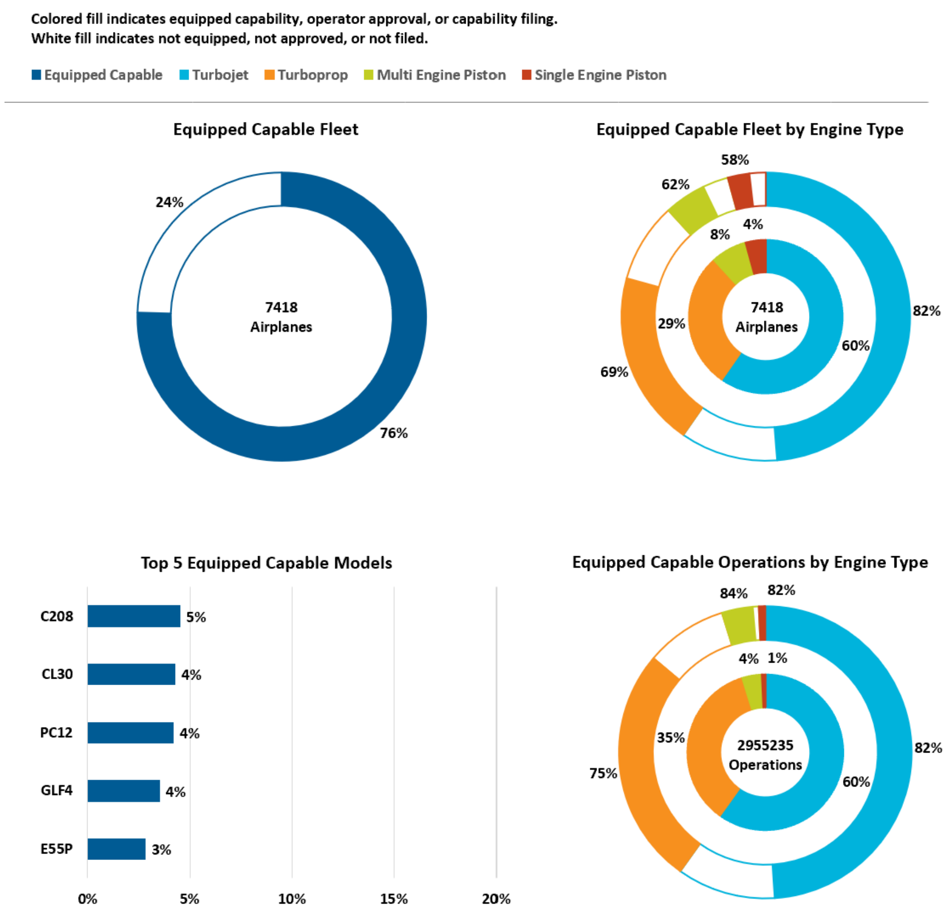
Forecast

- Trend is estimated to be flat.
- Standard capability for all new airplanes.

Significant Factors

- All airplanes have retrofit potential through GPS avionics that are affordable and widely available.
- Some operators do not have a business case for investing in retrofit solutions and/or operational approvals, often because of unknown future-fleet plans or operational needs. Investing for equipage and/or approvals on these airplanes risks a negative return.

VNAV Approach on Air Taxi Fleet



Current State

- Data sources other than IFR flight plans point to much higher equipage rates than are reflected in flight plan data. This is likely due to equipped operators not expecting to fly an LPV or LNAV/VNAV Approach for many of the filed flights.
- Other industry data sources suggest LPV equipage could be in the 70–90% range.
- New airplanes are delivered standard with significant level of PBN capability from GPS and WAAS with LPV Approach capability.
- VNAV Approach is defined in this report as an aircraft that can fly to LNAV/VNAV line of minima on an instrument approach chart.

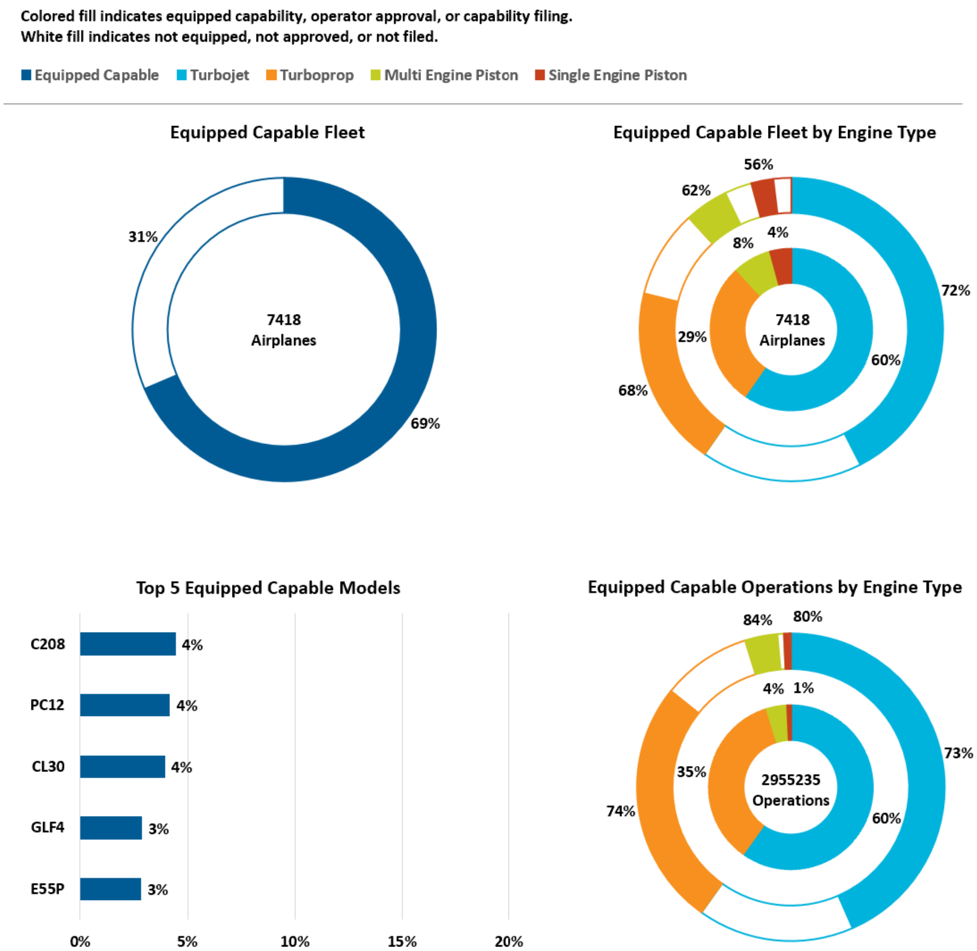
Forecast

- Trend is estimated to be increasing.
- Airplane manufacturer information suggests that new turbine-powered airplanes will come standard with coupled barometric VNAV, GPS, and an option for GLS I and/or LPV Approach. Piston airplanes may have LPV Approach options that enable VNAV Approach.

Significant Factors

- ADS-B Out equipage reports indicate many operators exercised options for LPV Approach capability while upgrading for the ADS-B Out mandate.

LPV Approach on Air Taxi Fleet



Current State

- Data sources other than IFR flight plans point to much higher equipage rates than are reflected in flight plan data. This is likely due to equipped operators not expecting to fly an LPV Approach for many of the filed flights.
- IFR flight plans show a 10 percent increase over last year, while other industry data sources suggest LPV equipage could be in the 70–90% range.
- New IFR airplanes are frequently delivered with LPV Approach capability.

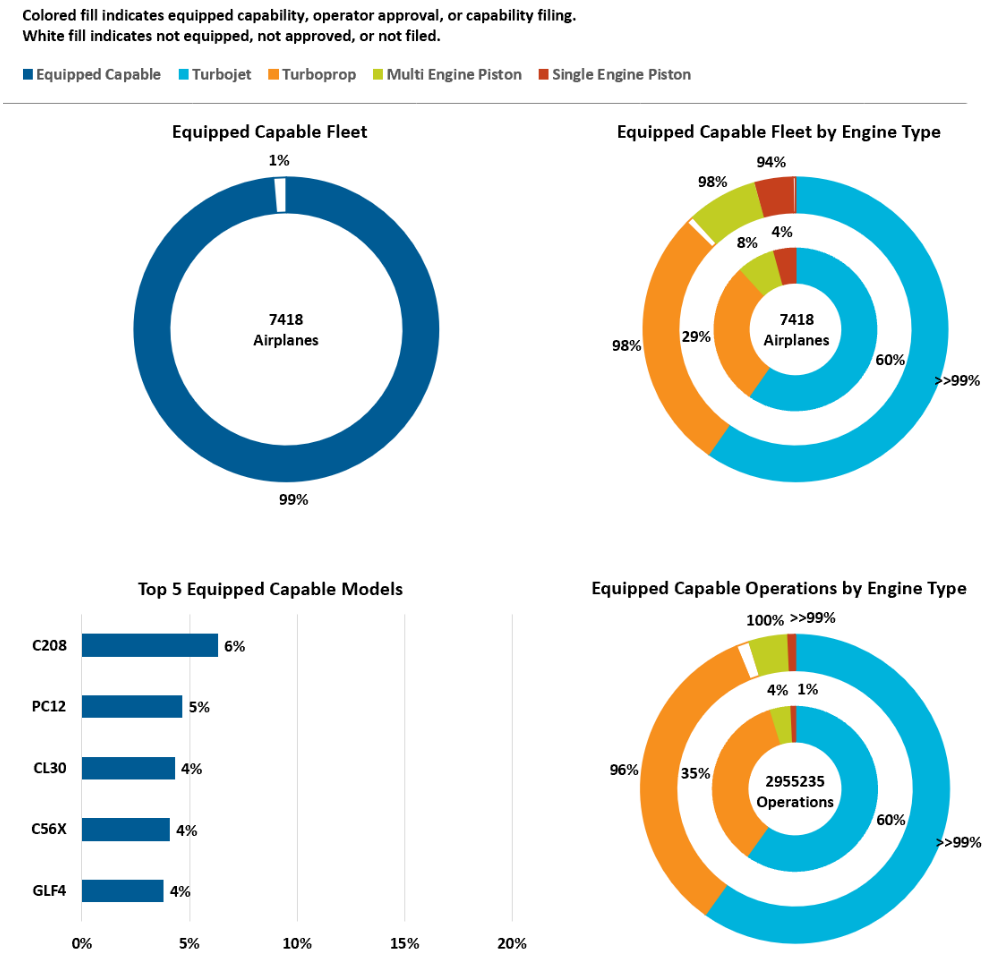
Forecast

- Trend is estimated to be increasing.
- The majority of airplanes in this fleet are expected to come standard with LPV Approach capability. As more airplanes come standard with SBAS MMR or GPS receivers to support ADS-B Out, it is expected more operators will develop a positive business case for LPV Approach capability, particularly as a backup in the event of ground-based instrument approach outages.

Significant Factors

- ADS-B Out equipage reports indicate many operators exercised options for LPV Approach capability while upgrading for the ADS-B Out mandate.

RNP Approach on Air Taxi Fleet



Current State

- Equipage is already high and increasing as new airplanes are delivered standard with significant levels of PBN capability from GPS and WAAS with LPV Approach capability.
- Enabling equipage is GPS with RNP 0.3 approach capability.

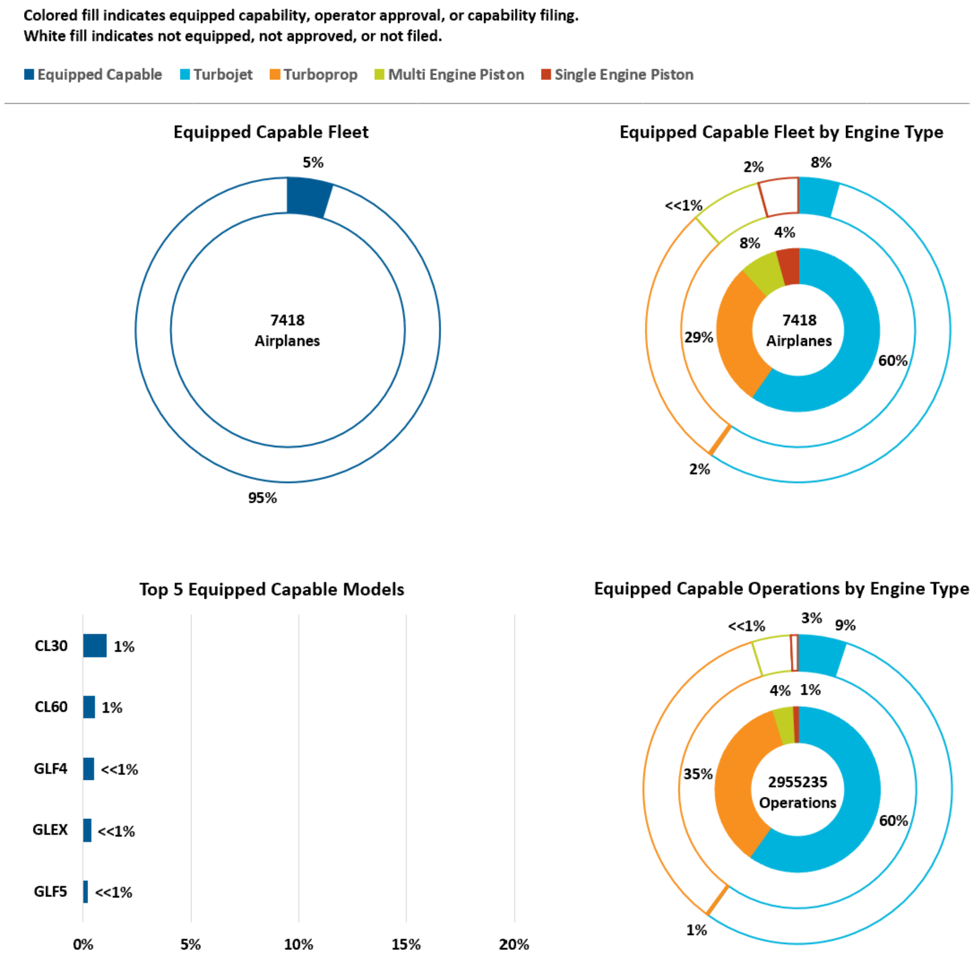
Forecast

- Trend is estimated to be flat.
- Standard capability for all new airplanes.

Significant Factors

- All airplanes have retrofit potential through GPS avionics that are affordable and widely available.
- Some operators do not have a business case for investing in retrofit solutions and/or operational approvals, often because of unknown future-fleet plans or operational needs. Investing for equipage and/or approvals on these airplanes risks a negative return.

RNP AR Approach on Air Taxi Fleet



Current State

- Current equipage includes long-range, large turbojet airplanes.
- Majority of operators do not have operational need for RNP AR Approach because ILS, LPV, and/or vision systems can provide the necessary airport access.

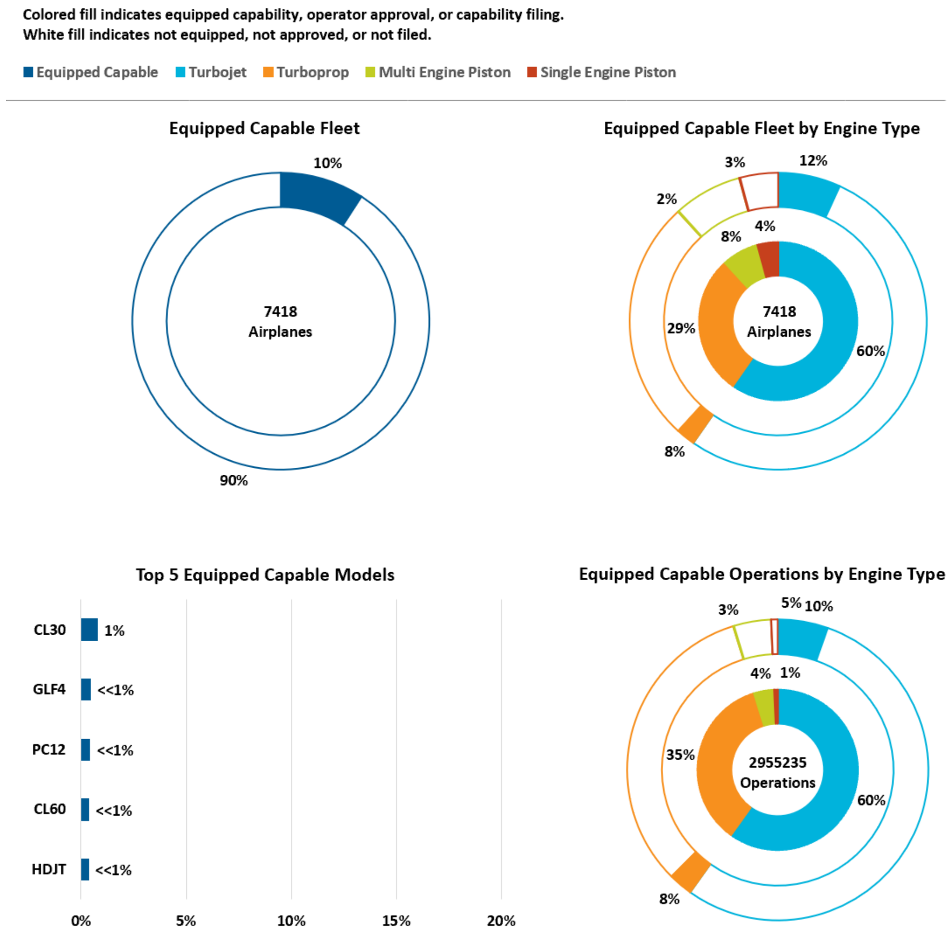
Forecast

- Trend is estimated to be flat.
- Many long-range, large turbojet airplanes come standard or have options available.
- RNP AR Approach will continue to grow slowly. Equipped, retired airplanes will be replaced by new deliveries with options exercised for this capability.

Significant Factors

- Piston airplanes do not generally have RNP AR Approach capability due to high cost and limited benefits. Prices are expected to reduce and positively impact equipage rates.
- U.S. and global demand for all-weather operations, environmental impact reductions, and predictable and repeatable paths may lead to higher rates of equipage offerings, standard equipage with RNP AR Approach, and/or additional options.

GLS I on Air Taxi Fleet



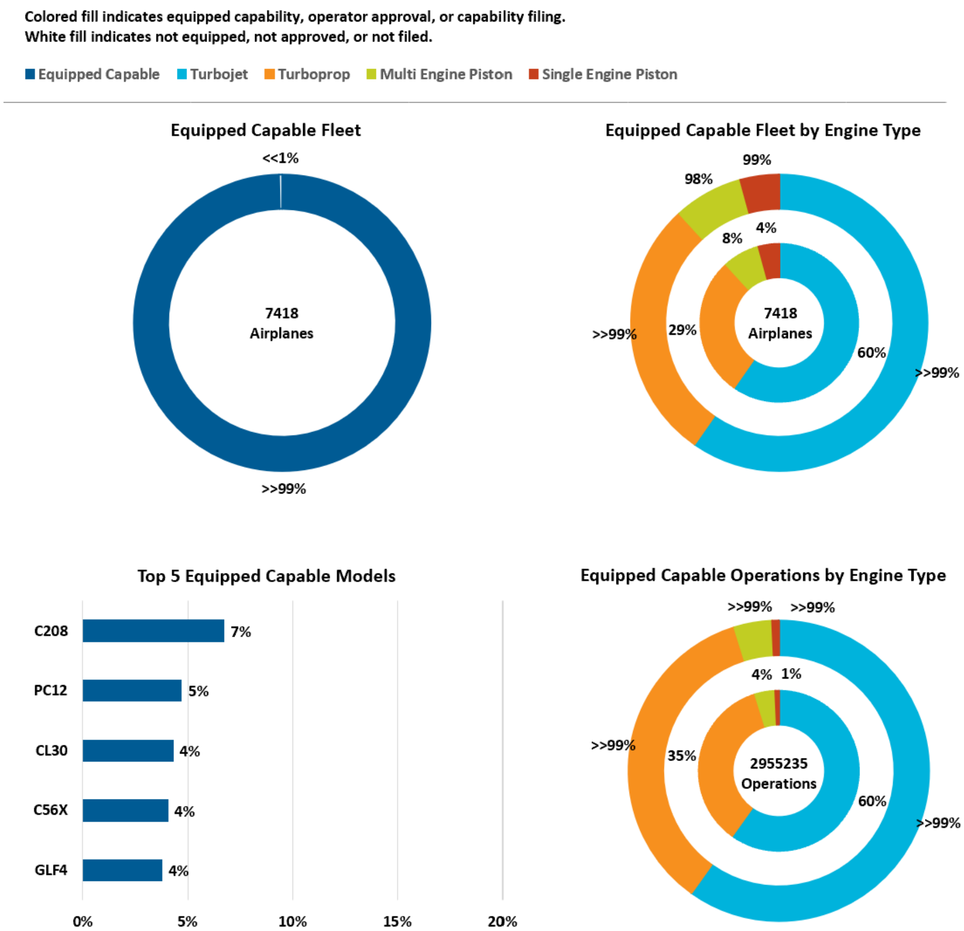
Current State
- Current equipage includes long-range, large turbojet and turboprop airplanes.

Forecast
- Trend is estimated to be flat.

Significant Factors
- Some large operators see potential operational value in key locations and are voicing their interest in having certain airport authorities acquire GLS ground systems.
- If airports or other entities were to begin fielding more GLS ground systems, it is likely more operators would equip with GLS I as a backup to ILS. This will be particularly true when GLS CAT III (GAST D) standards are complete and the business case for equipping is even stronger.
- International interest in GLS could result in more available options for operators to equip with the technology.

3.2.2 Automatic Dependent Surveillance-Broadcast Enablers for Air Taxi

ADS-B Out on Air Taxi Fleet

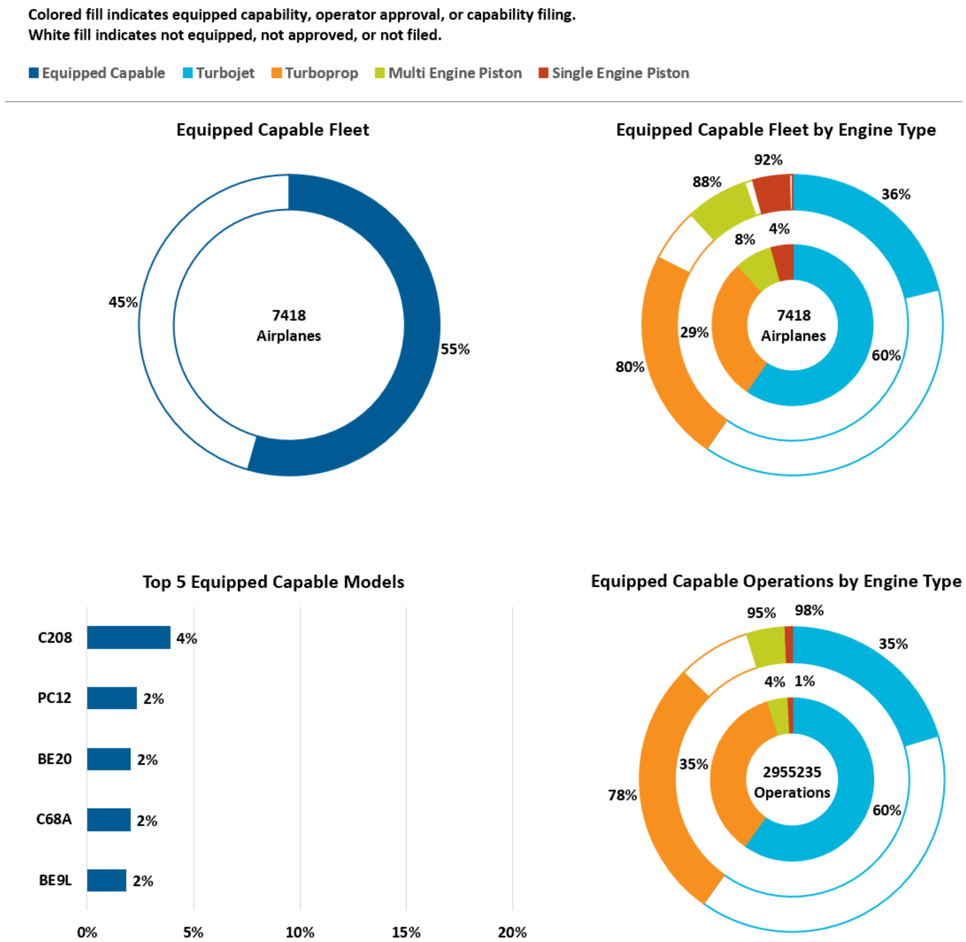


Current State
- Majority of Air Taxi airplanes equipped ahead of January 1, 2020 mandate, while a few airplanes had delayed installations and equipped just after rule implementation or were removed from operator fleets.
- Some equipage continues, but at much lower rates.
- New airplanes are coming delivered standard with rule compliant systems.

Forecast
- Trend is flat.
- New airplanes are being delivered with this capability.

Significant Factors
- ADS-B Out equipage reports indicate many operators exercised options for LPV Approach capability while upgrading for the ADS-B Out mandate.

ADS-B In – SA Apps on Air Taxi Fleet



Current State

- ADS-B Out equipage does not contribute to ADS-B In capability.
- Many operators who equipped for ADS-B Out chose to equip with solutions that provide both ADS-B Out and ADS-B In for CDTI Applications.
- Current ADS-B In equipage is primarily in support of operator interest in traffic awareness and weather in the cockpit.
- Data sources show a significant increase in equipage compared to previous reports and although additional analysis is required, it is believed this is due to a change in fleet composition and not due to data inaccuracies.

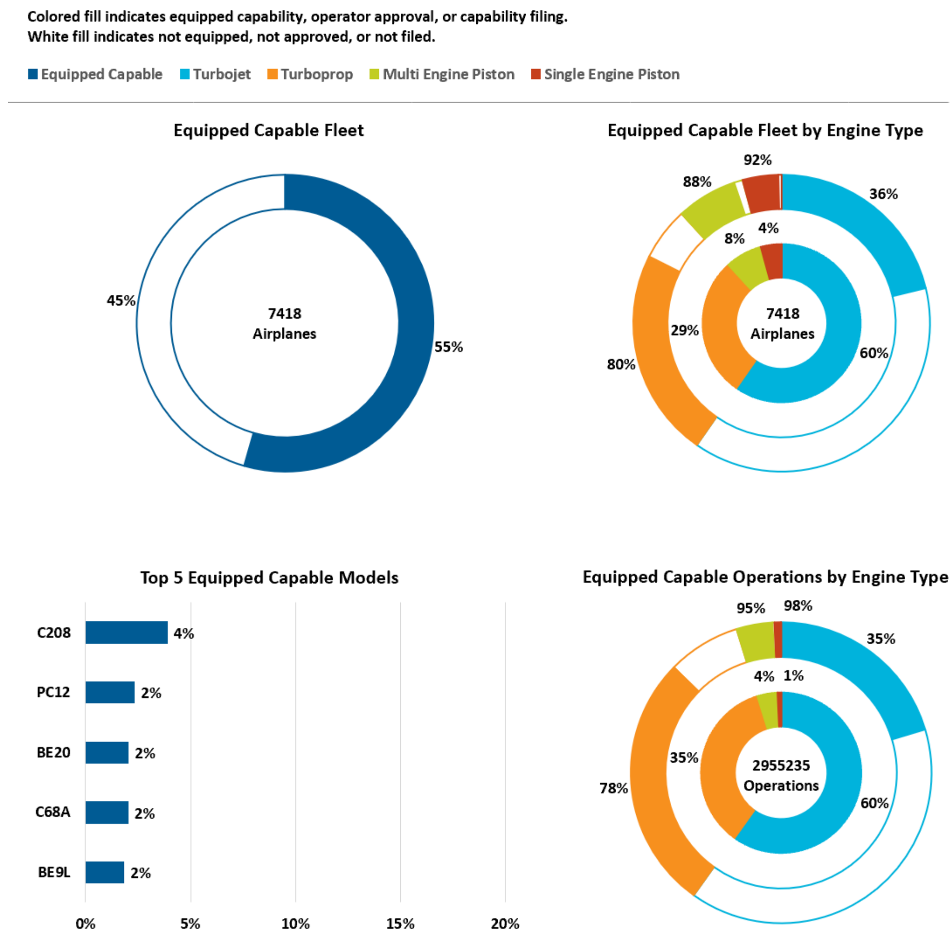
Forecast

- Trend is estimated to be increasing.

Significant Factors

- It is believed that as CAVS, IM, and other ADS-B In applications mature, more offerings will exist. Operators at busier airports who perceive operational benefit may increase their equipage if not previously equipped.
- Operators see the safety benefits of ADS-B In for SA through improved traffic awareness and weather in the cockpit and continue to strongly desire these capabilities.

ADS-B In – Approach Apps on Air Taxi Fleet



Current State

- ADS-B Out equipage does not contribute to ADS-B In capability.
- Many operators who equipped for ADS-B Out chose to equip with solutions that provide both ADS-B Out and ADS-B In for CDTI Applications.
- Current ADS-B In equipage is primarily in support of operator interest in traffic awareness and weather in the cockpit via Flight Information Services - Broadcast
- Data sources show a decrease in equipage compared to previous reports, and it is unclear if this is due to data inaccuracies in previous reports or a change in fleet composition

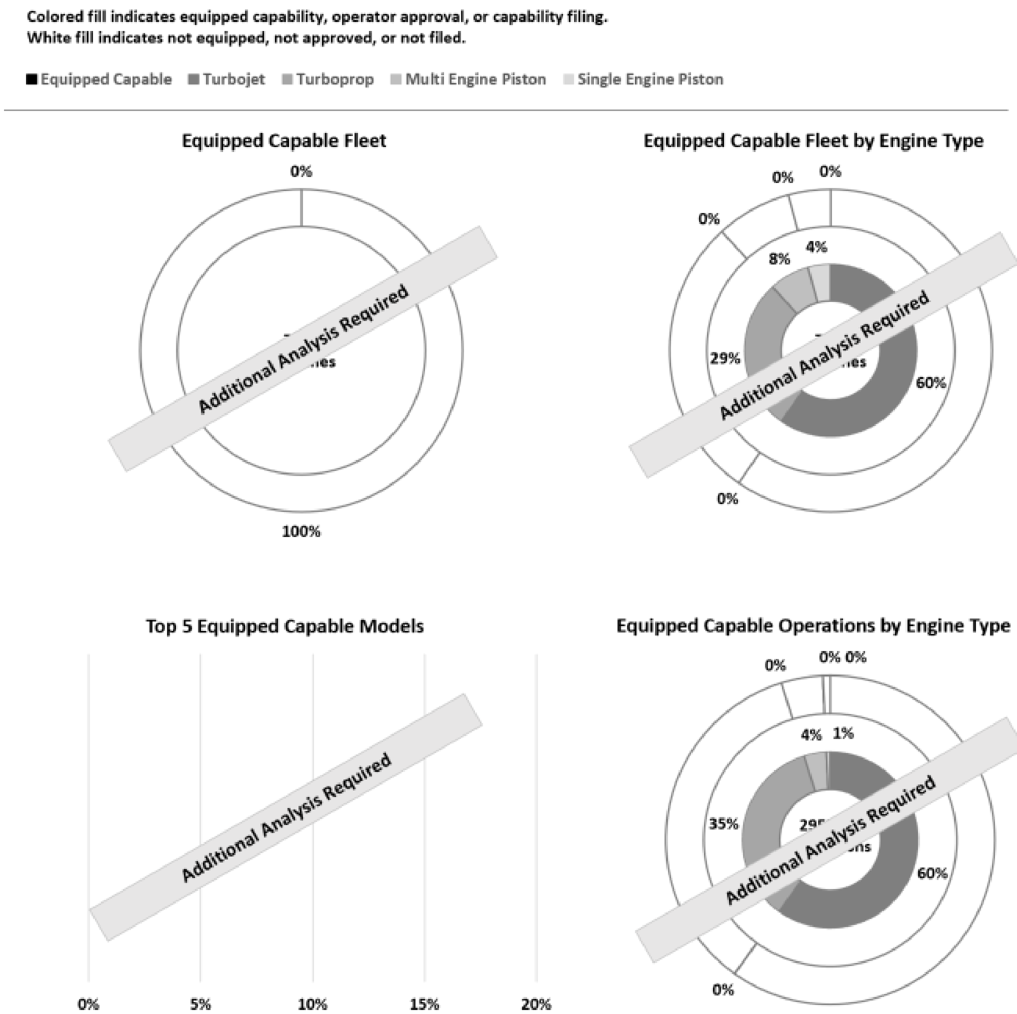
Forecast

- Trend is estimated to be increasing.

Significant Factors

- It is believed that as CAVS, IM, and other ADS-B In applications mature, manufacturers will provision/update their products to comply with applications requirements. Operators at busier airports who perceive operational benefit may increase their equipage if not previously equipped.
- ADS-B In approach applications offer improved capacity and efficiency in higher-density airports and airspace environments.
- Equipage for ADS-B In SA nearly doubled compared to previous reports, which may be a key enabler to future ADS-B In Approach App adoption.

ADS-B In – ITP Apps on Oceanic Air Taxi Fleet



Current State

- This capability is applicable to and reported against the oceanic fleet of airplanes.
- ADS-B Out equipage does not contribute to ADS-B In capability.
- There are no ITP operational approvals for Air Taxi operators.
- Current ADS-B In equipage is primarily in support of CDTI capability. However, long-range, large turbojet airplanes fly oceanic operations where ITP could be utilized even though no operators are showing approved.

Forecast

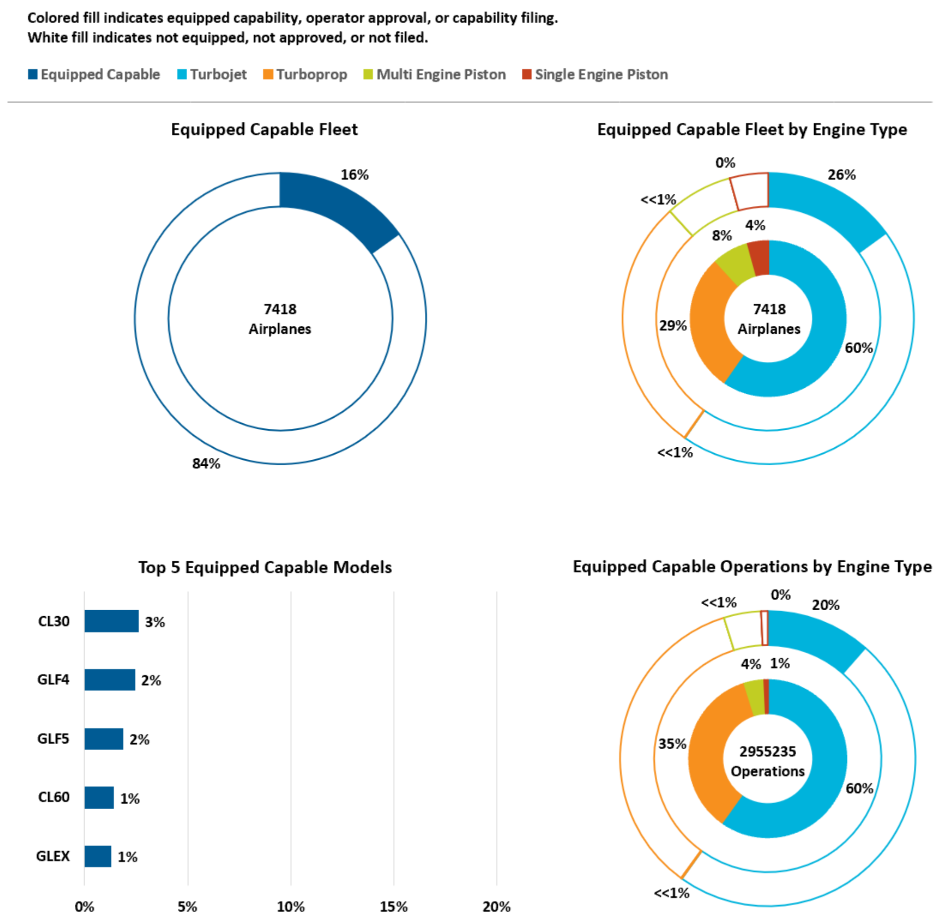
- Trend is estimated to be flat.
- Equipage will occur as Air Taxi operators flying in oceanic airspace are only a small portion of the Air Taxi fleet.

Significant Factors

- Impacts from COVID-19 and international travel constraints have drastically changed the makeup and operational pace of Oceanic Aircraft in the past year, resulting in significant equipage and capability variations in data sets over the past year.
- It is believed that as CAVS, IM, and other ADS-B In applications mature, operators of long-range, large Air Taxi turbojets will equip with a wide range of ADS-B In applications, including ITP.

3.2.3 Data Communications Enablers for Air Taxi

FANS 1/A Domestic – Tower Services on Air Taxi Fleet

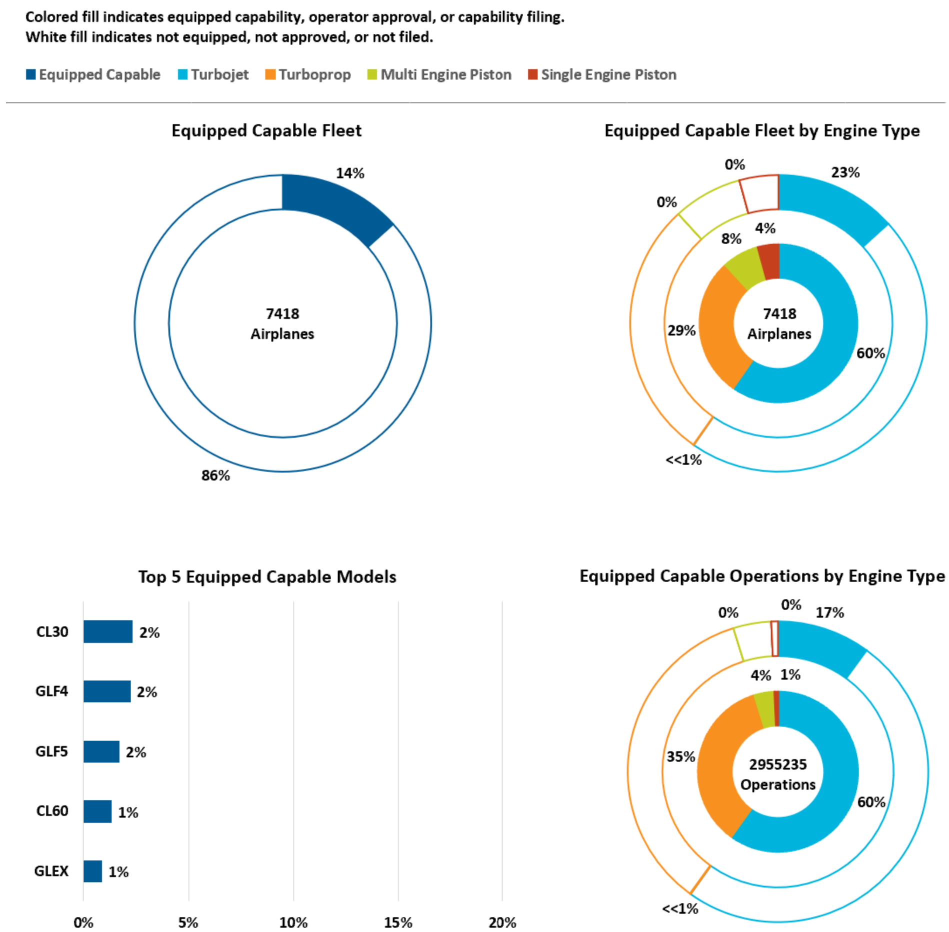


Current State
- FANS 1/A Domestic – Tower Services includes aircraft that are equipped with VDL Mode 0 or Mode 2.
- Long-range, large turbojets make up most of the Data Comm equipage and approvals, and data shows a two percent increase in equipage as compared to last year.

Forecast
- Trend is estimated to be flat.
- Equipage is increasing as operators select this capability for oceanic flight on their new, large, long-range airplanes.
- Equipage rates are lower on shorter-range and smaller jets and turboprops.

Significant Factors
- Access to North Atlantic airspace from FL290 to FL410 requires FANS capability, resulting in greater equipage.
- Success of initial Data Comm services will impact further equipage, but industry feedback indicates increased interest from operators who are assessing the applicability and value of tower and en route services to their individual operations.

FANS 1/A Domestic – En Route Services on Air Taxi Fleet



Current State

- FANS 1/A Domestic – En Route Services includes aircraft that are equipped with VDL Mode 2.
- Long-range, large turbojets make up most of the Data Comm equipage and approvals, and data shows a two percent increase in equipage as compared to last year.
- Piston equipage for domestic FANS is negligible.

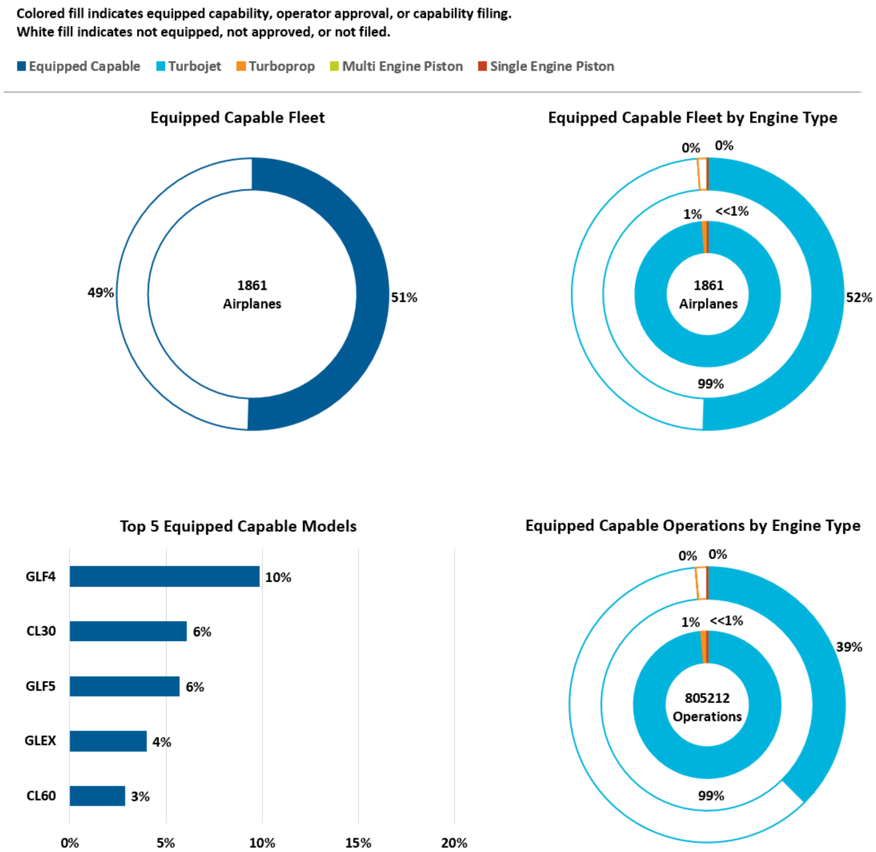
Forecast

- Trend is estimated to be flat.
- Majority of new turbojet airplane deliveries come standard or have options for FANS.
- Equipage is increasing as operators select this capability for oceanic flight on their new, large, long-range airplanes.
- Equipage rates are lower on shorter-range and smaller jets and turboprops.

Significant Factors

- Potential to apply Data Comm to improve system operations, particularly in the northeast corridor, may result in higher equipage and lower option costs.
- Success of initial Data Comm services will impact further equipage, but industry feedback indicates increased interest from operators who are assessing the applicability and value of tower and en route services to their individual operations.

FANS 1/A Oceanic on Oceanic Air Taxi Fleet



Current State

- This capability is applicable to and reported against the oceanic fleet of airplanes.
- Long-range, large turbojets operating in oceanic airspace make up all the FANS 1/A Oceanic equipage and approvals.
- Most new turbojet airplane deliveries are equipped with RNP 4. SATCOM equipage rates are lower on shorter-range and smaller non-oceanic airplanes.
- The percent of equipped capable aircraft did not increase compared to previous reports, but the overall oceanic fleet significantly increased as many less equipped aircraft were operated in oceanic airspace.

Forecast

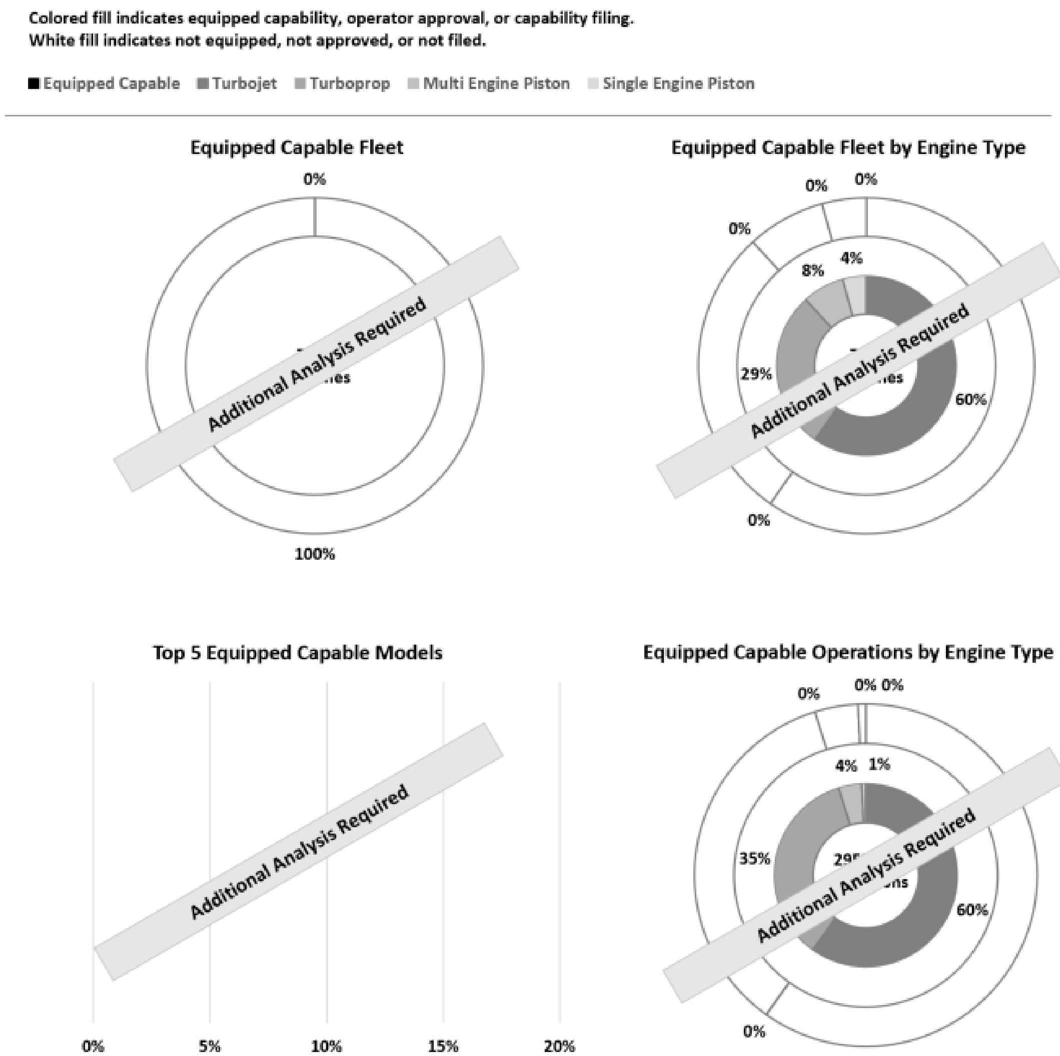
- Trend is estimated to be flat.
- Equipage occurs as operators select this capability for oceanic flight and inflight connectivity on their new, large, long-range airplanes.

Significant Factors

- Impacts from COVID-19 and international travel constraints have drastically changed the makeup and operational pace of Oceanic Aircraft in the past year, resulting in significant equipage and capability variations in data sets over the past year.
- An increase in FANS equipage may occur due to expanded use of mid-size airplanes in oceanic airspace and operators seeking access to North Atlantic airspace from FL290 to FL410.
- Success of initial Data Comm services could impact further equipage.

3.2.4 Low-Visibility Enablers for Air Taxi

HUD Approach on Air Taxi Fleet

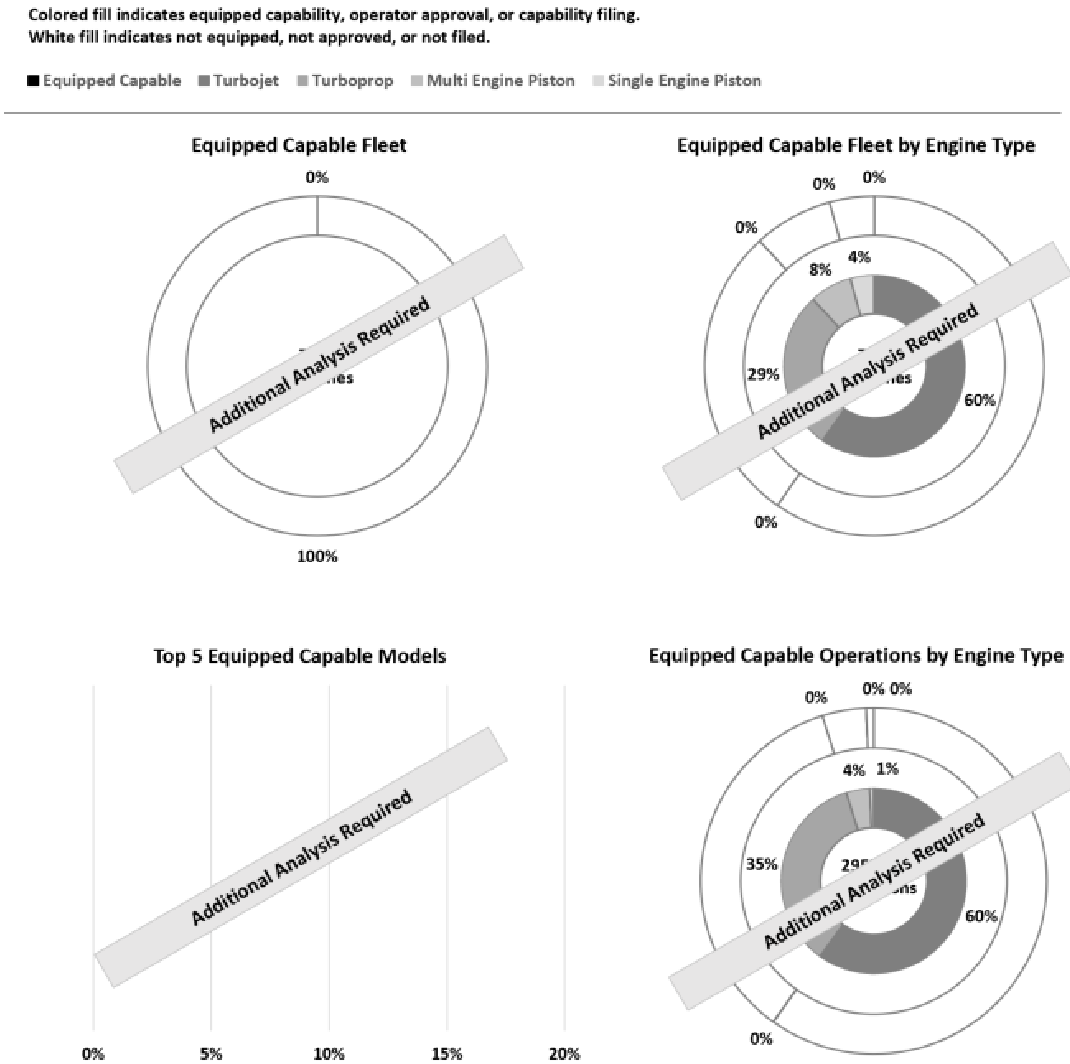


Current State
- Equipage is primarily on turbojet-powered airplanes where HUDs provide enhanced landing capability.
- Recent FAA regulatory efforts have improved IFR operational credit, which is considered by these operators as beneficial.

Forecast
- Trend is estimated to be flat.

Significant Factors
- System prices and physical size are decreasing, resulting in a more favorable business case for operators. Solutions coming to market without an IRU, along with smaller and lighter-weight systems, make for an improved potential business case across a wider range of airplanes and operators.
- Evolving market offerings and operational benefits for all types of vision system technologies are interpreted by some operators to improve safety, efficiency, and access. As a result, vision system technologies continue to garner significant operator interest.

EFVS on Air Taxi Fleet



Current State

- Equipage is primarily on turbojet-powered airplanes where enhanced situational awareness is provided by EFVS and HUDs.
- Recent FAA regulatory efforts have improved IFR operational credit, which is considered by these operators as beneficial.

Forecast

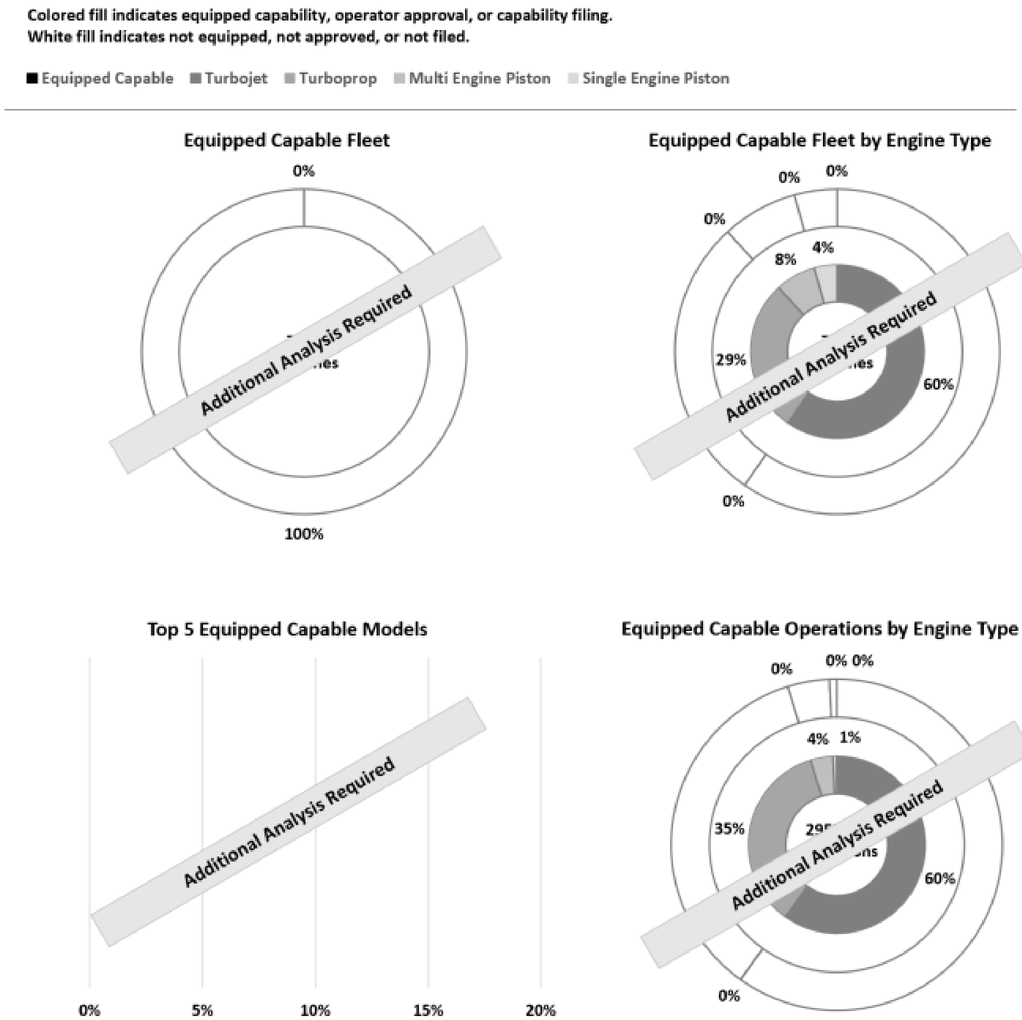
- Trend is estimated to be flat.
- Equipage will occur as some operators have sufficient business case to invest in EFVS.

Significant Factors

- System prices and physical size are decreasing, resulting in a more favorable business case for operators to pursue equipage. Solutions coming to market without an IRU, along with smaller and lighter-weight systems, make for an improved potential business case across a wider range of airplanes and operators.
- Evolving market offerings and operational benefits for all types of vision system technologies are interpreted by some operators to improve safety, efficiency, and access. As a result, vision system technologies continue to garner significant operator interest.

3.2.5 Avionics Safety-Enhancement Enablers for Air Taxi

EFB on Air Taxi Fleet



Current State
- Equipage numbers are not readily available, but data suggests the majority of airplanes are currently equipped with some form of EFB.
- EFBs are being utilized for additional cockpit capabilities such as flight planning, live weather, and moving map displays.

Forecast
- Trend is estimated to be flat.

Significant Factors
- AIDs and new market offerings allowing improved pairings (both one way and bi-directional), and connectivity of EFB with onboard avionics supporting emerging connected aircraft concepts, which will likely result in new operational use cases for EFB and/or new hardware and software market options.
- AAtS, live weather, CDTI, and potential for supplemental Data Comm-type applications may leverage the low cost of EFBs as a computing device or display, resulting in higher equipage rates for both EFBs and these other capabilities.

4 Foreign Carrier Fleet and Enablers

4.1 Foreign Carrier Fleet and Operators Overview

Figure 4-1 provides information about the Foreign Carrier operators and airplanes (helicopter analysis is included in Section 6 of this report). There are 522 operators certificated to operate airplanes under 14 Code of Federal Regulations (CFR) Parts 129 and 129.14. Operators include a mix of North American countries with fleets equipped primarily for over-land capability. Others operate oceanic fleets with high levels of equipage and capability for their oceanic operations. Not all airplanes certificated to operate to the U.S. are necessarily used in any given year. The fleet comprises 7,448 airplanes, of which 4,933 (67%) are designated for IFR, with 3,324 of those filing flight plans in oceanic airspace. This is a decrease of only 6 aircraft as compared to the previous year's reported fleet, but operations have increased by 110,000, indicating Foreign Carrier operations are growing while utilizing a smaller fleet of aircraft. Only the airplanes having flown IFR to/from U.S. airports are represented in the current analysis.

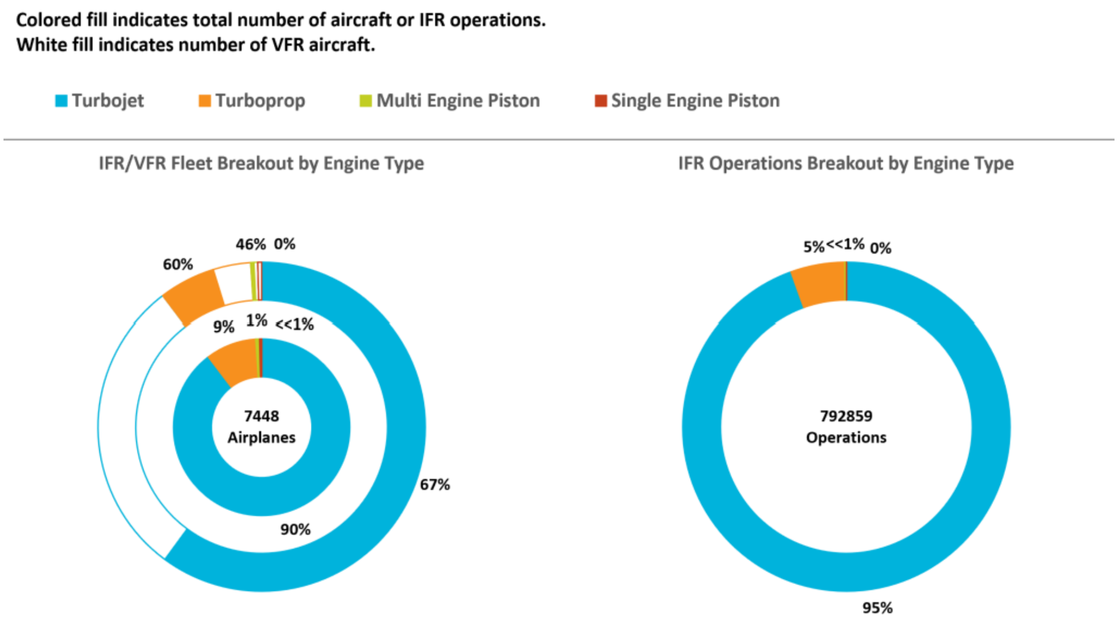


Figure 4-1. Foreign Carrier Fleet: IFR/VFR Fleet and Operations Breakout by Engine Type

Figure 4-2 shows the top-ten operators, measured by fleet size and total IFR operations. The top-ten operators account for 25% of the Foreign Carrier IFR fleet and 35% of the Foreign Carrier IFR operations. Taken together, Air Canada and their regional partner Jazz Aviation would be nearly double the size of the second largest Foreign Carrier operating to the U.S.

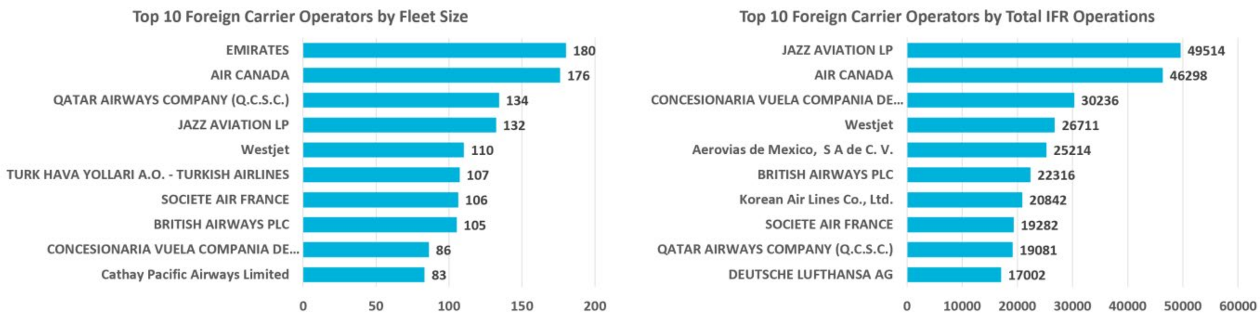


Figure 4-2. Foreign Carrier Fleet: Largest Operators

Figure 4-3 shows the top-ten airplane models, measured by fleet size and total IFR operations. The top-ten models account for 49% of the Foreign Carrier IFR fleet and 54% of the Foreign Carrier IFR operations. The top-ten models include narrow-body, wide-body, and regional jets. Regional airplanes in this list are predominantly Canadian airplanes flying to and from the U.S.

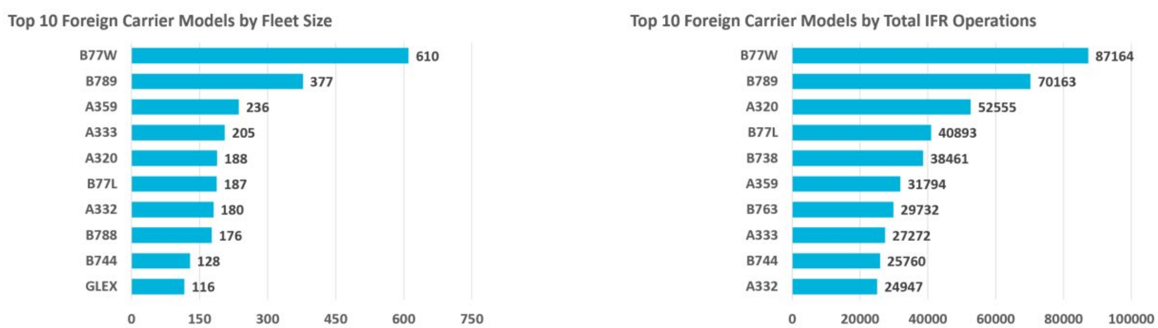


Figure 4-3. Foreign Carrier Fleet: Top-Ten Models

4.2 Foreign Carrier Current Capabilities

Figure 4-4 shows the assessment of current equipage for the Foreign Carrier fleet as derived from IFR flight plan filings (except for ADS-B equipage). The detailed pages that follow include additional information regarding significant factors influencing current state, key trend drivers, and potential factors that may impact the reported trend. Additionally, due to insufficient data available to MITRE at the time of the writing of this report, RCP and RSP capability, although likely for the majority of aircraft with RNP 4 reported capability, cannot yet be fully quantified. Available data suggests up to 80% of the RNP 4 equipped capable fleet is capable of RCP and RSP requirements.

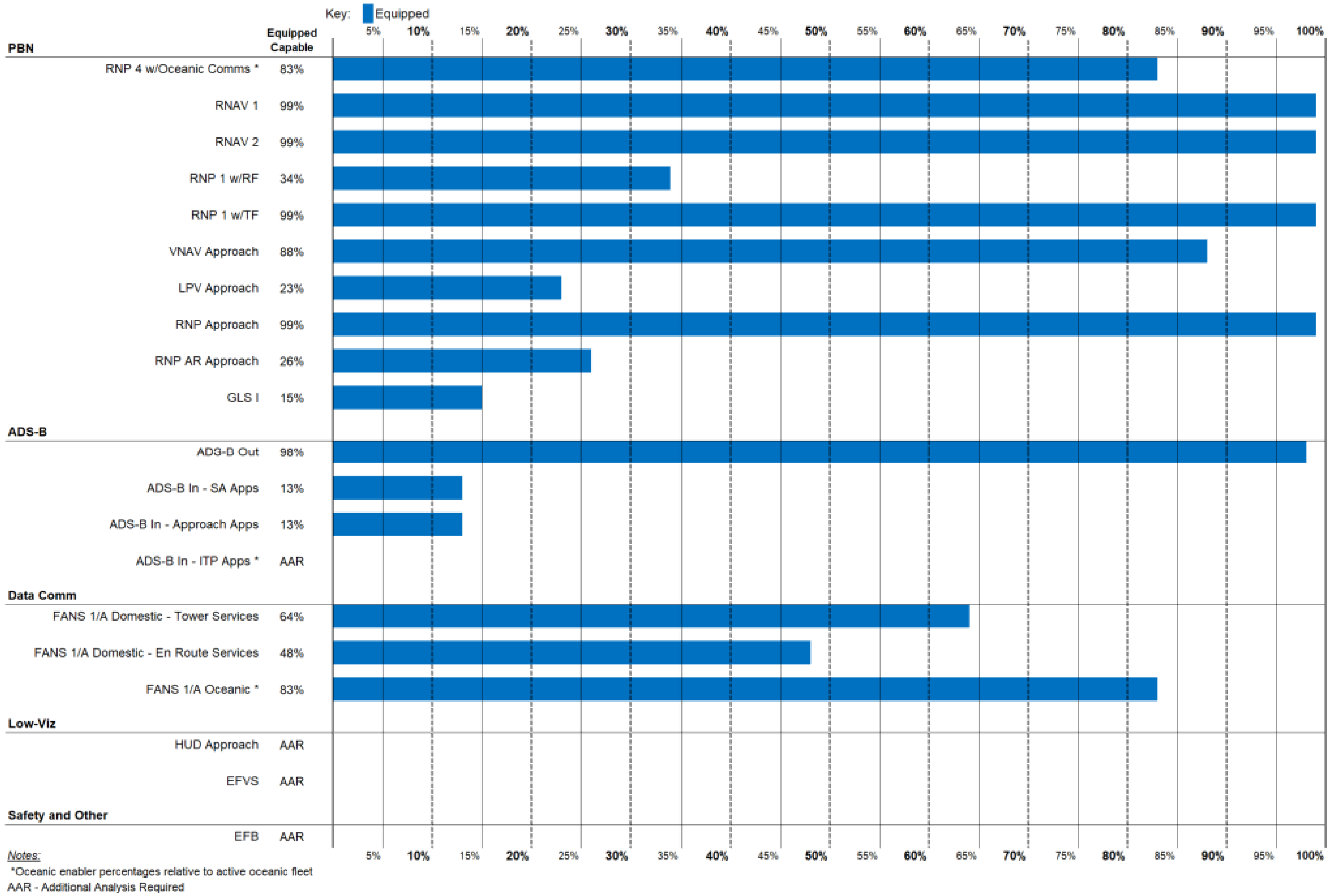
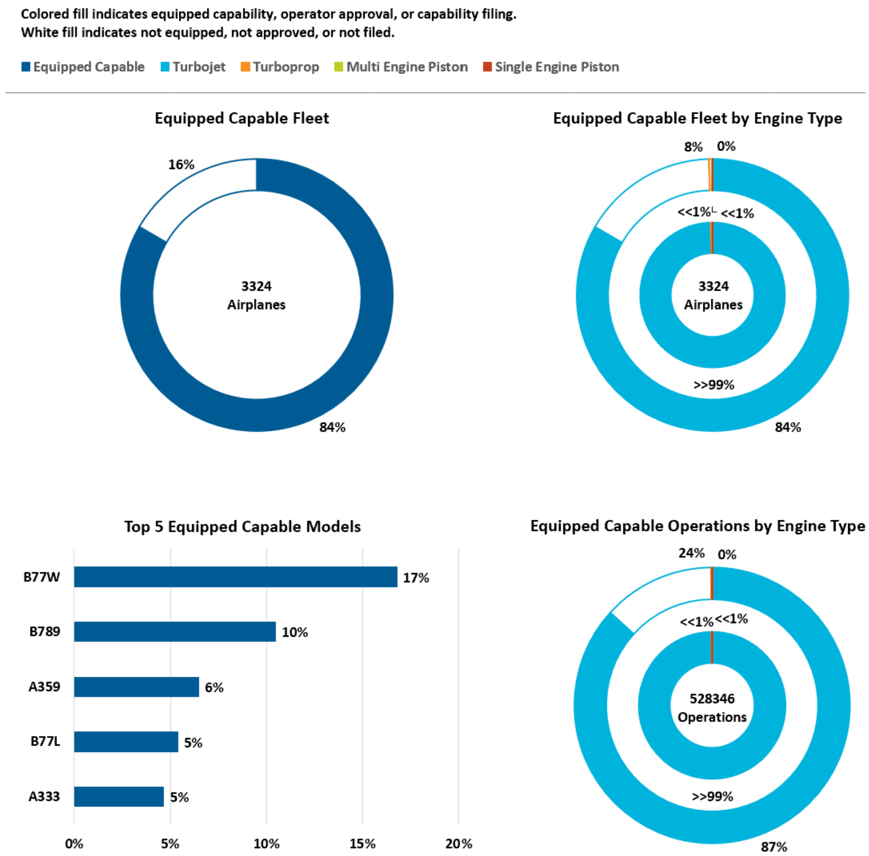


Figure 4-4. Foreign Carrier Enablers: Current Equipage Assessment

4.2.1 Performance Based Navigation Enablers for Foreign Carrier

RNP 4 with Oceanic Comms on Oceanic Foreign Carrier Fleet



Current State

- This capability is applicable to and reported against the oceanic fleet of airplanes.
- RNP 4 operations require RNP 4 navigation coupled with SATCOM; the presence of the two capabilities is reported for the oceanic fleet of airplanes.
- RNP 4 requires RSP 180 and RCP 240, and analysis of operational approvals indicates up to 80% of the aircraft approved for RNP 4 operations meet these requirements.
- Wide-body airplanes typically are RNP 4 capable; other fleet types typically are not.

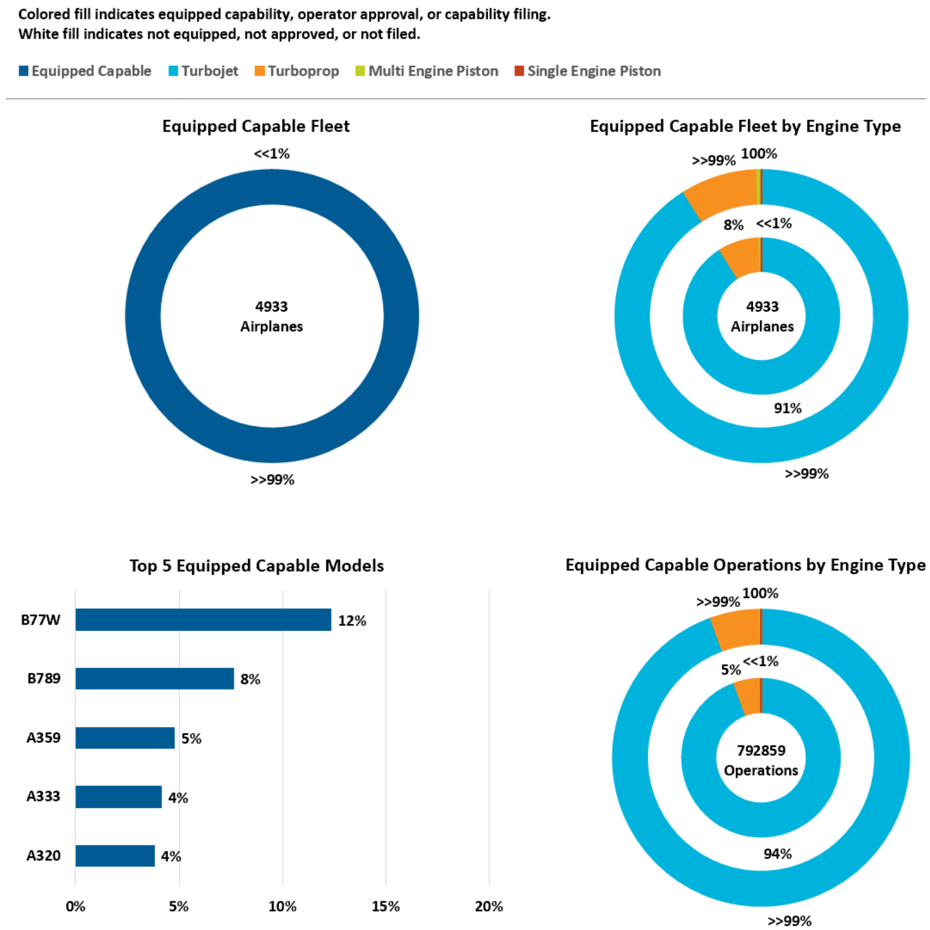
Forecast

- Trend is increasing, and new wide-body airplanes are delivered with standard capability.
- Narrow-body airplanes are growing in use in oceanic airspace and appear to be leveraging their RNP 4 standard capability and exercising SATCOM options to enable oceanic operations.

Significant Factors

- Impacts from COVID-19 and international travel constraints have drastically changed the makeup and operational pace of Oceanic Aircraft in the past year, resulting in significant equipage and capability variations in data sets over the past year.
- Operators are interested in improving passenger inflight connectivity. SATCOM is a key piece to many of these systems and is beginning to result in higher equipage rates.

RNAV 1 on Foreign Carrier Fleet

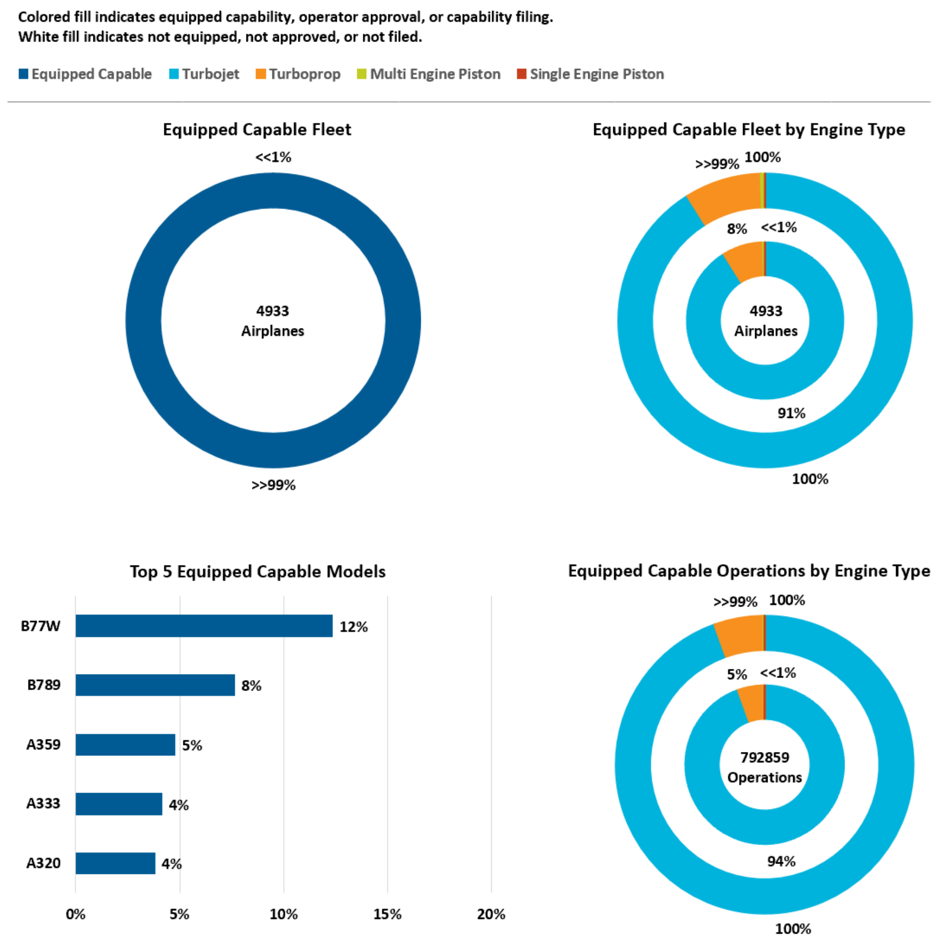


Current State
- Equipage is already high with almost all airplanes currently capable.
- Retirements are replaced with airplanes delivered with standard capability.

Forecast
- Trend is estimated to be flat.
- Standard capability for all new airplanes.

Significant Factors
- All airplanes have retrofit potential through GPS avionics that are affordable and widely available.
- Some operators do not have a business case for investing in retrofit solutions and/or operational approvals, often because of unknown future-fleet plans or operational needs. Investing for equipage and/or approvals on these airplanes risks a negative return.

RNAV 2 on Foreign Carrier Fleet



Current State

- Equipage is already high with almost all airplanes currently capable.
- Retirements are replaced with airplanes delivered with standard capability.

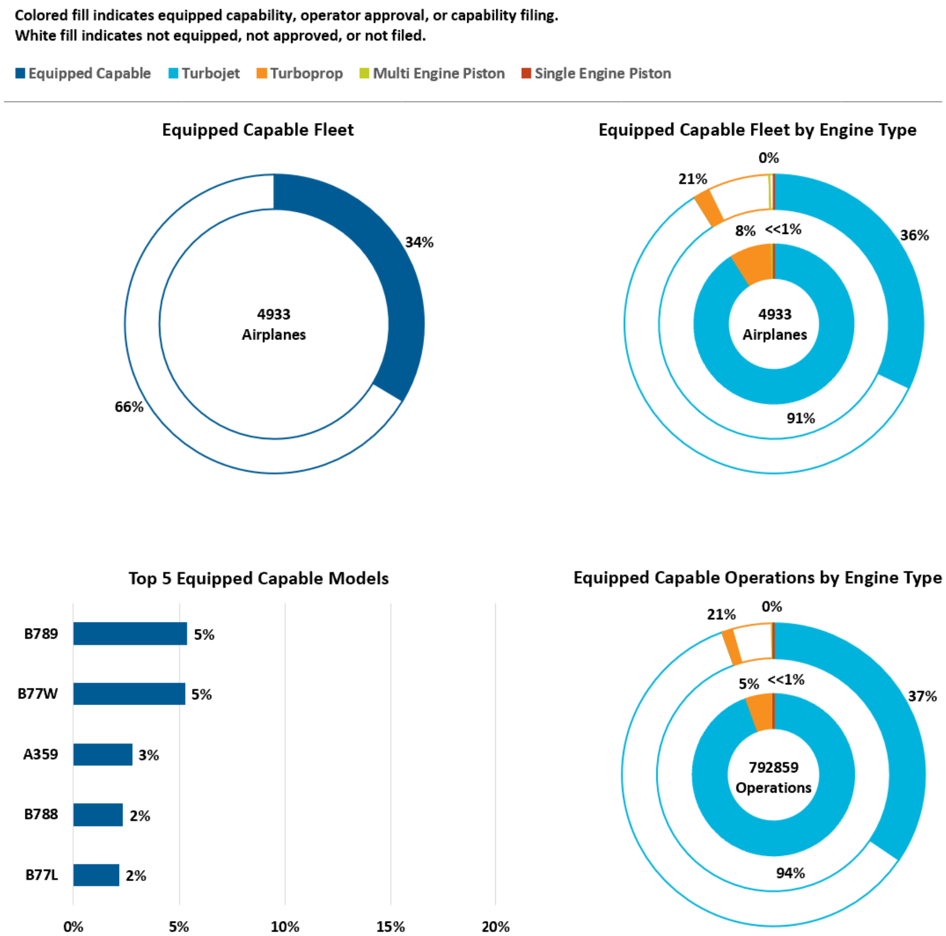
Forecast

- Trend is estimated to be flat.
- Standard capability for all new airplanes.

Significant Factors

- All airplanes have retrofit potential through GPS avionics that are affordable and widely available.
- Some operators do not have a business case for investing in retrofit solutions and/or operational approvals, often because of unknown future-fleet plans or operational needs. Investing for equipage and/or approvals on these airplanes risks a negative return.

RNP 1 with RF on Foreign Carrier Fleet



Current State

- Flight plan mappings show IFR flight plan available data from RNP AR or GBAS-equipped airplanes only. Actual equipage is likely much higher and equal to or greater than U.S. Air Transport fleet equipage at 84%, but data is not readily available to reduce the potential equipage range.
- RF leg capability does not require a specific operational approval when used with RNP 1, although OpSpec C063 does allow for operators to indicate these individual capabilities.

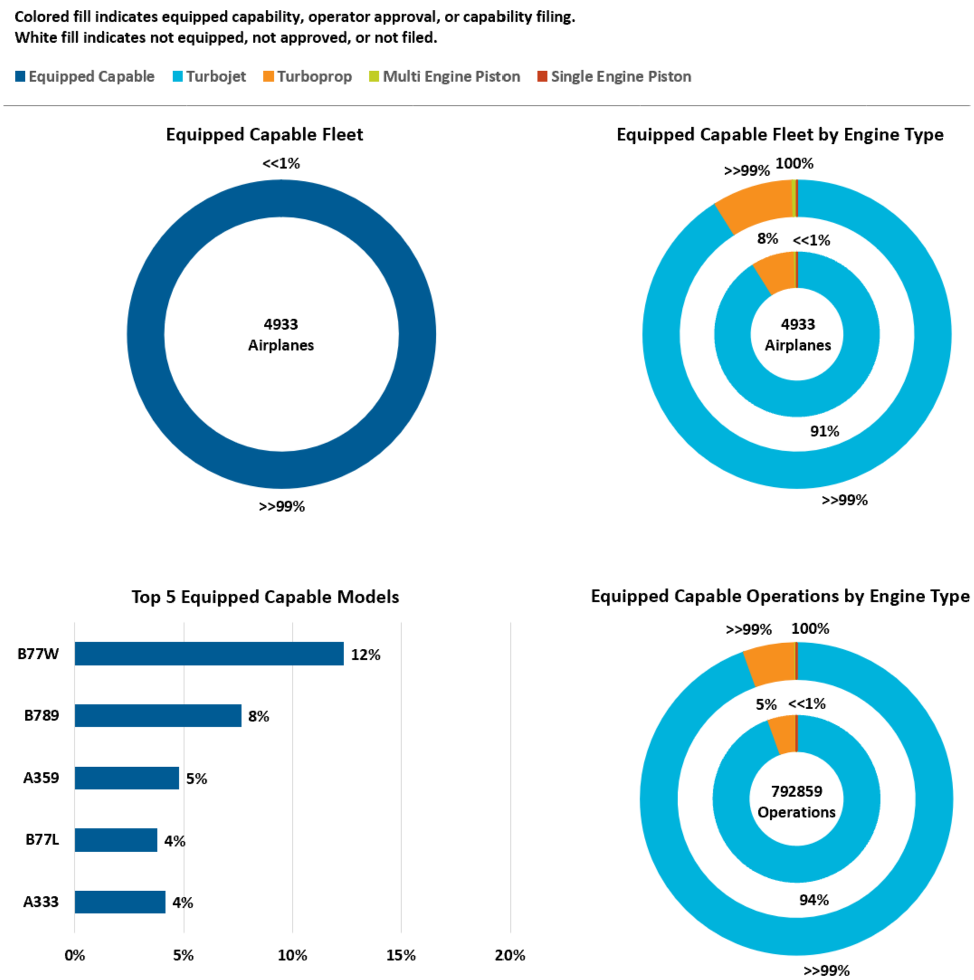
Forecast

- Trend is estimated to be flat.
- All new airplanes are delivered with standard capability, while some mixed equipage will persist.

Significant Factors

- Some NextGen operations, such as Advanced RNP, Established on RNP, RNP AR Approach, and GLS I may apply RF leg capability to specific operations. This could lead to an improved business case for unequipped operators to request forward-fit and retrofit options for RF leg capability, resulting in higher future equipage rates.

RNP 1 with TF on Foreign Carrier Fleet

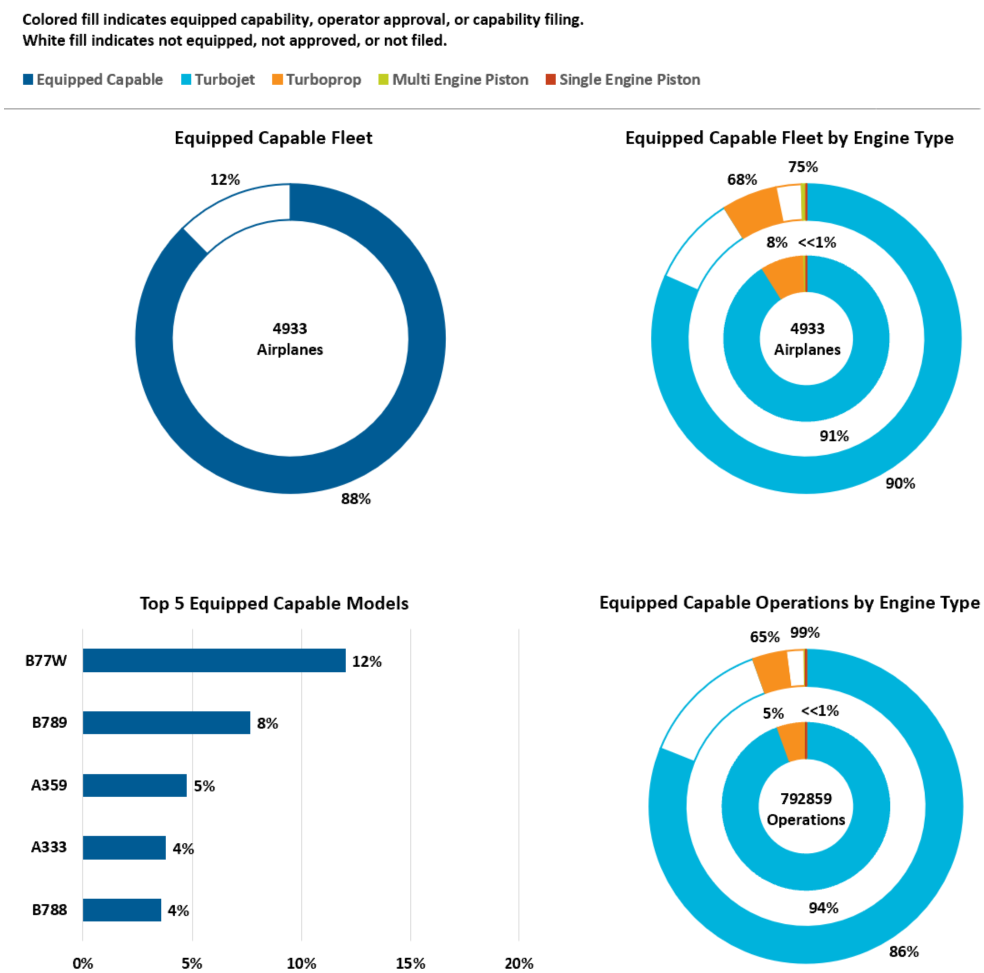


Current State
- Equipage is already high with almost all airplanes currently capable.
- Retirements are replaced with airplanes delivered with standard capability.

Forecast
- Trend is estimated to be flat.
- Standard capability for all new airplanes.

Significant Factors
- All airplanes have retrofit potential through GPS avionics that are affordable and widely available.
- Some operators do not have a business case for investing in retrofit solutions and/or operational approvals, often because of unknown future-fleet plans or operational needs. Investing for equipage and/or approvals on these airplanes risks a negative return.

VNAV Approach on Foreign Carrier Fleet



Current State

- VNAV Approach is defined in this report as an aircraft that can fly to LNAV/VNAV line of minima on an instrument approach chart.
- VNAV Approach can have different curve path leg types, TF and RF. This infographic covers VNAV Approach for TF legs.
- VNAV Approach with TF leg equipage rates are higher compared to VNAV Approach with RF leg.

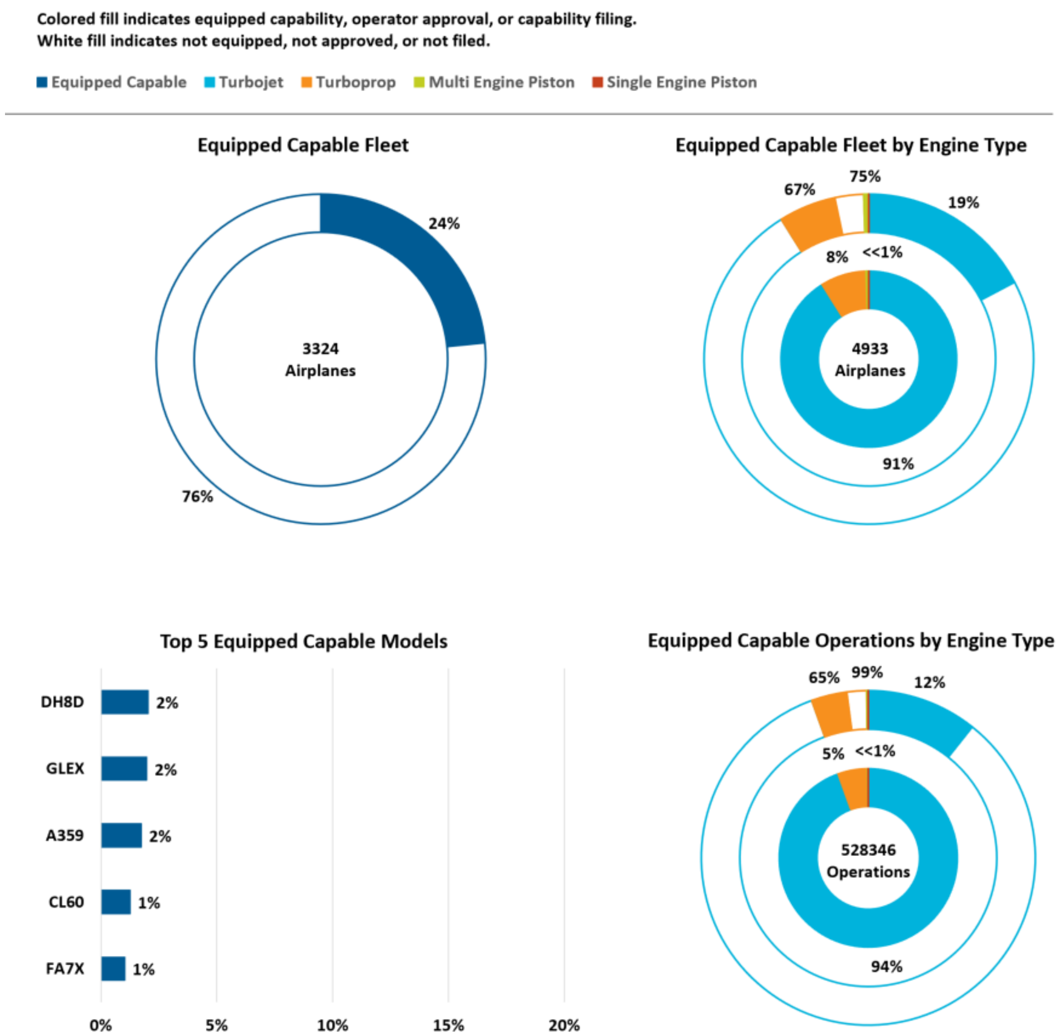
Forecast

- Trend is estimated to be flat.
- Standard capability for all new airplanes, apart from some regional jet and turboprop airplanes, for which it is an available option.
- Most new production airplanes will come standard with coupled barometric VNAV Approach, GPS, and an option for GLS I and/or LPV Approach.

Significant Factors

- Continued operator interest in GLS I, LPV Approach, and RNP AR Approach capabilities may result in higher future VNAV Approach equipage rates.

LPV Approach on Foreign Carrier Fleet



Current State

- Equipped airplanes consist of some turbojet aircraft such as A350 aircraft that come standard with LPV capability and some turboprop aircraft typically flown by Canadian operators into the U.S.

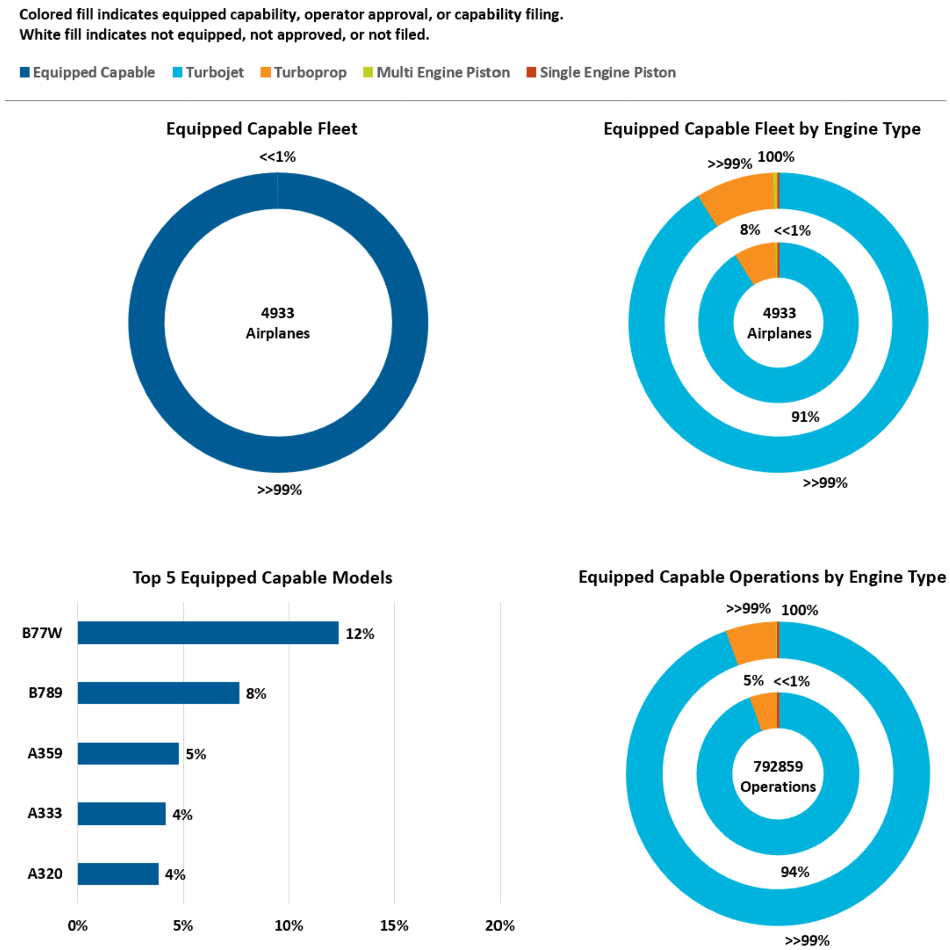
Forecast

- Trend is estimated to be increasing.
- Equipage increased four percent compared to previous reports.
- Few airplanes are expected to come standard with LPV Approach capability.

Significant Factors

- As more airplanes come standard with SBAS MMR to support ADS-B Out, it is expected more operators will develop a positive business case for LPV Approach capability.
- The inclusion of LPV Approach in the MCL Supplemental List could lead to higher rates of new delivery foreign carrier Air Transport aircraft being equipped by foreign carriers with LPV Approach.
- Potential global mandates, such as India, are driving widespread manufacturer offerings for LPV (SBAS) type approach capability.

RNP Approach on Foreign Carrier Fleet



Current State

- Equipage is already high with almost all airplanes currently capable.
- Retirements are replaced with airplanes delivered with standard capability.
- Enabling equipage is GPS with RNP 0.3 approach capability.

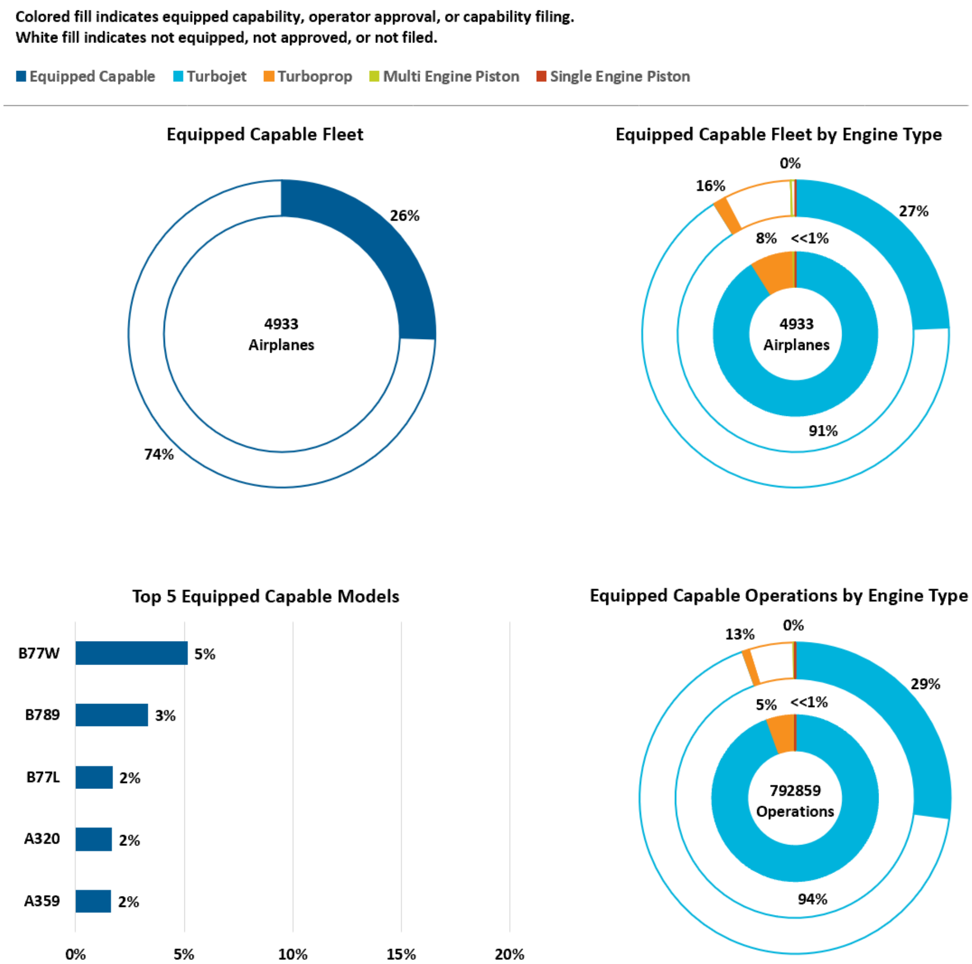
Forecast

- Trend is estimated to be flat.
- Standard capability for all new airplanes.

Significant Factors

- All airplanes have retrofit potential through GPS avionics that are affordable and widely available.
- Some operators do not have a business case for investing in retrofit solutions and/or operational approvals, often because of unknown future-fleet plans or operational needs. Investing for equipage and/or approvals on these airplanes risks a negative return.

RNP AR Approach on Foreign Carrier Fleet



Current State

- With large quantities of available ILS approaches at major international airports, many foreign operators do not see an operational need to file for RNP AR Approach in their flight plans, even if they are approved and equipped.
- Actual equipage is likely greater than or equal to U.S. Air Transport fleet equipage.
- Current equipage includes turbojet airplanes.

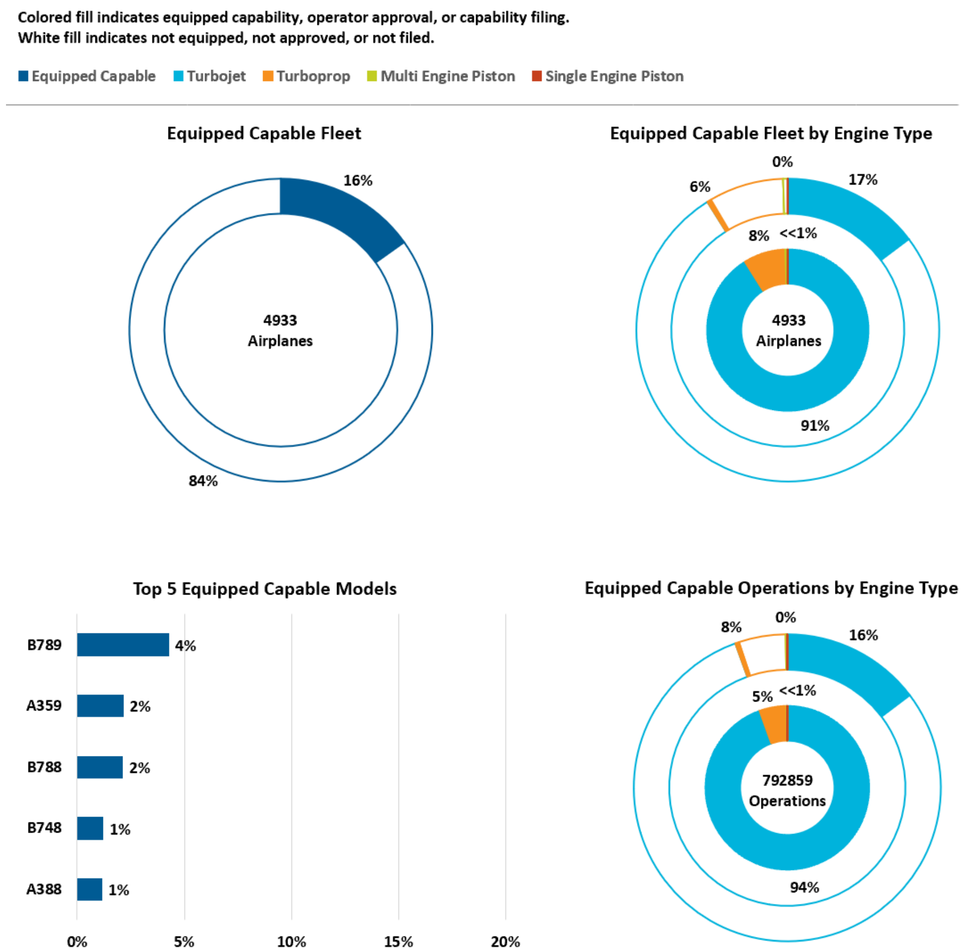
Forecast

- Trend is estimated to be increasing.
- Equipage increased four percent compared to previous reports.
- Equipage will occur as older, retired airplanes will be replaced by new deliveries with options exercised for this capability.

Significant Factors

- U.S. and global demand for all-weather operations, environmental impact reductions, and predictable and repeatable paths may lead to higher rates of equipage offerings, standard equipage with RNP AR Approach, and/or additional options.

GLS I on Foreign Carrier Fleet



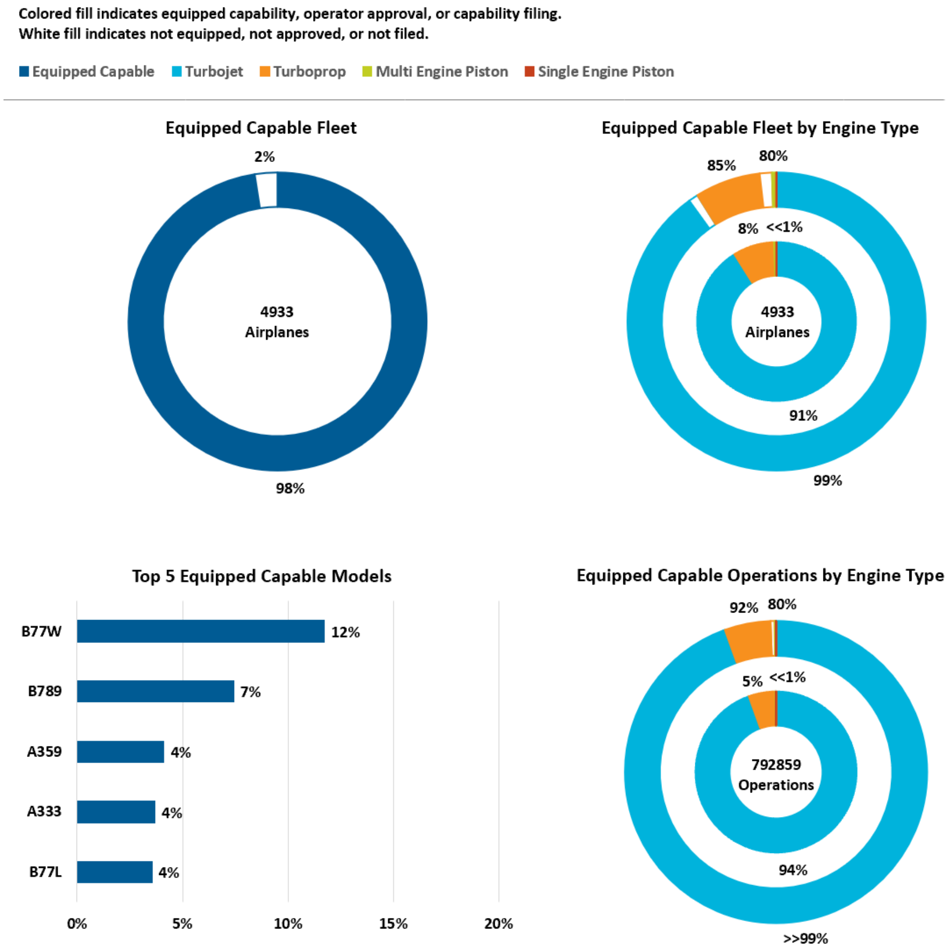
Current State
- Current equipage includes turbojet airplanes.

Forecast
- Trend is estimated to be increasing.
- GLS I is a standard offering on wide-body airplanes such as Boeing 747-8, 777, 787, and A350, with options on narrow-body airplanes.
- Some operators are exercising options on narrow-body airplanes.
- Some regional airplanes such as Embraer 170/190 are expected to have an available option in the near term.

Significant Factors
- Some large operators see potential operational value in key locations and are voicing their interest in having certain airport authorities acquire GLS ground systems.
- If airports or other entities were to begin fielding more GLS ground systems, it is likely more operators would equip with GLS I as a backup to ILS. This will be particularly true when GLS CAT III (GAST D) standards are complete and the business case for equipping is even stronger.
- International interest in GLS I could result in more oceanic narrow-body GLS I options being taken by operators and by lessors considering the global market.

4.2.2 Automatic Dependent Surveillance-Broadcast Enablers for Foreign Carrier

ADS-B Out on Foreign Carrier Fleet



Current State

- Majority of Foreign Carrier Aircraft equipped ahead of January 1, 2020 mandate, while a few aircraft had delayed installations and equipped just after rule implementation or were removed from operator fleets.
- Standard capability for all new Air Transport airplanes.
- Some operators have delayed position source upgrade through 2025 with application of the FAA Exemption 12555.

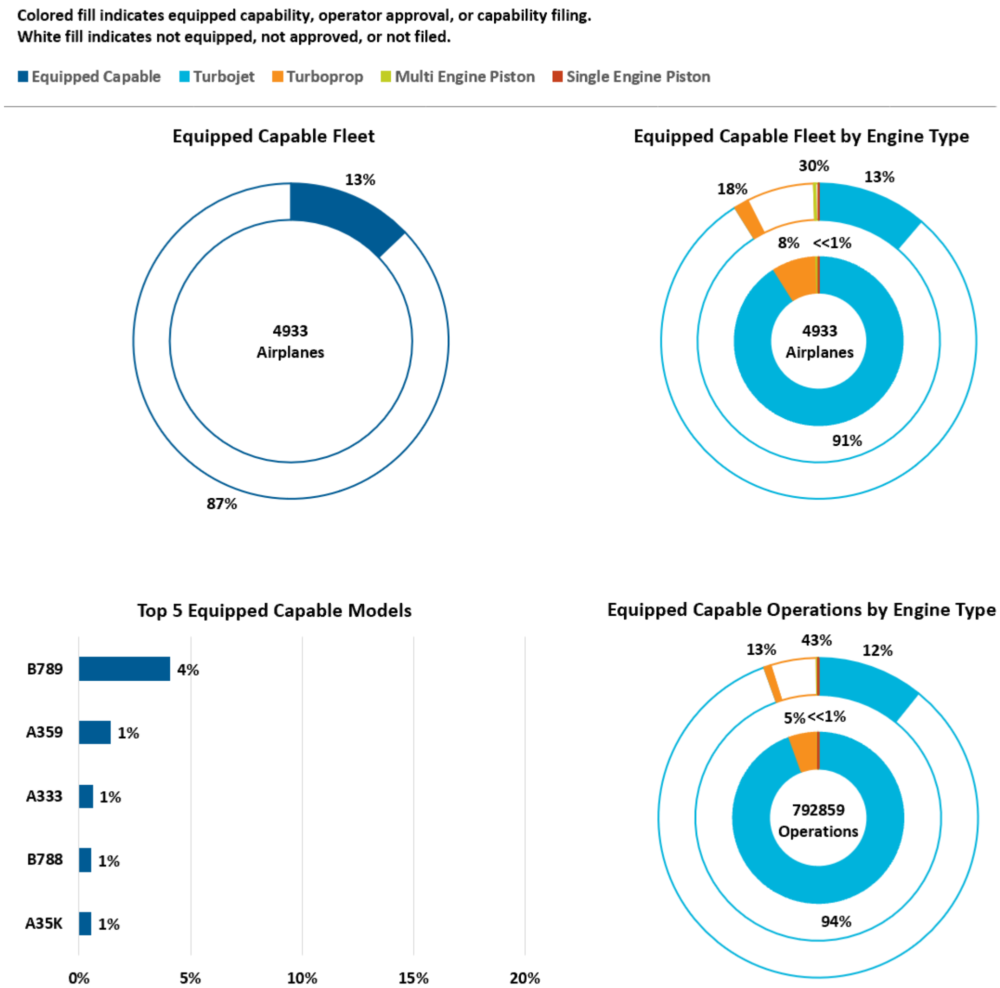
Forecast

- Trend is increasing.

Significant Factors

- The Performance Aviation Rulemaking Committee proposed Exemption 12555 has been made permanent, resulting in some operators delaying upgrades to their MMRs
- Industry feedback indicates some operators are interested in equipping with MMRs capable of utilizing Dual Frequency Multi Constellation GNSS.

ADS-B In – SA Apps on Foreign Carrier Fleet

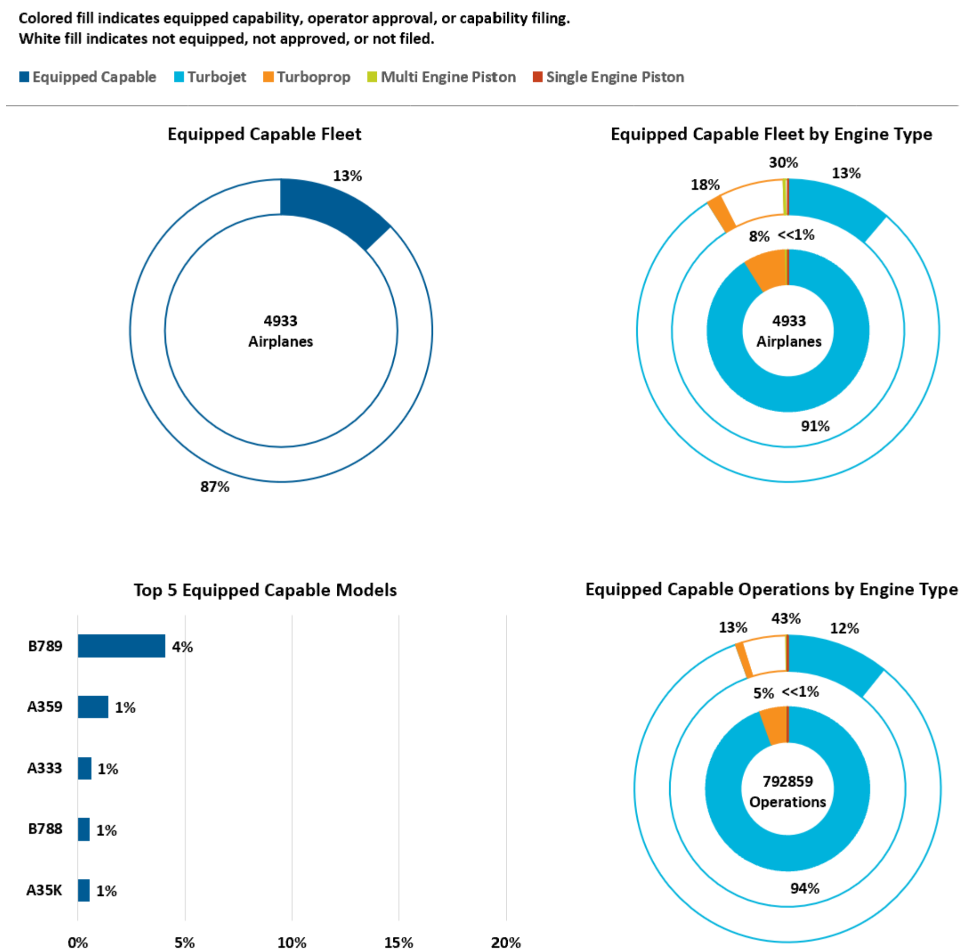


Current State
- ADS-B Out equipage does not contribute to ADS-B In capability.
- Forward-fit and retrofit solutions exist.
- Basic CDTI offerings support airborne situational awareness, but additional display modifications on some aircraft may be necessary to support basic surface awareness.
- Current equipage is primarily in support of oceanic ITP and SA applications.

Forecast
- Trend is estimated to be increasing.
- CDTI will continue to be offered as optional equipment on new airplanes.

Significant Factors
- Airlines and manufacturers are actively researching potential business cases for additional investment. It is believed that as CAVS, IM, and other ADS-B In applications mature, more offerings will exist, and airlines will increase their equipage rates in the 2025–2035 timeframe.

ADS-B In – Approach Apps on Foreign Carrier Fleet

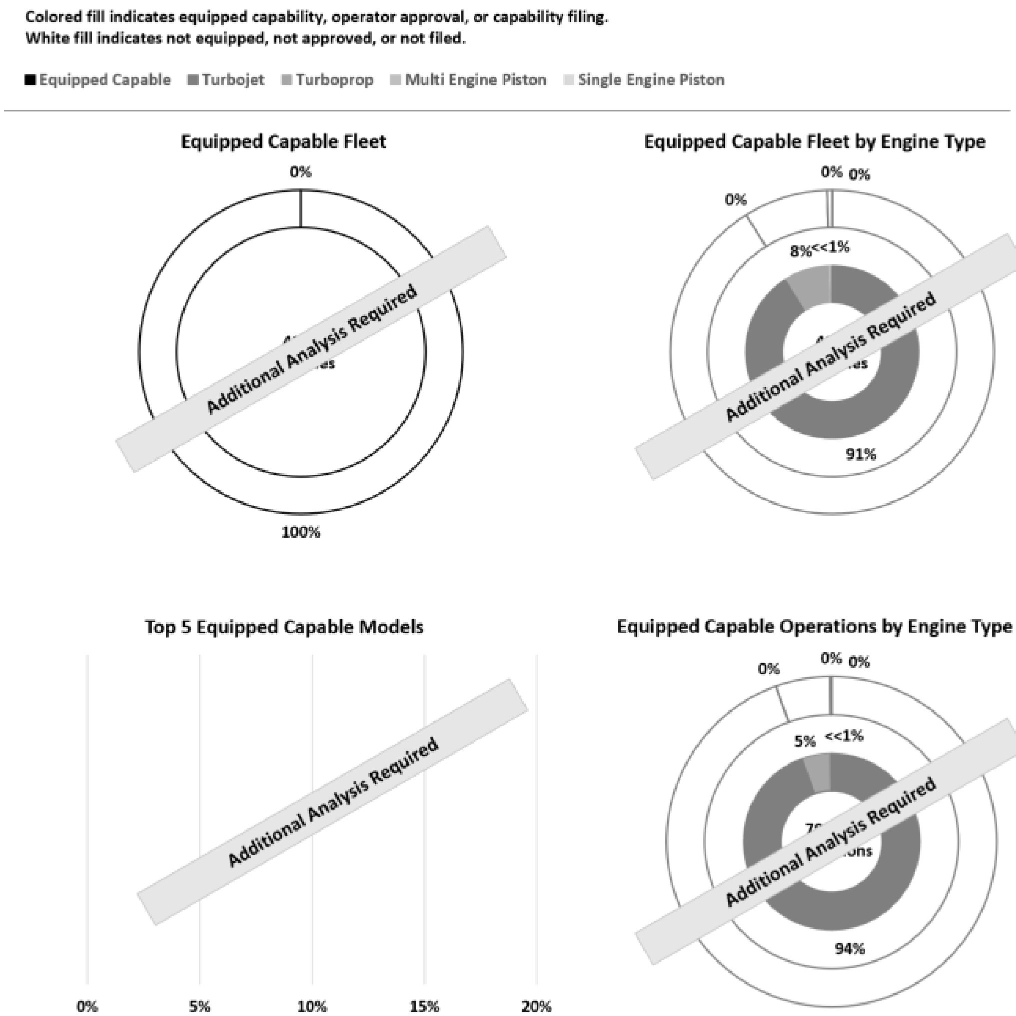


Current State
- ADS-B Out equipage does not contribute to ADS-B In capability.
- CAVS approach applications are available and usable throughout the NAS.
- Forward-fit and retrofit solutions exist.
- Current equipage is primarily in support of oceanic ITP and SA applications.

Forecast
- Trend is estimated to be flat.
- CAVS will continue to be offered as optional equipage on new airplanes.

Significant Factors
- Airlines and manufacturers are actively researching potential business cases for additional investment. It is believed that as CAVS, IM, and other ADS-B In applications mature, more offerings will exist, and airlines will increase their equipage rates in the 2025–2035 timeframe.
- Less expensive retrofit solutions are coming to market, and recent airline investments in ADS-B In equipage for safety and research purposes may result in positive business cases and higher future equipage rates.

ADS-B In – ITP Apps on Oceanic Foreign Carrier Fleet



Current State

- This capability is applicable to and reported against the oceanic fleet of airplanes.
- ADS-B Out equipage does not contribute to ADS-B In capability.
- Current equipage is primarily in support of oceanic ITP and SA applications. Basic CDTI offerings support airborne situational awareness, but additional display modifications on some aircraft may be necessary to support basic surface awareness.

Forecast

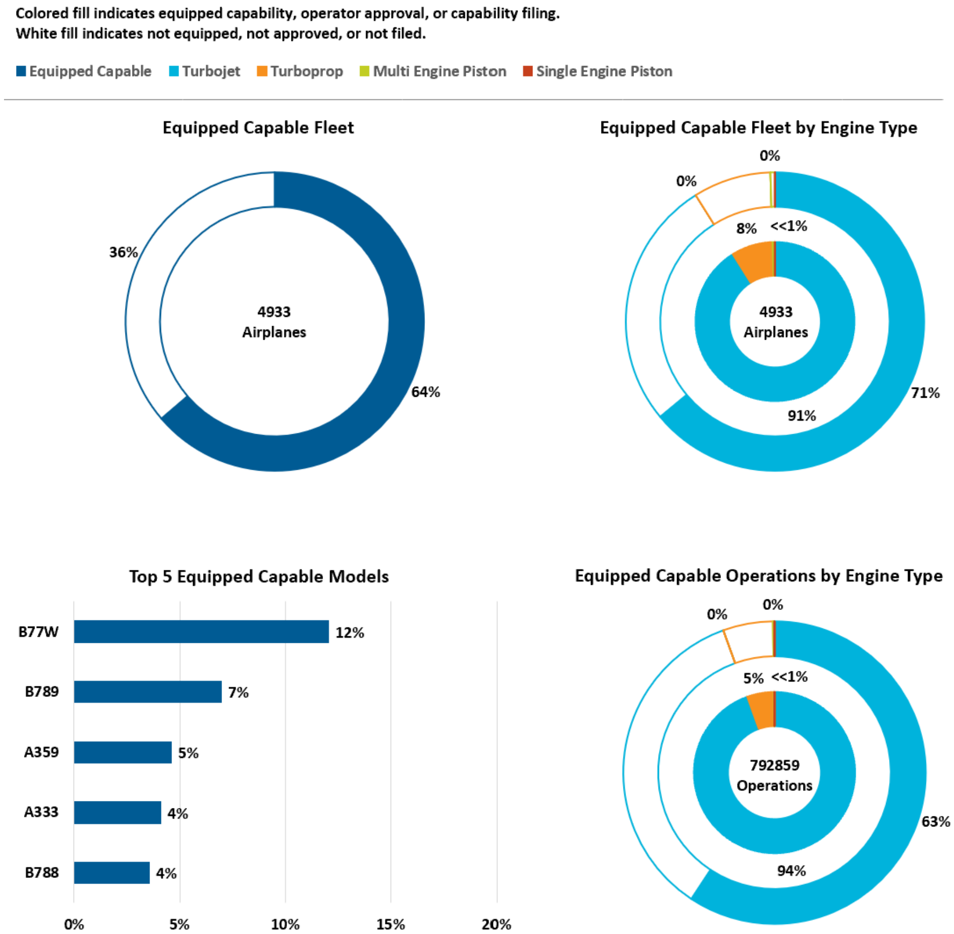
- Trend is estimated to be flat.

Significant Factors

- Impacts from COVID-19 and international travel constraints have drastically changed the makeup and operational pace of Oceanic Aircraft in the past year, resulting in significant equipage and capability variations in data sets over the past year.
- Airlines and manufacturers are actively researching potential business cases for additional investment. It is believed that as CAVS, IM, and other ADS-B In applications mature, more offerings will exist, and airlines will increase their equipage rates in the 2025–2035 timeframe.
- Less expensive retrofit solutions are coming to market, and recent airline investments in ADS-B In equipage for safety and research purposes may result in positive business cases and higher future equipage rates.

4.2.3 Data Communications Enablers for Foreign Carrier

FANS 1/A Domestic – Tower Services on Foreign Carrier Fleet



Current State

- FANS 1/A Domestic – Tower Services includes aircraft that are equipped with VDL Mode 0 or Mode 2.

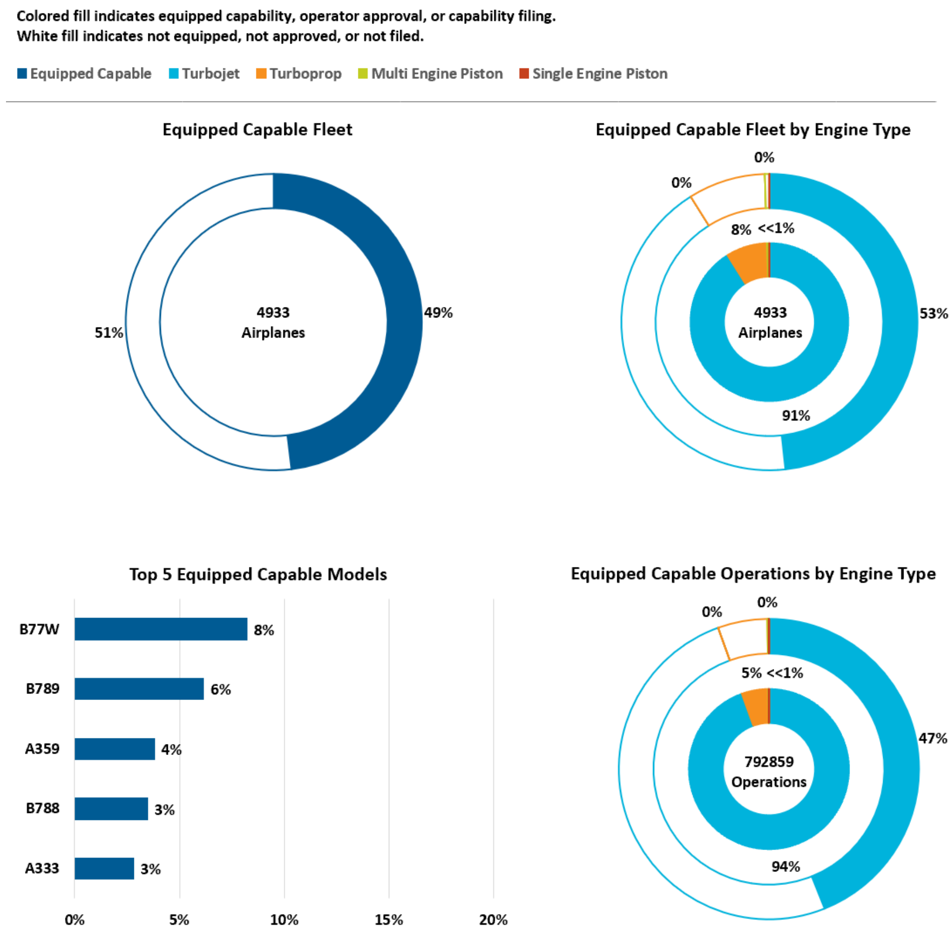
Forecast

- Trend is estimated to be increasing.
- All new wide-body airplanes are assumed standard with this capability, while narrow-body and regional airplanes have available forward-fit or retrofit options.
- Equipage increased four percent compared to previous reports.
- Data suggest that equipage is occurring as the FAA Domestic Data Communications Program plans and European Data Comm plans continue to mature.

Significant Factors

- Impacts from COVID-19 and international travel constraints have drastically changed the makeup and operational pace of Oceanic Aircraft in the past year, resulting in significant equipage and capability variations in data sets over the past year.
- If mainline airlines anticipate enough value, they may choose to work with their regional partners to increase regional airplanes equipage, resulting in higher Foreign Carrier equipage at companies such as Air Canada and Jazz.

FANS 1/A Domestic – En Route Services on Foreign Carrier Fleet



Current State

- FANS 1/A Domestic – En Route Services includes aircraft that are equipped with VDL Mode 2.
- Equipage is influenced by continued oceanic fleet capability and increasing domestic Data Comm FANS equipage.

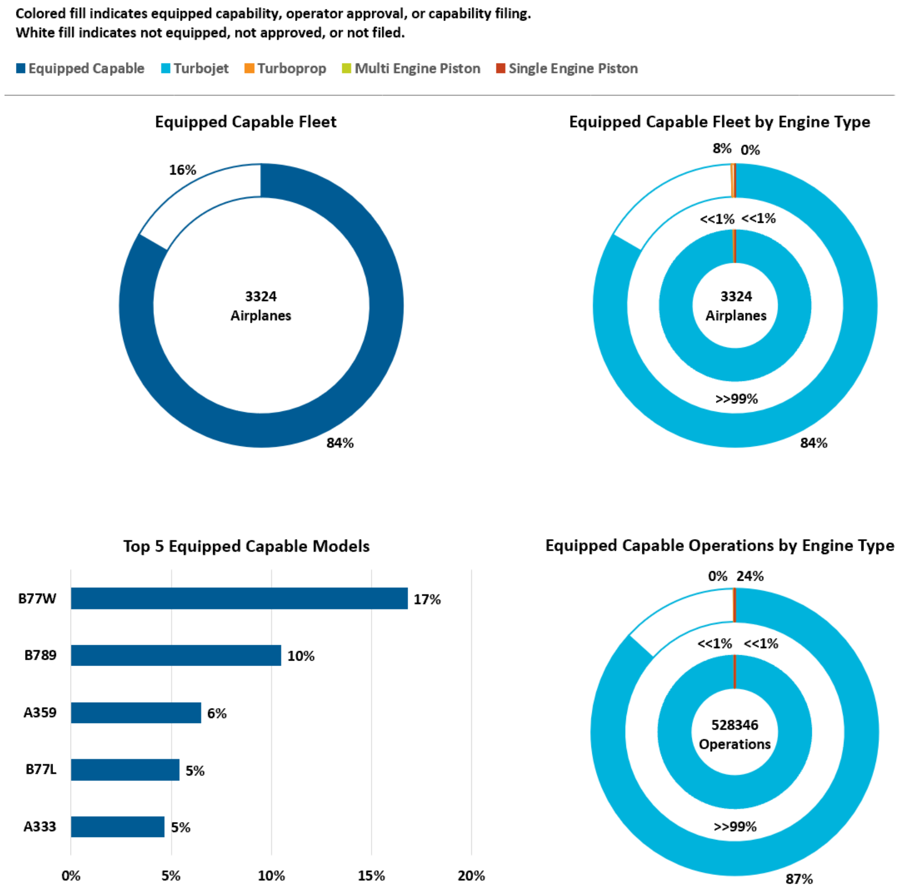
Forecast

- Trend is estimated to be increasing.
- All new wide-body airplanes are assumed standard with this capability, while narrow-body and regional airplanes have available forward-fit or retrofit options.
- Equipage increased seven percent compared to previous reports.
- Data suggest that equipage is occurring as the FAA Domestic Data Communications Program plans and European Data Comm plans continue to mature.

Significant Factors

- Impacts from COVID-19 and international travel constraints have drastically changed the makeup and operational pace of Oceanic Aircraft in the past year, resulting in significant equipage and capability variations in data sets over the past year.
- Success of initial Data Comm services will impact further equipage, but trends indicate a continued increase in equipage as operators see the value of tower and en route services.

FANS 1/A Oceanic on Oceanic Foreign Carrier Fleet



Current State

- This capability is applicable to and reported against the oceanic fleet of airplanes.
- Wide-body airplanes typically are SATCOM capable; other fleet types typically are not.

Forecast

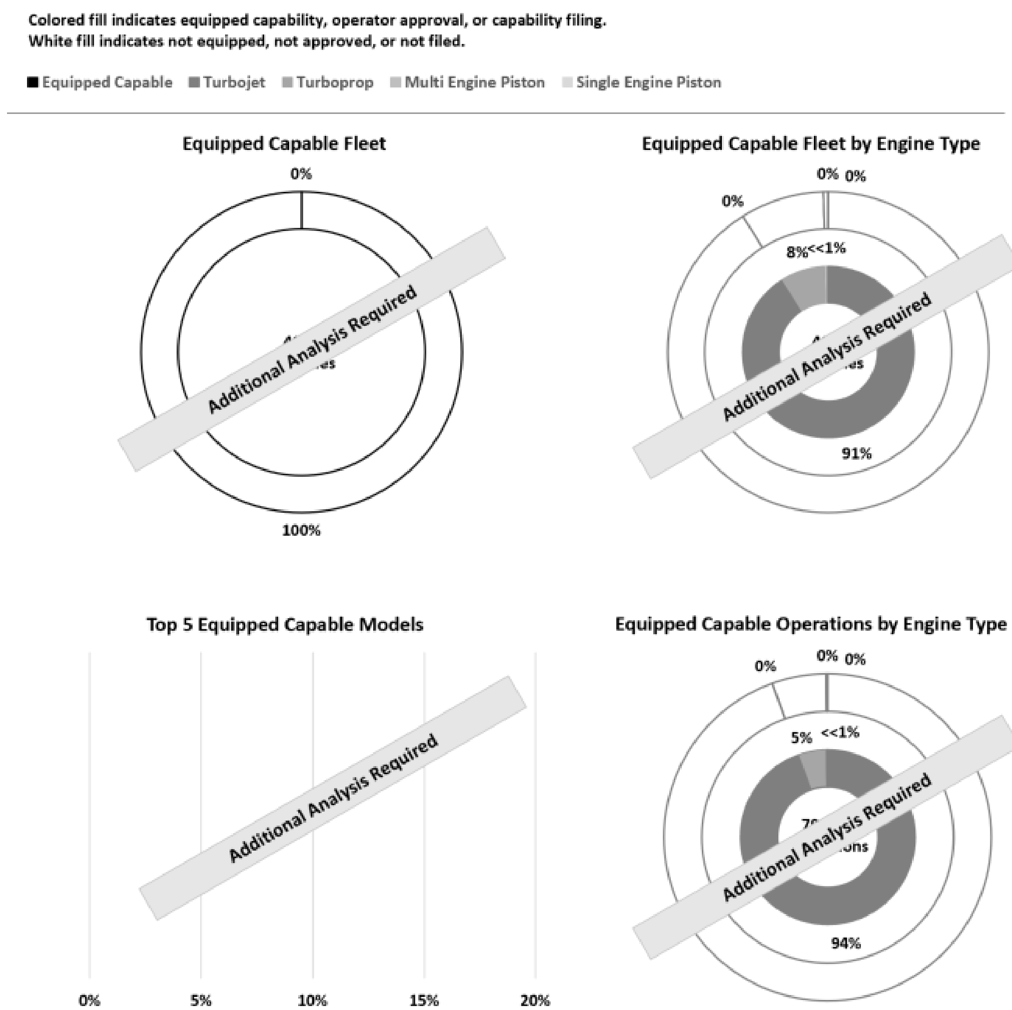
- Trend is estimated to be increasing.
- This capability is a standard forward-fit offering on new production, wide-body airplanes. It is an option on narrow-body airplanes.
- Narrow-body airplanes, where being used in oceanic airspace, will leverage their RNP 4 standard capability and exercise SATCOM options to enable oceanic operations.

Significant Factors

- Impacts from COVID-19 and international travel constraints have drastically changed the makeup and operational pace of Oceanic Aircraft in the past year, resulting in significant equipage and capability variations in data sets over the past year.
- Current and planned expanded use of narrow-body airplanes in oceanic airspace should result in more narrow-body equipage.
- Operators are interested in improving passenger inflight connectivity. SATCOM is a key piece of many of these systems and is beginning to result in higher equipage rates.
- Many operators are equipping with FANS, which could result in increased SATCOM.

4.2.4 Low-Visibility Enablers for Foreign Carrier

HUD Approach on Foreign Carrier Fleet

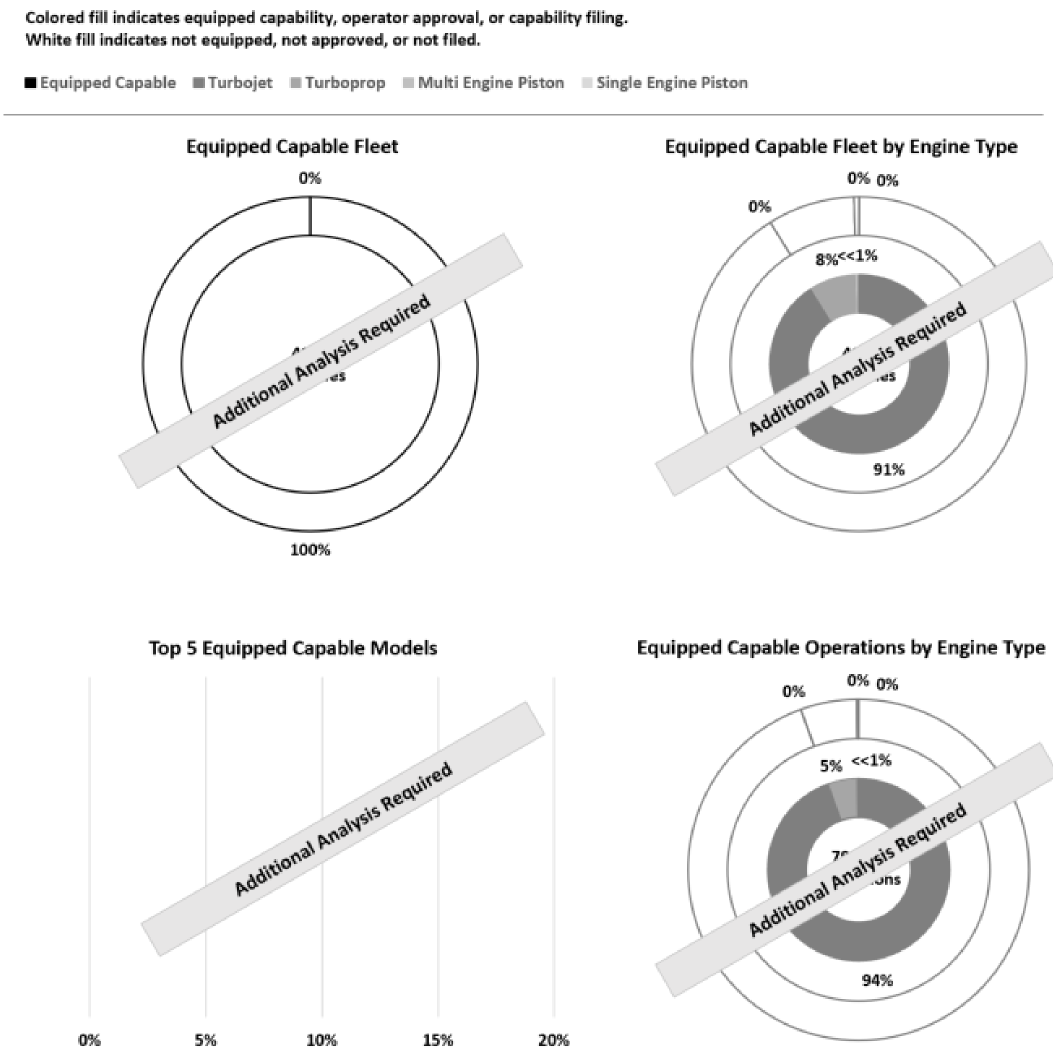


Current State
- Equipage is influenced by CAT III ILS capability where HUD can be used to manually fly the airplanes without the need for an operational auto-land capability.

Forecast
- Trend is estimated to be flat.
- Most airplanes, including narrow-body and regional airplanes, have available options. Some, such as the A350 and Boeing 787, come standard with this capability.

Significant Factors
- The inclusion of HUD in the MCL Supplemental List could lead to higher Air Transport equipage, while aircraft OEMs continue to pursue new HUD certifications.
- Solutions coming to market without an IRU, along with smaller and lighter-weight systems, and in some cases HWD, make for an improved potential business case across a wider range of airplanes and operators.
- Operational benefits in low-visibility conditions combining HUD with EFVS, runway safety systems, and other sensors/systems may provide a positive business case for some operators to equip with HUD/ILS.

EFVS on Foreign Carrier Fleet



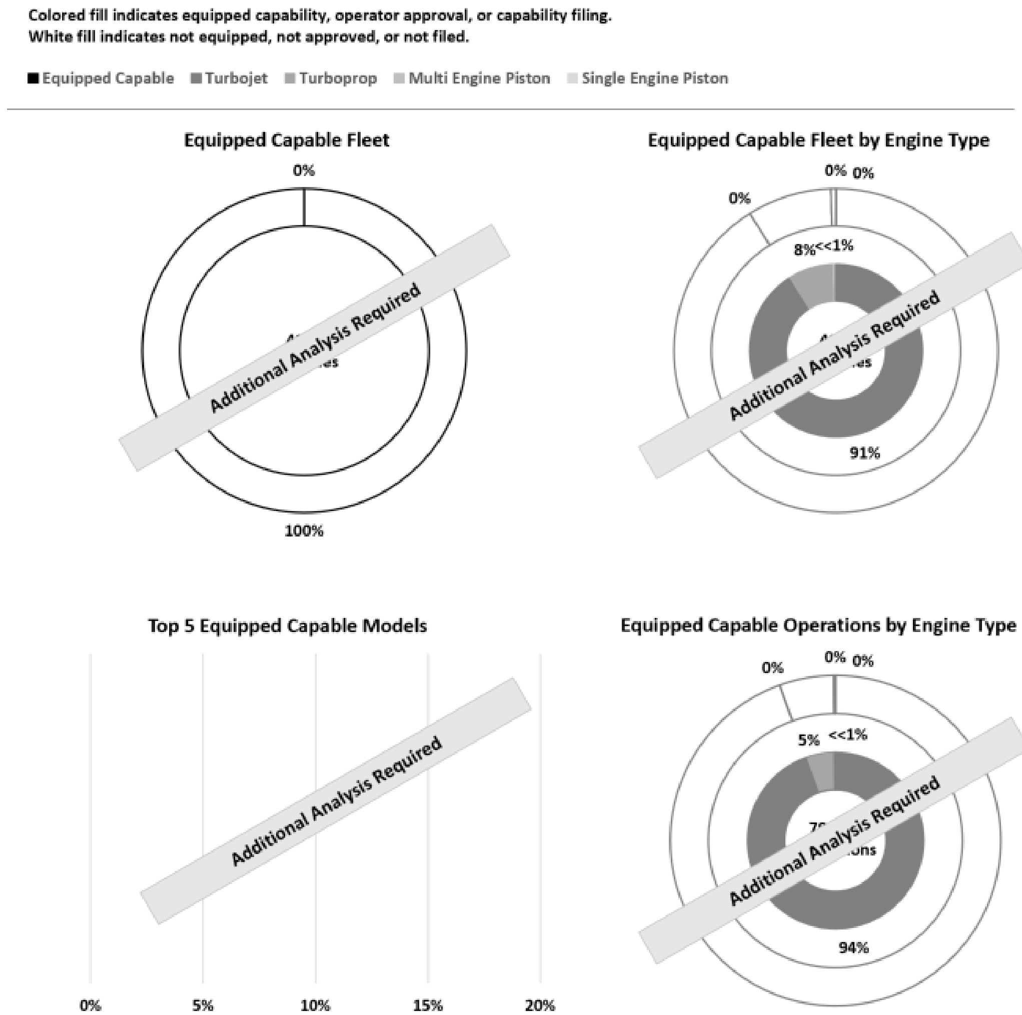
Current State
- Only two Foreign Carrier operators have approval for EFVS.

Forecast
- Trend is flat.

Significant Factors
- Trend is expected to increase slowly as system prices and physical size are expected to decrease, while industry activities continue to pursue additional credit for EFVS and CVS, resulting in a more favorable business case.
- New head-worn devices that are less expensive and easier to install on a wider range of smaller aircraft may result in greater equipage rates.
- Airlines have indicated that the approach credit authorization, lower takeoff and landing minimums, and mitigation for unavailable ground infrastructures have increased interest in this technology and that business case assessments are still underway.
- Industry feedback indicates manufacturers and suppliers have aggressive plans to expand available EFVS and CVS offerings in the next few years.

4.2.5 Avionics Safety-Enhancement Enablers for Foreign Carrier

EFB on Foreign Carrier Fleet



Current State

- EFBs are being utilized for additional cockpit capabilities such as flight planning, live weather, and moving map displays.
- Equipage numbers are not readily available, but data suggests that the majority of airplanes are currently equipped with some form of EFB.

Forecast

- Trend is estimated to be flat.

Significant Factors

- AIDs and new market offerings allowing improved pairings, both one way and bi-directional, and connectivity of EFB with onboard avionics support emerging connected aircraft concepts and will likely result in new operational use cases for EFB and/or new hardware and software market options.

5 Corporate/General Aviation Fleet and Enablers

5.1 Corporate/General Aviation Fleet and Operator Overview

Figure 5-1 provides information about the Corporate/GA operators and airplanes (helicopter analysis is included in Section 6 of this report). Many business GA airplanes are operated under multiple operating certificates (e.g., 14 CFR Part 91 and 14 CFR Part 135). For this report, multi-certificated airplanes are treated as Air Taxi if they have that certification.

The Corporate/GA fleet comprises 205,961 airplanes, of which 65,939 (32%) are designated for IFR, with 1,622 filing in oceanic airspace. The oceanic fleet of aircraft grew substantially this year at 1,622 compared to 1,182 in 2021. This increase in the oceanic fleet is similar to Air Taxi oceanic fleets in that more aircraft have been pressed into service for international operations due to COVID-19 and other contributing factors. It is a diverse fleet with many operators and a wide variety of airplanes, operational profiles, and capabilities. It is dominated by single-engine piston airplanes (82%) with a quarter of those airplanes operating IFR (25%). The smaller population of turbojet and turboprop airplanes (combined 11%) account for 60% of the total operations.

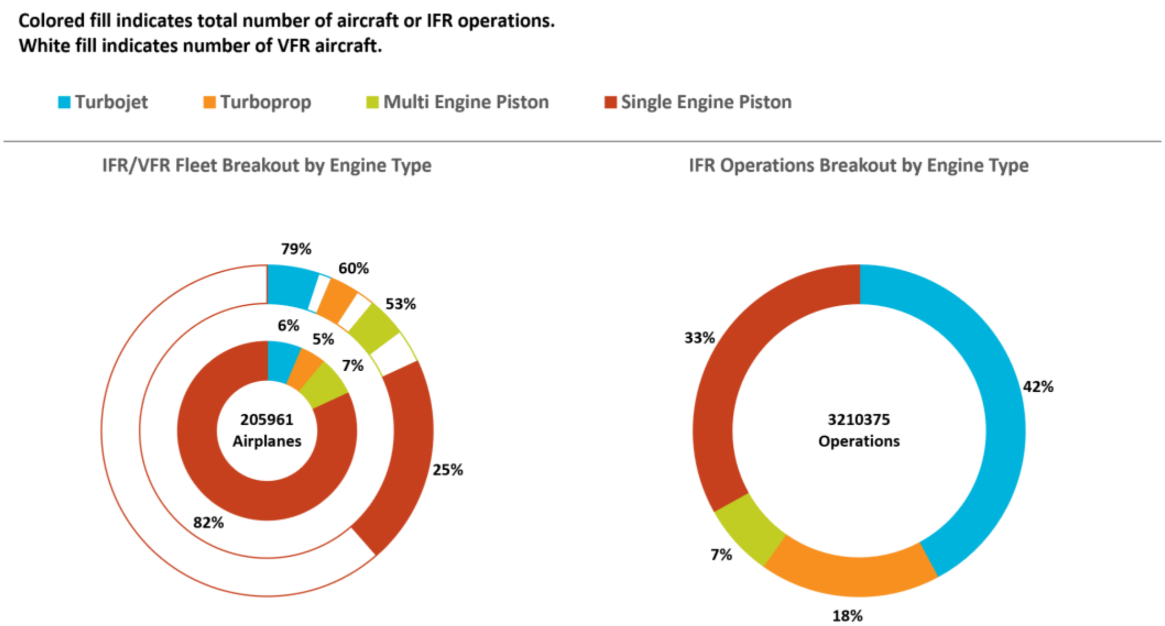


Figure 5-1. Corporate/GA Fleet: IFR/VFR Fleet and Operations Breakout by Engine Type

Every operator in the Air Transport, Air Taxi, and Foreign Carrier categories requires at least one OpSpec and is therefore represented in WebOPSS data. Registration data, by itself, is insufficient to determine operator identity, so the overall fleet is not easily characterized by number of operators. Of the more than 205,000 airplanes with the U.S. registration outside the Air Transport and Air Taxi categories, only eleven percent (~22,300) airplanes have an OpSpec approval under 14 CFR Parts 91 and 91K represented in WebOPSS.

There are 13,798 operators included in WebOPSS that are not in the Air Transport or Air Taxi categories; 12,215 (89%) operate IFR airplanes. For these aircraft, specific approvals can be determined to complement IFR filed flight plan information. Many of the listed operators of aircraft are actually finance companies and manufacturers who at some point have ownership, but only for the purposes of financial transactions, and the ultimate operators are therefore difficult to determine. Figure 5-2 shows examples of some of the largest operators that can be confidently measured by fleet size and total IFR operations, considering those operators that can be identified via WebOPSS. Numerous flight schools operate under multiple 14 CFR Parts and have more than 25 airplanes (e.g., Embry-Riddle Aeronautical University). These are included in this category.

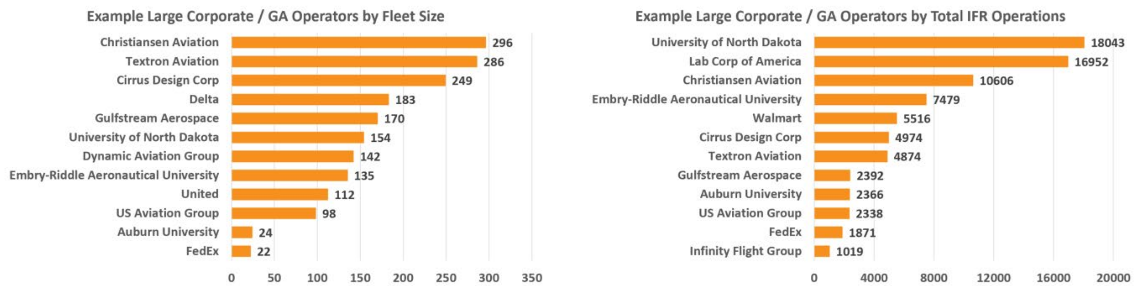


Figure 5-2. Corporate/GA WebOPSS Fleet*: Largest Operators

*(Note: *based on subset of overall Corporate/GA fleet that have one or more OpSpec approvals.)*

Figure 5-3 shows the top-ten airplane models, measured by fleet size and total IFR operations. The top-ten models by fleet size account for 43% of the Corporate/GA IFR fleet and include all engine type groupings (i.e., turbojet, turboprop, multi-engine piston, and single-engine piston). The top-ten models, based on total IFR operations, account for 32% of the Corporate/GA IFR operations and include a larger number of turbojet airplanes.

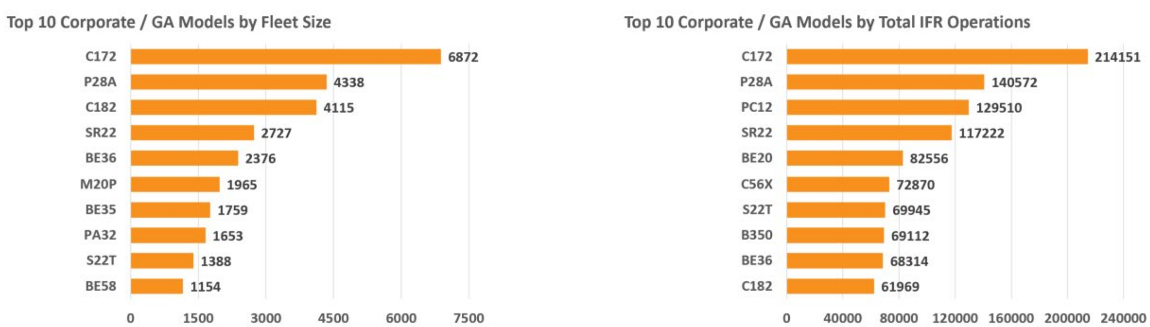


Figure 5-3. Corporate/GA WebOPSS Fleet*: Top Models

*(Note: *based on subset of overall Corporate/GA fleet that have one or more OpSpec approvals.)*

5.2 Corporate/General Aviation Current Capabilities

Figure 5-4 shows the assessment of current equipage for the Corporate/GA fleet as derived from IFR flight plan filings, except for ADS-B equipage, which is derived from the FAA ADS-B Compliance Monitor. The detailed pages that follow include additional information regarding significant factors influencing current state, key trend drivers, and potential factors that may impact the reported trend. Additionally, due to insufficient data available to MITRE at the time of the writing of this report, RCP and RSP capability, although likely for the majority of aircraft with RNP 4 reported capability, cannot yet be fully quantified.

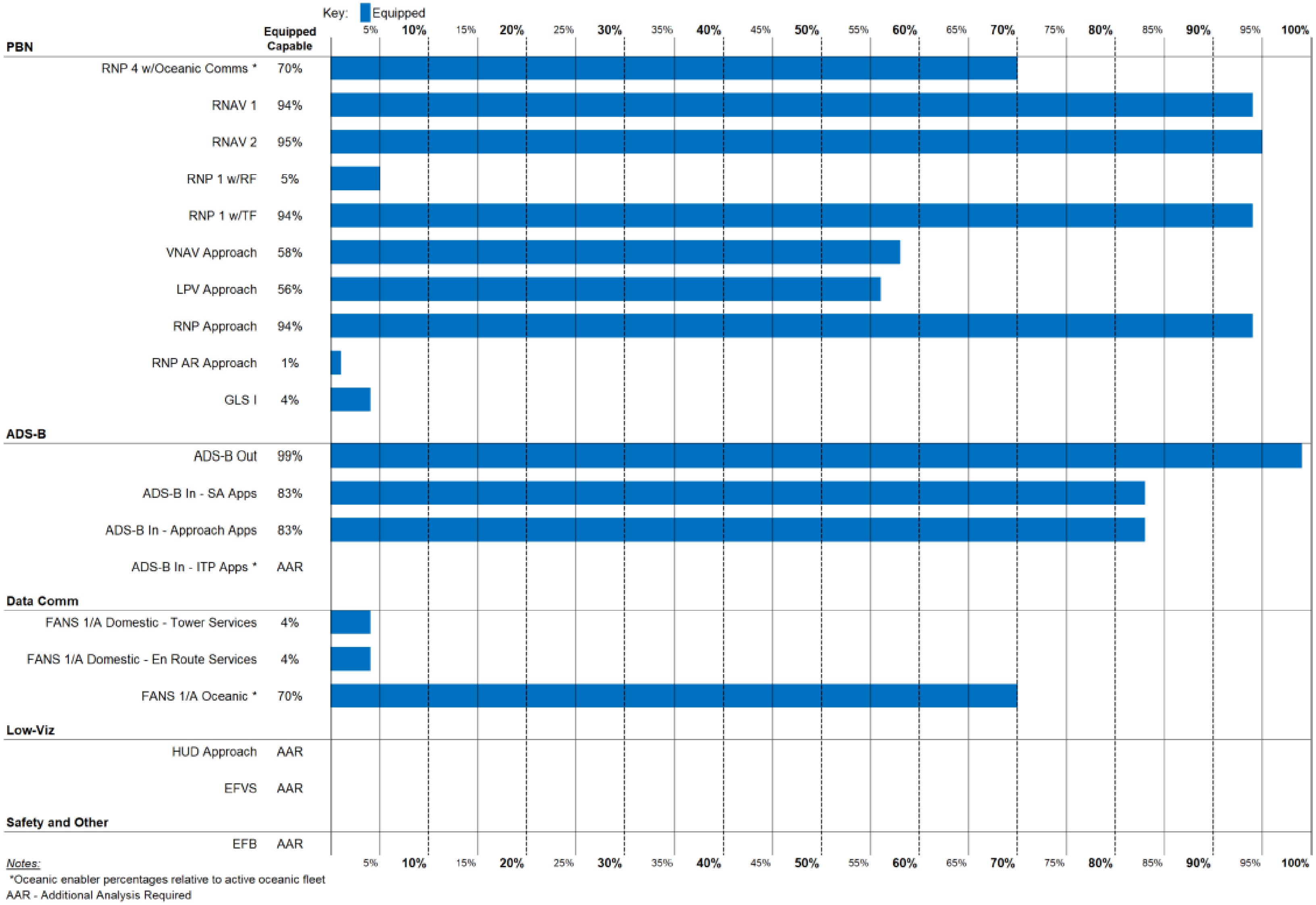
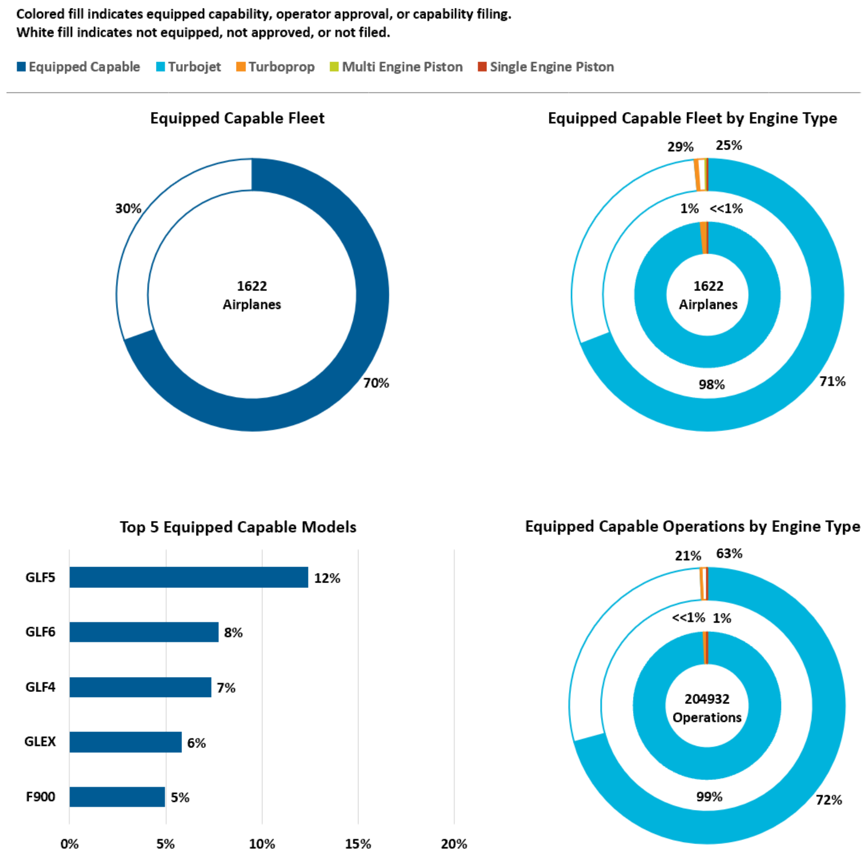


Figure 5-4. Corporate/GA Enablers: Current Equipage Assessment

5.2.1 Performance Based Navigation Enablers for Corporate/General Aviation

RNP 4 with Oceanic Comms on Oceanic Corporate/GA Fleet



Current State

- This capability is applicable to and reported against the oceanic fleet of airplanes.
- RNP 4 operations require RNP 4 navigation coupled with SATCOM; the presence of the two capabilities is reported for the oceanic fleet of airplanes.
- RNP 4 NAT HLA operations require RSP 180 and RCP 240.
- Large and long-range turbojets make up most of the equipage.
- Many new turbojet deliveries are equipped with RNP 4, but SATCOM equipage rates are lower on shorter range and smaller non-oceanic airplanes.
- Data sources show a decrease in equipage compared to previous reports, and it is unclear if this is due to data inaccuracies in previous reports or a change in fleet composition.

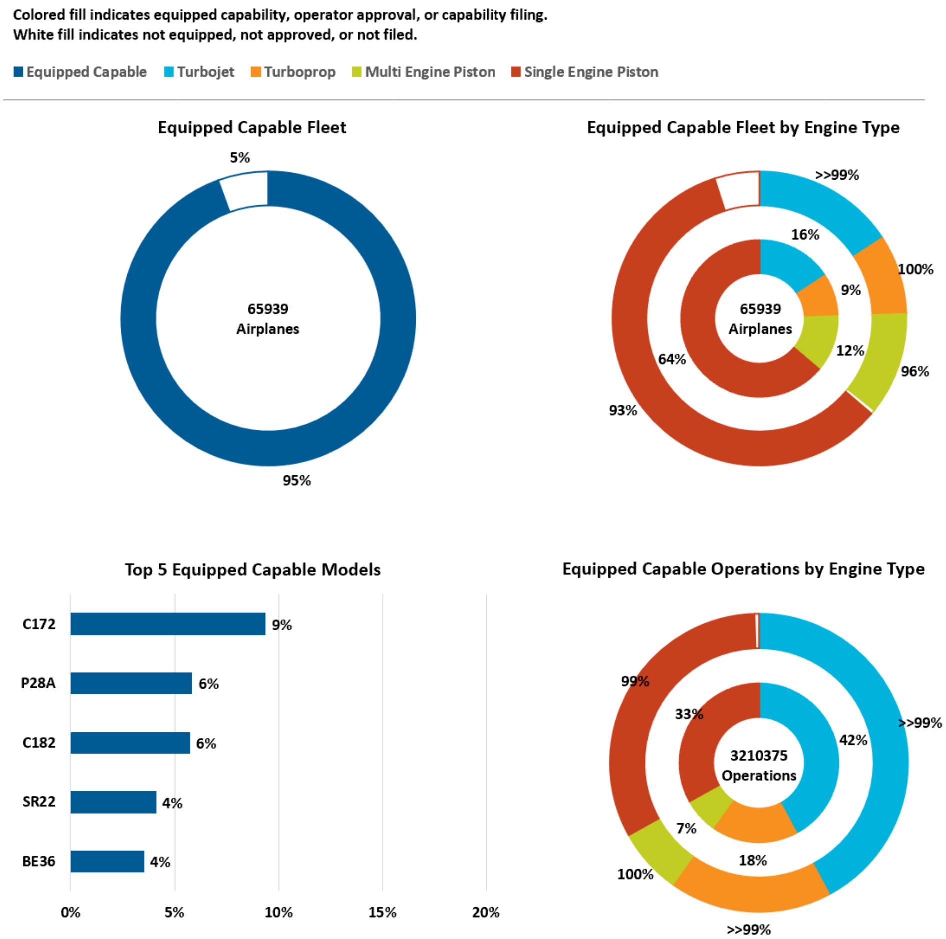
Forecast

- Trend is estimated to be decreasing.
- The decreasing trend is a result of substantial growth in oceanic fleet aircraft over the past year and those aircraft having less capability than historic averages.

Significant Factors

- Impacts from COVID-19 and international travel constraints have drastically changed the makeup and operational pace of Oceanic Aircraft in the past year, resulting in significant equipage and capability variations in data sets over the past year.
- An increase in SATCOM equipage may occur due to expanded use of mid-size airplanes in oceanic airspace and operators utilizing North Atlantic flight tracks.

RNAV 1 on Corporate/GA Fleet



Current State

- Equipage is already high and has increased as operators upgrading for ADS-B Out added additional GPS and WAAS with LPV Approach capabilities.
- New airplanes are delivered standard with significant level of PBN capability from GPS and WAAS with LPV Approach capability.

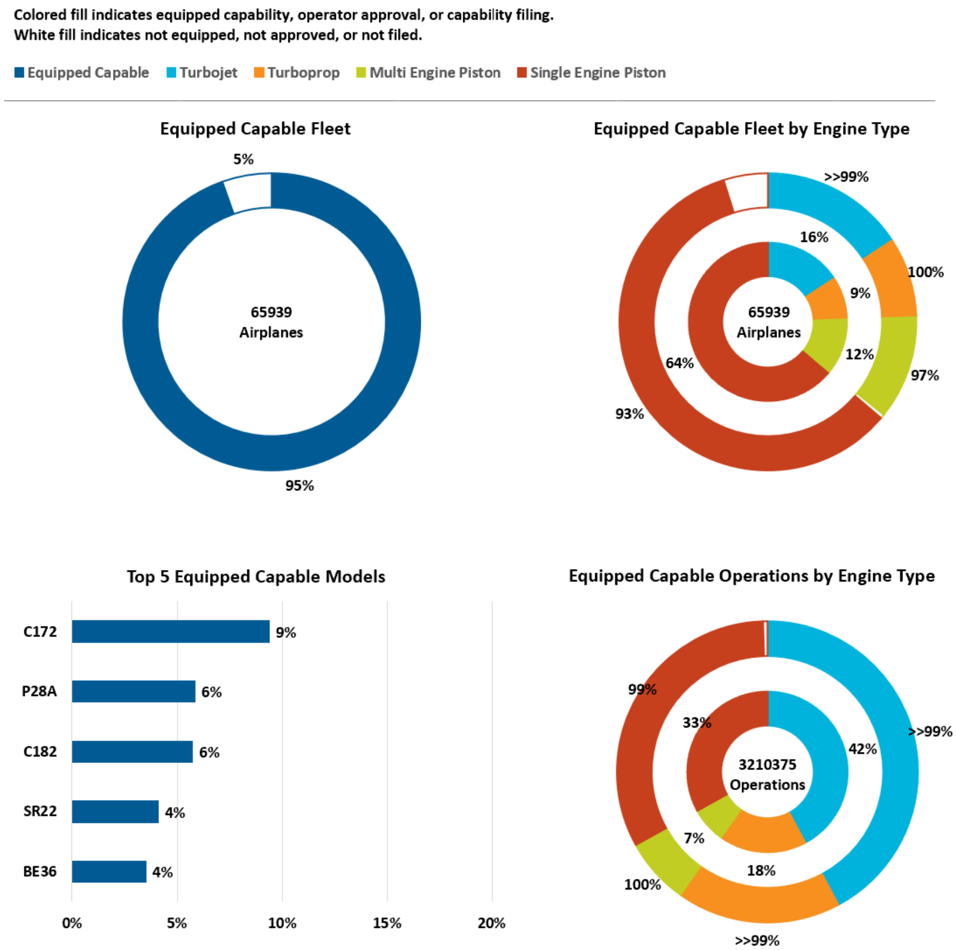
Forecast

- Trend is estimated to be flat.
- Standard capability for all new airplanes.
- Flight plan filings for this capability have not changed compared to previous reports.

Significant Factors

- All airplanes have retrofit potential through GPS avionics that are affordable and widely available.
- Some operators do not have a business case for investing in retrofit solutions and/or operational approvals, often because of unknown future-fleet plans or operational needs. Investing for equipage and/or approvals on these airplanes risks a negative return.
- Some aircraft are dependent upon GPS to provide RNAV 1 capability and when GPS signals are not available, these aircraft are not capable of RNAV 1.

RNAV 2 on Corporate/GA Fleet

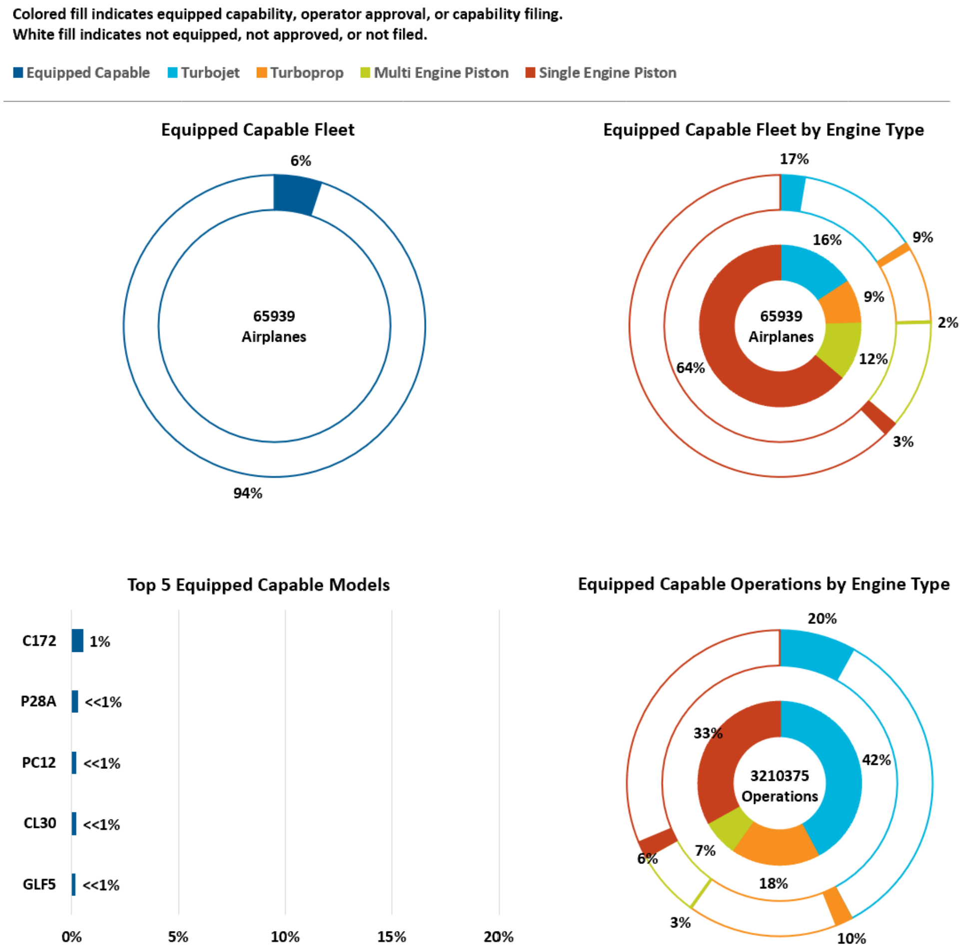


Current State
- Equipage is already high and has increased as operators upgrading for ADS-B Out added additional GPS and WAAS with LPV Approach capabilities.
- New airplanes are delivered standard with significant level of PBN capability from GPS and WAAS with LPV Approach capability.

Forecast
- Trend is estimated to be flat.
- Standard capability for all new airplanes.
- Data sources show a decrease in equipage compared to previous reports, and it is unclear if this is due to data inaccuracies in previous reports or a change in fleet composition.

Significant Factors
- All airplanes have retrofit potential through GPS avionics that are affordable and widely available.
- Some operators do not have a business case for investing in retrofit solutions and/or operational approvals, often because of unknown future-fleet plans or operational needs. Investing for equipage and/or approvals on these airplanes risks a negative return.

RNP 1 with RF on Corporate/GA Fleet



Current State

- RF leg capability does not require a specific operational approval when used with RNP 1, although OpSpec C063 does allow for operators to indicate these individual capabilities.
- Current estimates may be lower than actual equipage in cases where operators do not file flight plans that reflect all their aircraft's capabilities.
- Displays, capable of showing curved path, have been the significant limiter to higher levels of equipped capability.

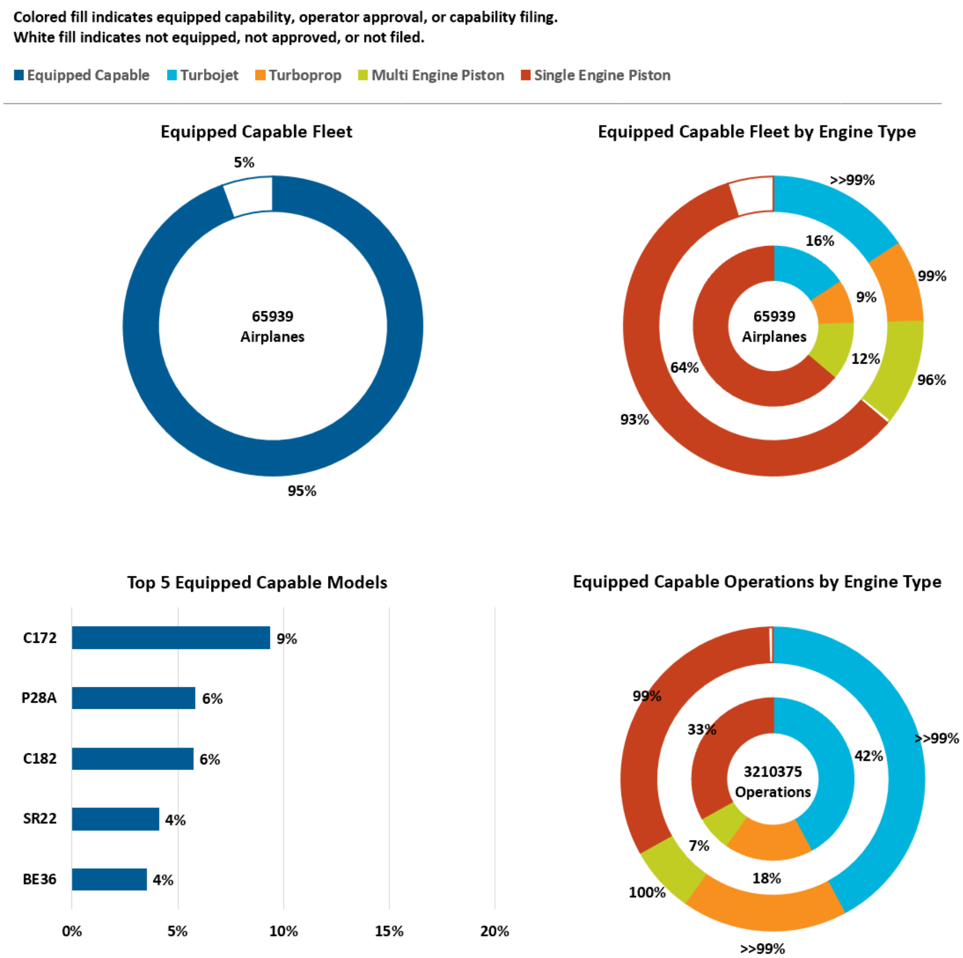
Forecast

- Trend is estimated to be increasing.
- Most new turbine-powered airplanes are delivered with standard capability.

Significant Factors

- Offerings on piston airplanes exist, but cost to retrofit avionics suites is too high for many operators.
- Some NextGen operations, such as Advanced RNP, EoR, RNP AR Approach, and GLS I, may apply RF leg capability to specific operations. This could lead to an improved business case for unequipped operators to request forward-fit and retrofit options for RF leg capability, resulting in higher future equipage rates.

RNP 1 with TF on Corporate/GA Fleet



Current State

- Equipage is already high and has increased as operators upgrading for ADS-B Out added additional GPS and WAAS with LPV Approach capabilities.
- New airplanes are delivered standard with significant level of PBN capability from GPS and WAAS with LPV Approach capability.

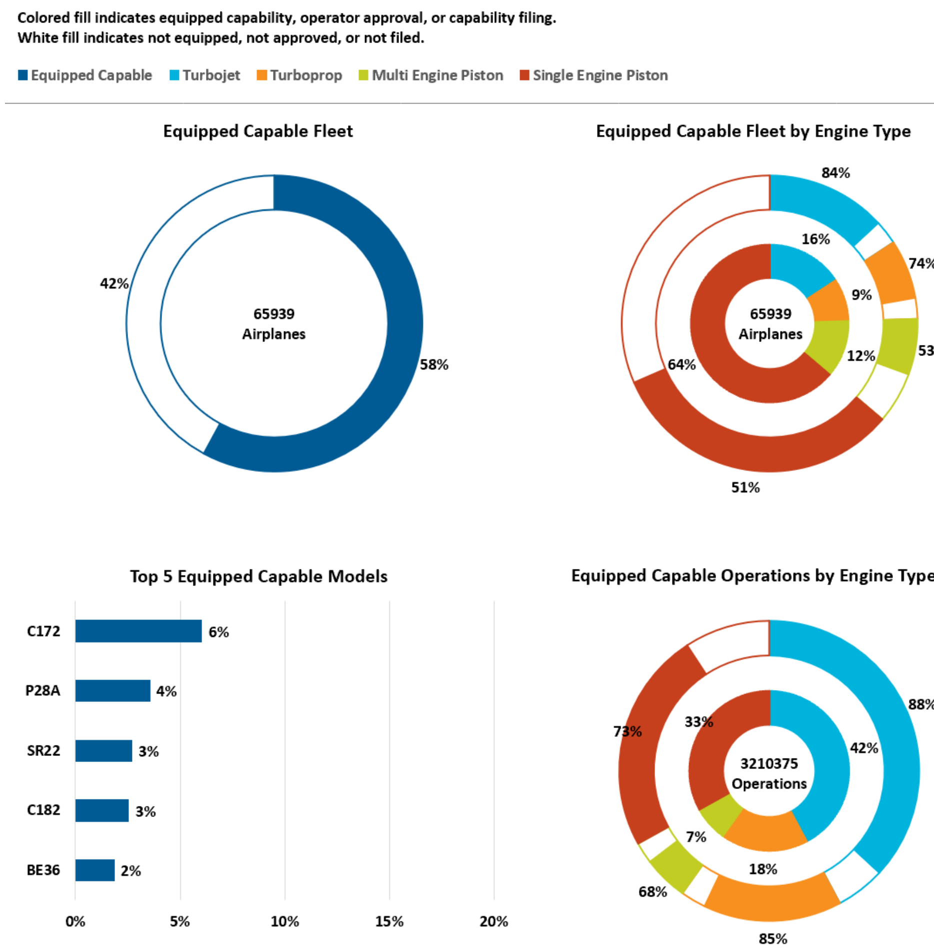
Forecast

- Trend is estimated to be increasing.
- Standard capability for majority of new turbine-powered airplanes.
- Data sources show a decrease in equipage compared to previous reports, and it is unclear if this is due to data inaccuracies in previous reports or a change in fleet composition.

Significant Factors

- All airplanes have retrofit potential through GPS avionics that are affordable and widely available.
- A significant number of single-engine piston operators do not have a business case for investing in retrofit solutions and/or operational approvals, often because of unknown future-fleet plans or operational needs. Investing for equipage and/or approvals on these airplanes risks a negative return.

VNAV Approach on Corporate/GA Fleet



Current State

- Data sources other than IFR flight plans point to much higher equipage rates than are reflected in flight plan data. This is likely due to equipped operators not expecting to fly an LPV or LNAV/VNAV Approach for many of the filed flights.
- Other industry data sources suggest LPV equipage could be in the 70–90% range.
- Equipage has increased as operators upgrading for ADS-B Out added additional GPS and WAAS with LPV Approach capabilities.
- New IFR airplanes are frequently delivered with LPV Approach capability.
- VNAV Approach is defined in this report as an aircraft that can fly to LNAV/VNAV line of minima on an instrument approach chart.

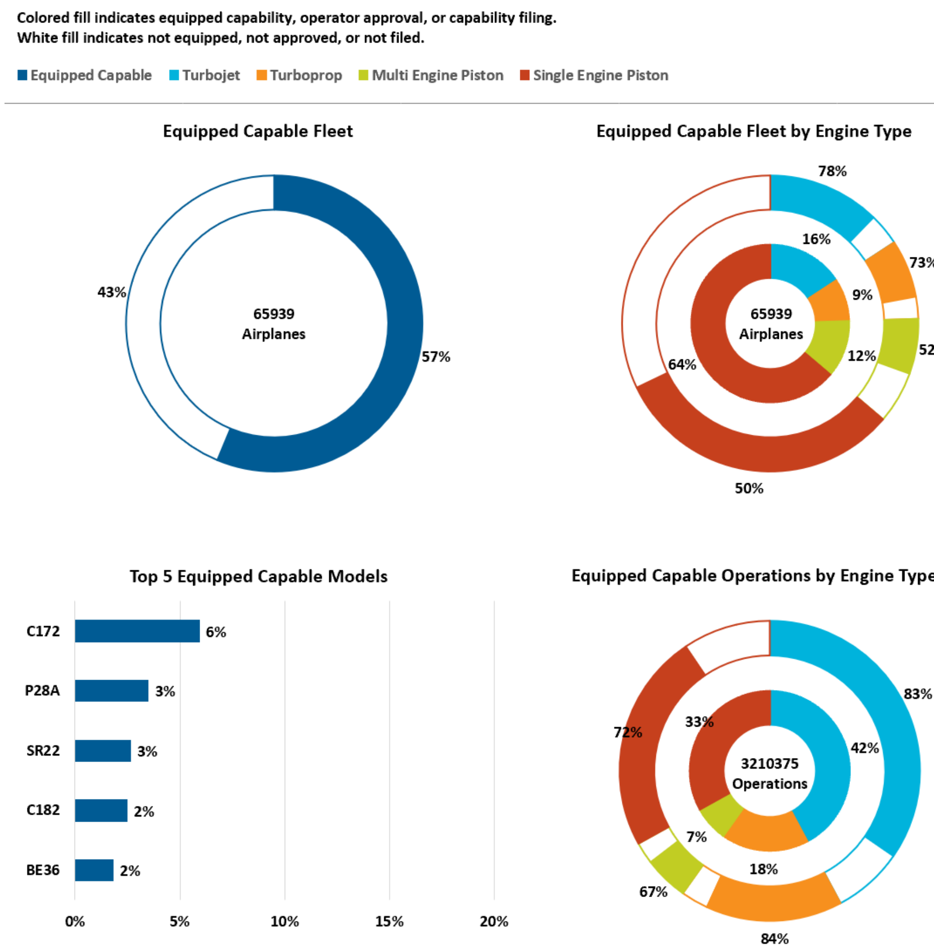
Forecast

- Trend is estimated to be increasing.
- Airplane manufacturer information suggests that new turbine-powered airplanes will come standard with coupled barometric VNAV, GPS, and an option for GLS I and/or LPV Approach.

Significant Factors

- ADS-B Out equipage reports indicate many operators exercised options for LPV Approach capability while upgrading for the ADS-B Out mandate.

LPV Approach on Corporate/GA Fleet



Current State

- Data sources other than IFR flight plans point to much higher equipage rates than are reflected in flight plan data. This is likely due to equipped operators not expecting to fly an LPV Approach for many of the filed flights.
- Other industry data sources suggest LPV equipage could be in the 70–90% range.
- Equipage has increased as operators upgrading for ADS-B Out added additional GPS and WAAS with LPV Approach capabilities.

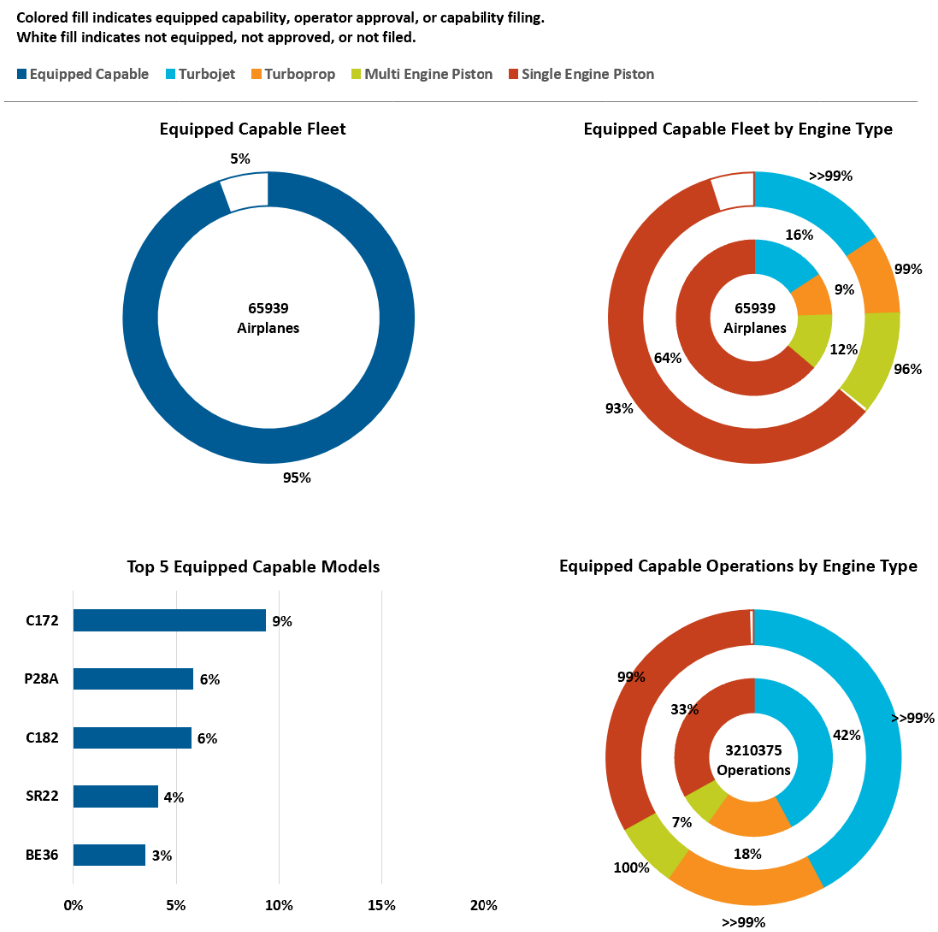
Forecast

- Trend is estimated to be increasing.
- Airplane manufacturer information suggests that new turbine-powered airplanes will come standard with coupled barometric VNAV, GPS, and an option for GLS I and/or LPV Approach. Piston airplanes may have LPV Approach options that enable VNAV Approach.
- Flight plan filings for this capability have increased four percent compared to previous reports.

Significant Factors

- ADS-B Out equipage reports indicate many operators exercised options for LPV Approach capability while upgrading for the ADS-B Out mandate.

RNP Approach on Corporate/GA Fleet



Current State

- Equipage is already high and increasing as new airplanes are delivered standard with significant level of PBN capability from GPS and WAAS with LPV Approach capability.
- Single-engine pistons account for the largest share of unequipped airplanes.
- Enabling equipage is GPS with RNP 0.3 approach capability.

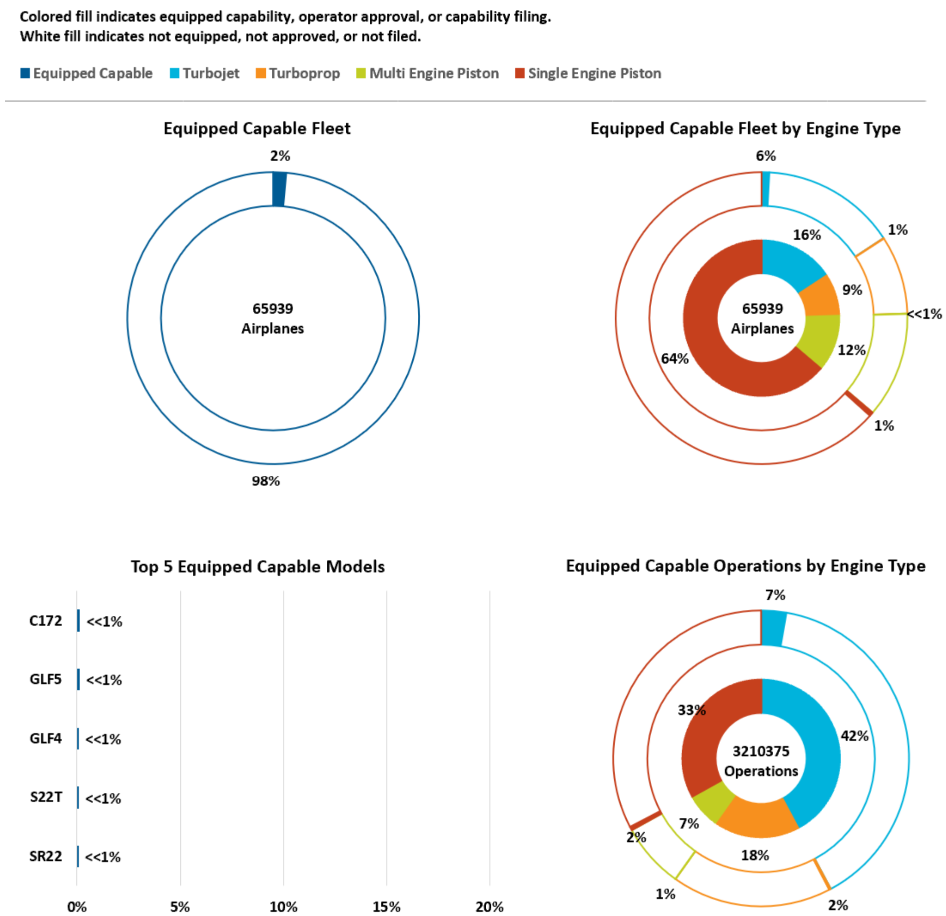
Forecast

- Trend is estimated to be flat.
- Standard capability for all new airplanes.
- Equipage has not changed compared to previous reports.

Significant Factors

- All airplanes have retrofit potential through GPS avionics that are affordable and widely available.
- Many single-engine piston operators do not fly IFR and/or have no operational use for this capability.
- For IFR operators, some operators may not have a business case for investing in retrofit solutions and/or operational approvals, often because of unknown future-fleet plans or operational needs. Investing for equipage and/or approvals on these airplanes risks a negative return.

RNP AR Approach on Corporate/GA Fleet



Current State

- Some equipage on long-range, large turbojet airplanes.
- Piston aircraft are generally not equipped.

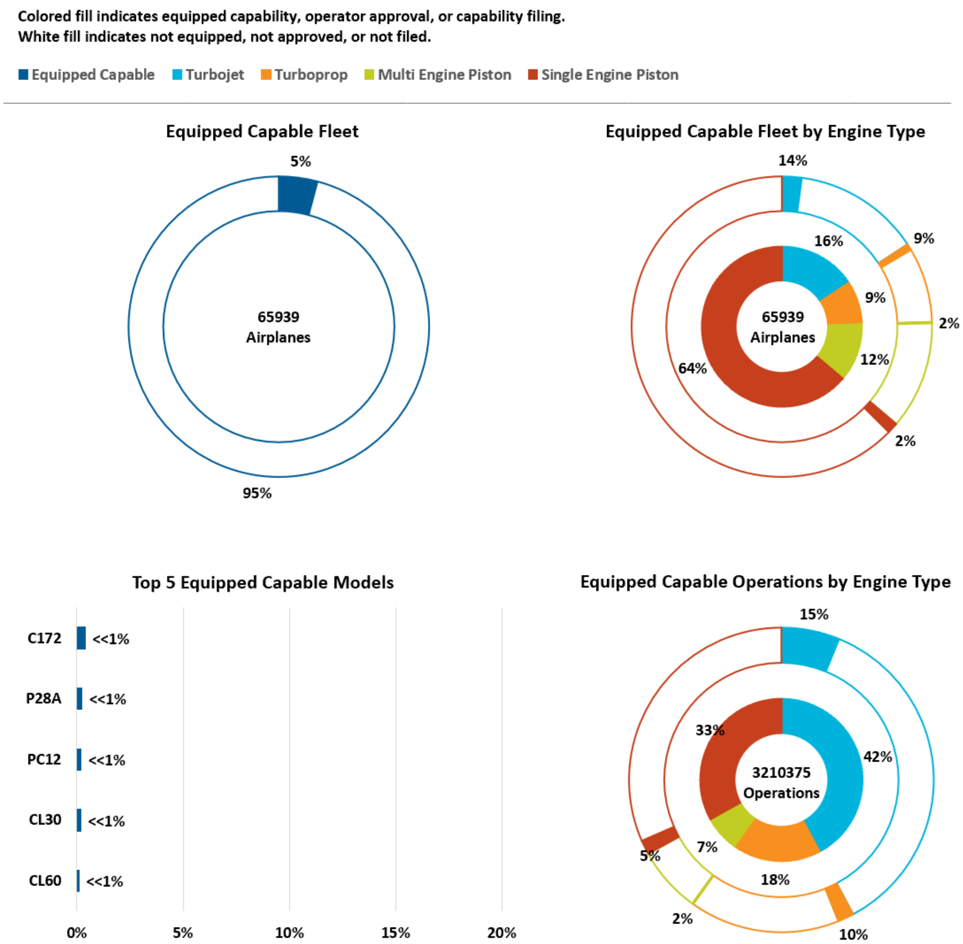
Forecast

- Trend is estimated to be flat.
- Many long-range, large turbojet airplanes come standard or have options available.
- RNP AR Approach will continue to grow slowly. Equipage will occur as retired turbojet and turboprop airplanes will be replaced by new deliveries with options exercised for this capability.
- Piston aircraft are generally expected not to be equipped with this capability.

Significant Factors

- U.S. and global demand for all-weather operations, environmental impact reductions, and predictable and repeatable paths may lead to higher rates of equipage offerings, standard equipage with RNP AR Approach, and/or additional options.
- Many single-engine piston operators do not fly IFR and/or have no operational use for this capability.
- For IFR operators, some operators may not have a business case for investing in retrofit solutions and/or operational approvals, often because of unknown future-fleet plans or operational needs. Investing for equipage and/or approvals on these airplanes risks a negative return.

GLS I on Corporate/GA Fleet



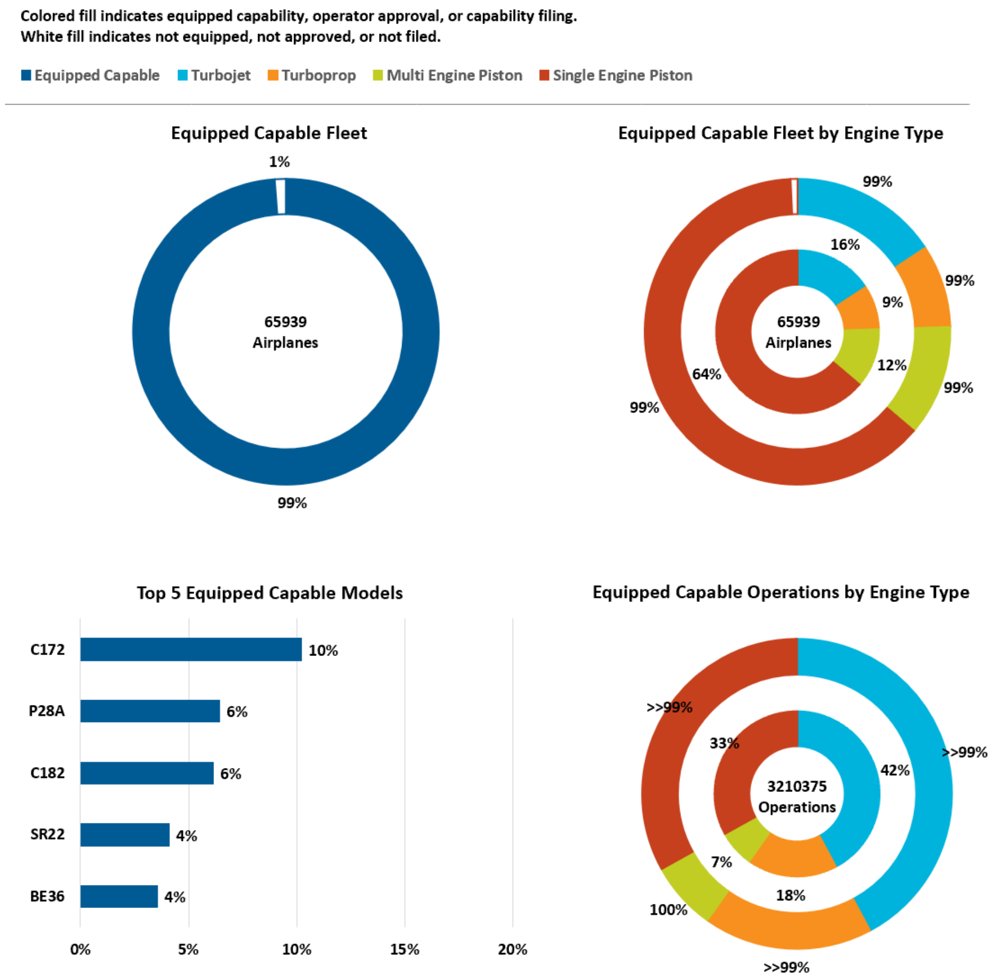
Current State
- Some equipage on long-range, large turbojet airplanes.
- Piston aircraft are generally not equipped.

Forecast
- Trend is estimated to be flat.
- Many long-range, large turbojet airplanes have options available.
- GLS equipage will occur as retired turbojet and turboprop airplanes are replaced by new deliveries with options exercised for this capability.

Significant Factors
- Some large operators see potential operational value in key locations and are voicing their interest in having certain airport authorities acquire GLS ground systems.
- If airports or other entities were to begin fielding more GLS ground systems, it is likely more operators would equip with GLS I as a backup to ILS. This will be particularly true when GLS CAT III (GAST D) standards are complete and the business case for equipping becomes even stronger.
- For IFR operators, a business case may not exist, often because of unknown future-fleet plans where any investment in these airplanes has a risk of negative returns.

5.2.2 Automatic Dependent Surveillance-Broadcast Enablers for Corporate/General Aviation

ADS-B Out on Corporate/GA Fleet



Current State

- Majority of Corporate/GA aircraft that had operational needs to access ADS-B Out airspace equipped ahead of January 1, 2020 mandate, while a few aircraft had delayed installations and equipped just after rule implementation or were removed from operator fleets.
- Some equipage continues, but at much lower rates.
- New aircraft are coming delivered standard with rule compliant systems.

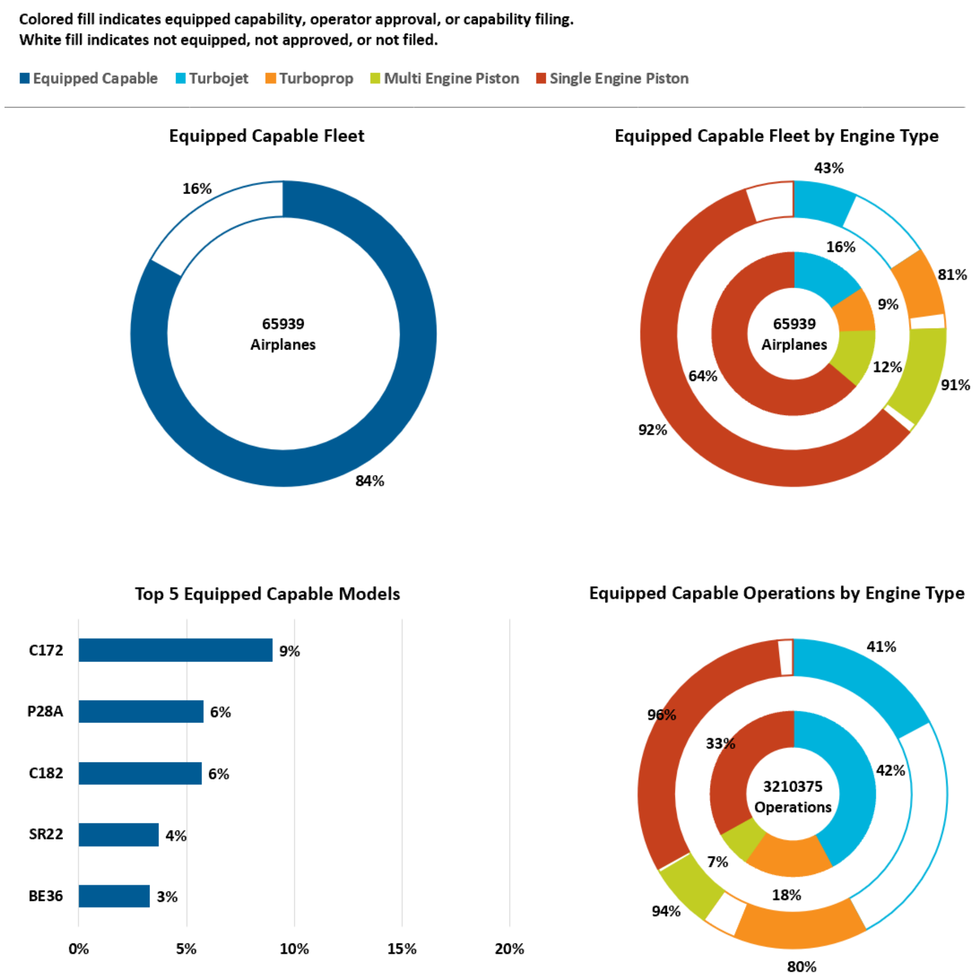
Forecast

- Trend is flat.

Significant Factors

- ADS-B Out equipage reports indicate many operators exercised options for LPV Approach capability while upgrading for the ADS-B Out mandate.
- Many operators are interested in Flight Information Services – Broadcast (FIS-B)/Traffic Information Services – Broadcast (TIS-B) services.

ADS-B In – SA Apps on Corporate/GA Fleet



Current State

- ADS-B Out equipage does not contribute to ADS-B In capability.
- Many operators who equipped for ADS-B Out chose to equip with solutions that provide both ADS-B Out and ADS-B In for CDTI applications.
- Current ADS-B In equipage is primarily in support of operator interest in traffic awareness and weather in the cockpit.

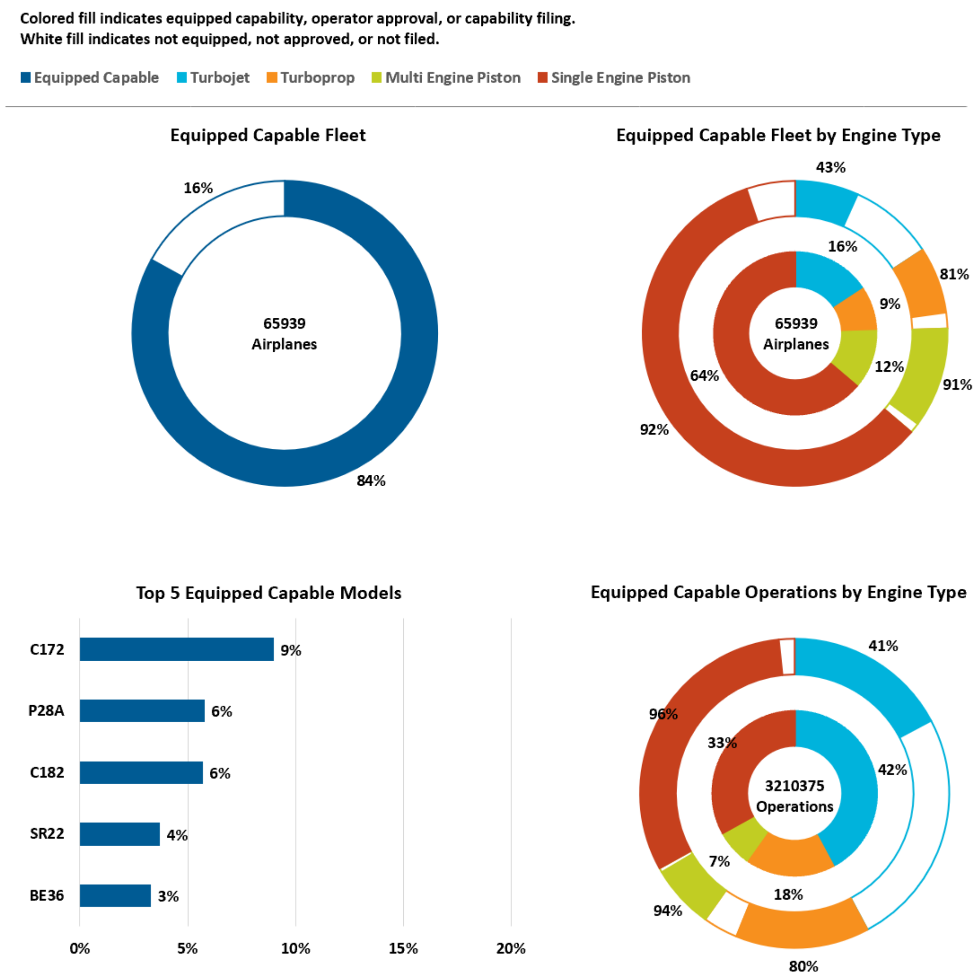
Forecast

- Trend is increasing.
- Equipped Capability has increased eight percent as compared to previous year's report.
- Many Corporate/GA operators, particularly those that fly IFR, have significant exposure to rule compliant airspace, and many operators will continue to equip with ADS-B In while equipping for ADS-B Out.

Significant Factors

- It is believed that as CAVS, IM, and other ADS-B In applications mature, more offerings will exist. Operators at busier airports will increase their equipage if not previously equipped.
- Operators see the safety benefits of ADS-B In for SA through improved traffic awareness and weather in the cockpit and continue to strongly desire these capabilities.

ADS-B In – Approach Apps on Corporate/GA Fleet



Current State

- ADS-B Out equipage does not contribute to ADS-B In capability.
- Many operators who equipped for ADS-B Out chose to equip with solutions that provide both ADS-B Out and ADS-B In for CDTI Applications.
- Current ADS-B In equipage is primarily in support of operator interest in traffic awareness and weather in the cockpit.

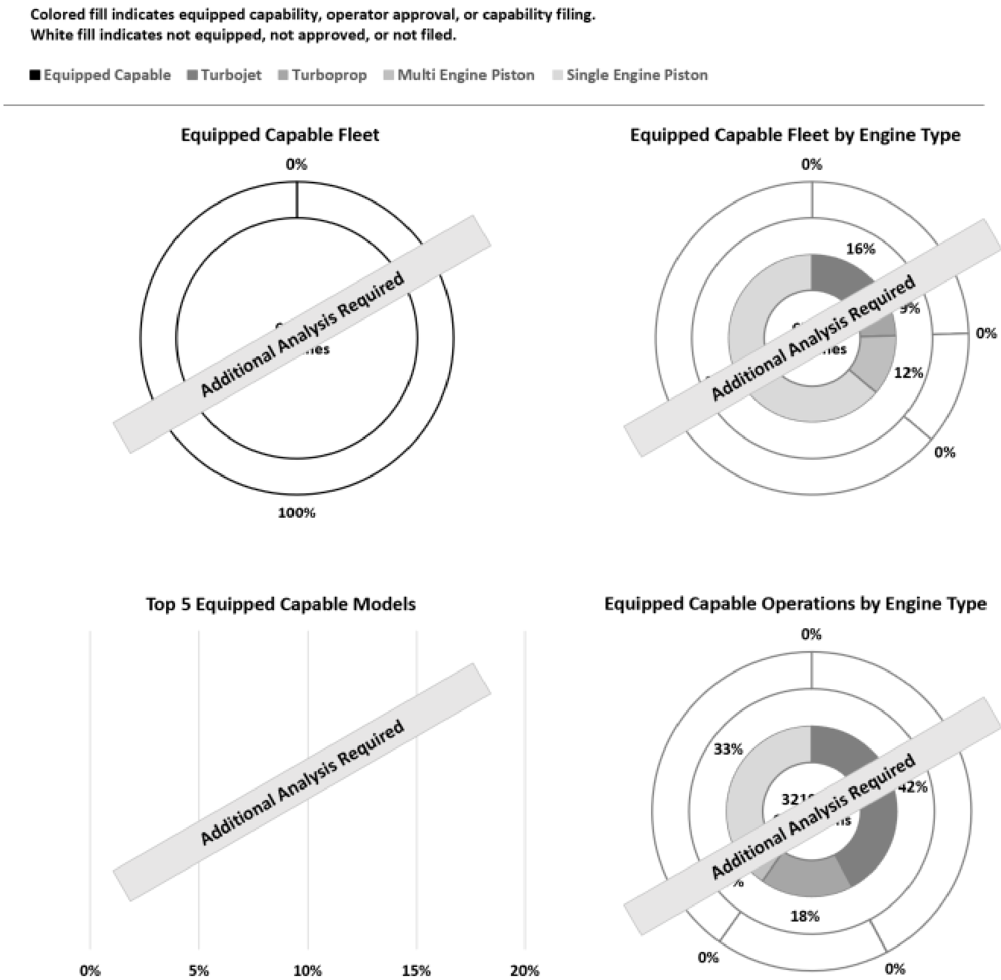
Forecast

- Trend is increasing.
- Equipped Capability has increased eight percent compared to previous year's report.
- Many Corporate/GA operators, particularly those that fly IFR, have significant exposure to rule compliant airspace, and many operators will continue to equip with ADS-B In while equipping for ADS-B Out.

Significant Factors

- It is believed that as CAVS, IM, and other ADS-B In applications mature, manufacturers will provision/update their products to comply with applications requirements.
- Increasing slowly, and equipage will likely occur on large and long-range turbojet airplanes that operate in high-density airports and airspace where these applications may be beneficial.

ADS-B In – ITP Apps on Oceanic Corporate/GA Fleet



Current State

- This capability is applicable to and reported against the oceanic fleet of airplanes.
- ADS-B Out equipage does not contribute to ADS-B In capability.
- There are no ITP operational approvals for Corporate/GA operators.
- Current ADS-B In equipage is primarily in support of CDTI capability. However, long-range, large turbojet airplanes fly oceanic operations where ITP could be utilized even though no operators are showing approved.

Forecast

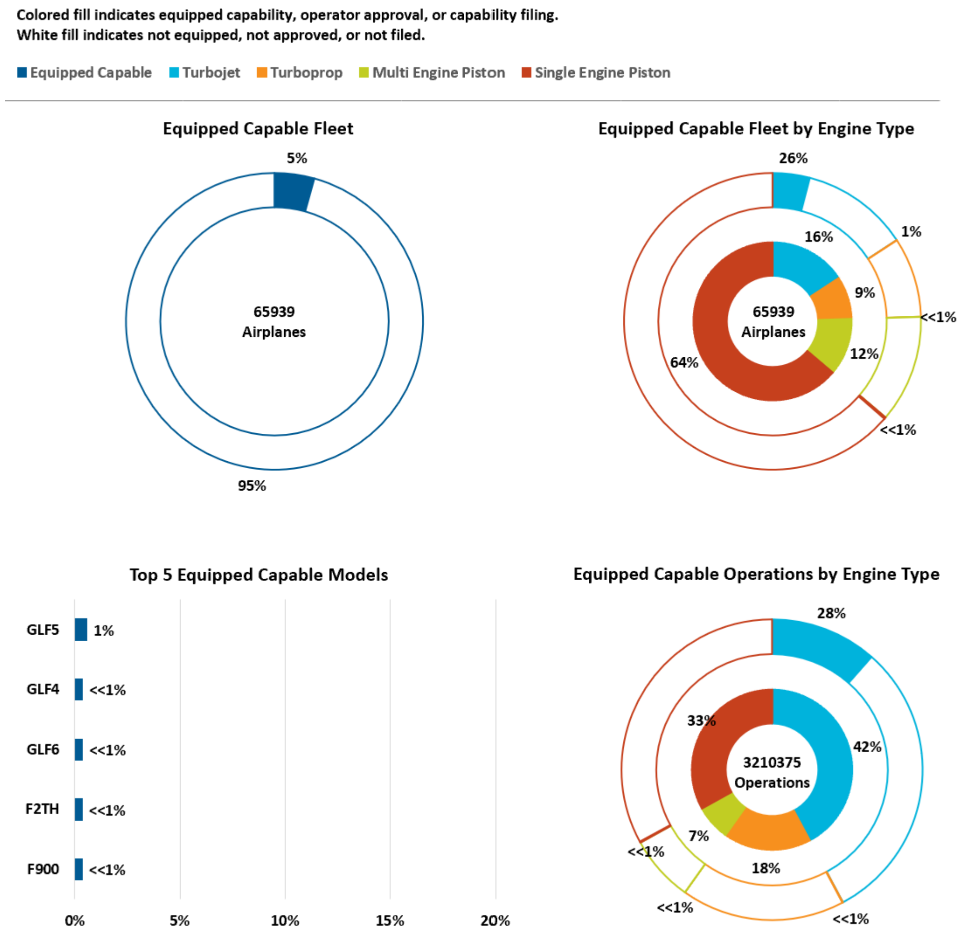
- Trend is estimated to be flat.

Significant Factors

- Impacts from COVID-19 and international travel constraints have drastically changed the makeup and operational pace of Oceanic Aircraft in the past year, resulting in significant equipage and capability variations in data sets over the past year.
- It is believed that as CAVS, IM, and other ADS-B In applications mature, operators of long-range, large Corporate/GA turbojets will equip with a wide range of ADS-B In applications, including ITP.

5.2.3 Data Communications Enablers for Corporate/General Aviation

FANS 1/A Domestic – Tower Services on Corporate/GA Fleet



Current State

- FANS 1/A Domestic – Tower Services includes aircraft that are equipped with VDL Mode 0 or Mode 2.
- Long-range, large turbojets have most of the Data Comm equipage and approvals.
- Piston equipage for domestic FANS is negligible.

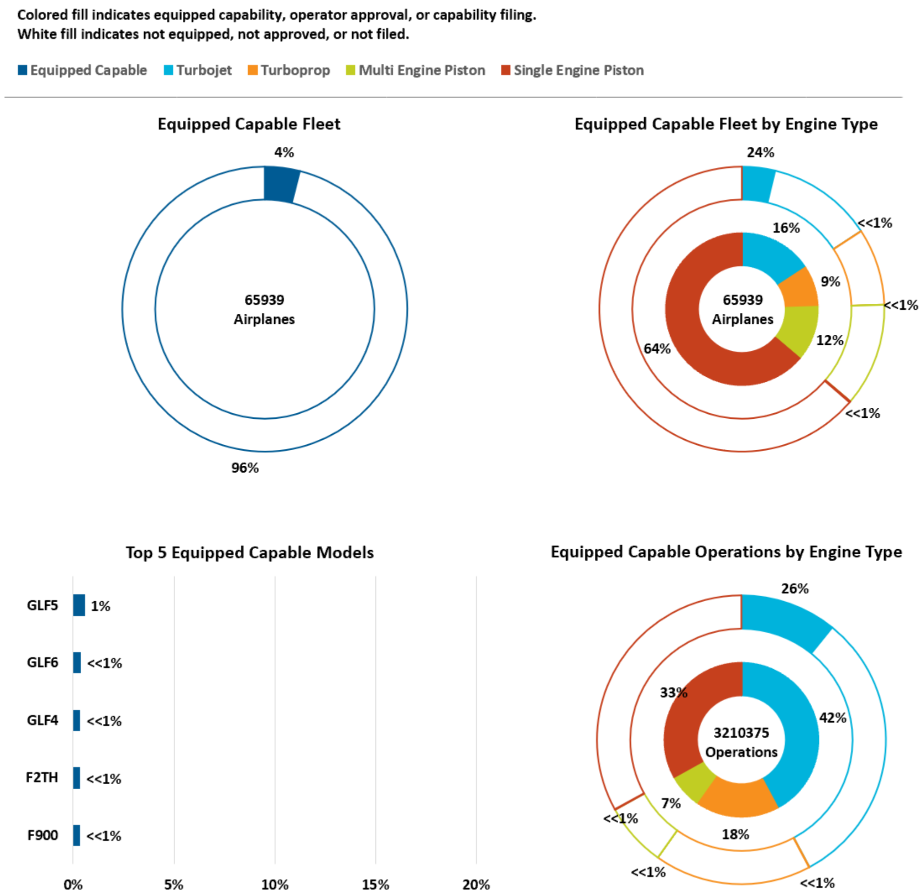
Forecast

- Trend is estimated to be flat.
- Equipage is increasing as operators select this capability for oceanic flight on their new, large, long-range airplanes.
- Equipage rates are lower on shorter-range and smaller jets and turboprops.

Significant Factors

- Impacts from COVID-19 and international travel constraints have drastically changed the makeup and operational pace of Oceanic Aircraft in the past year, resulting in significant equipage and capability variations in data sets over the past year.
- Access to North Atlantic airspace from FL290 to FL410 requires FANS capability, resulting in greater equipage.
- Success of initial Data Comm services will impact further equipage, but industry feedback indicates increased interest from operators who are assessing the applicability and value of tower and en route services to their individual operations.

FANS 1/A Domestic – En Route Services on Corporate/GA Fleet



Current State

- FANS 1/A Domestic – En Route Services includes aircraft that are equipped with VDL Mode 2.
- Long-range, large turbojets make up most of the Data Comm equipage and approvals.
- Piston equipage for domestic FANS is negligible.

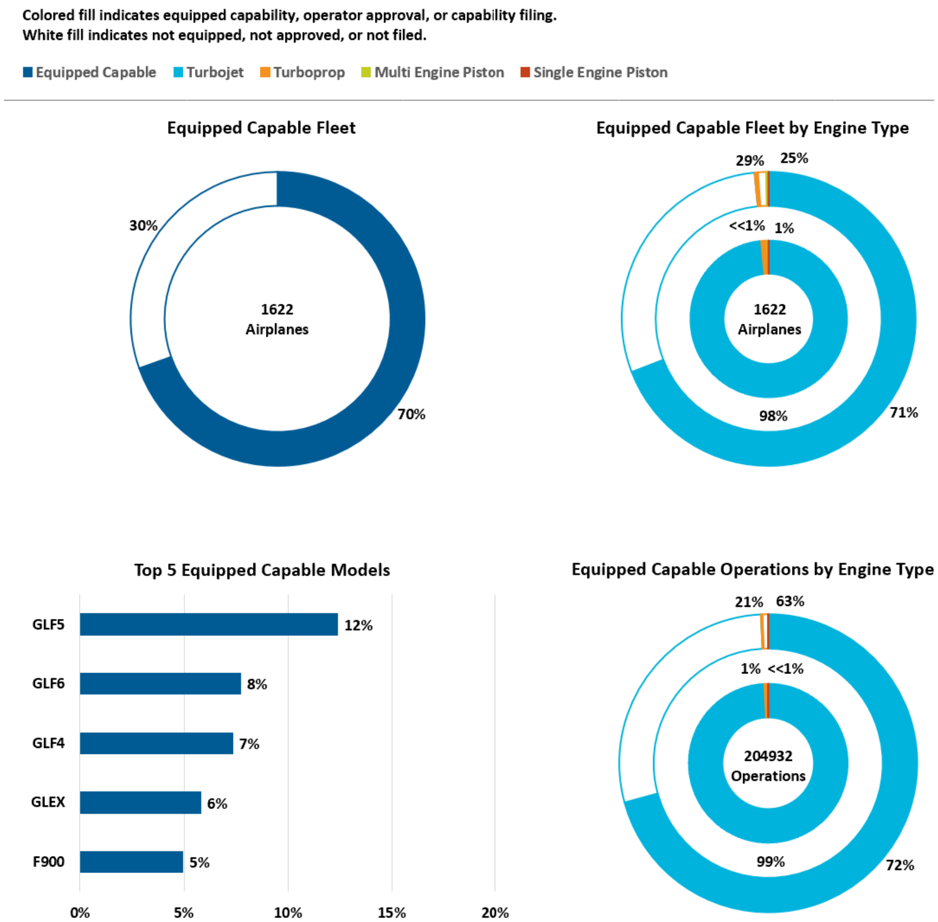
Forecast

- Trend is estimated to be flat.
- Majority of new turbojet airplane deliveries come standard or have options for FANS.
- Equipage rates are lower on shorter-range and smaller jets and turboprops.

Significant Factors

- Impacts from COVID-19 and international travel constraints have drastically changed the makeup and operational pace of Oceanic Aircraft in the past year, resulting in significant equipage and capability variations in data sets over the past year.
- An increase in FANS equipage may occur due to expanded use of mid-size airplanes in oceanic airspace.
- Potential to apply Data Comm to improve system operations, particularly in the northeast corridor, may result in higher equipage and lower option costs.
- Success of initial Data Comm services will impact further equipage, but industry feedback indicates increased interest from operators who are assessing the applicability and value of tower and en route services to their individual operations.

FANS 1/A Oceanic on Oceanic Corporate/GA Fleet



Current State

- This capability is applicable to and reported against the oceanic fleet of airplanes.
- Long-range, large turbojets operating in oceanic airspace make up the majority of the FANS 1/A Oceanic equipage and approvals.
- Most new turbojet airplane deliveries are equipped RNP 4 capable. SATCOM equipage rates are lower on shorter-range and smaller non-oceanic airplanes.

Forecast

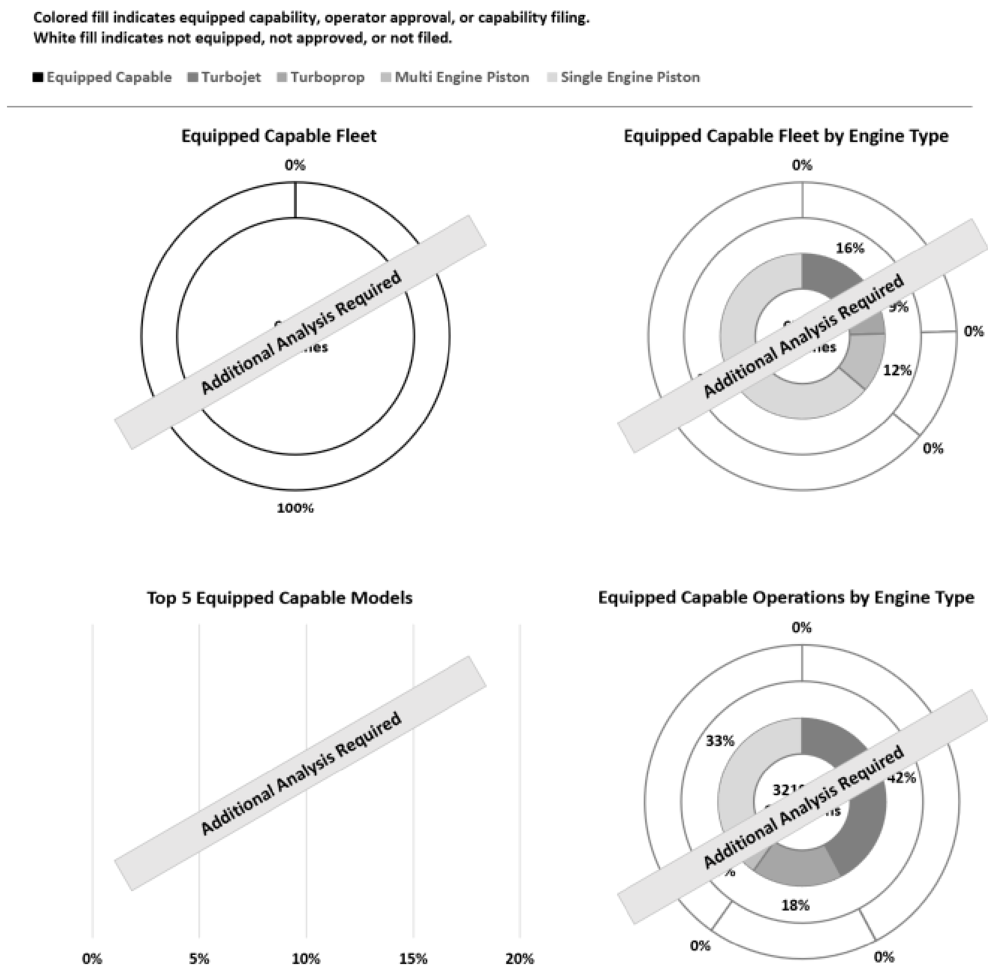
- Trend is estimated to be decreasing.
- Equipage is occurring as operators select this capability for oceanic flight and inflight connectivity on their new, large, long-range airplanes.

Significant Factors

- Impacts from COVID-19 and international travel constraints have drastically changed the makeup and operational pace of Oceanic Aircraft in the past year, resulting in significant equipage and capability variations in data sets over the past year.
- An increase in SATCOM equipage may occur due to expanded use of mid-size airplanes in oceanic airspace, the FAA Domestic Data Communications Programs, desire for live weather, and increased inflight connectivity.

5.2.4 Low-Visibility Enablers for Corporate/General Aviation

HUD Approach on Corporate/GA Fleet

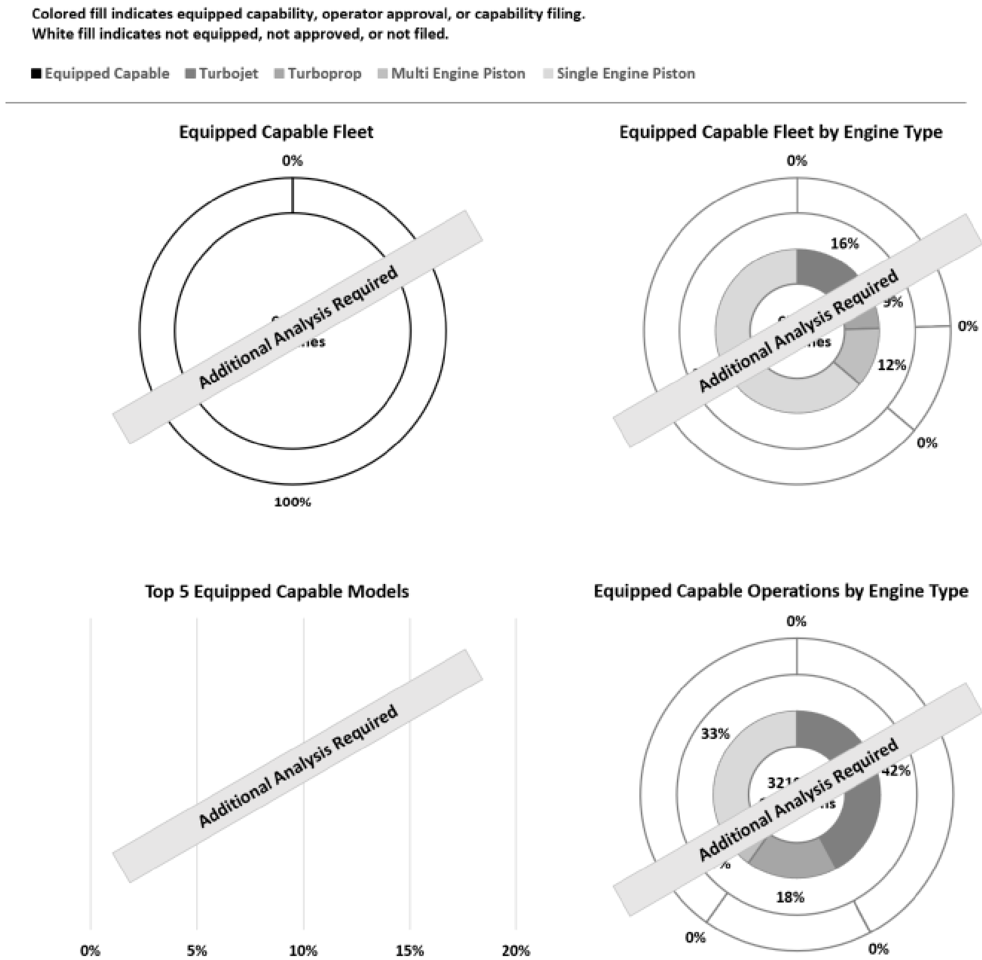


Current State
- Equipage is primarily on turbojet-powered airplanes where HUDs provide enhanced landing capability.
- Recent FAA regulatory efforts have improved IFR operational credit, which is considered by these operators as beneficial.

Forecast
- Trend is estimated to be flat.

Significant Factors
- System prices and physical size are decreasing, resulting in a more favorable business case for operators to pursue equipage. Solutions coming to market without an IRU, along with smaller and lighter-weight systems, make for an improved potential business case across a wider range of airplanes and operators.
- Evolving market offerings and operational benefits for all types of vision system technologies are interpreted by some operators to improve safety, efficiency, and access, and as a result, vision system technologies continue to garner significant operator interest.

EFVS on Corporate/GA Fleet



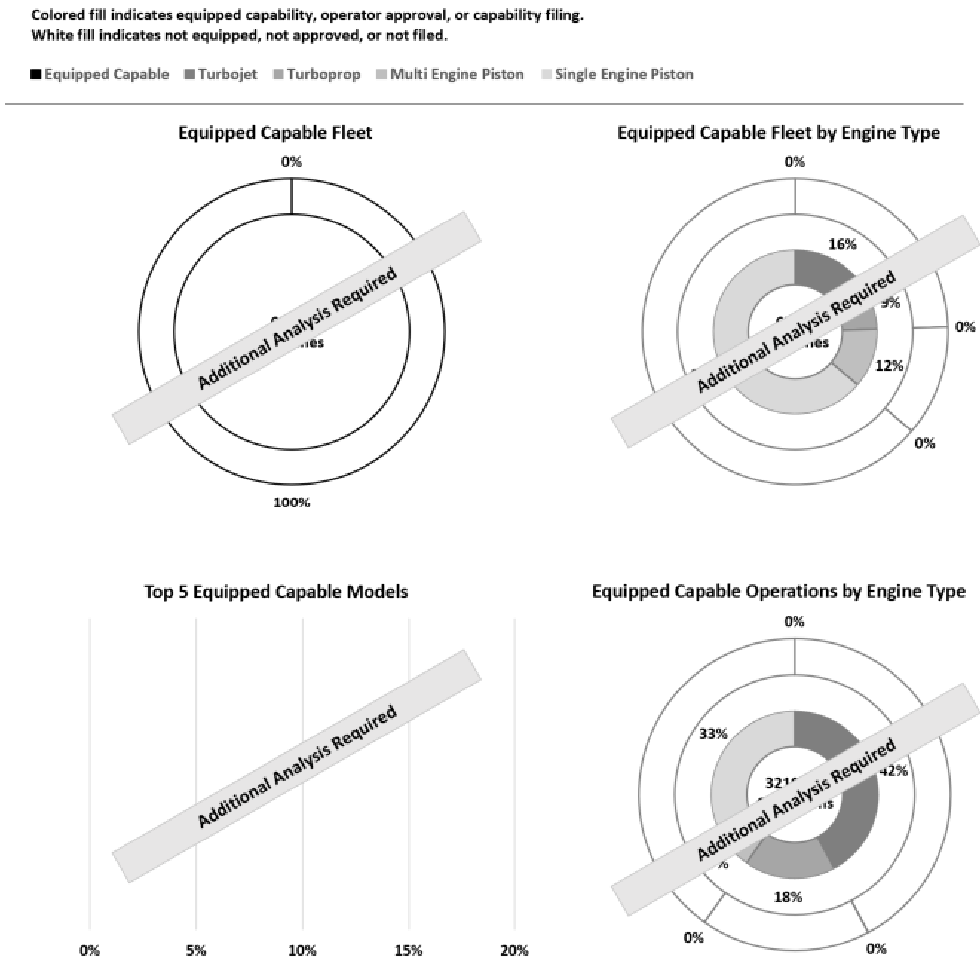
Current State
- Equipage is primarily on turbojet-powered airplanes where enhanced situational awareness is provided by EFVS and HUDs.
- Recent FAA regulatory efforts have improved IFR operational credit, which is considered by these operators as beneficial.

Forecast
- Trend is estimated to be flat.
- Equipage will occur as some operators have sufficient business case to invest. However, most operators continue to be challenged to have a positive business case.

Significant Factors
- System prices and physical size are decreasing, resulting in a more favorable business case for operators to pursue equipage. Solutions coming to market without an IRU, along with smaller and lighter-weight systems, make for an improved potential business case across a wider range of airplanes and operators.
- Evolving market offerings and operational benefits for all types of vision system technologies are interpreted by some operators to improve safety, efficiency, and access, and as a result, vision system technologies continue to garner significant operator interest.

5.2.5 Avionics Safety-Enhancement Enablers for Corporate/General Aviation

EFB on Corporate/GA Fleet



Current State

- Increasing use as more operators adopt Apple iPad® and similar platforms into all airplane types, including new turbine airplanes with installed EFB systems.
- EFBs are being utilized for additional cockpit capabilities such as flight planning, live weather, and moving map displays.
- Equipage numbers are not readily available, but data suggests the majority of airplanes are currently equipped with some form of EFB.

Forecast

- Trend is estimated to be flat.

Significant Factors

- AIDs and new market offerings allowing improved pairings, both one way and bi-directional, and connectivity of EFB with onboard avionics support emerging connected aircraft concepts and will likely result in new operational use cases for EFB and/or new hardware and software market options
- AAtS, live weather, CDTI, and potential for supplemental Data Comm-type applications may leverage the low cost of EFBs as a computing device or display, resulting in higher equipage rates for both EFBs and these other capabilities.

6 Helicopter Fleet and Enablers

6.1 Helicopter Fleet and Operator Overview

Figure 6-1 provides information about the Helicopter operators. The fleet comprises 12,329 helicopters, of which 1,098 (9%) are designated for IFR. Helicopters are not included in oceanic enabler assessments.

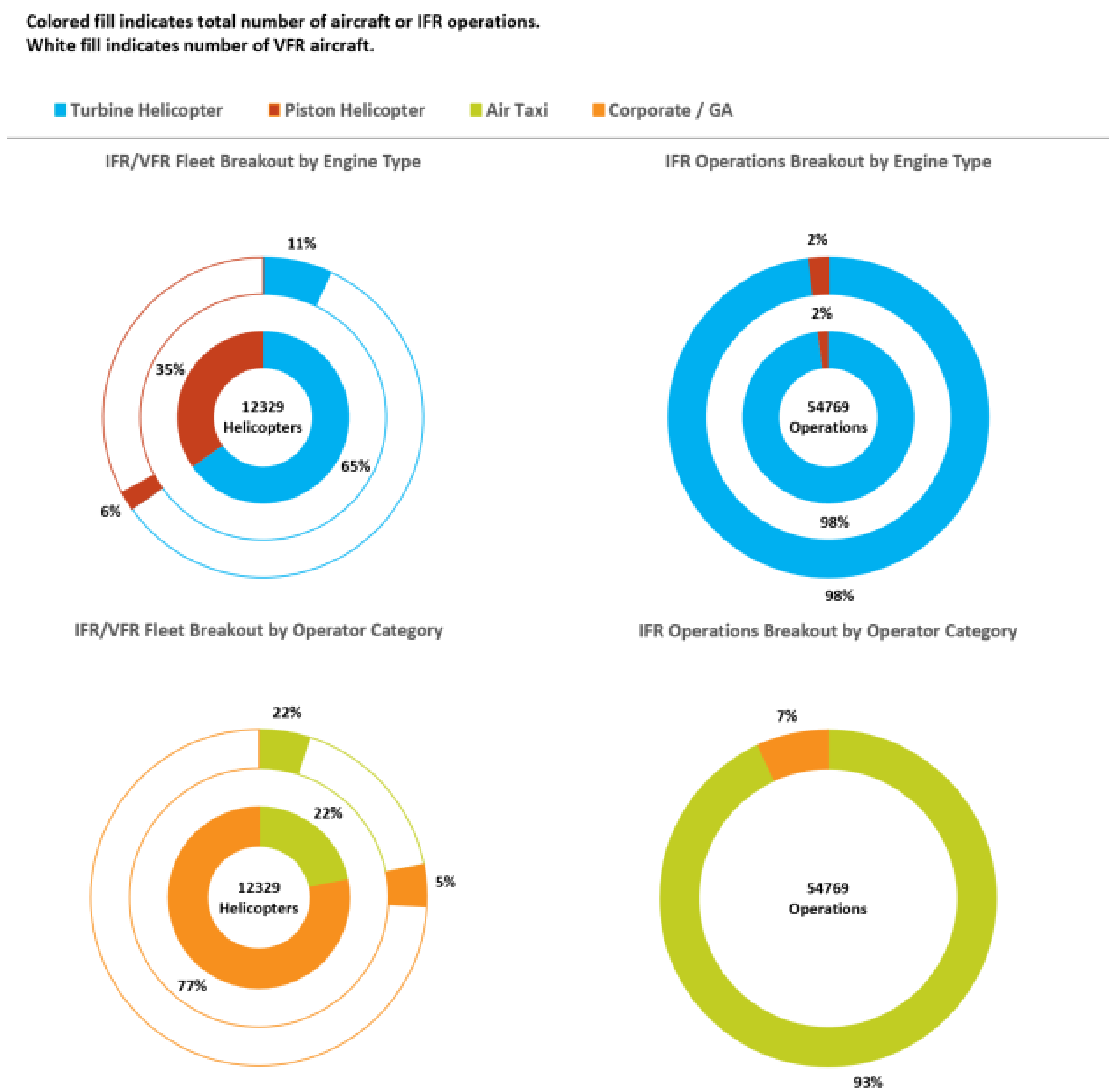


Figure 6-1. Helicopter Fleet: IFR/VFR Fleet and Operations Breakout by Engine Type and Operator Category

As with Corporate/GA airplanes, only a subset of helicopters is subject to OpSpec approvals. Nevertheless, of the 12,329 helicopters, 4,716 (38%) are represented in WebOPSS. Further, individual helicopters are often certificated to operate under multiple 14 CFR Parts, including commercial type (e.g., agriculture, external load) operations. It is common for helicopters to operate under both 14 CFR Part 91 and Part 135. There are 111 foreign helicopters that are present in 2022 data, but only 11 of these helicopters were operated IFR with 41 total operations and therefore are omitted from these results.

There are 1,266 certificated helicopter operators across the multiple operator categories in WebOPSS. Of these, 848 (67%) operate only helicopters; 418 operators have a mixed airplane/helicopter fleet. The fleet is split between Air Taxi operators (20%) and other certifications (80%). Foreign Carriers have authorizations for 14 CFR Part 129 helicopters to operate in the U.S. This report does not cover military helicopters.

Figure 6-2 shows the top-ten operators, measured by fleet size and total IFR operations. Of the 1,266 certificated helicopter operators, 259 operate IFR helicopters. The top-ten IFR operators account for 35% of the helicopter IFR fleet and 73% of the helicopter IFR operations. The top operators primarily comprise medical and oil services focused companies.

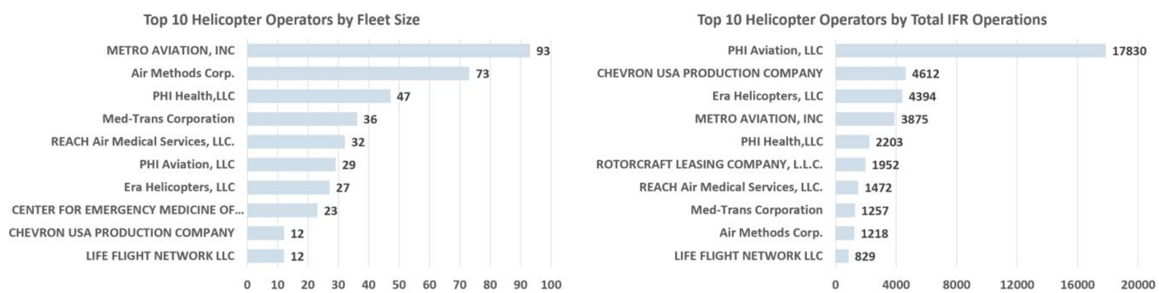


Figure 6-2. Helicopter WebOPSS Fleet*: Largest Operators

*(Note: *based on subset of overall Helicopter fleet that have one or more OpSpec approvals.)*

Figure 6-3 shows the top-ten helicopter models, measured by fleet size and total IFR operations. These top-ten models account for 82% of the Helicopter IFR fleet and 98% of the Helicopter IFR operations. The top-ten models include turbine and piston engine types.

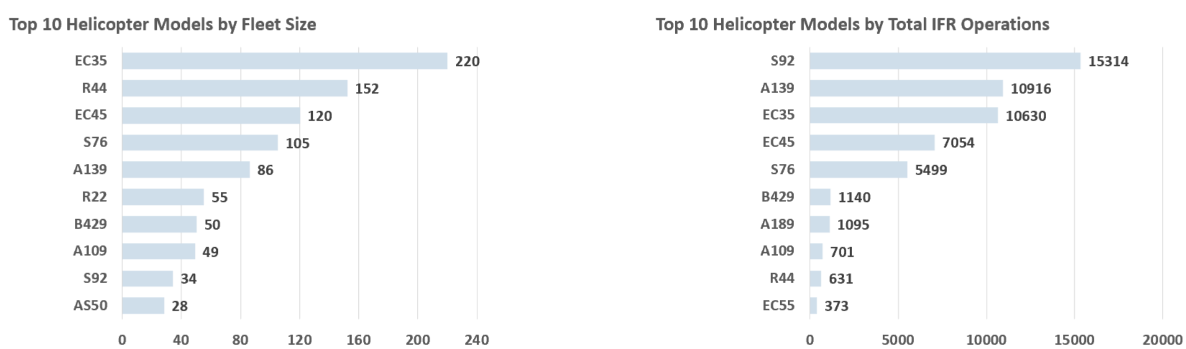


Figure 6-3. Helicopter WebOPSS Fleet*: Top Models

*(Note: *based on subset of overall Helicopter fleet that have one or more OpSpec approvals.)*

6.2 Helicopter Current Capabilities

Figure 6-4 shows the assessment of current equipage for the Helicopter fleet as derived from IFR flight plan filings (except for ADS-B equipage). The detailed pages that follow include additional information regarding significant factors influencing current state, key trend drivers, and potential factors that may impact the reported trend.

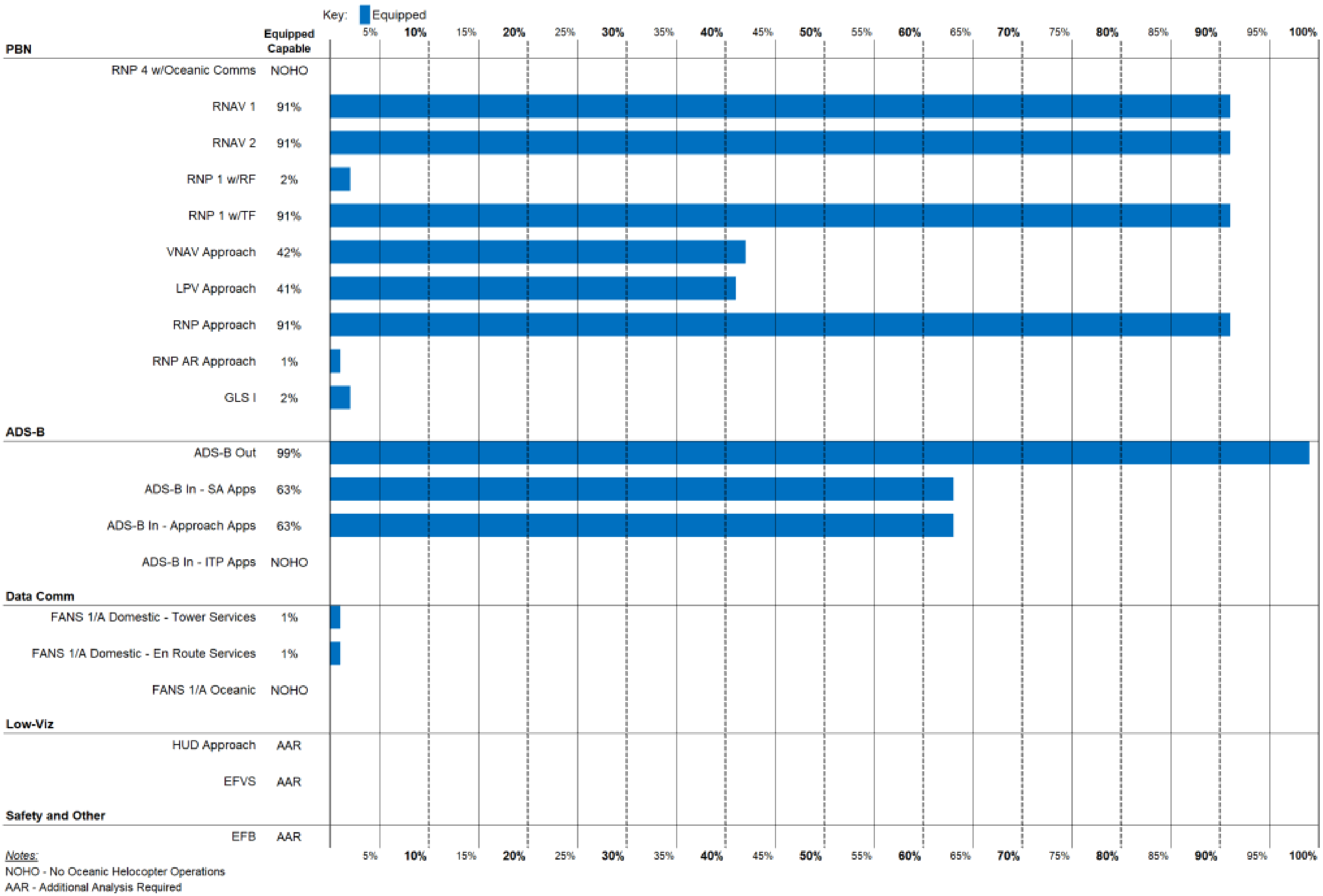
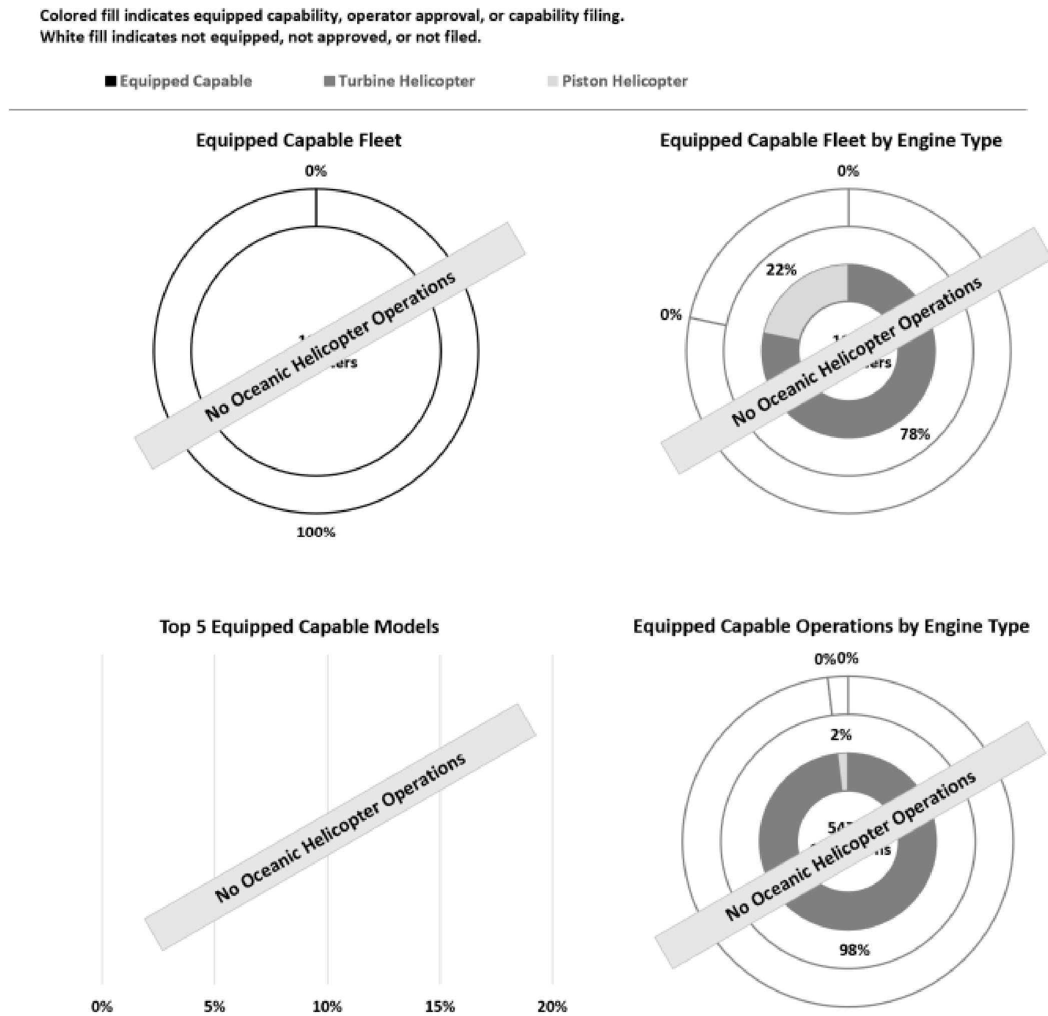


Figure 6-4. Helicopter Enablers: Current Equipage Assessment

6.2.1 Performance Based Navigation Enablers for Helicopter

RNP 4 with Oceanic Comms on Oceanic Helicopter Fleet



Current State

- RNP 4 with Oceanic Comms is applicable to airplanes flying across the Atlantic and Pacific Oceans.
- Some helicopters do fly over water, typically in medevac, search and rescue, and oil services use, but rarely fly in oceanic airspace.
- Helicopters can have dual redundant navigation systems and may even have SATCOM. The use of these capabilities is more in support of terrestrial operations than oceanic.

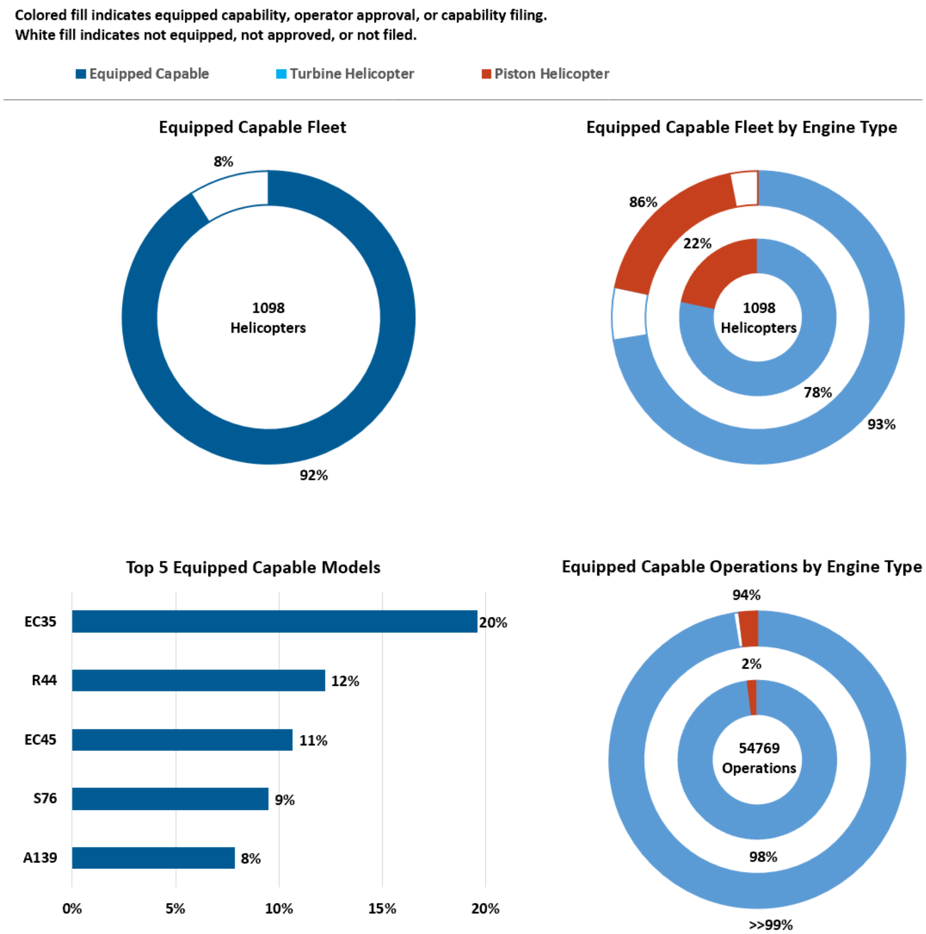
Forecast

- Trend is estimated to be flat.
- Helicopters are not expected to be operating in oceanic airspace routinely.

Significant Factors

- If RNP 4 was utilized for non-oceanic, overwater airspace, then helicopter equipage and capability would be more relevant for reporting purposes.

RNAV 1 on Helicopter Fleet



Current State

- Equipage is already high and has increased as operators upgrading for ADS-B Out added additional GPS and WAAS with LPV Approach capabilities.
- Data sources show a small decrease of three percent in equipped capability compared to previous reports. It is unclear if this is due to data inaccuracies in previous reports or a change in fleet composition, but it is likely due to COVID-19 fleet variations and IFR filings.
- Turbine-powered helicopters have higher RNAV 1 equipage and fly more IFR operations than piston helicopters.
- New turbine-powered helicopters are delivered standard with a significant level of PBN capability from GPS and WAAS with LPV Approach capability.

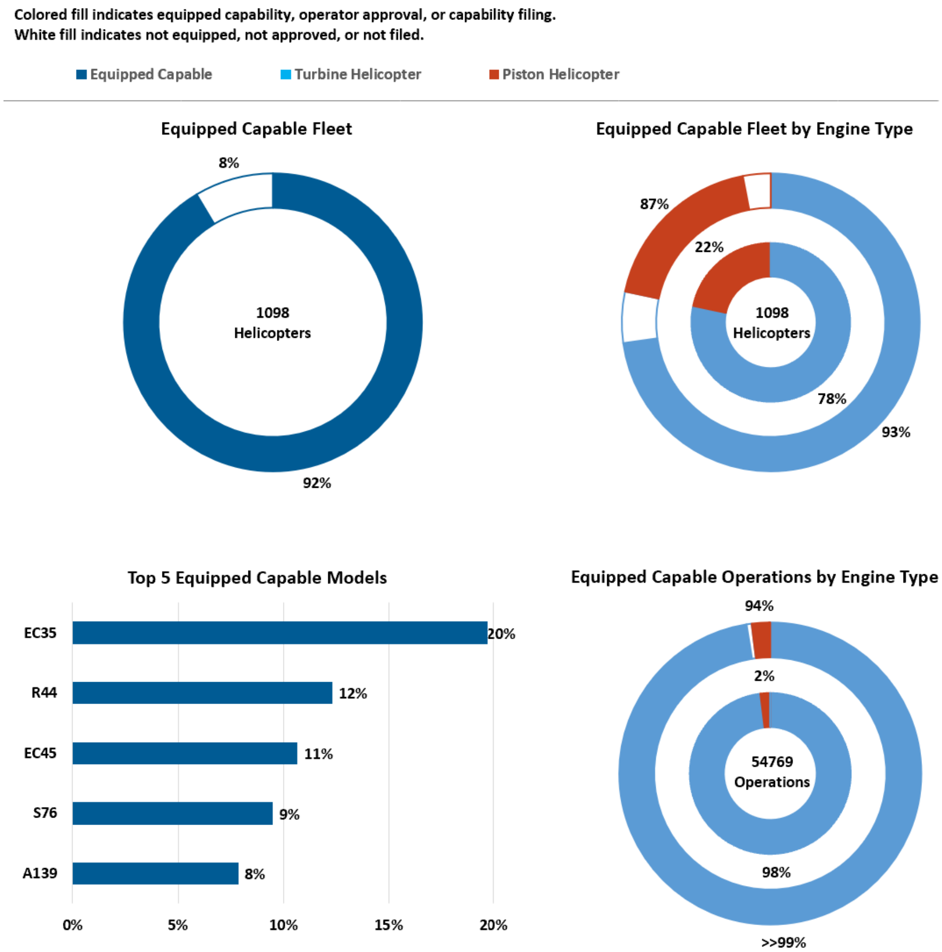
Forecast

- Trend is estimated to be flat.
- Equipage occurs with new turbine-powered helicopters being delivered standard with GPS, and piston helicopters having available options for GPS with RNAV 1 capability.

Significant Factors

- Smaller, lighter, and less expensive avionics options may result in higher equipage.

RNAV 2 on Helicopter Fleet



Current State

- Equipage is already high and has increased as operators upgrading for ADS-B Out added additional GPS and WAAS with LPV Approach capabilities.
- Data sources show a small decrease of three percent in equipped capability compared to previous reports. It is unclear if this is due to data inaccuracies in previous reports or a change in fleet composition, but it is likely due to COVID-19 fleet variations and IFR filings.
- Turbine-powered helicopters have higher RNAV 1 equipage and fly more IFR operations than piston helicopters.
- New turbine-powered helicopters are delivered standard with a significant level of PBN capability from GPS and WAAS with LPV Approach capability.

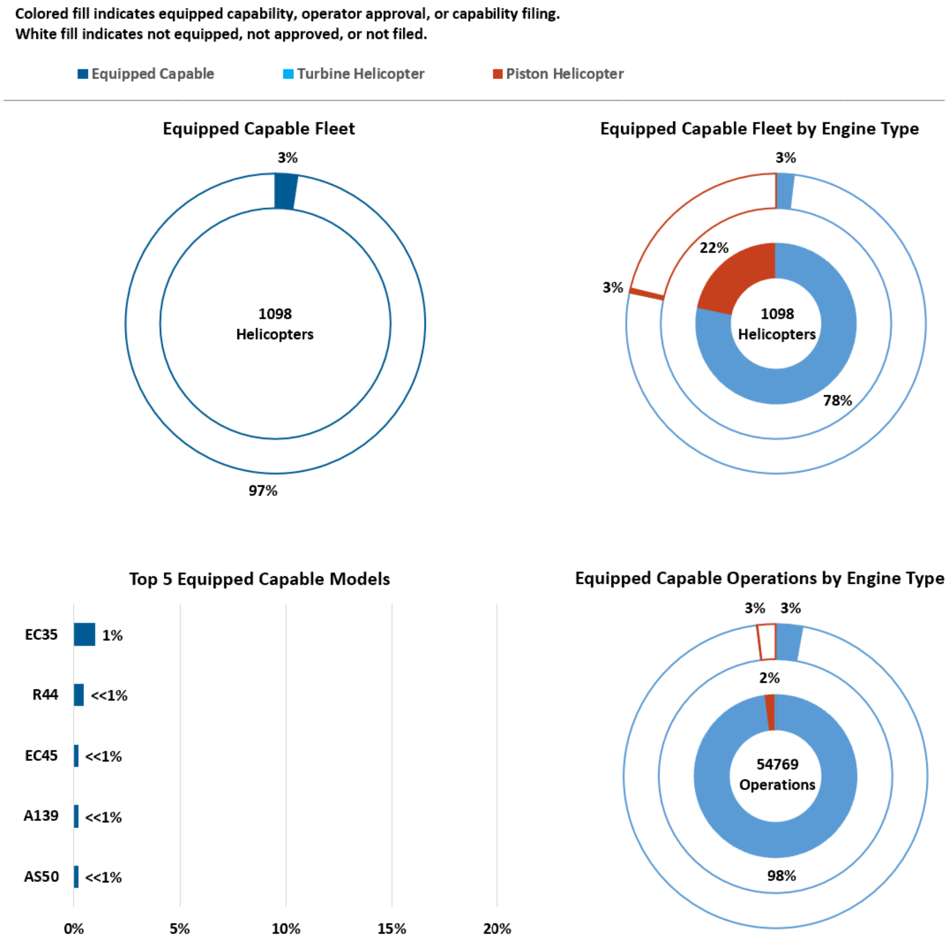
Forecast

- Trend is estimated to be flat.
- Equipage occurs with new turbine-powered helicopters being delivered standard with GPS and piston helicopters having available options for GPS with RNAV 2 capability.

Significant Factors

- Smaller, lighter, and less expensive avionics options may result in higher equipage.

RNP 1 with RF on Helicopter Fleet



Current State

- Some helicopters have RF leg capability, particularly large turbine-powered aircraft routinely operated on IFR flight plans.
- Flight-plan analysis shows helicopters rarely file for RNP 1 with RF, even if they may be equipped.
- Infrequent filings for RNP 1 with RF may suggest operators do not have operational exposure to RNP 1 with RF or do not have the required pilot training.

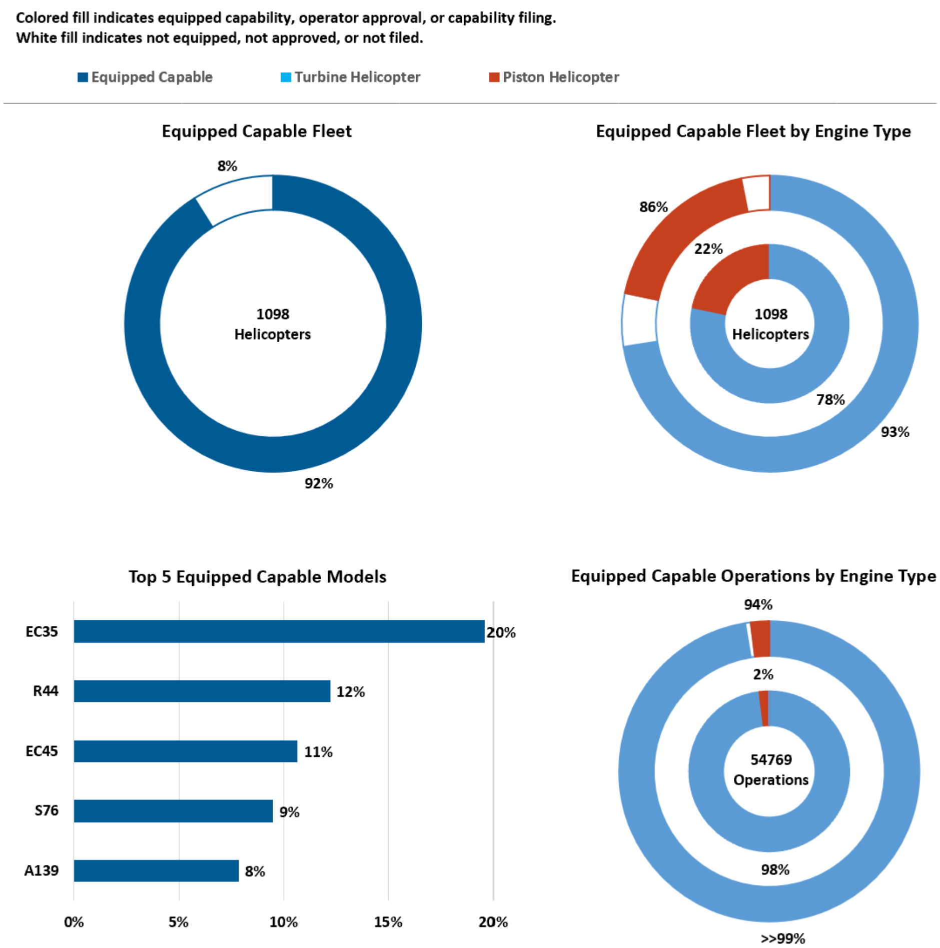
Forecast

- Trend is estimated to be flat.
- Small quantities of new turbine-powered helicopters delivered standard with RNP 1 with RF.

Significant Factors

- Most helicopters do not fly IFR and/or have no operational use for RNP 1 with RF.
- Forward-fit and retrofit offerings on turbine and piston helicopters exist.
- Cost, weight, and size constraints on helicopters make forward-fit or retrofit avionics prohibitive for many operators until smaller and less expensive options are available.

RNP 1 with TF on Helicopter Fleet



Current State

- Equipage is already high and has increased as operators upgrading for ADS-B Out added additional GPS and WAAS with LPV Approach capabilities.
- Data sources show a small decrease of three percent in equipped capability compared to previous reports. It is unclear if this is due to data inaccuracies in previous reports or a change in fleet composition, but it is likely due to COVID-19 fleet variations and IFR filings.
- Turbine-powered helicopters have higher RNP 1 equipage and fly more IFR operations than piston helicopters.
- New turbine-powered helicopters are delivered standard with a significant level of PBN capability from GPS and WAAS with LPV Approach capability.

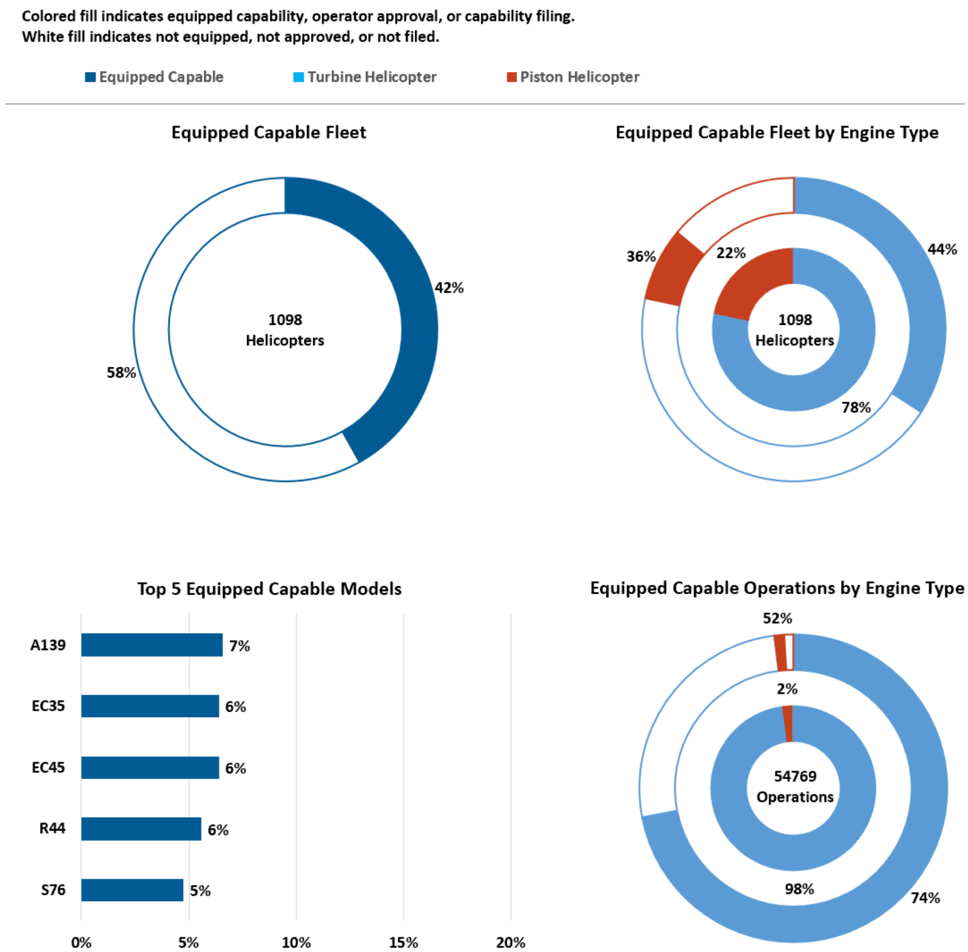
Forecast

- Trend is estimated to be flat.
- Equipage occurs with new turbine-powered helicopters being delivered standard with GPS, and piston helicopters having available options for GPS with RNP 1 capability.

Significant Factors

- Smaller, lighter, and less expensive avionics options may result in higher equipage.

VNAV Approach on Helicopter Fleet



Current State

- VNAV Approach is defined in this report as an aircraft that can fly to LNAV/VNAV line of minima on an instrument approach chart.
- Data sources other than IFR flight plans point to much higher equipage rates than are reflected in flight plan data.
- Equipage has increased as operators upgrading for ADS-B Out added additional GPS and WAAS with LPV Approach capabilities.
- Filings for VNAV Approach may suggest operators do not have operational exposure to VNAV Approach or do not have pilot training to support the use of the capability.

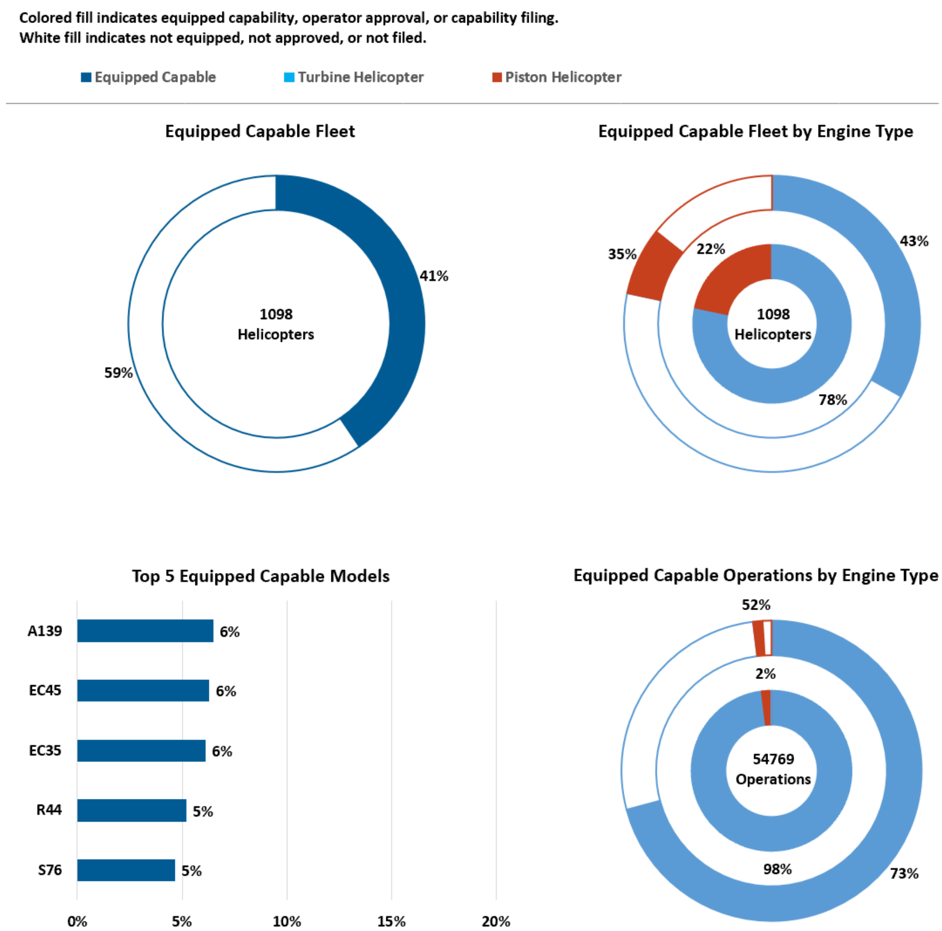
Forecast

- Trend is estimated to be flat.

Significant Factors

- Most helicopters do not fly IFR and/or have no operational use for VNAV Approach.

LPV Approach on Helicopter Fleet



Current State

- LPV aircraft are capable of flying vertically guided approaches, including both LPV and LNAV/VNAV line of minima on an instrument approach chart.
- Data sources other than IFR flight plans point to much higher equipage rates than are reflected in flight plan data.
- Equipage has increased as operators upgrading for ADS-B Out added additional GPS and WAAS with LPV Approach capabilities.
- Many new IFR flown helicopters have options for LPV Approach capability.
- Filings for LPV Approach may suggest operators do not have operational exposure to LPV Approach or do not have pilot training to support the use of the capability.

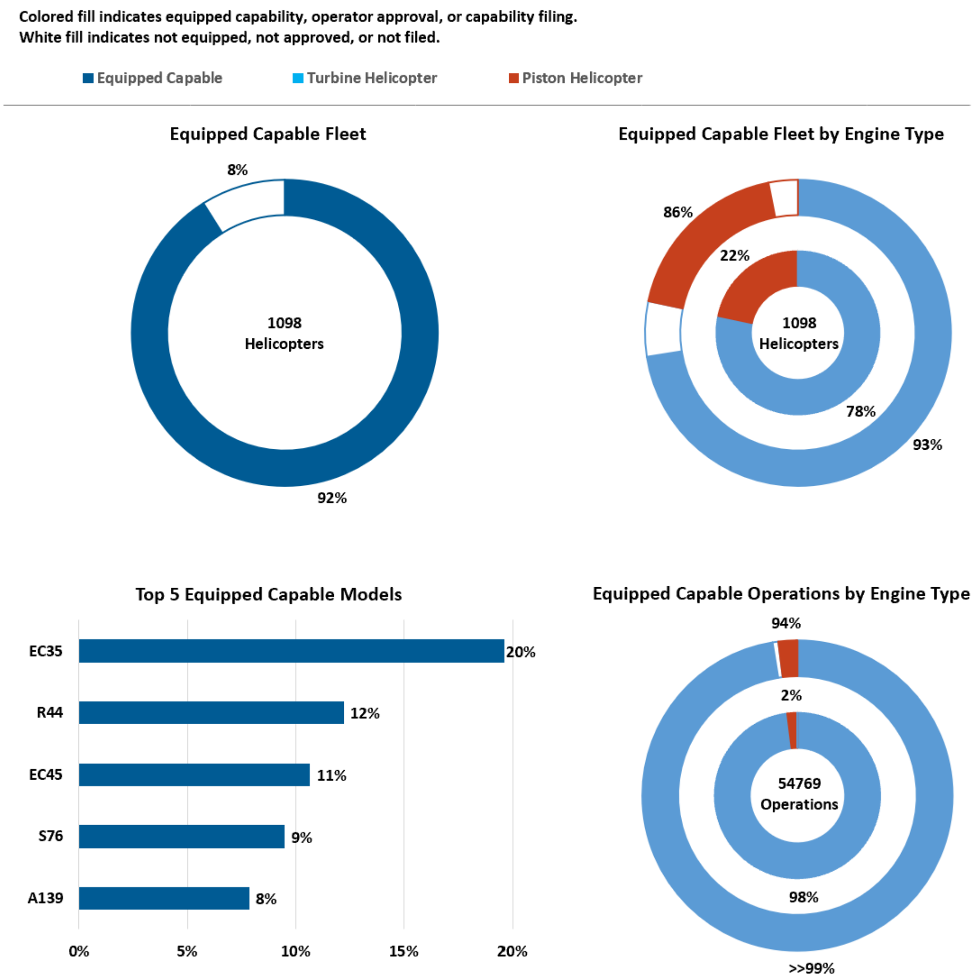
Forecast

- Trend is estimated to be flat.

Significant Factors

- Most helicopters do not fly IFR and/or have no operational use for LPV Approach.

RNP Approach on Helicopter Fleet



Current State

- Enabling equipage is GPS with RNP 0.3 approach capability.
- Data sources show a small decrease of three percent in equipped capability compared to previous reports. It is unclear if this is due to data inaccuracies in previous reports or a change in fleet composition, but it is likely due to COVID-19 fleet variations and IFR filings.
- GPS equipage exists in piston- and turbine-powered helicopters.
- Turbine-powered helicopters have higher RNP Approach equipage and fly more IFR operations than piston helicopters.

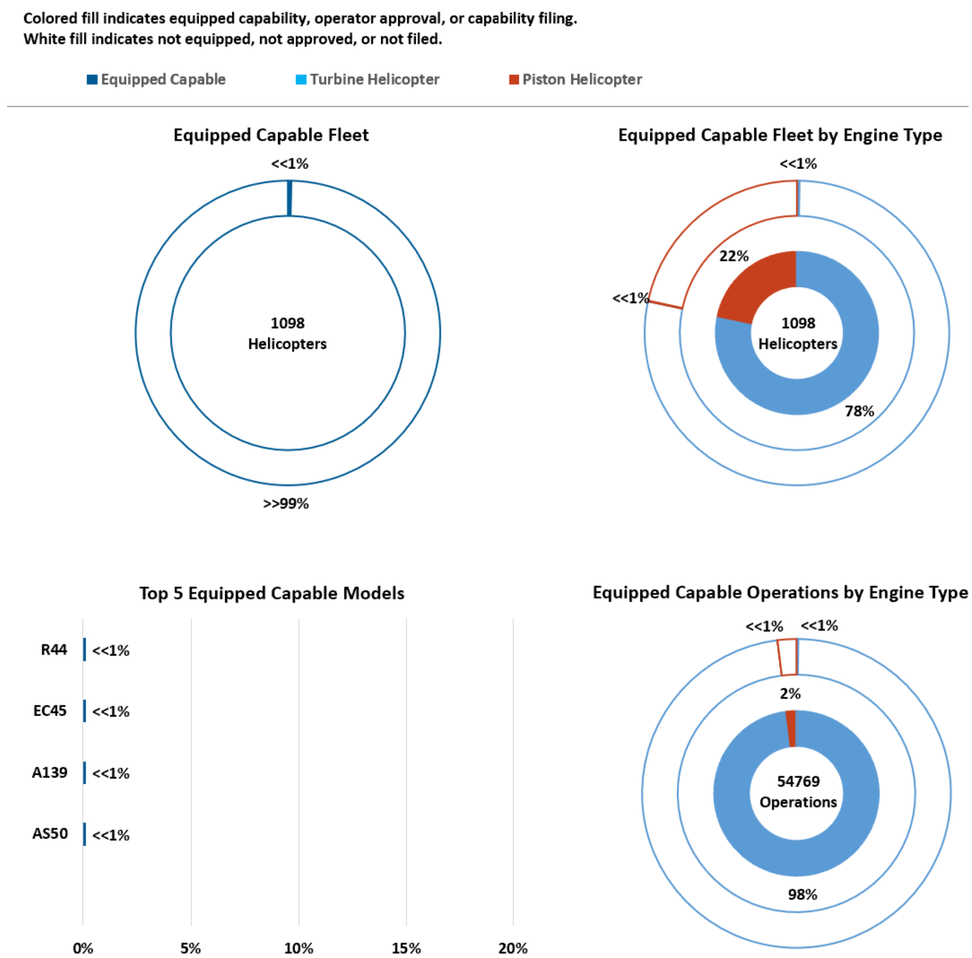
Forecast

- Trend is estimated to be flat.
- Flight plan filings for this capability have increased 26% compared to previous reports.
- Equipage occurs as new turbine-powered helicopters are being delivered standard with GPS. Piston helicopters have available options for GPS with RNP Approach capability.

Significant Factors

- Smaller, lighter, and less expensive avionics options may result in higher equipage rates.

RNP AR Approach on Helicopter Fleet



Current State

- Some helicopters, particularly large turbine-powered IFR flown units, have RNP AR Approach capability.
- Flight-plan analysis shows helicopters rarely file for RNP AR Approach, even if they may be equipped.
- Infrequent filings for RNP AR Approach may suggest operators do not have operational exposure to RNP AR Approach or do not have pilot training to support the use of the capability.

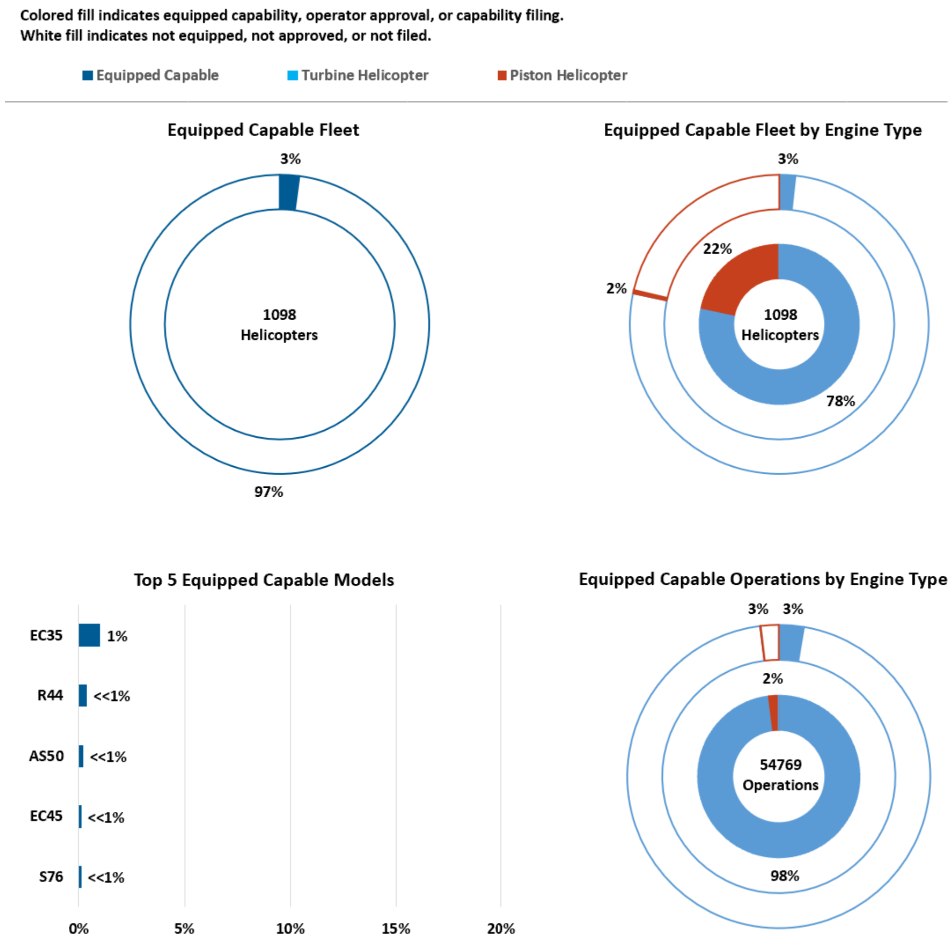
Forecast

- Trend is estimated to be flat.
- Small quantities of new turbine-powered helicopters are delivered standard with RNP AR Approach.

Significant Factors

- Most helicopters do not fly IFR and/or have no operational use for RNP AR Approach.
- Smaller, lighter, and less expensive avionics options may result in higher equipage.

GLS I on Helicopter Fleet



Current State

- Some helicopters, particularly large turbine-powered IFR flown units, have GLS I.
- Flight-plan analysis shows helicopters rarely file for GLS I, even if they may be equipped.
- Infrequent filings for GLS I may suggest operators do not have operational exposure to GLS I or do not have pilot training to support the use of the capability.

Forecast

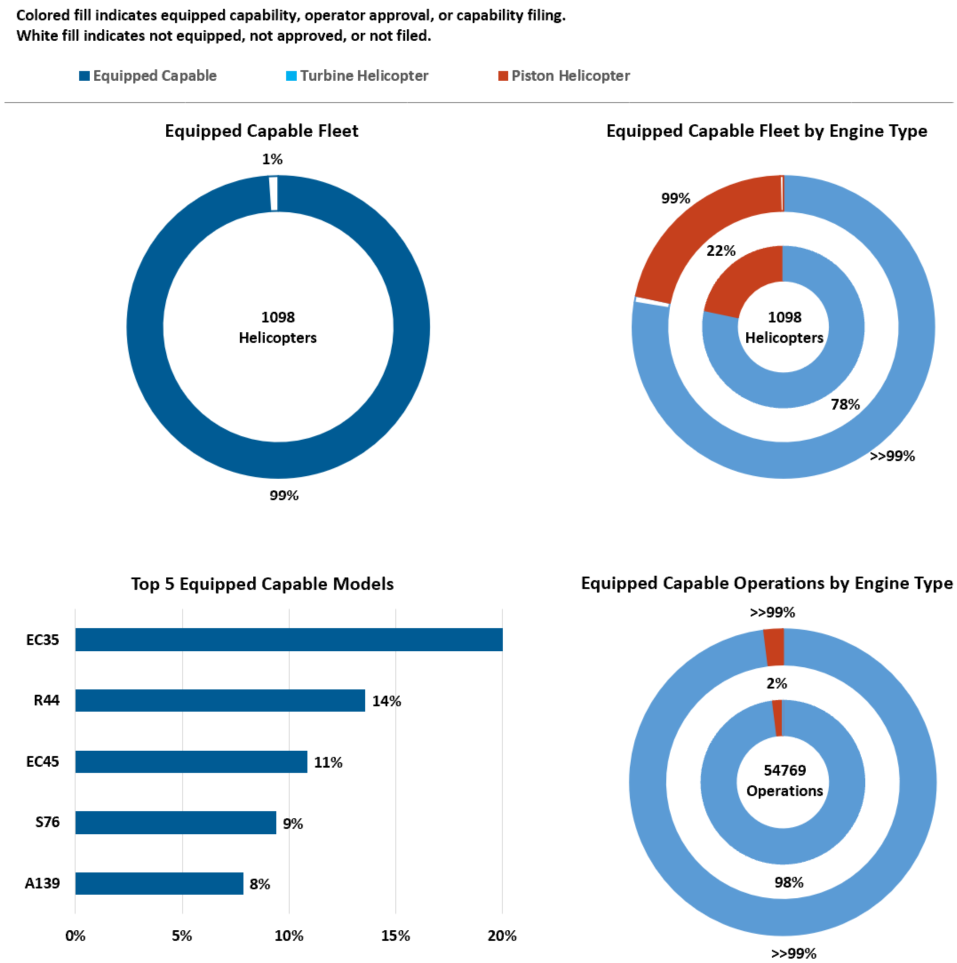
- Trend is estimated to be flat.
- Small quantities of new turbine-powered airplanes are delivered with GLS I.

Significant Factors

- Most helicopters do not fly IFR and/or have no operational use for GLS I.
- Cost, weight, and size constraints on helicopters makes forward-fit or retrofit avionics prohibitive for many operators.
- Smaller, lighter, and less expensive avionics options may result in higher equipage.

6.2.2 Automatic Dependent Surveillance-Broadcast Enablers for Helicopter

ADS-B Out on Helicopter Fleet



Current State

- Majority of IFR-operated helicopters with operational need to access ADS-B Out airspace equipped ahead of January 1, 2020 mandate, while a few helicopters had delayed installations and equipped just after rule implementation or were removed from operator fleets.
- Some equipage continues, but at much lower rates.
- Many operators equipping for ADS-B Out chose to equip with solutions that provide both ADS-B Out and ADS-B In for CDTI Applications.

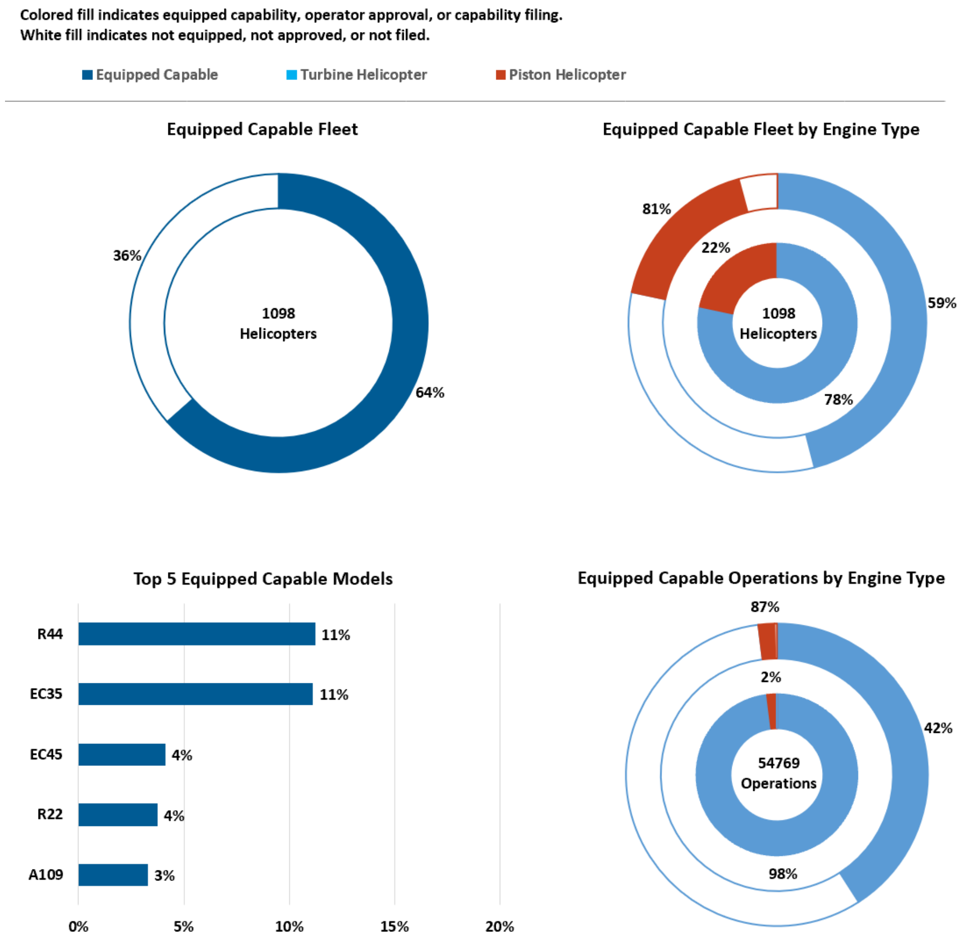
Forecast

- Trend is flat.

Significant Factors

- ADS-B Out equipage reports indicate some IFR-operated helicopters exercised options for LPV Approach capability and/or ADS-B In while upgrading for the ADS-B Out mandate.

ADS-B In – SA Apps on Helicopter Fleet



Current State

- Majority of IFR-operated helicopters with operational need to access ADS-B Out airspace equipped ahead of January 1, 2020 mandate, while a few helicopters had delayed installations and equipped just after rule implementation or were removed from operator fleets.
- Some equipage continues, but at lower rates than last year's report.
- Equipped Capability has increased 13% compared to last year's report.
- Many operators equipping for ADS-B Out chose to equip with solutions that provide both ADS-B Out and ADS-B In for CDTI Applications.

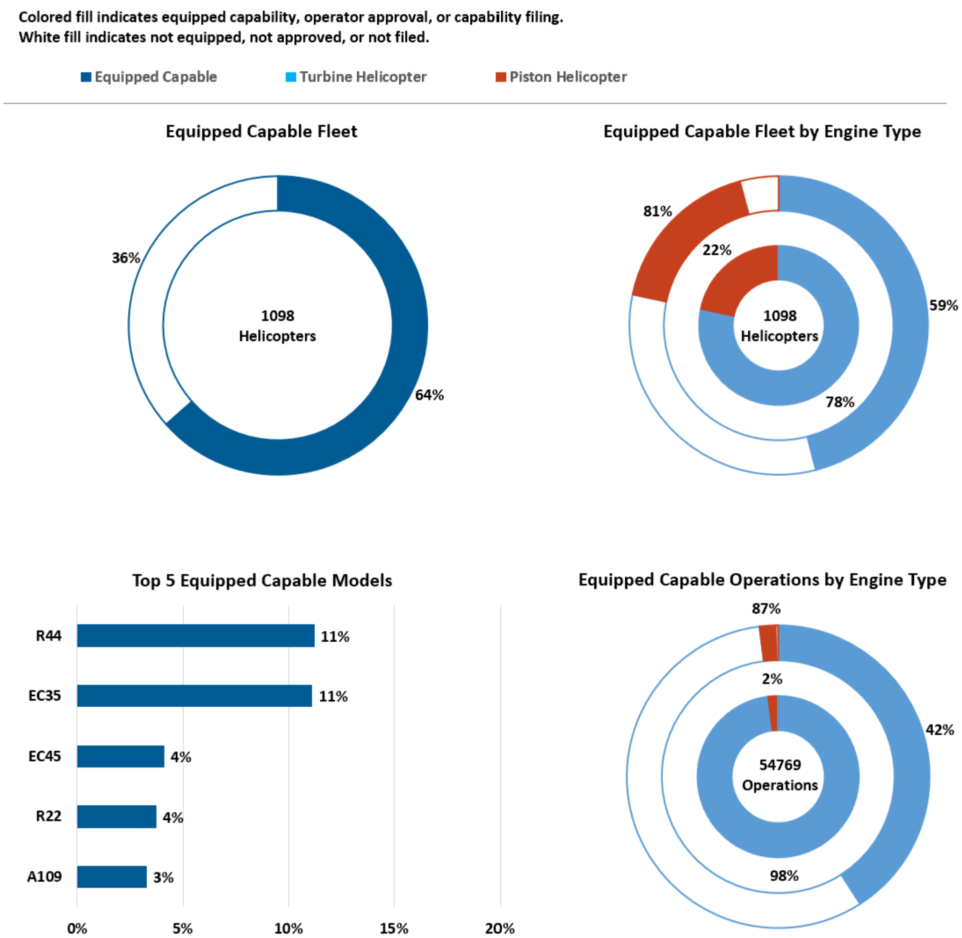
Forecast

- Trend is increasing.

Significant Factors

- Operators see the safety benefits of ADS-B In for SA through improved traffic awareness and weather in the cockpit and continue to strongly desire these capabilities.

ADS-B In – Approach Apps on Helicopter Fleet

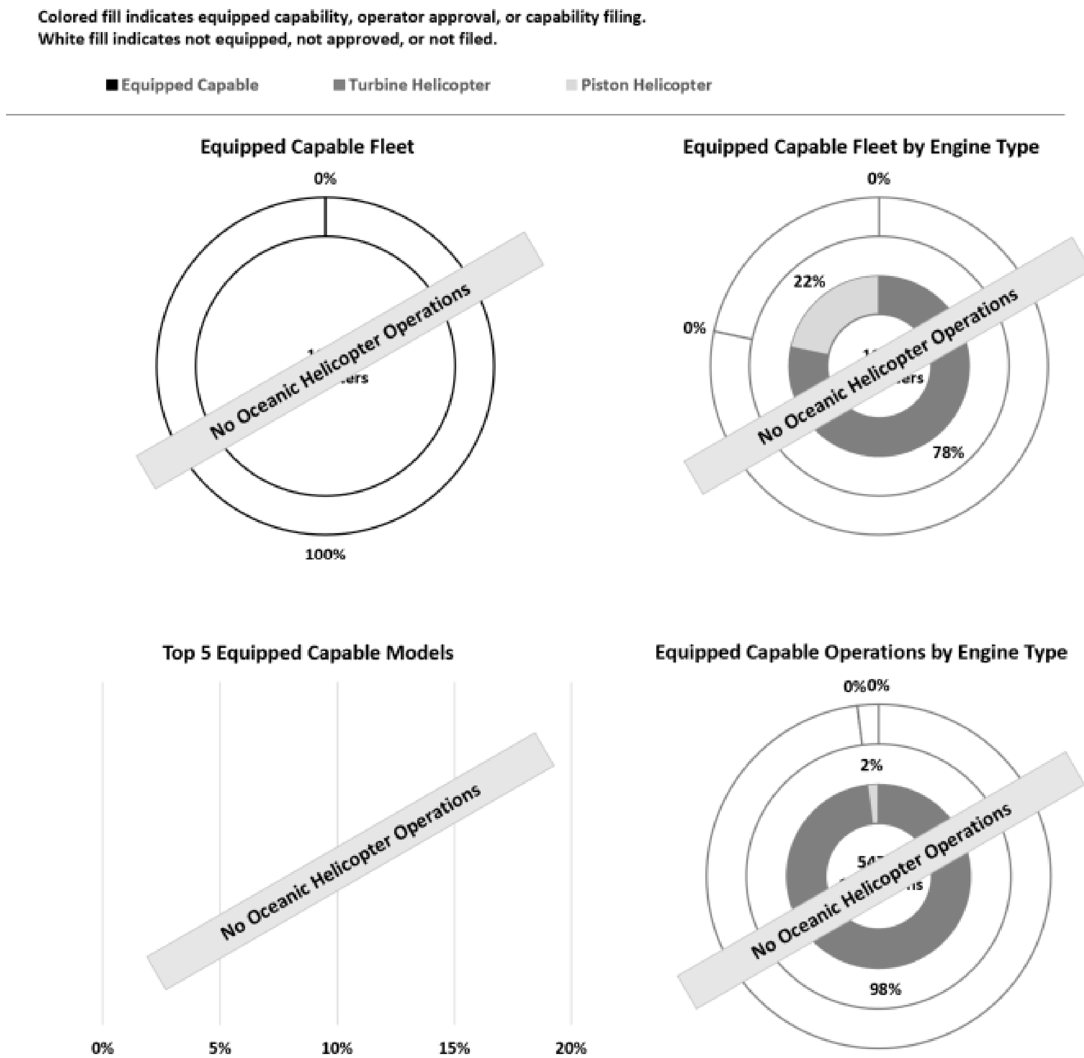


Current State
- ADS-B Out equipage does not contribute to ADS-B In capability.
- Current ADS-B In equipage is primarily in support of traffic awareness and weather in the cockpit.
- CAVS capable avionics and approach applications are not available for helicopters.

Forecast
- Trend is estimated to be flat.

Significant Factors
- ADS-B In approach applications offer improved capacity and efficiency in higher-density airports and airspace environments, but only small quantities of helicopters operate in these environments and would utilize CAVS approaches.
- Operators see the safety benefits of ADS-B In for SA through improved traffic awareness and weather in the cockpit and continue to strongly desire these capabilities.

ADS-B In – ITP Apps on Oceanic Helicopter Fleet



Current State

- ADS-B In for ITP applications is applicable to airplanes flying across the Atlantic and Pacific Oceans.
- Some helicopters do fly over water, typically in medevac, search and rescue, and oil services use, but rarely fly in oceanic airspace on a routine basis.

Forecast

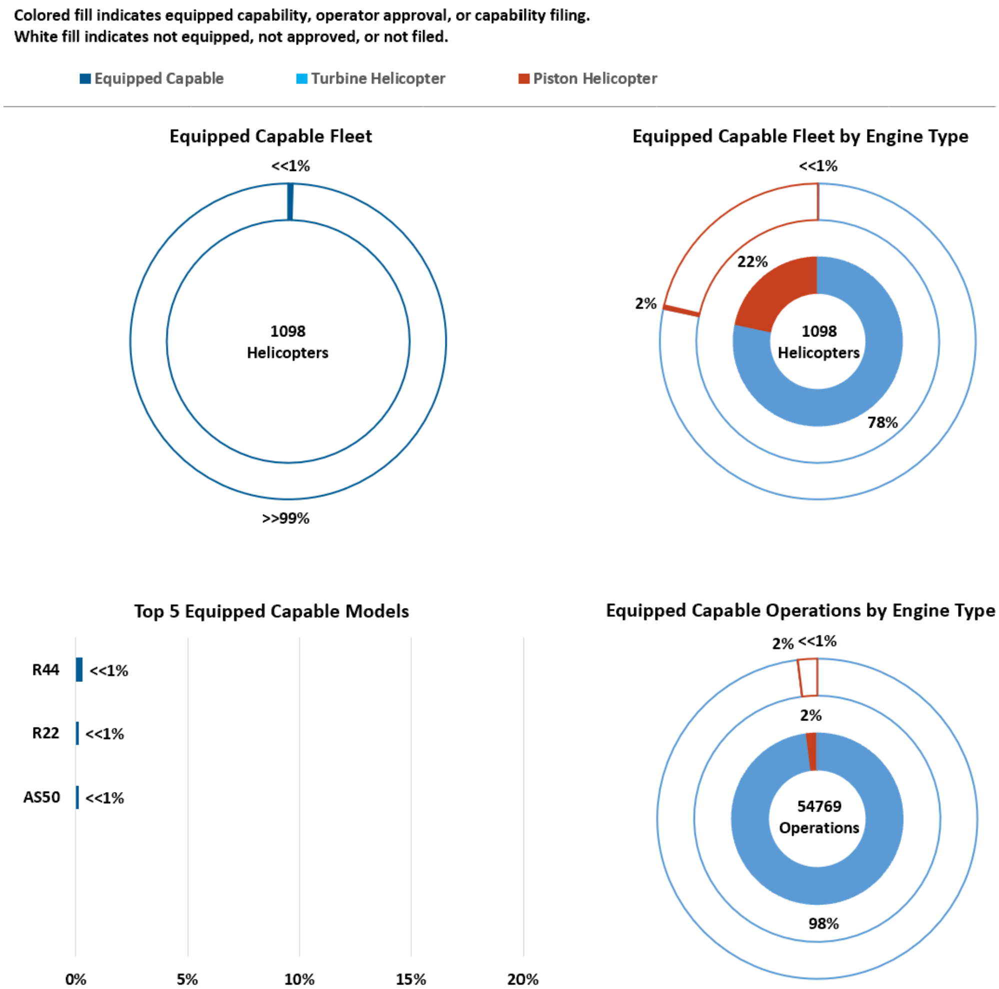
- Trend is estimated to be flat.
- Helicopters are not expected to be operating in oceanic airspace routinely.

Significant Factors

- If ITP applications were used in non-oceanic, overwater airspace, then helicopter equipage and capability would be more relevant for reporting purposes.

6.2.3 Data Communications Enablers for Helicopter

FANS 1/A Domestic – Tower Services on Helicopter Fleet



Current State

- FANS 1/A Domestic – Tower Services includes aircraft that are equipped with VDL Mode 0 or Mode 2.
- Equipage is negligible.
- Data suggests operators do not have operational exposure to FANS 1/A Domestic – Tower Services or do not have pilot training to support the use of the capability.

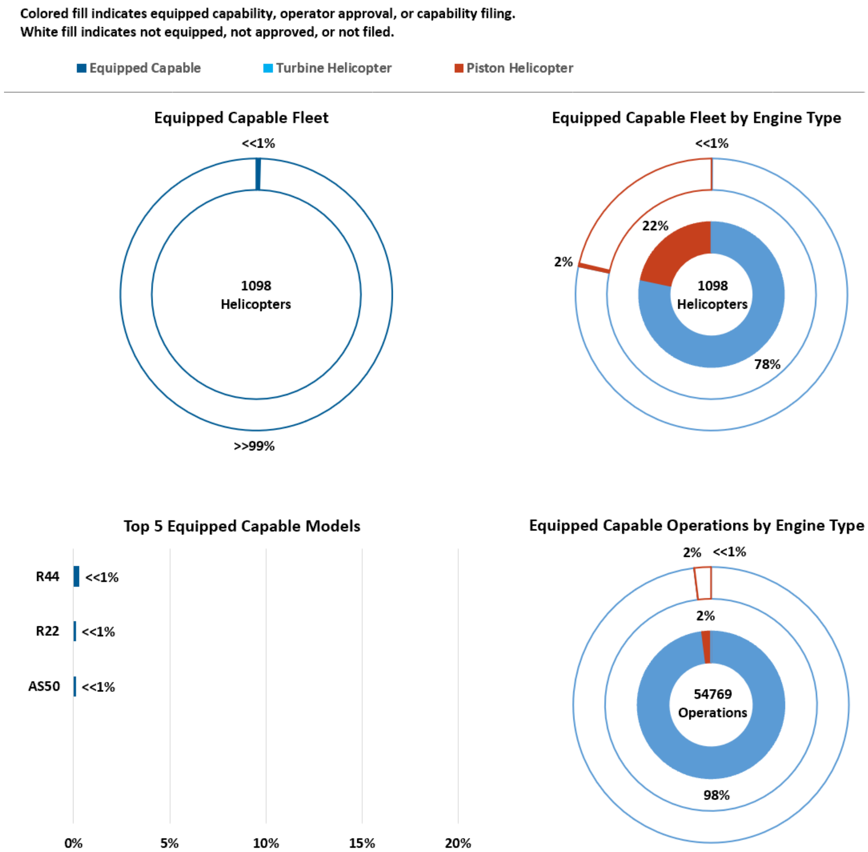
Forecast

- Trend is estimated to be flat.
- Helicopters are not expected to be routinely operating in areas where FANS 1/A equipage would be beneficial.

Significant Factors

- Most helicopters do not fly IFR and/or have no operational use for FANS 1/A.

FANS 1/A Domestic – En Route Services on Helicopter Fleet



Current State

- FANS 1/A Domestic – En Route Services includes aircraft that are equipped with VDL Mode 2.
- Equipage is negligible.
- Data suggests operators do not have operational exposure to FANS 1/A Domestic – En Route Services or do not have pilot training to support the use of the capability.

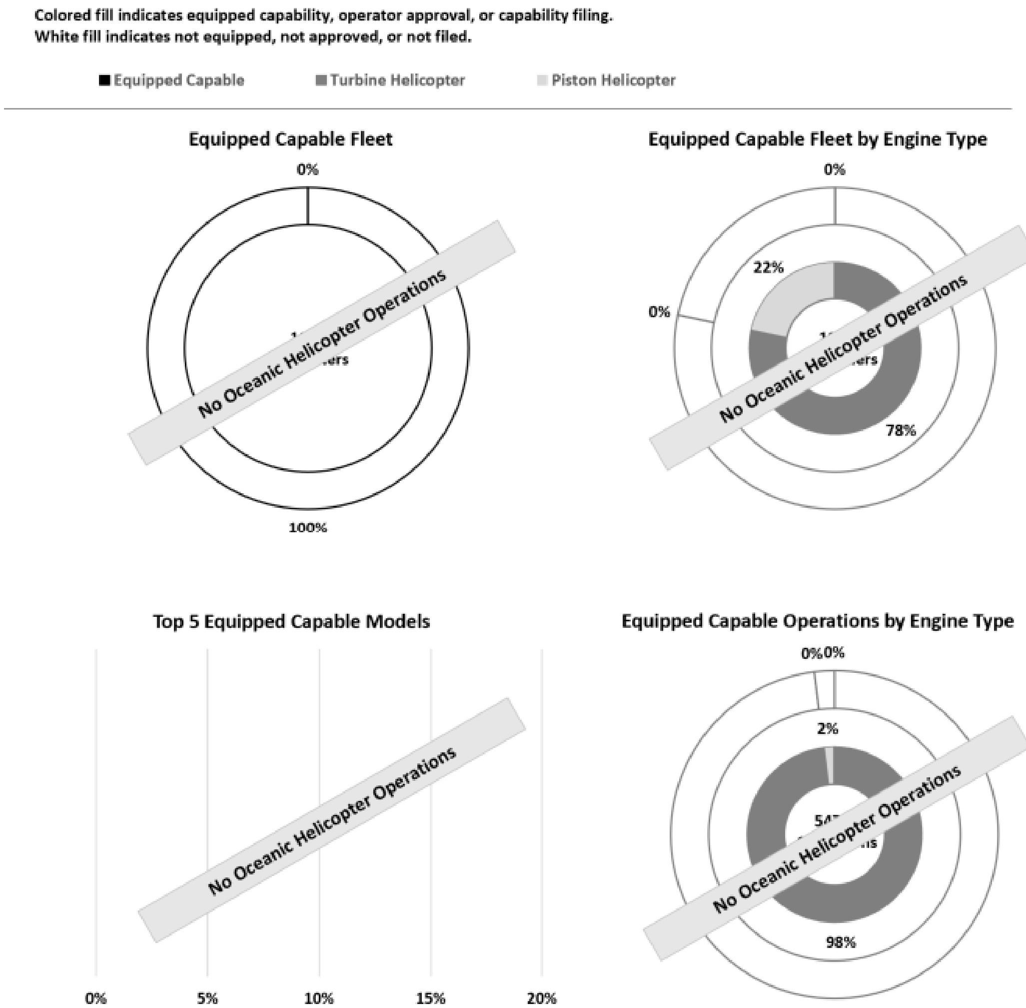
Forecast

- Trend is estimated to be flat.
- Helicopters are not expected to be routinely operating in areas where FANS 1/A equipage would be beneficial.

Significant Factors

- Most helicopters do not fly IFR and/or have no operational use for FANS 1/A.
- Cost, weight, and size constraints on helicopters make forward-fit or retrofit avionics prohibitive for many operators.
- The FAA Domestic Data Communications Program may result in some operators seeing potential benefits of equipping with FANS 1/A at airports where tower services are available.

FANS 1/A Oceanic on Oceanic Helicopter Fleet



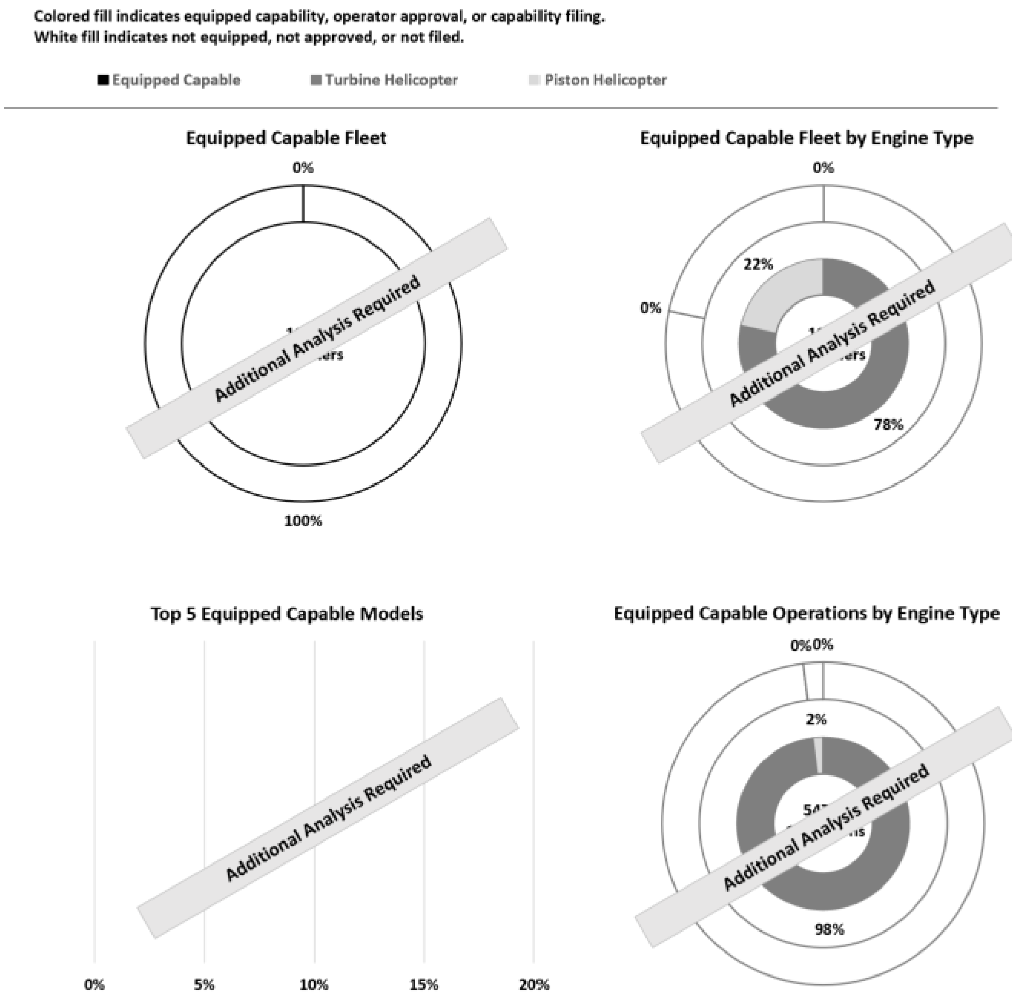
Current State
- Equipage is negligible.
- Data suggests operators do not have operational exposure to FANS 1/A Oceanic or do not have pilot training to support the use of the capability.
- Helicopters may have SATCOM in support of terrestrial operations rather than oceanic.

Forecast
- Trend is estimated to be flat.
- Helicopters are not expected to be operating in oceanic airspace routinely.

Significant Factors
- If FANS 1/A Oceanic were used in non-oceanic, overwater airspace, then helicopter equipage and capability would be more relevant for reporting purposes.

6.2.4 Low-Visibility Enablers for Helicopter

HUD Approach on Helicopter Fleet



Current State

- Low overall equipage rate. Equipage is primarily on turbine-powered helicopters where HUDs provide enhanced landing capability.
- Recent FAA regulatory efforts have improved IFR operational credit, which is considered by these operators as beneficial.

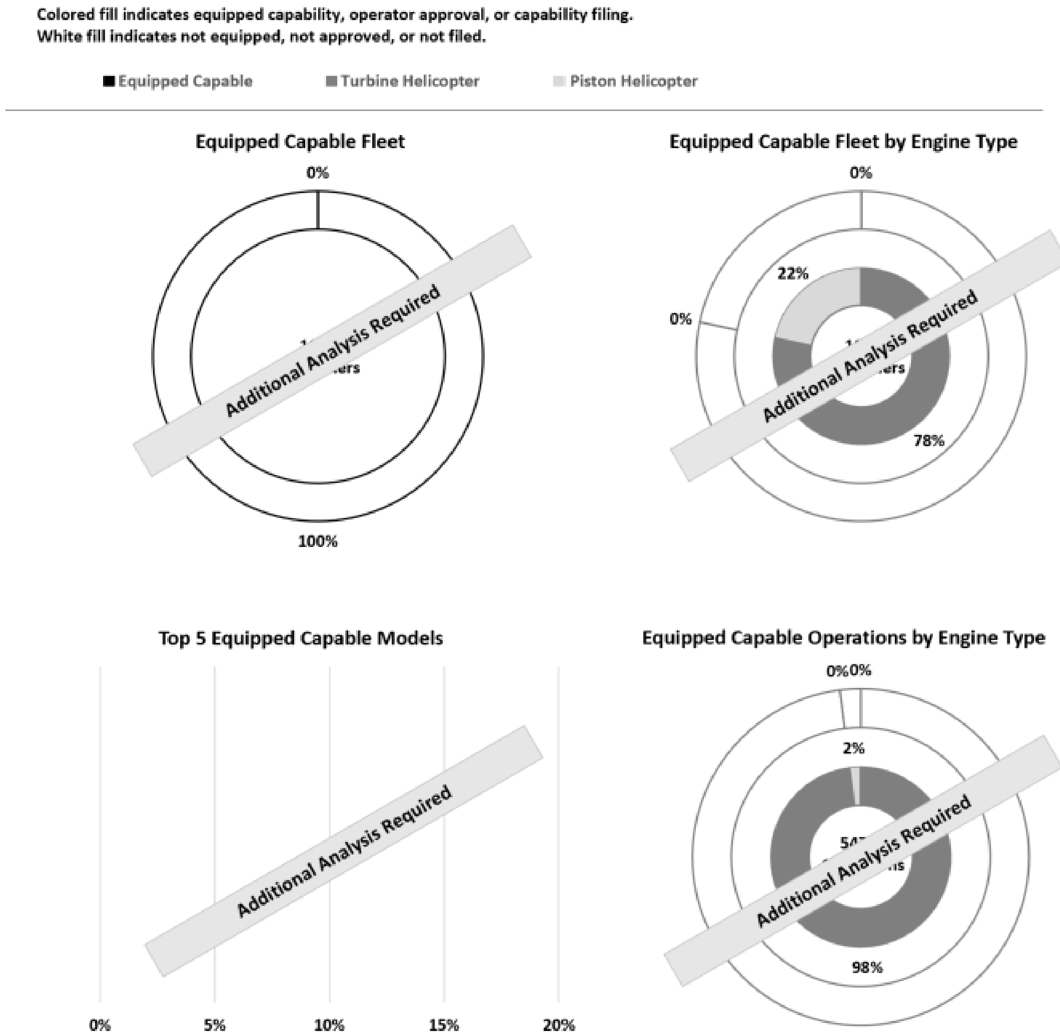
Forecast

- Trend is estimated to be flat.
- The majority of helicopters do not fly IFR and/or have no operational use for this expensive capability.

Significant Factors

- High cost is a significant barrier for many operators and lessors.
- Solutions coming to market without an IRU, along with smaller and lighter systems, improve the business case for a wider range of helicopters and operators.
- Evolving head-worn display avionics options may result in higher equipage rates.

EFVS on Helicopter Fleet



Current State

- Helmet-mounted EFVS, EFVS displayed on EFBs, and other display capabilities exist on many search and rescue, medevac, police, and other night/IFR-use helicopters.
- Low overall equipage rate. Equipage is primarily on turbine-powered helicopters where enhanced landing capability is provided by EFVS.
- Recent FAA regulatory efforts have improved IFR operational credit, which is considered by these operators as beneficial.

Forecast

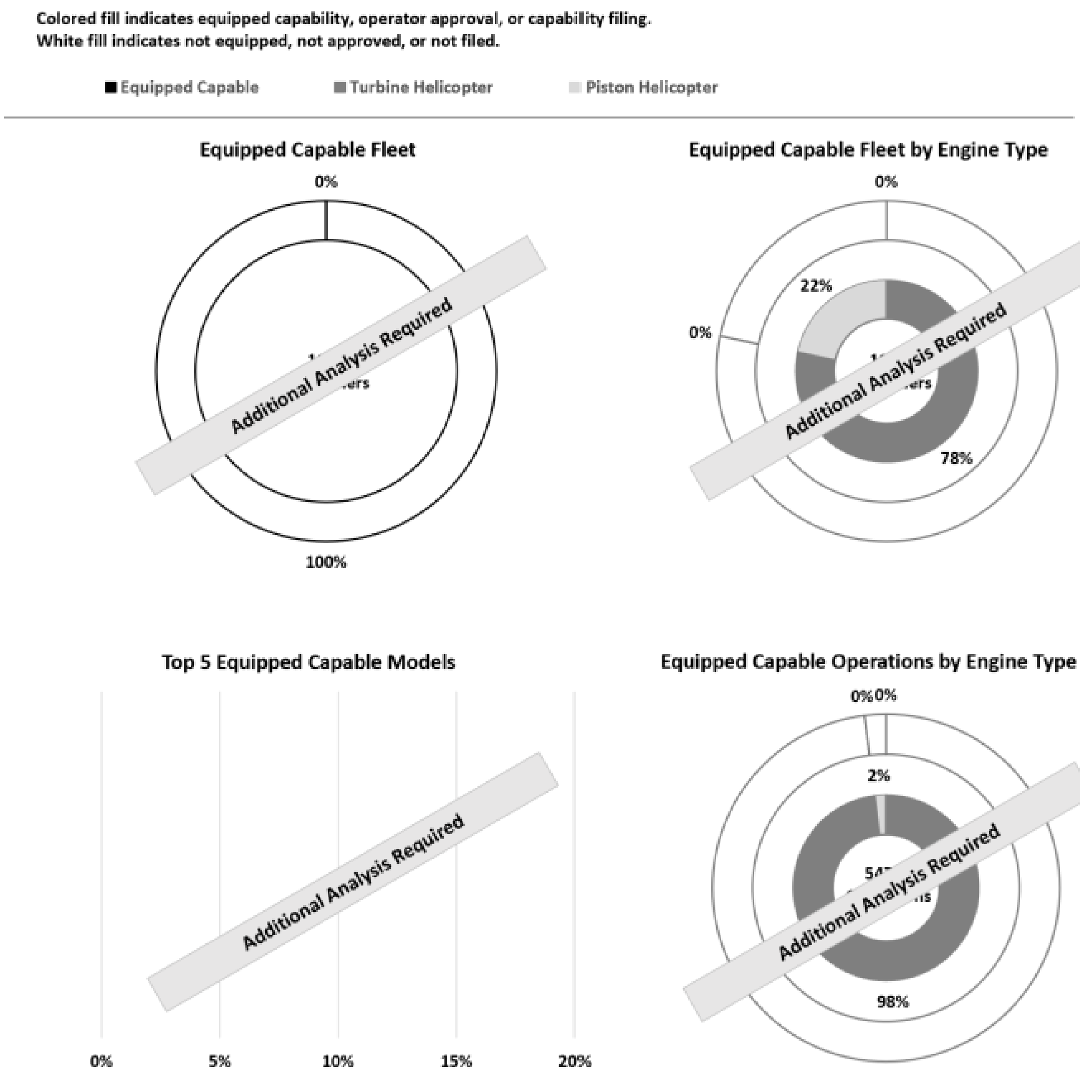
- Trend is estimated to be flat.
- Most helicopters do not routinely fly IFR and/or have limited operational use for EFVS, but improved safety is of great interest and could drive equipage.

Significant Factors

- System prices and physical size are decreasing, resulting in a more favorable business case for operators to pursue equipage.
- Operational benefits in low-visibility operations combining HUD with EFVS and other sensors/systems may improve the business case for some operators to equip.
- Evolving head-worn display avionics options may result in higher equipage rates.

6.2.5 Avionics Safety-Enhancement Enablers for Helicopter

EFB on Helicopter Fleet



Current State

- Many operators have adopted Apple iPad® and similar platforms into all helicopter types, including new airplanes with installed EFB systems.
- EFBs are being utilized for additional cockpit capabilities such as flight planning, live weather, and moving map displays.

Forecast

- Trend is estimated to be flat.
- Equipage occurs as new helicopters are delivered with option capability, while some mixed equipage will persist.

Significant Factors

- AAtS, live weather, CDTI, and potential for supplemental Data Comm type applications may leverage the low cost of EFBs as a computing device or display, resulting in higher equipage rates for EFBs and these other capabilities.

7 Aircraft and Avionics Technologies and Trends Watch List

In addition to the mature NextGen enablers captured in this report, MITRE tracks and assesses a watch list of less mature, but potentially impactful emerging fleet and avionics subjects. The accelerating pace of technology development across a broad range of aircraft and operator communities is resulting in quicker implementations of new technology in aircraft and avionics. This section is intended to provide insights on the evolving direction of aircraft, avionics, and capabilities that are not yet broadly available or adopted but could significantly shape the landscape of NextGen related aircraft capabilities and avionics over the next ten to fifteen years. MITRE monitors a wide range of data and trend information related to NextGen equipage. Additional information and potential aircraft fleet and capability impacts can be made available upon request to MITRE.

7.1 Connected Aircraft

Aircraft OEMs, avionics suppliers, and operators continue to evolve their aircraft connectivity architectures and capabilities. These evolutions are primarily driven by passenger connectivity demands and operator desires to improve passenger experiences. This demand for data exchange between the aircraft and the ground has been further bolstered by continued implementations of aircraft and engine health monitoring and the desire for enhanced flight deck capabilities. These passenger, aircraft monitoring, and improved flight deck capabilities when combined are supporting positive business cases for operators to continue to implement and improve connected aircraft systems. All of this allows for more data collection, aggregation, and exchange between ground and aircraft, and thus supports the connected aircraft and hyper connected aircraft concepts.

Key avionics architectural elements enabling these connected aircraft systems are commercial terrestrial and satellite air to ground communications systems, aircraft servers, aircraft smart routers, and installed and not installed Electronic Flight Bags. From a NextGen and evolving National Airspace System perspective, EFB with aircraft integration and expanding availability of SATCOM systems are significant enablers. Aircraft continue to be forward-fit and retrofit with not installed and installed EFB systems with both one way and two way connectivity to avionics systems. Connectivity is enabled by wired architectures leveraging Aircraft Interface Devices and Quick Access Recorders, and also by wireless implementations using Blue tooth–type technologies. Expansion of commercial terrestrial links such as 5G is being complemented by expanding SATCOM offerings such as StarLink. Many of these new enabled capabilities are non-safety services and thus lower levels of certification are required, resulting in simpler certification and approvals and corresponding lower costs for implementation. These expanded connected aircraft capabilities are being implemented on a wide range of aircraft, including those used in Air Transport, Foreign Carrier, Air Taxi, Corporate GA and Helicopter fleet operations, meaning there are many potential opportunities to enhance NAS operations by leveraging these capabilities.

These emerging air–ground flight deck and avionics data exchange capabilities support NextGen and future NAS operations, particularly the move toward Trajectory Based Operations (TBO). These connected aircraft systems, particularly the installed and not installed EFB with ground connectivity, allow for aircraft to improve their operational capabilities with minor or no changes to their Flight Management or other systems. One example of a capability that benefits from these architectures is Extended Projected Profile (EPP) information. For aircraft that have limited ability to compute and transmit FMS-generated next waypoints flight plan information to support TBO using EPP, EFBs with connectivity could significantly increase the quantity of aircraft able to execute these operations.

7.2 New Aircraft Entrants

As reported in previous versions of this annual report, MITRE has been tracking aircraft and avionics evolution in the context of Part 91 piston airplane, helicopter, and experimental aircraft avionics technologies with potential for insertion in other categories of aircraft (e.g., large air transport). Included below are examples of further new entrant developments in 2022.

Unmanned Aircraft Systems (UAS) and AAM. New entrant aircraft are continuing to progress rapidly, with new designs and market offerings being announced at an elevated pace compared to the pre-pandemic pace. These new aircraft designs often include unique propulsion systems and are designed to support new operations such as Advanced Air Mobility and supersonic flight. These aircraft are planned to include high degrees of technologies and automation systems that support NextGen and the evolution toward more automated flight. In the case of AAM, their operations will likely be similar to current helicopter flight profiles, but with expected reduced operating costs and improved safety features. These new aircraft designs have gathered the attention of U.S. and global operators of passenger and cargo airlines. With the development of economically viable aircraft concepts, in 2022 the need to move toward certificated operators to provide initial UAS and AAM service moved forward, with five companies gaining 14 CFR Part 135 on-demand charter authorization (Wing, UPS Flight Forward, Amazon, Zipline, and Joby). Additionally, the Department of Defense has contracted for the purchase of UAM aircraft, improving the likelihood that these aircraft increase their footprint in NAS operations in 2023 and beyond.

Reintroduction of Supersonic Aircraft to Commercial Passenger Service. In June 2021, United Airlines announced they would purchase 15 Boom Supersonic Overture passenger airliners for introduction to fleet service in 2029, as well as options for 35 additional aircraft. As of August 2022, American Airlines has committed to the purchase of 20 Overture supersonic passenger airliners, with options for another 40 aircraft – all conditional on the aircraft meeting specific safety, operational, and sustainability requirements prior to first delivery. If successful, the introduction of the Overture to service would mark the first return of supersonic passenger service since Air France and British Airways transatlantic passenger service using the Aerospatiale/BAC Concorde was terminated in 2003. Research continues as to suitability for use on domestic, over-land routes of the low-boom supersonic technologies originally researched by the National Aeronautics and Space Administration (NASA). The premise is that ground-level sound pressure values may be low enough to allow routine supersonic Mach 1 flight over land in the U.S. In February 2021, the FAA’s final rule on a modernized procedure to obtain Special Flight Authorizations (SFA) for operations in excess of Mach 1 over land in the U.S. took effect, significantly reducing the complexity and time required to obtain an SFA. How the aircraft will ultimately change or impact NAS operations and support NextGen operations is unclear. It can be presumed the aircraft will have highly capable avionics systems and thus be capable of many NextGen operations, but aircraft performance characteristics might constrain the aircraft for some NextGen operational capabilities.

7.3 Evolving Avionics Designs for Radio Frequency Interference and Spectrum Evolution

The evolving use of spectrum both in the U.S. and globally, coupled with legacy and evolving aircraft technologies, has heightened awareness of the potential for radio frequency interference (RFI) on avionics systems. Examples of potential system impacts from RFI include radar altimeters, MMM/GPS receivers, and other onboard systems. This is resulting in near-term and longer-term equipage plans, which can either enhance aircraft capabilities to support future NAS operations, or have a negative impact. Enhancements could come from temporarily removing aircraft from revenue service for spectrum-related improvements, allowing for other avionics modifications at the same time, or through improved technologies such as Dual Frequency Multi-Constellation upgrades that could enhance aircraft abilities to fly GNSS procedures. Conversely, negative impacts may occur if the need to invest in new equipment that provides RFI protections detracts from operator and OEM abilities to invest in future NAS and NextGen related capabilities.

In 2021 and 2022, significant attention has been given to the potential impacts of RFI from 5G signals on aircraft radar altimeters, and the need for a balanced approach to improving telecommunications systems while minimizing aircraft operational impacts and ensuring continued high levels of aviation safety. The need to ensure this co-existence between evolving spectrum technologies and uses with aviation stakeholders has resulted in extensive collaboration between the U.S. government, the telecommunications industry, and the aviation industry. The potential impact of 5G RFI has resulted in some aircraft modifying their radar altimeter systems for improved performance, while industry groups like RTCA work on longer-term standards for robustness.

Complementary Position, Navigation, and Timing (C-PNT). GPS continues to be a foundational enabling technology for critical infrastructure, including aviation, and ensuring its resiliency has emerged as a major concern for all stakeholders who could be affected by service interruptions or denials. Many aircraft systems depend on GPS-derived position, navigation and timing. The aircraft system impacts and corresponding operational capabilities include communications, navigation, surveillance, and other systems. Although aircraft are certified to operate safely without GPS signals, normal operations are highly dependent on RNAV and RNP using GPS to achieve operator schedules. That reality, along with growing concern over the potential for signal jamming and spoofing, has prompted stakeholders to examine alternative technologies that support GPS resiliency and continuity of operations in a degraded environment. Any improvement operators make toward more resilient operations, driven from domestic U.S. need or international requirements, will benefit NextGen. The benefits may extend beyond the immediate motivation for operator schedule integrity to a wider range of potential uses of resilient avionics to improve access, safety and equity. MITRE is actively involved in alternative C-PNT studies, as well as tracking other activities related to C-PNT that may have direct impact on MMR and other avionics systems evolution that would positively impact NextGen implementation.

Spectrum Management. RTCA established SC-242, Spectrum Management in December 2021 to – with coordination with EUROCAE Working Group 124 - collect relevant information and produce a report on current RTCA and EUROCAE aeronautical standards for RF systems and the RF performance documented in those standards, identifying potential variations in how such performance is documented. The committee was tasked with three products: for December 2022, to develop high-level material to assist non-aviation stakeholders to understand how aeronautical RF systems are used and the performance necessary (e.g. availability, reliability, continuity, latency, etc.) for safety-of-life functions and how they fit into the overall management of airspace, for December 2023, a primer on aeronautical radio frequency systems, there regulatory framework, and operational considerations, and for June, 2024, a spectrum guidance document for developers of standards for aviation wireless systems (DO-XXX).

Dual Frequency Multi Constellation (DFMC) and Multi Frequency Multi Constellation (MFMC). DFMC and MFMC capabilities exist in ground systems for precision users today. Those capabilities are planned for incorporation into aircraft MMR/GPS avionics in the next decade. Operators expect the addition of DFMC and MFMC, particularly when paired with software defined radios, to provide them with improved accuracy, redundancy, and resiliency. Additionally, DFMC and MFMC capability will allow operators to comply with future global requirements for specific GNSS signals to be used in a variety of locations.

As these technologies continue to evolve, they are becoming more capable, less costly, and more space efficient, which – when coupled with ever evolving operational benefits provided to operators – are positively impacting the business case for new MMR/GPS avionics. These new designs allow for improved resiliency and, ultimately, are expected to provide improved operational and safety performance. It should be noted that this evolution of MMR/GPS avionics and their signals may also result in new and unexpected challenges to GPS/GNSS resiliency. An example of this type of challenge is when new avionics and uses of signals may create unintended hazards or errors due to shortcomings in designs or a lack of understanding of the interaction between connected avionics systems. MITRE recommends continued tracking of MMR/GPS/GNSS evolution and the resultant aircraft capabilities to ensure aviation stakeholders can properly plan for new and improved GNSS operations while balancing and mitigating the implications of GNSS signal loss or disruption.

7.4 Pilot Shortages

Business drivers to fleet evolution, such as industry mergers and acquisitions, as well as evolution of operator and supplier business models are complicating fleet rationalization plans , with significant impact seen in 2022 from widespread early and age-related mandatory retirements of commercial airline pilots. Both trends contributed to widespread flight cancellations due to crew shortages during the 2022 summer vacation air travel season. In addition, four new airlines commenced operations in 2022, placing further stress on air carrier to find and hire qualified flight crew members in a tightening cockpit crew labor market. The strategic business analysis company Oliver Wyman noted a need for nearly 8,000 new pilots for U.S. carriers, and a near 30,000 new pilot shortfall by 2032 absent either maximum age, minimum qualification, or other regulatory relief for Part 121 operators. This shortage of air carrier pilots results in accelerated hiring from the available pool of Part 135 and Part 91 corporate operators, shrinking the pool of available pilots in those NAS operator segments as well. Thus, air transport pilot shortages are quickly reflected in pilot shortages across other segments of the professional pilot community.

Some air carriers, on seeing the increasing level of difficulty in hiring qualified pilots, have committed to filling cockpit seats with ab initio training program graduates (an approach long employed by international operators). Others such as SkyWest – noting the differences in crew minimum qualification requirements between on-demand charter and scheduled air carrier operations – have sought to expand into 14 CFR Part 135 operations with reconfigured CRJ-200 aircraft to both tap into the booming air charter market and provide a steady pipeline of company-trained pilots to their 14 CFR Part 121 operation. If passed and signed into law, legislation recently introduced in the U.S. Congress to raise the maximum pilot retirement age from the current age 65 to age 67 would provide some temporary relief to the industry, but MITRE expects the current pilot shortage to impact airline operations, fleet mix decisions, and route structure decision-making for the next several years and possibly through the mid-2030s.

Appendix A Enabler References

A.1 Performance Based Navigation Enablers

RNP 4 with Oceanic Comms

Active IFR Oceanic Fleet	• For this analysis, the oceanic fleet consists of airplanes that are observed in Advanced Technologies and Oceanic Procedures (ATOP) data flying in oceanic regions • RNP 4 approval governed by OpSpec B036: Oceanic and Remote Continental Navigation Using Multiple Long-Range Navigation Systems (LRNS) • Oceanic SATCOM approval governed by OpSpec A056: Data Link Communications • For fuller treatment of SATCOM references, see FANS 1/A Oceanic
A Air Transport Fleet	• OpSpec B036: Oceanic and Remote Continental Navigation Using Multiple Long-Range Navigation Systems (LRNS) • 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 (3/7/2016) • AC 20-138D (including Change 2) – Airworthiness Approval of Positioning and Navigation Systems (4/7/2016) • High-confidence data from Flight Plan for airplanes filing “L1 – RNP 4”
B Air Taxi Fleet	• Applicable OpSpec B036: Oceanic and Remote Continental Navigation Using Multiple Long-Range Navigation Systems (LRNS)
C Foreign Carrier Fleet	• There is no current approval document available for RNP 4 on the Foreign Carrier oceanic fleet
D Corporate/GA Fleet	• Applicable LOA B036: Oceanic and Remote Continental Navigation Using Multiple Long-Range Navigation Systems (LRNS)
H Helicopter Fleet	• Oceanic enablers not applicable for helicopters

RNAV 1

Active IFR Fleet	
A Air Transport Fleet	• OpSpec C063: Area Navigation (RNAV) and Required Navigation Performance (RNP) Terminal Operations • Medium-confidence data because OpSpec C063 specifies make, model, and series but not serial number/tail level, producing partial potential fleet equipage inaccuracy • AC 90-100A (including Change 2) – U.S. Terminal and En Route Area Navigation (RNAV) Operations (4/14/2015) • AC 20-138D (including Change 2) – Airworthiness Approval of Positioning and Navigation Systems (4/7/2016) • RNAV 1 Terminal Only assumptions = a GPS Navigator with approach capability or a Flight Management Computer (FMC) integrated with multi-scan DME/DME and/or GPS
B Air Taxi Fleet	• Applicable OpSpec C063: Area Navigation (RNAV) and Required Navigation Performance (RNP) Terminal Operations

C	Foreign Carrier Fleet	• Applicable OpSpec C063: IFR RNAV 1 Departure Procedures (DP) and Standard Terminal Arrivals (STAR) – U.S. Airports (Optional)
D	Corporate/GA Fleet	• Applicable LOA C063: Area Navigation (RNAV) and Required Navigation Performance (RNP) Terminal Operations
H	Helicopter Fleet	• Applicable OpSpec H123: Class I Navigation Using Area or Long-Range Navigation Systems with Wide Area Augmentation System (WAAS) for Rotorcraft Required Navigation Performance (RNP) 0.3 En Route and Terminal Operations.

RNAV 2

Active IFR Fleet

A	Air Transport Fleet	• OpSpec B035: Class I Navigation in U.S. Class A Airspace Using Area or Long-Range Navigation Systems • Medium-confidence data because OpSpec B035 specifies make, model, and series but not serial number/tail level, producing partial potential fleet equipage inaccuracy • AC 90-100A (including Change 2) – U.S. Terminal and En Route Area Navigation (RNAV) Operations (4/14/2015) • AC 20-138D (including Change 2) – Airworthiness Approval of Positioning and Navigation Systems (4/7/2016) • RNAV 2 assumptions = a GPS Navigator with en route capability or an FMC integrated with multi-scan DME/DME or GPS. This is the basic system requirement used in this report when considering RNAV 2 capability. It is acknowledged that in some cases where gaps in DME coverage exist and a route is not labeled “GNSS REQUIRED,” IRU equipment would also be needed.
B	Air Taxi Fleet	• Applicable OpSpec B035: Class I Navigation in U.S. Class A Airspace Using Area or Long-Range Navigation Systems
C	Foreign Carrier Fleet	• Applicable OpSpec B035: Class I Navigation En Route in U.S. Airspace Using Area or Long-Range Navigation Systems (Optional for Foreign Air Carriers Operating to the United States)
D	Corporate/GA Fleet	• Applicable LOA B035: Class I Navigation in U.S. Class A Airspace Using Area or Long-Range Navigation Systems
H	Helicopter Fleet	• Applicable OpSpec H123: Class I Navigation Using Area or Long-Range Navigation Systems with Wide Area Augmentation System (WAAS) for Rotorcraft Required Navigation Performance (RNP) 0.3 En Route and Terminal Operations.

RNP 1 with RF

Active IFR Fleet

A	Air Transport Fleet	• OpSpec C063: Area Navigation (RNAV) and Required Navigation Performance (RNP) Terminal Operations • Alternatively, OpSpec C384: Required Navigation Performance Procedures with Authorization Required • Medium-confidence data because OpSpecs C063 and C384 specify make, model, and series but not serial number/tail level, producing partial potential fleet equipage inaccuracy

		• Note: OpSpec B034: IFR Class I Terminal and En Route Navigation Using Area Navigation Systems provides RNP 1 authorization, but does not specifically authorize RF paths • 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, Appendices H and I (3/7/2016) • AC 20-138D (including Change 2) – Airworthiness Approval of Positioning and Navigation Systems (4/7/2016) • RNP 1 with Curved Path assumptions = an RNP able FMC capable of outputting and displaying RF leg, integrated with multi-scan DME/DME and GPS sensors
B	Air Taxi Fleet	• OpSpec C063: Area Navigation (RNAV) and Required Navigation Performance (RNP) Terminal Operations • Alternatively, OpSpec C384: Required Navigation Performance Procedures with Authorization Required
C	Foreign Carrier Fleet	• OpSpec C063: IFR RNAV 1 Departure Procedures (DP) and Standard Terminal Arrivals (STAR) – U.S. Airports (Optional) • Alternatively, OpSpec C384: RNP AR – Area Navigation (RNAV) Required Navigation Performance (RNP) Authorization Required (AR) (Optional for Foreign Air Carriers Operating to the United States)
D	Corporate/GA Fleet	• LOA C063: Area Navigation (RNAV) and Required Navigation Performance (RNP) Terminal Operations • Alternatively, LOA C384: Required Navigation Performance Procedures with Authorization Required
H	Helicopter Fleet	• Applicable OpSpec H123: Class I Navigation Using Area or Long-Range Navigation Systems with Wide Area Augmentation System (WAAS) for Rotorcraft Required Navigation Performance (RNP) 0.3 En Route and Terminal Operations.

RNP 1 with TF

Active IFR Fleet

A	Air Transport Fleet	• OpSpec C063: Area Navigation (RNAV) and Required Navigation Performance (RNP) Terminal Operations • Note: OpSpec B034: IFR Class I Terminal and En Route Navigation Using Area Navigation Systems provides RNP 1 authorization, but does not specifically authorize TF paths • 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 (3/7/2016) • AC 20-138D (including Change 2) – Airworthiness Approval of Positioning and Navigation Systems (4/7/2016) • RNP 1 with Track to Fix assumptions = an RNP able FMC capable of outputting and displaying TF leg, integrated with multi-scan DME/DME and GPS sensors
B	Air Taxi Fleet	• OpSpec C063: Area Navigation (RNAV) and Required Navigation Performance (RNP) Terminal Operations
C	Foreign Carrier Fleet	• OpSpec C063: IFR RNAV 1 Departure Procedures (DP) and Standard Terminal Arrivals (STAR) – U.S. Airports (Optional)

D Corporate/GA Fleet	• LOA C063: Area Navigation (RNAV) and Required Navigation Performance (RNP) Terminal Operations
H Helicopter Fleet	• Applicable OpSpec H123: Class I Navigation Using Area or Long-Range Navigation Systems with Wide Area Augmentation System (WAAS) for Rotorcraft Required Navigation Performance (RNP) 0.3 En Route and Terminal Operations.

VNAV Approach

Active IFR Fleet

A Air Transport Fleet	• OpSpec C073: Vertical Navigation (VNAV) Instrument Approach Procedures (IAP) Using Minimum Descent Altitude (MDA) as a Decision Altitude (DA)/Decision Height (DH) • Alternatively, OpSpec C384: Required Navigation Performance Procedures with Authorization Required • Medium-confidence data because OpSpecs C073 and C384 specify make, model, and series but not serial number/tail level, producing potential fleet equipage inaccuracy, while some operators utilize C052 for VNAV authorization at a make and model level • 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 (3/7/2016) • AC 20-138D (including Change 2) – Airworthiness Approval of Positioning and Navigation Systems (4/7/2016) • VNAV assumptions = FMC with baro-VNAV, Vertical Path Following Guidance regardless of ability to couple to the path
B Air Taxi Fleet	• Applicable OpSpec C073: Vertical Navigation (VNAV) Instrument Approach Procedures (IAP) Using Minimum Descent Altitude (MDA) as a Decision Altitude (DA)/Decision Height (DH) • Alternatively, OpSpec C384: Required Navigation Performance Procedures with Authorization Required
C Foreign Carrier Fleet	• If available, OpSpec C384: Required Navigation Performance Procedures with Authorization Required
D Corporate/GA Fleet	• Applicable LOA C073: Vertical Navigation (VNAV) Instrument Approach Procedures (IAP) Using Minimum Descent Altitude (MDA) as a Decision Altitude (DA)/Decision Height (DH) • Alternatively, LOA C384: Required Navigation Performance Procedures with Authorization Required
H Helicopter Fleet	• Applicable OpSpec H112: Instrument Approach Operations Using an Area Navigation System

LPV Approach

Active IFR Fleet

A Air Transport Fleet	• OpSpec C052: Straight-In Non-Precision, APV, and Category I Precision Approach and Landing Minima – All Airports • OpSpec B034: IFR Class I Terminal and En Route Navigation Using Area Navigation Systems • OpSpecs C052 and B034 must be used together to determine applicable equipage • High-confidence data from operators and FAA Navigation Services

		• 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 (3/7/2016) • AC 90-107 – Guidance for Localizer Performance with Vertical Guidance and Localizer Performance without Vertical Guidance Approach Operations in the U.S. National Airspace System (2/11/2011) • AC 20-138D (including Change 2) – Airworthiness Approval of Positioning and Navigation Systems (4/7/2016)
B	Air Taxi Fleet	• Applicable OpSpec C052: Straight-In Non-Precision, APV, and Category I Precision Approach and Landing Minima – All Airports • Applicable OpSpec B034: IFR Class I Terminal and En Route Navigation Using Area Navigation Systems • OpSpecs C052 and B034 must be used together to determine applicable equipage
C	Foreign Carrier Fleet	• There is no current approval document available for LPV on the Foreign Carrier oceanic fleet
D	Corporate/GA Fleet	• Applicable LOA C052: Straight-In Non-Precision, APV, and Category I Precision Approach and Landing Minima – All Airports • Applicable LOA B034: IFR Class I Terminal and En Route Navigation Using Area Navigation Systems • OpSpecs C052 and B034 must be used together to determine applicable equipage
H	Helicopter Fleet	• Applicable OpSpec H112: Instrument Approach Operations Using an Area Navigation System

RNP Approach

Active IFR Fleet

A	Air Transport Fleet	• OpSpec C052: Straight-In Non-Precision, APV, and Category I Precision Approach and Landing Minima – All Airports • Note: OpSpec C052 does not specify make, model, series, or serial number/tail level detail • 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 (3/7/2016) • AC 20-138D (including Change 2) – Airworthiness Approval of Positioning and Navigation Systems (4/7/2016) • RNP Approach assumptions = a GPS Navigator with approach capability or an FMC integrated with GPS
B	Air Taxi Fleet	• Applicable OpSpec C052: Straight-In Non-Precision, APV, and Category I Precision Approach and Landing Minima – All Airports
C	Foreign Carrier Fleet	• Applicable OpSpec C052: Straight-In Non-Precision, APV, and Category I Precision Approach and Landing Minima – All U.S. Airports (Required for All Air Carriers Conducting IFR Operations)
D	Corporate/GA Fleet	• Applicable LOA C052: Straight-In Non-Precision, APV, and Category I Precision Approach and Landing Minima – All Airports
H	Helicopter Fleet	• Applicable OpSpec H123: Class I Navigation Using Area or Long-Range Navigation Systems with Wide Area Augmentation System (WAAS) for Rotorcraft Required Navigation Performance (RNP) 0.3 En Route and Terminal Operations.

RNP AR Approach

Active IFR Fleet

A	Air Transport Fleet	• OpSpec C384: Required Navigation Performance Procedures with Authorization Required • Medium-confidence data because OpSpec C384 specifies make, model, and series but not serial number/tail level, producing partial potential fleet equipage inaccuracy • AC 90-101A (including Change 1) – Approval Guidance for Required Navigation Performance (RNP) Procedures with Authorization Required (AR) (2/9/2016) • AC 20-138D (including Change 2) – Airworthiness Approval of Positioning and Navigation Systems (4/7/2016) • RNP AR assumptions = RNP able dual FMCs integrated with multi-scan DME/DME, RNP alerting, IRU, and GPS sensors, or the company has been alternately approved via AC 90-101A
B	Air Taxi Fleet	• Applicable OpSpec C384: Required Navigation Performance Procedures with Authorization Required
C	Foreign Carrier Fleet	• Applicable OpSpec C384: RNP AR – Area Navigation (RNAV) Required Navigation Performance (RNP) Authorization Required (AR) (Optional for Foreign Air Carriers Operating to the United States)
D	Corporate/GA Fleet	• Applicable LOA C384: Required Navigation Performance Procedures with Authorization Required
H	Helicopter Fleet	• Applicable OpSpec H123: Class I Navigation Using Area or Long-Range Navigation Systems with Wide Area Augmentation System (WAAS) for Rotorcraft Required Navigation Performance (RNP) 0.3 En Route and Terminal Operations.

GLS I

Active IFR Fleet

A	Air Transport Fleet	• OpSpec C052: Straight-In Non-Precision, APV, and Category I Precision Approach and Landing Minima – All Airports • Medium-confidence data because OpSpec C052 specifies make, model, and series but not serial number/tail level, producing partial potential fleet equipage inaccuracy • 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 (3/7/2016) • AC 20-138D (including Change 2) – Airworthiness Approval of Positioning and Navigation Systems (4/7/2016) • GBAS I assumptions = a GBAS MMR integrated appropriately to the flight management system and auto flight system
B	Air Taxi Fleet	• Applicable OpSpec C052: Straight-In Non-Precision, APV, and Category I Precision Approach and Landing Minima – All Airports
C	Foreign Carrier Fleet	• Applicable OpSpec C052: Straight-In Non-Precision, APV, and Category I Precision Approach and Landing Minima – All U.S. Airports (Required for All Air Carriers Conducting IFR Operations)

D	Corporate/GA Fleet	• Applicable LOA C052: Straight-In Non-Precision, APV, and Category I Precision Approach and Landing Minima – All Airports
H	Helicopter Fleet	• Applicable OpSpec H117: CAT I, ILS, MLS, or GLS Approach Procedures with Specific IFR Landing Minimums

A.2 Automatic Dependent Surveillance-Broadcast Enablers

ADS-B Out

Equipage Need Assumptions

- Have active registration on file AND
- Are based within 25 miles of a Class B or Class C airport (AND/OR)
- Filed a flight plan within the last 12 months to or from an airport within 25 miles of a Class B or Class C airport (AND/OR)
- Within the last 12 months flew through airspace where ADS-B Out was required as of 01/01/2020

Rule Airspace Definition

- https://www.faa.gov/air_traffic/technology/equipadsb/

Airspace	Altitude
A	All
B	Generally, from surface to 10,000 ft. mean sea level (MSL), including the airspace from portions of Class Bravo that extend beyond the Mode C veil up to 10,000 ft. MSL (i.e., KSEA [Seattle], KCLE [Cleveland], KPHX [Phoenix])
C	Generally, from surface up to 4,000 ft. MSL, including the airspace above the lateral boundary up to 10,000 ft. MSL
E	Above 10,000 ft. MSL over the 48 states and DC, excluding airspace at and below 2,500 ft. Above Ground Level (AGL)
E	Over the Gulf of Mexico at and above 3,000 ft. MSL within 12 nm of the coastline of the United States
Note:	Airspace within 30 nautical miles (Mode C veil) at all Class B locations form the surface up to 10,000 ft. MSL

Active Fleet

- FAA has stated that there will be no specific Ops approval required to conduct ADS-B Out (TSO-C166b)

A Air Transport Fleet

- Defined by FAA SBS Program count of compliant equipage
- AC 20-165B – Airworthiness Approval of Automatic Dependent Surveillance-Broadcast OUT Systems (12/7/2015)
- AC 90-114B – Automatic Dependent Surveillance-Broadcast Operations (12/30/2019)
- 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) (12/2/2009)

B Air Taxi Fleet

- Defined by FAA SBS Program count of compliant equipage
- AC 20-165B – Airworthiness Approval of Automatic Dependent Surveillance-Broadcast OUT Systems (12/7/2015)
- AC 90-114B – Automatic Dependent Surveillance-Broadcast Operations (12/30/2019)
- 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) (12/2/2009) • TSO-C154c – Universal Access Transceiver (UAT) Automatic Dependent Surveillance-Broadcast (ADS-B) Equipment Operating on Frequency of 978 MHz (12/2/2009)
C	International Fleet	• Defined by FAA SBS Program count of compliant equipage • International Fleet includes other foreign registrations in addition to Foreign Carriers
D	Corporate/GA Fleet	• Defined by FAA SBS Program count of compliant equipage
H	Helicopter Fleet	• Defined by FAA SBS Program count of compliant equipage

ADS-B In – SA Apps

Active IFR Fleet

A	Air Transport Fleet	• Note: No single OpSpec applies • Active fleet denominator used for computation • AC 20-172B – Airworthiness Approval for ADS-B In Systems and Applications (5/20/2015) • TSO-C195b – Avionics Supporting Automatic Dependent Surveillance-Broadcast (ADS-B) Aircraft Surveillance Applications (ASA) (9/29/2014) • High-confidence data reported from FAA SBS Program • Key system components for ADS-B In for Airborne/Ground CDTI include adequate display (including Class III EFB) and Surveillance Processor
B	Air Taxi Fleet	• Insufficient data is available to develop equipage and approval figures for ADS-B In for SA on operator categories other than Air Transport
C	Foreign Carrier Fleet	• Insufficient data is available to develop equipage and approval figures for ADS-B In for SA on operator categories other than Air Transport
D	Corporate/GA Fleet	• Insufficient data is available to develop equipage and approval figures for ADS-B In for SA on operator categories other than Air Transport
H	Helicopter Fleet	• Insufficient data is available to develop equipage and approval figures for ADS-B In for SA on operator categories other than Air Transport

ADS-B In – Approach Apps

Active IFR Fleet

A	Air Transport Fleet	• OpSpec A355: Automatic Dependent Surveillance-Broadcast (ADS-B) In Operations • High-confidence data because OpSpec A355 specifies approved tail numbers • Active fleet denominator used for computation • AC 20-172B – Airworthiness Approval for ADS-B In Systems and Applications (5/20/2015)

		• TSO-C195b – Avionics Supporting Automatic Dependent Surveillance-Broadcast (ADS-B) Aircraft Surveillance Applications (ASA) (9/29/2014) • High-confidence data reported from FAA SBS Program • Key system components for ADS-B In for Airborne/Ground CDTI include adequate display (including Class III EFB) and Surveillance Processor
B	Air Taxi Fleet	• Insufficient data is available to develop equipage and approval figures for ADS-B In for Situational Awareness-Surface (SURF), CAVS, and Situational Awareness-Airborne (AIRB) on operator categories other than Air Transport
C	Foreign Carrier Fleet	• Insufficient data is available to develop equipage and approval figures for ADS-B In for SURF, CAVS, and AIRB on operator categories other than Air Transport
D	Corporate/GA Fleet	• Insufficient data is available to develop equipage and approval figures for ADS-B In for SURF, CAVS, and AIRB on operator categories other than Air Transport
H	Helicopter Fleet	• Insufficient data is available to develop equipage and approval figures for ADS-B In for SURF, CAVS, and AIRB on operator categories other than Air Transport

ADS-B In – ITP Apps

Active IFR Oceanic Fleet		• For this analysis, the oceanic fleet consists of airplanes that are observed in ATOP data flying in oceanic regions
A	Air Transport Fleet	• OpSpec A354: Automatic Dependent Surveillance-Broadcast (ADS-B) In-Trail Procedure (ITP) • High-confidence data because OpSpec A354 provides approved tail numbers • AC 20-172B – Airworthiness Approval for ADS-B In Systems and Applications (5/20/2015) • AC 90-114B – Automatic Dependent Surveillance-Broadcast Operations (12/30/2019) • TSO-C195b – Avionics Supporting Automatic Dependent Surveillance-Broadcast (ADS-B) Aircraft Surveillance Applications (ASA) (9/29/2014) • Key system components for ADS-B In for Airborne/Ground CDTI include adequate display (including Class III EFB) and Surveillance Processor
B	Air Taxi Fleet	• AC 20-172B – Airworthiness Approval for ADS-B In Systems and Applications (5/20/2015) • TSO-C195b – Avionics Supporting Automatic Dependent Surveillance-Broadcast (ADS-B) Aircraft Surveillance Applications (ASA) (9/29/2014)
C	International Fleet	• Insufficient data is available to develop equipage and approval figures for ADS-B In for ITP on operator categories other than Air Transport and Air Taxi
D	Corporate/GA Fleet	• Insufficient data is available to develop equipage and approval figures for ADS-B In for ITP on operator categories other than Air Transport and Air Taxi
H	Helicopter Fleet	• Oceanic enablers not applicable for helicopters

A.3 Data Communications Enablers

FANS 1/A Domestic – Tower Services

Active IFR Fleet

A Air Transport Fleet
- OpSpec A056: Data Link Communications
- Medium-confidence data because OpSpec A056 specifies make, model, and series but not serial number/tail level, producing partial potential fleet equipage inaccuracy
- AC 90-117 – Data Link Communications (10/3/2017)
- TSO-C159e – Next Generation Satellite Systems (NGSS) Equipment (3/25/2022)
- TSO-C160a – Very High Frequency (VHF) Digital Link (VDL) Mode 2 Communications Equipment (3/27/2012)
- High-confidence data reported from FAA DCIS Program

B Air Taxi Fleet
- Applicable OpSpec A056: Data Link Communications

C Foreign Carrier Fleet
- No OpSpec Template Available (NOTA)

D Corporate/GA Fleet
- Applicable LOA A056: Data Link Communications

H Helicopter Fleet
- No OpSpec Template Available (NOTA)

FANS 1/A Domestic – En Route Services

Active IFR Fleet

A Air Transport Fleet
- OpSpec A056: Data Link Communications
- Medium-confidence data because OpSpec A056 specifies make, model, and series but not serial number/tail level, producing partial potential fleet equipage inaccuracy
- AC 90-117 – Data Link Communications (10/3/2017)
- High-confidence data reported from FAA DCIS Program

B Air Taxi Fleet
- Applicable OpSpec A056: Data Link Communications

C Foreign Carrier Fleet
- No OpSpec Template Available

D Corporate/GA Fleet
- Applicable LOA A056: Data Link Communications

H Helicopter Fleet
- No OpSpec Template Available (NOTA)

FANS 1/A Oceanic

Active IFR Oceanic Fleet
- For this analysis, the oceanic fleet consists of airplanes that are observed in ATOP data flying in oceanic regions

A Air Transport Fleet
- OpSpec A056: Data Link Communications
- Medium-confidence data because OpSpec A056 specifies make, model, and series but not serial number/tail level, producing partial potential fleet equipage inaccuracy
- AC 90-117 NOTA Data Link Communications (10/3/2017)
- TSO-C159e NOTA Next Generation Satellite Systems (NGSS) Equipment (3/25/2022)
- High-confidence data from Flight Plan for airplanes filing "J5 – CPDLC FANS 1/A SATCOM (INMARSAT); J6 – CP

B	Air Taxi Fleet	• Applicable OpSpec A056: Data Link Communications
C	Foreign Carrier Fleet	• No OpSpec Template Available
D	Corporate/GA Fleet	• Applicable LOA A056: Data Link Communications
H	Helicopter Fleet	• Oceanic enablers not applicable for helicopters

A.4 Low-Visibility Enablers

HUD Approach

Active IFR Fleet

A	Air Transport Fleet	• OpSpec C062: Manually Flown Flight Control Guidance System Certified for Landing Operations Other Than Categories II and III • There are six U.S. Air Transport operators listed under OpSpec C062 • Medium-confidence data because OpSpec C062 specifies make, model, and series but not serial number/tail level, producing potential fleet equipage inaccuracy • Order 8400.13F – Procedures for the Evaluation and Approval of Facilities for Special Authorization Category I Operations and All Category II and III Operations (10/25/2019)
B	Air Taxi Fleet	• Insufficient data is available to develop equipage and approval figures for low-visibility enablers in operator categories other than Air Transport
C	Foreign Carrier Fleet	• Insufficient data is available to develop equipage and approval figures for low-visibility enablers in operator categories other than Air Transport
D	Corporate/GA Fleet	• Insufficient data is available to develop equipage and approval figures for low-visibility enablers in operator categories other than Air Transport
H	Helicopter Fleet	• Insufficient data is available to develop equipage and approval figures for low-visibility enablers in operator categories other than Air Transport

EFVS

Active IFR Fleet

A	Air Transport Fleet	• OpSpec C048: Enhanced Flight Vision System (EFVS) Operations • Medium-confidence data because OpSpec C048 specifies make, model, and series but not serial number/tail level, producing potential fleet equipage inaccuracy • AC 20-167A – Airworthiness Approval of Enhanced Vision System, Synthetic Vision System, Combined Vision System, and Enhanced Flight Vision System Equipment (12/6/2016) • AC 90-106B – Enhanced Flight Vision System Operations (5/2/2022)
B	Air Taxi Fleet	• Insufficient data is available to develop equipage and approval figures for low-visibility enablers in operator categories other than Air Transport

C	Foreign Carrier Fleet	• Insufficient data is available to develop equipage and approval figures for low-visibility enablers in operator categories other than Air Transport
D	Corporate/GA Fleet	• Insufficient data is available to develop equipage and approval figures for low-visibility enablers in operator categories other than Air Transport
H	Helicopter Fleet	• Insufficient data is available to develop equipage and approval figures for low-visibility enablers in operator categories other than Air Transport

A.5 Safety-Enhancement Enablers

EFB

Active IFR Fleet		
A	Air Transport Fleet	• OpSpec A061: Electronic Flight Bag (EFB) Program • Medium-confidence data because OpSpec A061 specifies make, model, and series but not serial number/tail level, producing partial fleet equipage inaccuracy • AC 20-173 – Installation of Electronic Flight Bag Components (9/27/2011) • AC 120-76D – Authorization for Use of Electronic Flight Bags (10/27/2017) • AC 91-78 – Use of Class 1 or Class 2 Electronic Flight Bag (EFB) (7/20/2007)
B	Air Taxi Fleet	• Insufficient data is available to develop equipage and approval figures for safety-enhancement enablers in operator categories other than Air Transport
C	Foreign Carrier Fleet	• Insufficient data is available to develop equipage and approval figures for safety-enhancement enablers in operator categories other than Air Transport
D	Corporate/GA Fleet	• Insufficient data is available to develop equipage and approval figures for safety-enhancement enablers in operator categories other than Air Transport
H	Helicopter Fleet	• Insufficient data is available to develop equipage and approval figures for safety-enhancement enablers in operator categories other than Air Transport

A.6 Approval and Equipage Data Sources Summary

Table A-1 summarizes the correlations of OpSpecs to enablers used to determine Ops Approval levels for each of the operator categories. Table A-2 identifies the primary data source used to assess Equipped Capability for the reported enablers in each of the operator categories.

Table A-1. Primary Data Sources – Operations Approval

		Air Transport	Air Taxi	Foreign Carrier	Corporate / GA	Helicopter
PBN	RNP 4 w/Oceanic Comms	B036 and A056	B036 and A056	NOTA	B036 and A056	NOHO
	RNAV 1	NR	C063	C063	C063	H123
	RNAV 2	NR	B035	B035	NOTA	H123
	RNAV 1 & 2	C063 and B035	NR	NR	NR	NR
	RNP 1 w/RF	C063 or C384	C063 or C384	C063 or C384	C063 or C384	H123
	RNP 1 w/TF	C063	C063	C063	C063	H123
	VNAV Approach	C073 or C384	C073 or C384	NOTA	C073 or C384	H112
	LPV Approach	B034 and C052	B034 and C052	NOTA	B034 and C052	H112
	RNP Approach	C052	C052	C052	C052	H123
	RNP AR Approach	C384	C384	C384	C384	H123
	GLS I	C052	C052	C052	C052	H117
ADS-B	ADS-B Out	NR	NOAR	NOAR	NOAR	NOAR
	ADS-B In - CAS/CAVS	A355	NR	NR	NR	NR
	ADS-B In - SA Apps	NSOA	NSOA	NSOA	NSOA	NSOA
	ADS-B In - Approach Apps	A355	A355	NOTA	NOTA	NOTA
	ADS-B In - ITP Apps	A354	A354	NOTA	NOTA	NOHO
Data Comm	FANS 1/A Domestic - Tower Services	A056	A056	NOTA	A056	NOTA
	FANS 1/A Domestic - En Route Services	A056	A056	NOTA	A056	NOTA
	FANS 1/A Oceanic	A056	A056	NOTA	A056	NOHO
Low-Viz	HUD Approach	C062	C062	NOTA	NOTA	NOTA
	EFVS	C048	C048	C048	C048	NOTA
Safety and Other	EFB	A061	A061	NOTA	NOTA	NOTA
	EFB w/Aircraft Integration	NSOA	NR	NR	NR	NR

Key:

NOHO	No Oceanic Helicopter Operations
NSOA	No Specific OpSpec Applies
NOAR	No Operational Approval Required
NOTA	No OpSpec Template Available
NR	Not Reported

Table A-2. Primary Data Sources – Equipped Capability

		Air Transport	Air Taxi	Foreign Carrier	Corporate / GA	Helicopter
PBN	RNP 4 w/Oceanic Comms	Industry	Flight Plans	Flight Plans	Flight Plans	NOHO
	RNAV 1	NR	Flight Plans	Flight Plans	Flight Plans	Flight Plans
	RNAV 2	NR	Flight Plans	Flight Plans	Flight Plans	Flight Plans
	RNAV 1 & 2	Industry	NR	NR	NR	NR
	RNP 1 w/RF	Industry	Flight Plans	Flight Plans	Flight Plans	Flight Plans
	RNP 1 w/TF	Industry	Flight Plans	Flight Plans	Flight Plans	Flight Plans
	VNAV Approach	Industry	Flight Plans	Flight Plans	Flight Plans	Flight Plans
	LPV Approach	Industry	Flight Plans	Flight Plans	Flight Plans	Flight Plans
	RNP Approach	Industry	Flight Plans	Flight Plans	Flight Plans	Flight Plans
	RNP AR Approach	Industry	Flight Plans	Flight Plans	Flight Plans	Flight Plans
	GLS I	Industry	Flight Plans	Flight Plans	Flight Plans	Flight Plans
ADS-B	ADS-B Out	NR	FAA Program	FAA Program	FAA Program	FAA Program
	ADS-B In - CAS/CAVS	Industry	NR	NR	NR	NR
	ADS-B In - SA Apps	FAA Program	FAA Program	FAA Program	FAA Program	FAA Program
	ADS-B In - Approach Apps	FAA Program	FAA Program	FAA Program	FAA Program	FAA Program
	ADS-B In - ITP Apps	Industry	AAR	AAR	AAR	NOHO
Data Comm*	FANS 1/A Domestic - Tower Services	Industry	Flight Plans	Flight Plans	Flight Plans	Flight Plans
	FANS 1/A Domestic - En Route Services	Industry	Flight Plans	Flight Plans	Flight Plans	Flight Plans
	FANS 1/A Oceanic	Industry	Flight Plans	Flight Plans	Flight Plans	NOHO
Low-Viz	HUD Approach	Industry	AAR	AAR	AAR	AAR
	EFVS	Industry	AAR	AAR	AAR	AAR
Safety and Other	EFB	Industry	AAR	AAR	AAR	AAR
	EFB w/Aircraft Integration	Industry	NR	NR	NR	NR

Key:

AAR	Additional Analysis Required
NOHO	No Oceanic Helicopter Operations
NR	Not Reported
*	Industry and Flight Plan reporting consistent with FAA Program understanding

A.7 Enabler Reference Documents List

The following FAA Advisory Circular (AC), Order, and Technical Standard Order (TSO) documents are used in defining one or more of the NextGen enablers covered in this report.

AC 20-138D (including Change 2) – *Airworthiness Approval of Positioning and Navigation Systems*. 4/7/2016

AC 20-165B – *Airworthiness Approval of Automatic Dependent Surveillance-Broadcast OUT Systems*. 12/7/2015

AC 20-167A – *Airworthiness Approval of Enhanced Vision System, Synthetic Vision System, Combined Vision System, and Enhanced Flight Vision System Equipment.* 12/6/2016

AC 20-172B – *Airworthiness Approval for ADS-B In Systems and Applications.* 5/20/2015

AC 20-173 – *Installation of Electronic Flight Bag Components.* 9/27/2011

AC 90-100A (including Change 2) – *U.S. Terminal and En Route Area Navigation (RNAV) Operations.* 4/14/2015

AC 90-101A (including Change 1) – *Approval Guidance for Required Navigation Performance (RNP) Procedures with Authorization Required (AR)*. 2/9/2016

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.* 3/7/2016

AC 90-106B – *Enhanced Flight Vision System Operations.* 5/2/2022

AC 90-107 – *Guidance for Localizer Performance with Vertical Guidance and Localizer Performance without Vertical Guidance Approach Operations in the U.S. National Airspace System.* 2/11/2011

AC 90-114B – *Automatic Dependent Surveillance-Broadcast Operations.* 12/30/2019

AC 90-117 – *Data Link Communications.* 10/3/2017

AC 91-78 – *Use of Class 1 or Class 2 Electronic Flight Bag (EFB)*. 7/20/2007

AC 120-76D – *Authorization for Use of Electronic Flight Bags.* 10/27/2017

TSO-C154c – *Universal Access Transceiver (UAT) Automatic Dependent Surveillance-Broadcast (ADS-B) Equipment Operating on Frequency of 978 MHz.* 12/2/2009

TSO-C159e – *Next Generation Satellite Systems (NGSS) Equipment.* 3/25/2022

TSO-C160a – *Very High Frequency (VHF) Digital Link (VDL) Mode 2 Communications Equipment.* 3/27/2012

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).* 12/2/2009

TSO-C195b – *Avionics Supporting Automatic Dependent Surveillance-Broadcast (ADS-B) Aircraft Surveillance Applications (ASA).* 9/29/2014

Order 8400.13F – *Procedures for the Evaluation and Approval of Facilities for Special Authorization Category I Operations and All Category II and III Operations.* 10/25/2019

Order 8900.1 (Change 799) – *Flight Standards Information Management System (FSIMS).* 8/4/2022

OpSpec requirements used for the domestic aircraft fleet for one or more of the NextGen enablers covered in this report are defined in the following sections and paragraphs of Order 8900.1, Volume 3 General Technical Administration, Chapter 18 Operations Specifications.[2]

Section 3 Part A Operations Specifications – General, Subsection 3-737 Part A Operations and Management Specifications Paragraphs

Paragraph OpSpec[/MSpec][/LOA] A056: *Data Link Communications.*

Paragraph OpSpec[/MSpec][/LOA] A061: *Electronic Flight Bag (EFB) Program.*

Paragraph OpSpec[/MSpec][/LOA] A354: *Automatic Dependent Surveillance-Broadcast (ADS-B) In-Trail Procedure (ITP).*

[2] http://fsims.faa.gov

Paragraph OpSpec[/MSpec][/LOA] A355: *Automatic Dependent Surveillance-Broadcast (ADS-B) In Operations.*

Section 4 Part B Operations Specifications – En Route Authorization and Limitations, Subsection 3-816 Part B Operations Specifications (OPSPECS)

Paragraph OpSpec[/MSpec][/LOA] B034: *IFR Class I Terminal and En Route Navigation Using Area Navigation Systems.*

Paragraph OpSpec[/MSpec][/LOA] B035: *Class I Navigation in U.S. Class A Airspace Using Area or Long-Range Navigation Systems.*

Paragraph OpSpec[/MSpec][/LOA] B036: *Oceanic and Remote Continental Navigation Using Multiple Long-Range Navigation Systems (LRNS).*

Section 5 Part C Operations Specifications – Airplane Terminal Instrument Procedures and Airport Authorizations and Limitations, Subsection 3-871 General

Paragraph OpSpec[/MSpec][/LOA] C048: *Enhanced Flight Vision System (EFVS) Operations.*

Paragraph OpSpec[/MSpec][/LOA] C052: *Straight-In Non-Precision, APV, and Category I Precision Approach and Landing Minima – All Airports.*

Paragraph OpSpec[/MSpec][/LOA] C062: *Manually Flown Flight Control Guidance System Certified for Landing Operations Other Than Categories II and III.*

Paragraph OpSpec[/MSpec][/LOA] C063: *Area Navigation (RNAV) and Required Navigation Performance (RNP) Terminal Operations.*

Paragraph OpSpec[/MSpec][/LOA] C073: *Vertical Navigation (VNAV) Instrument Approach Procedures (IAP) Using Minimum Descent Altitude (MDA) as a Decision Altitude (DA)/Decision Height (DH).*

Paragraph OpSpec[/MSpec][/LOA] C384: *Required Navigation Performance Procedures with Authorization Required.*

Section 7 Part H Operations Specifications – Helicopter Terminal Instrument Procedures and Airport Authorizations and Limitations, Subsection 3-986 General

Paragraph OpSpec H101: *Terminal Instrument Procedures.*

Paragraph OpSpec H102: *Basic Instrument Approach Procedure Authorizations – All Airports.*

Paragraph OpSpec H103: *IFR Landing Minimums Other Than Airborne Radar and Categories II and III Approaches – All Airports.*

Paragraph OpSpec[/MSpec] H111: *Manually Flown Flight Control Guidance System Certified for Landing Operations Other Than Categories II and III.*

Paragraph OpSpec H112: *Instrument Approach Operations Using an Area Navigation System.*

Paragraph OpSpec H117: *CAT I, ILS, MLS, or GLS Approach Procedures with Specific IFR Landing Minimums.*

Paragraph OpSpec[/MSpec] H123: *Class I Navigation Using Area or Long-Range Navigation Systems with Wide Area Augmentation System (WAAS) for Rotorcraft Required Navigation Performance (RNP) 0.3 En Route and Terminal Operations.*

OpSpec requirements used for the Foreign Air Carrier Fleet are defined in Order 8900.1, Volume 12 International Aviation, Chapter 4, Part 129 Operations.[3]

Section 3 Part 129 Part B Operations Specifications – En Route Authorization and Limitations, Subsection 3.3 Part B OPSPECS

Paragraph OpSpec B035: *Class I Navigation En Route in U.S. Airspace Using Area or Long-Range Navigation Systems (Optional for Foreign Air Carriers Operating to the United States).*

Section 4 Part 129 Part C Operations Specifications – Airplane Terminal Instrument Procedures and Airport Authorizations and Limitations, Subsection 4.3 Part C OPSPEC Paragraphs

Paragraph OpSpec C048: *Enhanced Flight Vision System (EFVS) Operations.*

Paragraph OpSpec C052: *Straight-In Non-Precision, APV, and Category I Precision Approach and Landing Minima – All U.S. Airports (Required for All Air Carriers Conducting IFR Operations).*

Paragraph OpSpec C063: *IFR RNAV 1 Departure Procedures (DP) and Standard Terminal Arrivals (STAR) – U.S. Airports (Optional)*

Paragraph OpSpec C384: *RNP AR – Area Navigation (RNAV) Required Navigation Performance (RNP) Authorization Required (AR) (Optional for Foreign Air Carriers Operating to the United States).*

[3] http://fsims.faa.gov

Appendix B Flight-Plan Mappings

Instrument Flight Rules (IFR) flight plans offer information on an airplane's specific equipage and capabilities, filed on a per-flight basis. Thus, they provide an additional source for verifying operational capability and approvals for Air Transport, Air Taxi, and other certificated operator categories.

Airplanes operated as Visual Flight Rules (VFR) only are not required to file a flight plan, and consequently no IFR flight plan data is available. The Federal Aviation Administration (FAA) General Aviation (GA) and Air Taxi Survey may provide insight into VFR-operated airplanes.

Several fields available in flight plans are used to filter data and provide further analysis opportunities, with specific reference to equipage and capabilities such as GPS. Flight plans also enable geographic-specific analyses for airports, centers (Air Route Traffic Control Center and Terminal Radar Approach Control), and metroplexes. Flight plans filed through Advanced Technologies and Oceanic Procedures (ATOP) identify oceanic fleets and operations.

International Civil Aviation Organization (ICAO) flight plans, the primary source of flight plan data used to generate this report, are pulled in through the En Route Automation Modernization system, which covers both domestic (Common Messaging System) and oceanic (ATOP) flights. The ICAO format includes 76 fields. For cases of missing or incomplete ICAO flight plan data, legacy NAS IFR flight plans are used to supplement ICAO flight plan data.

Sections B.1 to B.3 map fields in ICAO flight plans to enabler capabilities. For those sections, green-shaded boxes indicate the flight plan filing codes are used in this report to determine equipage, equipped capable, and operational approvals, as applicable to each specific enabler.

B.1 Performance Based Navigation Flight Plan Mappings

RNP 4 with Oceanic Comms Flight Plan Mapping

Legacy NAS Slant Filings

REDUCED VERTICAL SEPARATION MINIMUM (RVSM)

/H	Any nav. capability with failed transponder or failed Mode C	/Z	RNAV, no GNSS, and transponder with Mode C
/W	No GNSS, no RNAV, and transponder with Mode C	/L	GNSS and transponder with Mode C

NO RVSM

No DME		DME		TACAN		RNAV, No GNSS		GNSS	
/X	No transponder	/D	No transponder	/M	No transponder	/Y	No transponder	/V	No transponder
/T	Transponder with no Mode C	/B	Transponder with no Mode C	/N	Transponder with no Mode C	/C	Transponder with no Mode C	/S	Transponder with no Mode C
/U	Transponder with Mode C	/A	Transponder with Mode C	/P	Transponder with Mode C	/I	Transponder with Mode C	/G	Transponder with Mode C

ICAO Flight Plan Field 10a

N	No Capabilities	E1	ACARS - FMC WPR	I	INS	J6	FANS 1/A - Satcom MTSAT	M3	RTF - Iridium	T	TACAN
S	Standard	E2	ACARS - D-FIS	J1	ATN - VDL Mode 2	J7	FANS 1/A - Satcom Iridium	O	VOR	U	UHF RTF
A	GBAS Landing System	E3	ACARS - PDC	J2	FANS 1/A - HFDL	K	MLS	P1	RCP400 (CPDLC)	V	VHF RTF
B	LPV (APV w/SBAS)	F	ADF	J3	FANS 1/A - VDL Mode A	L	ILS	P2	RCP240 (CPDLC)	W	RVSM
C	LORAN C	G	GNSS	J4	FANS 1/A - VDL Mode 2	M1	RTF - Inmarsat	P3	RCP400 (Satvoice)	X	MNPS
D	DME	H	HF RTF	J5	FANS 1/A - Satcom Inmarsat	M2	RTF - MTSAT	R	PBN	Y	8.33 kHz VHF

ICAO Flight Plan Field 18

A1	RNAV 10 (RNP10)	B6	RNAV 5 - LORANC	D2	RNAV1 - GNSS	O3	RNP1 - DME/DME
B1	RNAV 5 - All	C1	RNAV2 - All	D3	RNAV1 - DME/DME	O4	RNP1 - DME/DME/IRU
B2	RNAV 5 - GNSS	C2	RNAV2 - GNSS	D4	RNAV1 - DME/DME/IRU	S1	RNP APCH
B3	RNAV 5 - DME/DME	C3	RNAV2 - DME/DME	L1	RNP 4	S2	RNP APCH w/ BARO VNAV
B4	RNAV 5 - VOR/DME	C4	RNAV2 - DME/DME/IRU	O1	RNP1 - All	T1	RNP AR APCH With RF
B5	RNAV 5 - INS or IRS	D1	RNAV1 - All	O2	RNP1 - GNSS	T2	RNP AR APCH Without RF

ICAO Flight Plan Field 10b

N	No surveillance equipment	L	Mode S AC id. ADS-B	U1	ADS-B Out cap. using UAT
A	Mode A	P	Mode S Pres Alt No AC ID	U2	ADS-B Out and In cap. UAT
C	Mode A and Mode C	S	Mode S Pres Alt and AC ID	V1	ADS-B Out cap. VDL Mode 4
E	Mode S AC id. Ext Sq	X	Mode S No Pres Alt No AC ID	V2	ADS-B Out/In cap. VDL Mode 4
H	Mode S AC id. Enh Surv	B1	ADS-B w/ 1090MHz ADS-B Out	D1	ADS-C with FANS 1/A cap.
I	Mode S AC id. No Pres Alt	B2	ADS-B 1090 MHz ADS-B Out/In	G1	ADS-C with ATN cap

Note:
Shaded filing codes indicate capability

ICAO Flight Plan NAV/ Free Text Field

RNP2	GBAS	WAAS	GPS
RNP4	SBAS	GNSS	

RNAV 1 Flight Plan Mapping

Legacy NAS Slant Filings

REDUCED VERTICAL SEPARATION MINIMUM (RVSM)

/H	Any nav. capability with failed transponder or failed Mode C	/Z	RNAV, no GNSS, and transponder with Mode C
/W	No GNSS, no RNAV, and transponder with Mode C	/L	GNSS and transponder with Mode C

NO RVSM

No DME		DME		TACAN		RNAV, No GNSS		GNSS	
/X	No transponder	/D	No transponder	/M	No transponder	/Y	No transponder	/V	No transponder
/T	Transponder with no Mode C	/B	Transponder with no Mode C	/N	Transponder with no Mode C	/C	Transponder with no Mode C	/S	Transponder with no Mode C
/U	Transponder with Mode C	/A	Transponder with Mode C	/P	Transponder with Mode C	/I	Transponder with Mode C	/G	Transponder with Mode C

ICAO Flight Plan Field 10a

N	No Capabilities	E1	ACARS - FMC WPR	I	INS	J6	FANS 1/A - Satcom MTSAT	M3	RTF - Iridium	T	TACAN
S	Standard	E2	ACARS - D-FIS	J1	ATN - VDL Mode 2	J7	FANS 1/A - Satcom Iridium	O	VOR	U	UHF RTF
A	GBAS Landing System	E3	ACARS - PDC	J2	FANS 1/A - HFDL	K	MLS	P1	RCP400 (CPDLC)	V	VHF RTF
B	LPV (APV w/SBAS)	F	ADF	J3	FANS 1/A - VDL Mode A	L	ILS	P2	RCP240 (CPDLC)	W	RVSM
C	LORAN C	G	GNSS	J4	FANS 1/A - VDL Mode 2	M1	RTF - Inmarsat	P3	RCP400 (Satvoice)	X	MNPS
D	DME	H	HF RTF	J5	FANS 1/A - Satcom Inmarsat	M2	RTF - MTSAT	R	PBN	Y	8.33 kHz VHF

ICAO Flight Plan Field 18

A1	RNAV 10 (RNP10)	B6	RNAV 5 - LORANC	D2	RNAV1 - GNSS	O3	RNP1 - DME/DME
B1	RNAV 5 - All	C1	RNAV2 - All	D3	RNAV1 - DME/DME	O4	RNP1 - DME/DME/IRU
B2	RNAV 5 - GNSS	C2	RNAV2 - GNSS	D4	RNAV1 - DME/DME/IRU	S1	RNP APCH
B3	RNAV 5 - DME/DME	C3	RNAV2 - DME/DME	L1	RNP 4	S2	RNP APCH w/ BARO VNAV
B4	RNAV 5 - VOR/DME	C4	RNAV2 - DME/DME/IRU	O1	RNP1 - All	T1	RNP AR APCH With RF
B5	RNAV 5 - INS or IRS	D1	RNAV1 - All	O2	RNP1 - GNSS	T2	RNP AR APCH Without RF

ICAO Flight Plan Field 10b

N	No surveillance equipment	L	Mode S AC id. ADS-B	U1	ADS-B Out cap. using UAT
A	Mode A	P	Mode S Pres Alt No AC ID	U2	ADS-B Out and In cap. UAT
C	Mode A and Mode C	S	Mode S Pres Alt and AC ID	V1	ADS-B Out cap. VDL Mode 4
E	Mode S AC id. Ext Sq	X	Mode S No Pres Alt No AC ID	V2	ADS-B Out/In cap. VDL Mode 4
H	Mode S AC id. Enh Surv	B1	ADS-B w/ 1090MHz ADS-B Out	D1	ADS-C with FANS 1/A cap.
I	Mode S AC id. No Pres Alt	B2	ADS-B 1090 MHz ADS-B Out/In	G1	ADS-C with ATN cap

Note:
Shaded filing codes indicate capability

ICAO Flight Plan NAV/ Free Text Field

RNP2	GBAS	WAAS	GPS
RNP4	SBAS	GNSS	

RNAV 2 Flight Plan Mapping

Legacy NAS Slant Filings			
REDUCED VERTICAL SEPARATION MINIMUM (RVSM)			
/H	Any nav. capability with failed transponder or failed Mode C	**/Z**	**RNAV, no GNSS, and transponder with Mode C**
/W	No GNSS, no RNAV, and transponder with Mode C	**/L**	**GNSS and transponder with Mode C**

NO RVSM									
No DME		*DME*		*TACAN*		*RNAV, No GNSS*		*GNSS*	
/X	No transponder	/D	No transponder	/M	No transponder	**/Y**	**No transponder**	**/V**	**No transponder**
/T	Transponder with no Mode C	/B	Transponder with no Mode C	/N	Transponder with no Mode C	**/C**	**Transponder with no Mode C**	**/S**	**Transponder with no Mode C**
/U	Transponder with Mode C	/A	Transponder with Mode C	/P	Transponder with Mode C	**/I**	**Transponder with Mode C**	**/G**	**Transponder with Mode C**

ICAO Flight Plan Field 10a													
N	No Capabilities	E1	ACARS - FMC WPR	I	INS	J6	FANS 1/A - Satcom MTSAT	M3	RTF - Iridium	T	TACAN
S	Standard	E2	ACARS - D-FIS	J1	ATN - VDL Mode 2	J7	FANS 1/A - Satcom Iridium	O	VOR	U	UHF RTF
A	**GBAS Landing System**	E3	ACARS - PDC	J2	FANS 1/A - HFDL	K	MLS	P1	RCP400 (CPDLC)	V	VHF RTF
B	**LPV (APV w/SBAS)**	F	ADF	J3	FANS 1/A - VDL Mode A	L	ILS	P2	RCP240 (CPDLC)	W	RVSM
C	LORAN C	**G**	**GNSS**	J4	FANS 1/A - VDL Mode 2	M1	RTF - Inmarsat	P3	RCP400 (Satvoice)	X	MNPS
D	DME	H	HF RTF	J5	FANS 1/A - Satcom Inmarsat	M2	RTF - MTSAT	R	PBN	Y	8.33 kHz VHF

ICAO Flight Plan Field 18							
A1	RNAV 10 (RNP10)	B6	RNAV 5 - LORANC	**D2**	**RNAV1 - GNSS**	**O3**	**RNP1 - DME/DME**
B1	**RNAV 5 - All**	**C1**	**RNAV2 - All**	**D3**	**RNAV1 - DME/DME**	**O4**	**RNP1 - DME/DME/IRU**
B2	**RNAV 5 - GNSS**	**C2**	**RNAV2 - GNSS**	**D4**	**RNAV1 - DME/DME/IRU**	**S1**	**RNP APCH**
B3	**RNAV 5 - DME/DME**	**C3**	**RNAV2 - DME/DME**	**L1**	**RNP 4**	**S2**	**RNP APCH w/ BARO VNAV**
B4	RNAV 5 - VOR/DME	**C4**	**RNAV2 - DME/DME/IRU**	**O1**	**RNP1 - All**	**T1**	**RNP AR APCH With RF**
B5	RNAV 5 - INS or IRS	**D1**	**RNAV1 - All**	**O2**	**RNP1 - GNSS**	**T2**	**RNP AR APCH Without RF**

ICAO Flight Plan Field 10b					
N	No surveillance equipment	L	Mode S AC id. ADS-B	U1	ADS-B Out cap. using UAT
A	Mode A	P	Mode S Pres Alt No AC ID	U2	ADS-B Out and In cap. UAT
C	Mode A and Mode C	S	Mode S Pres Alt and AC ID	V1	ADS-B Out cap. VDL Mode 4
E	Mode S AC id. Ext Sq	X	Mode S No Pres Alt No AC ID	V2	ADS-B Out/In cap. VDL Mode 4
H	Mode S AC id. Enh Surv	B1	ADS-B w/ 1090MHz ADS-B Out	D1	ADS-C with FANS 1/A cap.
I	Mode S AC id. No Pres Alt	B2	ADS-B 1090 MHz ADS-B Out/In	G1	ADS-C with ATN cap

Note:
Shaded filing codes indicate capability

ICAO Flight Plan NAV/ Free Text Field			
RNP2	**GBAS**	**WAAS**	**GPS**
RNP4	**SBAS**	**GNSS**	

RNP 1 with RF Flight Plan Mapping

Legacy NAS Slant Filings			
REDUCED VERTICAL SEPARATION MINIMUM (RVSM)			
/H	Any nav. capability with failed transponder or failed Mode C	/Z	RNAV, no GNSS, and transponder with Mode C
/W	No GNSS, no RNAV, and transponder with Mode C	/L	GNSS and transponder with Mode C

NO RVSM									
No DME		*DME*		*TACAN*		*RNAV, No GNSS*		*GNSS*	
/X	No transponder	/D	No transponder	/M	No transponder	/Y	No transponder	/V	No transponder
/T	Transponder with no Mode C	/B	Transponder with no Mode C	/N	Transponder with no Mode C	/C	Transponder with no Mode C	/S	Transponder with no Mode C
/U	Transponder with Mode C	/A	Transponder with Mode C	/P	Transponder with Mode C	/I	Transponder with Mode C	/G	Transponder with Mode C

ICAO Flight Plan Field 10a													
N	No Capabilities	E1	ACARS - FMC WPR	I	INS	J6	FANS 1/A - Satcom MTSAT	M3	RTF - Iridium	T	TACAN
S	Standard	E2	ACARS - D-FIS	J1	ATN - VDL Mode 2	J7	FANS 1/A - Satcom Iridium	O	VOR	U	UHF RTF
A	**GBAS Landing System**	E3	ACARS - PDC	J2	FANS 1/A - HFDL	K	MLS	P1	RCP400 (CPDLC)	V	VHF RTF
B	LPV (APV w/SBAS)	F	ADF	J3	FANS 1/A - VDL Mode A	L	ILS	P2	RCP240 (CPDLC)	W	RVSM
C	LORAN C	G	GNSS	J4	FANS 1/A - VDL Mode 2	M1	RTF - Inmarsat	P3	RCP400 (Satvoice)	X	MNPS
D	DME	H	HF RTF	J5	FANS 1/A - Satcom Inmarsat	M2	RTF - MTSAT	R	PBN	Y	8.33 kHz VHF

ICAO Flight Plan Field 18							
A1	RNAV 10 (RNP10)	B6	RNAV 5 - LORANC	D2	RNAV1 - GNSS	O3	RNP1 - DME/DME
B1	RNAV 5 - All	C1	RNAV2 - All	D3	RNAV1 - DME/DME	O4	RNP1 - DME/DME/IRU
B2	RNAV 5 - GNSS	C2	RNAV2 - GNSS	D4	RNAV1 - DME/DME/IRU	S1	RNP APCH
B3	RNAV 5 - DME/DME	C3	RNAV2 - DME/DME	L1	RNP 4	S2	RNP APCH w/ BARO VNAV
B4	RNAV 5 - VOR/DME	C4	RNAV2 - DME/DME/IRU	O1	RNP1 - All	**T1**	**RNP AR APCH With RF**
B5	RNAV 5 - INS or IRS	D1	RNAV1 - All	O2	RNP1 - GNSS	T2	RNP AR APCH Without RF

ICAO Flight Plan Field 10b					
N	No surveillance equipment	L	Mode S AC id. ADS-B	U1	ADS-B Out cap. using UAT
A	Mode A	P	Mode S Pres Alt No AC ID	U2	ADS-B Out and In cap. UAT
C	Mode A and Mode C	S	Mode S Pres Alt and AC ID	V1	ADS-B Out cap. VDL Mode 4
E	Mode S AC id. Ext Sq	X	Mode S No Pres Alt No AC ID	V2	ADS-B Out/In cap. VDL Mode 4
H	Mode S AC id. Enh Surv	B1	ADS-B w/ 1090MHz ADS-B Out	D1	ADS-C with FANS 1/A cap.
I	Mode S AC id. No Pres Alt	B2	ADS-B 1090 MHz ADS-B Out/In	G1	ADS-C with ATN cap

Note:
Shaded filing codes indicate capability

ICAO Flight Plan NAV/ Free Text Field			
RNP2	**GBAS**	WAAS	GPS
RNP4	SBAS	GNSS	

RNP 1 with TF Flight Plan Mapping

Legacy NAS Slant Filings									
REDUCED VERTICAL SEPARATION MINIMUM (RVSM)									
/H	Any nav. capability with failed transponder or failed Mode C			/Z	RNAV, no GNSS, and transponder with Mode C				
/W	No GNSS, no RNAV, and transponder with Mode C			/L	GNSS and transponder with Mode C				
NO RVSM									
No DME		*DME*		*TACAN*		*RNAV, No GNSS*		*GNSS*	
/X	No transponder	/D	No transponder	/M	No transponder	/Y	No transponder	/V	No transponder
/T	Transponder with no Mode C	/B	Transponder with no Mode C	/N	Transponder with no Mode C	/C	Transponder with no Mode C	/S	Transponder with no Mode C
/U	Transponder with Mode C	/A	Transponder with Mode C	/P	Transponder with Mode C	/I	Transponder with Mode C	/G	Transponder with Mode C

ICAO Flight Plan Field 10a											
N	No Capabilities	E1	ACARS - FMC WPR	I	INS	J6	FANS 1/A - Satcom MTSAT	M3	RTF - Iridium	T	TACAN
S	Standard	E2	ACARS - D-FIS	J1	ATN - VDL Mode 2	J7	FANS 1/A - Satcom Iridium	O	VOR	U	UHF RTF
A	GBAS Landing System	E3	ACARS - PDC	J2	FANS 1/A - HFDL	K	MLS	P1	RCP400 (CPDLC)	V	VHF RTF
B	LPV (APV w/SBAS)	F	ADF	J3	FANS 1/A - VDL Mode A	L	ILS	P2	RCP240 (CPDLC)	W	RVSM
C	LORAN C	G	GNSS	J4	FANS 1/A - VDL Mode 2	M1	RTF - Inmarsat	P3	RCP400 (Satvoice)	X	MNPS
D	DME	H	HF RTF	J5	FANS 1/A - Satcom Inmarsat	M2	RTF - MTSAT	R	PBN	Y	8.33 kHz VHF

ICAO Flight Plan Field 18							
A1	RNAV 10 (RNP10)	B6	RNAV 5 - LORANC	D2	RNAV1 - GNSS	O3	RNP1 - DME/DME
B1	RNAV 5 - All	C1	RNAV2 - All	D3	RNAV1 - DME/DME	O4	RNP1 - DME/DME/IRU
B2	RNAV 5 - GNSS	C2	RNAV2 - GNSS	D4	RNAV1 - DME/DME/IRU	S1	RNP APCH
B3	RNAV 5 - DME/DME	C3	RNAV2 - DME/DME	L1	RNP 4	S2	RNP APCH w/ BARO VNAV
B4	RNAV 5 - VOR/DME	C4	RNAV2 - DME/DME/IRU	O1	RNP1 - All	T1	RNP AR APCH With RF
B5	RNAV 5 - INS or IRS	D1	RNAV1 - All	O2	RNP1 - GNSS	T2	RNP AR APCH Without RF

ICAO Flight Plan Field 10b					
N	No surveillance equipment	L	Mode S AC id. ADS-B	U1	ADS-B Out cap. using UAT
A	Mode A	P	Mode S Pres Alt No AC ID	U2	ADS-B Out and In cap. UAT
C	Mode A and Mode C	S	Mode S Pres Alt and AC ID	V1	ADS-B Out cap. VDL Mode 4
E	Mode S AC id. Ext Sq	X	Mode S No Pres Alt No AC ID	V2	ADS-B Out/In cap. VDL Mode 4
H	Mode S AC id. Enh Surv	B1	ADS-B w/ 1090MHz ADS-B Out	D1	ADS-C with FANS 1/A cap.
I	Mode S AC id. No Pres Alt	B2	ADS-B 1090 MHz ADS-B Out/In	G1	ADS-C with ATN cap

Note:
Shaded filing codes indicate capability

ICAO Flight Plan NAV/ Free Text Field			
RNP2	GBAS	WAAS	GPS
RNP4	SBAS	GNSS	

VNAV Approach Flight Plan Mapping

Legacy NAS Slant Filings									
REDUCED VERTICAL SEPARATION MINIMUM (RVSM)									
/H	Any nav. capability with failed transponder or failed Mode C			/Z	RNAV, no GNSS, and transponder with Mode C				
/W	No GNSS, no RNAV, and transponder with Mode C			/L	GNSS and transponder with Mode C				
NO RVSM									
No DME		*DME*		*TACAN*		*RNAV, No GNSS*		*GNSS*	
/X	No transponder	/D	No transponder	/M	No transponder	/Y	No transponder	/V	No transponder
/T	Transponder with no Mode C	/B	Transponder with no Mode C	/N	Transponder with no Mode C	/C	Transponder with no Mode C	/S	Transponder with no Mode C
/U	Transponder with Mode C	/A	Transponder with Mode C	/P	Transponder with Mode C	/I	Transponder with Mode C	/G	Transponder with Mode C

ICAO Flight Plan Field 10a											
N	No Capabilities	E1	ACARS - FMC WPR	I	INS	J6	FANS 1/A - Satcom MTSAT	M3	RTF - Iridium	T	TACAN
S	Standard	E2	ACARS - D-FIS	J1	ATN - VDL Mode 2	J7	FANS 1/A - Satcom Iridium	O	VOR	U	UHF RTF
A	GBAS Landing System	E3	ACARS - PDC	J2	FANS 1/A - HFDL	K	MLS	P1	RCP400 (CPDLC)	V	VHF RTF
B	LPV (APV w/SBAS)	F	ADF	J3	FANS 1/A - VDL Mode A	L	ILS	P2	RCP240 (CPDLC)	W	RVSM
C	LORAN C	G	GNSS	J4	FANS 1/A - VDL Mode 2	M1	RTF - Inmarsat	P3	RCP400 (Satvoice)	X	MNPS
D	DME	H	HF RTF	J5	FANS 1/A - Satcom Inmarsat	M2	RTF - MTSAT	R	PBN	Y	8.33 kHz VHF

ICAO Flight Plan Field 18							
A1	RNAV 10 (RNP10)	B6	RNAV 5 - LORANC	D2	RNAV1 - GNSS	O3	RNP1 - DME/DME
B1	RNAV 5 - All	C1	RNAV2 - All	D3	RNAV1 - DME/DME	O4	RNP1 - DME/DME/IRU
B2	RNAV 5 - GNSS	C2	RNAV2 - GNSS	D4	RNAV1 - DME/DME/IRU	S1	RNP APCH
B3	RNAV 5 - DME/DME	C3	RNAV2 - DME/DME	L1	RNP 4	S2	RNP APCH w/ BARO VNAV
B4	RNAV 5 - VOR/DME	C4	RNAV2 - DME/DME/IRU	O1	RNP1 - All	T1	RNP AR APCH With RF
B5	RNAV 5 - INS or IRS	D1	RNAV1 - All	O2	RNP1 - GNSS	T2	RNP AR APCH Without RF

ICAO Flight Plan Field 10b					
N	No surveillance equipment	L	Mode S AC id. ADS-B	U1	ADS-B Out cap. using UAT
A	Mode A	P	Mode S Pres Alt No AC ID	U2	ADS-B Out and In cap. UAT
C	Mode A and Mode C	S	Mode S Pres Alt and AC ID	V1	ADS-B Out cap. VDL Mode 4
E	Mode S AC id. Ext Sq	X	Mode S No Pres Alt No AC ID	V2	ADS-B Out/In cap. VDL Mode 4
H	Mode S AC id. Enh Surv	B1	ADS-B w/ 1090MHz ADS-B Out	D1	ADS-C with FANS 1/A cap.
I	Mode S AC id. No Pres Alt	B2	ADS-B 1090 MHz ADS-B Out/In	G1	ADS-C with ATN cap

Note:
Shaded filing codes indicate capability

ICAO Flight Plan NAV/ Free Text Field			
RNP2	GBAS	WAAS	GPS
RNP4	SBAS	GNSS	

LPV Approach Flight Plan Mapping

Legacy NAS Slant Filings									
REDUCED VERTICAL SEPARATION MINIMUM (RVSM)									
/H	Any nav. capability with failed transponder or failed Mode C			/Z	RNAV, no GNSS, and transponder with Mode C				
/W	No GNSS, no RNAV, and transponder with Mode C			/L	GNSS and transponder with Mode C				
NO RVSM									
No DME		DME		TACAN		RNAV, No GNSS		GNSS	
/X	No transponder	/D	No transponder	/M	No transponder	/Y	No transponder	/V	No transponder
/T	Transponder with no Mode C	/B	Transponder with no Mode C	/N	Transponder with no Mode C	/C	Transponder with no Mode C	/S	Transponder with no Mode C
/U	Transponder with Mode C	/A	Transponder with Mode C	/P	Transponder with Mode C	/I	Transponder with Mode C	/G	Transponder with Mode C

ICAO Flight Plan Field 10a											
N	No Capabilities	E1	ACARS - FMC WPR	I	INS	J6	FANS 1/A - Satcom MTSAT	M3	RTF - Iridium	T	TACAN
S	Standard	E2	ACARS - D-FIS	J1	ATN - VDL Mode 2	J7	FANS 1/A - Satcom Iridium	O	VOR	U	UHF RTF
A	GBAS Landing System	E3	ACARS - PDC	J2	FANS 1/A - HFDL	K	MLS	P1	RCP400 (CPDLC)	V	VHF RTF
B	LPV (APV w/SBAS)	F	ADF	J3	FANS 1/A - VDL Mode A	L	ILS	P2	RCP240 (CPDLC)	W	RVSM
C	LORAN C	G	GNSS	J4	FANS 1/A - VDL Mode 2	M1	RTF - Inmarsat	P3	RCP400 (Satvoice)	X	MNPS
D	DME	H	HF RTF	J5	FANS 1/A - Satcom Inmarsat	M2	RTF - MTSAT	R	PBN	Y	8.33 kHz VHF

ICAO Flight Plan Field 18							
A1	RNAV 10 (RNP10)	B6	RNAV 5 - LORANC	D2	RNAV1 - GNSS	O3	RNP1 - DME/DME
B1	RNAV 5 - All	C1	RNAV2 - All	D3	RNAV1 - DME/DME	O4	RNP1 - DME/DME/IRU
B2	RNAV 5 - GNSS	C2	RNAV2 - GNSS	D4	RNAV1 - DME/DME/IRU	S1	RNP APCH
B3	RNAV 5 - DME/DME	C3	RNAV2 - DME/DME	L1	RNP 4	S2	RNP APCH w/ BARO VNAV
B4	RNAV 5 - VOR/DME	C4	RNAV2 - DME/DME/IRU	O1	RNP1 - All	T1	RNP AR APCH With RF
B5	RNAV 5 - INS or IRS	D1	RNAV1 - All	O2	RNP1 - GNSS	T2	RNP AR APCH Without RF

ICAO Flight Plan Field 10b					
N	No surveillance equipment	L	Mode S AC id. ADS-B	U1	ADS-B Out cap. using UAT
A	Mode A	P	Mode S Pres Alt No AC ID	U2	ADS-B Out and In cap. UAT
C	Mode A and Mode C	S	Mode S Pres Alt and AC ID	V1	ADS-B Out cap. VDL Mode 4
E	Mode S AC id. Ext Sq	X	Mode S No Pres Alt No AC ID	V2	ADS-B Out/In cap. VDL Mode 4
H	Mode S AC id. Enh Surv	B1	ADS-B w/ 1090MHz ADS-B Out	D1	ADS-C with FANS 1/A cap.
I	Mode S AC id. No Pres Alt	B2	ADS-B 1090 MHz ADS-B Out/In	G1	ADS-C with ATN cap

Note:
Shaded filing codes indicate capability

ICAO Flight Plan NAV/ Free Text Field			
RNP2	GBAS	WAAS	GPS
RNP4	SBAS	GNSS	

RNP Approach Flight Plan Mapping

Legacy NAS Slant Filings									
REDUCED VERTICAL SEPARATION MINIMUM (RVSM)									
/H	Any nav. capability with failed transponder or failed Mode C			/Z	RNAV, no GNSS, and transponder with Mode C				
/W	No GNSS, no RNAV, and transponder with Mode C			/L	GNSS and transponder with Mode C				
NO RVSM									
No DME		DME		TACAN		RNAV, No GNSS		GNSS	
/X	No transponder	/D	No transponder	/M	No transponder	/Y	No transponder	/V	No transponder
/T	Transponder with no Mode C	/B	Transponder with no Mode C	/N	Transponder with no Mode C	/C	Transponder with no Mode C	/S	Transponder with no Mode C
/U	Transponder with Mode C	/A	Transponder with Mode C	/P	Transponder with Mode C	/I	Transponder with Mode C	/G	Transponder with Mode C

ICAO Flight Plan Field 10a											
N	No Capabilities	E1	ACARS - FMC WPR	I	INS	J6	FANS 1/A - Satcom MTSAT	M3	RTF - Iridium	T	TACAN
S	Standard	E2	ACARS - D-FIS	J1	ATN - VDL Mode 2	J7	FANS 1/A - Satcom Iridium	O	VOR	U	UHF RTF
A	GBAS Landing System	E3	ACARS - PDC	J2	FANS 1/A - HFDL	K	MLS	P1	RCP400 (CPDLC)	V	VHF RTF
B	LPV (APV w/SBAS)	F	ADF	J3	FANS 1/A - VDL Mode A	L	ILS	P2	RCP240 (CPDLC)	W	RVSM
C	LORAN C	G	GNSS	J4	FANS 1/A - VDL Mode 2	M1	RTF - Inmarsat	P3	RCP400 (Satvoice)	X	MNPS
D	DME	H	HF RTF	J5	FANS 1/A - Satcom Inmarsat	M2	RTF - MTSAT	R	PBN	Y	8.33 kHz VHF

ICAO Flight Plan Field 18							
A1	RNAV 10 (RNP10)	B6	RNAV 5 - LORANC	D2	RNAV1 - GNSS	O3	RNP1 - DME/DME
B1	RNAV 5 - All	C1	RNAV2 - All	D3	RNAV1 - DME/DME	O4	RNP1 - DME/DME/IRU
B2	RNAV 5 - GNSS	C2	RNAV2 - GNSS	D4	RNAV1 - DME/DME/IRU	S1	RNP APCH
B3	RNAV 5 - DME/DME	C3	RNAV2 - DME/DME	L1	RNP 4	S2	RNP APCH w/ BARO VNAV
B4	RNAV 5 - VOR/DME	C4	RNAV2 - DME/DME/IRU	O1	RNP1 - All	T1	RNP AR APCH With RF
B5	RNAV 5 - INS or IRS	D1	RNAV1 - All	O2	RNP1 - GNSS	T2	RNP AR APCH Without RF

ICAO Flight Plan Field 10b					
N	No surveillance equipment	L	Mode S AC id. ADS-B	U1	ADS-B Out cap. using UAT
A	Mode A	P	Mode S Pres Alt No AC ID	U2	ADS-B Out and In cap. UAT
C	Mode A and Mode C	S	Mode S Pres Alt and AC ID	V1	ADS-B Out cap. VDL Mode 4
E	Mode S AC id. Ext Sq	X	Mode S No Pres Alt No AC ID	V2	ADS-B Out/In cap. VDL Mode 4
H	Mode S AC id. Enh Surv	B1	ADS-B w/ 1090MHz ADS-B Out	D1	ADS-C with FANS 1/A cap.
I	Mode S AC id. No Pres Alt	B2	ADS-B 1090 MHz ADS-B Out/In	G1	ADS-C with ATN cap

Note:
Shaded filing codes indicate capability

ICAO Flight Plan NAV/ Free Text Field			
RNP2	GBAS	WAAS	GPS
RNP4	SBAS	GNSS	

RNP AR Approach Flight Plan Mapping

Legacy NAS Slant Filings									
REDUCED VERTICAL SEPARATION MINIMUM (RVSM)									
/H	Any nav. capability with failed transponder or failed Mode C			/Z	RNAV, no GNSS, and transponder with Mode C				
/W	No GNSS, no RNAV, and transponder with Mode C			/L	GNSS and transponder with Mode C				
NO RVSM									
No DME		*DME*		*TACAN*		*RNAV, No GNSS*		*GNSS*	
/X	No transponder	/D	No transponder	/M	No transponder	/Y	No transponder	/V	No transponder
/T	Transponder with no Mode C	/B	Transponder with no Mode C	/N	Transponder with no Mode C	/C	Transponder with no Mode C	/S	Transponder with no Mode C
/U	Transponder with Mode C	/A	Transponder with Mode C	/P	Transponder with Mode C	/I	Transponder with Mode C	/G	Transponder with Mode C

ICAO Flight Plan Field 10a											
N	No Capabilities	E1	ACARS - FMC WPR	I	INS	J6	FANS 1/A - Satcom MTSAT	M3	RTF - Iridium	T	TACAN
S	Standard	E2	ACARS - D-FIS	J1	ATN - VDL Mode 2	J7	FANS 1/A - Satcom Iridium	O	VOR	U	UHF RTF
A	GBAS Landing System	E3	ACARS - PDC	J2	FANS 1/A - HFDL	K	MLS	P1	RCP400 (CPDLC)	V	VHF RTF
B	LPV (APV w/SBAS)	F	ADF	J3	FANS 1/A - VDL Mode A	L	ILS	P2	RCP240 (CPDLC)	W	RVSM
C	LORAN C	G	GNSS	J4	FANS 1/A - VDL Mode 2	M1	RTF - Inmarsat	P3	RCP400 (Satvoice)	X	MNPS
D	DME	H	HF RTF	J5	FANS 1/A - Satcom Inmarsat	M2	RTF - MTSAT	R	PBN	Y	8.33 kHz VHF

ICAO Flight Plan Field 18							
A1	RNAV 10 (RNP10)	B6	RNAV 5 - LORANC	D2	RNAV1 - GNSS	O3	RNP1 - DME/DME
B1	RNAV 5 - All	C1	RNAV2 - All	D3	RNAV1 - DME/DME	O4	RNP1 - DME/DME/IRU
B2	RNAV 5 - GNSS	C2	RNAV2 - GNSS	D4	RNAV1 - DME/DME/IRU	S1	RNP APCH
B3	RNAV 5 - DME/DME	C3	RNAV2 - DME/DME	L1	RNP 4	S2	RNP APCH w/ BARO VNAV
B4	RNAV 5 - VOR/DME	C4	RNAV2 - DME/DME/IRU	O1	RNP1 - All	T1	RNP AR APCH With RF
B5	RNAV 5 - INS or IRS	D1	RNAV1 - All	O2	RNP1 - GNSS	T2	RNP AR APCH Without RF

ICAO Flight Plan Field 10b					
N	No surveillance equipment	L	Mode S AC id. ADS-B	U1	ADS-B Out cap. using UAT
A	Mode A	P	Mode S Pres Alt No AC ID	U2	ADS-B Out and In cap. UAT
C	Mode A and Mode C	S	Mode S Pres Alt and AC ID	V1	ADS-B Out cap. VDL Mode 4
E	Mode S AC id. Ext Sq	X	Mode S No Pres Alt No AC ID	V2	ADS-B Out/In cap. VDL Mode 4
H	Mode S AC id. Enh Surv	B1	ADS-B w/ 1090MHz ADS-B Out	D1	ADS-C with FANS 1/A cap.
I	Mode S AC id. No Pres Alt	B2	ADS-B 1090 MHz ADS-B Out/In	G1	ADS-C with ATN cap

Note:
Shaded filing codes indicate capability

ICAO Flight Plan NAV/ Free Text Field			
RNP2	GBAS	WAAS	GPS
RNP4	SBAS	GNSS	

GLS I Flight Plan Mapping

Legacy NAS Slant Filings									
REDUCED VERTICAL SEPARATION MINIMUM (RVSM)									
/H	Any nav. capability with failed transponder or failed Mode C			/Z	RNAV, no GNSS, and transponder with Mode C				
/W	No GNSS, no RNAV, and transponder with Mode C			/L	GNSS and transponder with Mode C				
NO RVSM									
No DME		*DME*		*TACAN*		*RNAV, No GNSS*		*GNSS*	
/X	No transponder	/D	No transponder	/M	No transponder	/Y	No transponder	/V	No transponder
/T	Transponder with no Mode C	/B	Transponder with no Mode C	/N	Transponder with no Mode C	/C	Transponder with no Mode C	/S	Transponder with no Mode C
/U	Transponder with Mode C	/A	Transponder with Mode C	/P	Transponder with Mode C	/I	Transponder with Mode C	/G	Transponder with Mode C

ICAO Flight Plan Field 10a											
N	No Capabilities	E1	ACARS - FMC WPR	I	INS	J6	FANS 1/A - Satcom MTSAT	M3	RTF - Iridium	T	TACAN
S	Standard	E2	ACARS - D-FIS	J1	ATN - VDL Mode 2	J7	FANS 1/A - Satcom Iridium	O	VOR	U	UHF RTF
A	GBAS Landing System	E3	ACARS - PDC	J2	FANS 1/A - HFDL	K	MLS	P1	RCP400 (CPDLC)	V	VHF RTF
B	LPV (APV w/SBAS)	F	ADF	J3	FANS 1/A - VDL Mode A	L	ILS	P2	RCP240 (CPDLC)	W	RVSM
C	LORAN C	G	GNSS	J4	FANS 1/A - VDL Mode 2	M1	RTF - Inmarsat	P3	RCP400 (Satvoice)	X	MNPS
D	DME	H	HF RTF	J5	FANS 1/A - Satcom Inmarsat	M2	RTF - MTSAT	R	PBN	Y	8.33 kHz VHF

ICAO Flight Plan Field 18							
A1	RNAV 10 (RNP10)	B6	RNAV 5 - LORANC	D2	RNAV1 - GNSS	O3	RNP1 - DME/DME
B1	RNAV 5 - All	C1	RNAV2 - All	D3	RNAV1 - DME/DME	O4	RNP1 - DME/DME/IRU
B2	RNAV 5 - GNSS	C2	RNAV2 - GNSS	D4	RNAV1 - DME/DME/IRU	S1	RNP APCH
B3	RNAV 5 - DME/DME	C3	RNAV2 - DME/DME	L1	RNP 4	S2	RNP APCH w/ BARO VNAV
B4	RNAV 5 - VOR/DME	C4	RNAV2 - DME/DME/IRU	O1	RNP1 - All	T1	RNP AR APCH With RF
B5	RNAV 5 - INS or IRS	D1	RNAV1 - All	O2	RNP1 - GNSS	T2	RNP AR APCH Without RF

ICAO Flight Plan Field 10b					
N	No surveillance equipment	L	Mode S AC id. ADS-B	U1	ADS-B Out cap. using UAT
A	Mode A	P	Mode S Pres Alt No AC ID	U2	ADS-B Out and In cap. UAT
C	Mode A and Mode C	S	Mode S Pres Alt and AC ID	V1	ADS-B Out cap. VDL Mode 4
E	Mode S AC id. Ext Sq	X	Mode S No Pres Alt No AC ID	V2	ADS-B Out/In cap. VDL Mode 4
H	Mode S AC id. Enh Surv	B1	ADS-B w/ 1090MHz ADS-B Out	D1	ADS-C with FANS 1/A cap.
I	Mode S AC id. No Pres Alt	B2	ADS-B 1090 MHz ADS-B Out/In	G1	ADS-C with ATN cap

Note:
Shaded filing codes indicate capability

ICAO Flight Plan NAV/ Free Text Field			
RNP2	GBAS	WAAS	GPS
RNP4	SBAS	GNSS	

B.2 Automatic Dependent Surveillance-Broadcast Flight Plan Mappings

ADS-B Out Flight Plan Mapping

Legacy NAS Slant Filings									
REDUCED VERTICAL SEPARATION MINIMUM (RVSM)									
/H	Any nav. capability with failed transponder or failed Mode C			/Z	RNAV, no GNSS, and transponder with Mode C				
/W	No GNSS, no RNAV, and transponder with Mode C			/L	GNSS and transponder with Mode C				
NO RVSM									
No DME		*DME*		*TACAN*		*RNAV, No GNSS*		*GNSS*	
/X	No transponder	/D	No transponder	/M	No transponder	/Y	No transponder	/V	No transponder
/T	Transponder with no Mode C	/B	Transponder with no Mode C	/N	Transponder with no Mode C	/C	Transponder with no Mode C	/S	Transponder with no Mode C
/U	Transponder with Mode C	/A	Transponder with Mode C	/P	Transponder with Mode C	/I	Transponder with Mode C	/G	Transponder with Mode C

ICAO Flight Plan Field 10a											
N	No Capabilities	E1	ACARS - FMC WPR	I	INS	J6	FANS 1/A - Satcom MTSAT	M3	RTF - Iridium	T	TACAN
S	Standard	E2	ACARS - D-FIS	J1	ATN - VDL Mode 2	J7	FANS 1/A - Satcom Iridium	O	VOR	U	UHF RTF
A	GBAS Landing System	E3	ACARS - PDC	J2	FANS 1/A - HFDL	K	MLS	P1	RCP400 (CPDLC)	V	VHF RTF
B	LPV (APV w/SBAS)	F	ADF	J3	FANS 1/A - VDL Mode A	L	ILS	P2	RCP240 (CPDLC)	W	RVSM
C	LORAN C	G	GNSS	J4	FANS 1/A - VDL Mode 2	M1	RTF - Inmarsat	P3	RCP400 (Satvoice)	X	MNPS
D	DME	H	HF RTF	J5	FANS 1/A - Satcom Inmarsat	M2	RTF - MTSAT	R	PBN	Y	8.33 kHz VHF

ICAO Flight Plan Field 18							
A1	RNAV 10 (RNP10)	B6	RNAV 5 - LORANC	D2	RNAV1 - GNSS	O3	RNP1 - DME/DME
B1	RNAV 5 - All	C1	RNAV2 - All	D3	RNAV1 - DME/DME	O4	RNP1 - DME/DME/IRU
B2	RNAV 5 - GNSS	C2	RNAV2 - GNSS	D4	RNAV1 - DME/DME/IRU	S1	RNP APCH
B3	RNAV 5 - DME/DME	C3	RNAV2 - DME/DME	L1	RNP 4	S2	RNP APCH w/ BARO VNAV
B4	RNAV 5 - VOR/DME	C4	RNAV2 - DME/DME/IRU	O1	RNP1 - All	T1	RNP AR APCH With RF
B5	RNAV 5 - INS or IRS	D1	RNAV1 - All	O2	RNP1 - GNSS	T2	RNP AR APCH Without RF

ICAO Flight Plan Field 10b					
N	No surveillance equipment	L	Mode S AC id. ADS-B	U1	ADS-B Out cap. using UAT
A	Mode A	P	Mode S Pres Alt No AC ID	U2	ADS-B Out and In cap. UAT
C	Mode A and Mode C	S	Mode S Pres Alt and AC ID	V1	ADS-B Out cap. VDL Mode 4
E	Mode S AC id. Ext Sq	X	Mode S No Pres Alt No AC ID	V2	ADS-B Out/In cap. VDL Mode 4
H	Mode S AC id. Enh Surv	B1	ADS-B w/ 1090MHz ADS-B Out	D1	ADS-C with FANS 1/A cap.
I	Mode S AC id. No Pres Alt	B2	ADS-B 1090 MHz ADS-B Out/In	G1	ADS-C with ATN cap

Note:
Shaded filing codes indicate capability

ADS-B In Flight Plan Mapping

Legacy NAS Slant Filings									
REDUCED VERTICAL SEPARATION MINIMUM (RVSM)									
/H	Any nav. capability with failed transponder or failed Mode C			/Z	RNAV, no GNSS, and transponder with Mode C				
/W	No GNSS, no RNAV, and transponder with Mode C			/L	GNSS and transponder with Mode C				
NO RVSM									
No DME		*DME*		*TACAN*		*RNAV, No GNSS*		*GNSS*	
/X	No transponder	/D	No transponder	/M	No transponder	/Y	No transponder	/V	No transponder
/T	Transponder with no Mode C	/B	Transponder with no Mode C	/N	Transponder with no Mode C	/C	Transponder with no Mode C	/S	Transponder with no Mode C
/U	Transponder with Mode C	/A	Transponder with Mode C	/P	Transponder with Mode C	/I	Transponder with Mode C	/G	Transponder with Mode C

ICAO Flight Plan Field 10a											
N	No Capabilities	E1	ACARS - FMC WPR	I	INS	J6	FANS 1/A - Satcom MTSAT	M3	RTF - Iridium	T	TACAN
S	Standard	E2	ACARS - D-FIS	J1	ATN - VDL Mode 2	J7	FANS 1/A - Satcom Iridium	O	VOR	U	UHF RTF
A	GBAS Landing System	E3	ACARS - PDC	J2	FANS 1/A - HFDL	K	MLS	P1	RCP400 (CPDLC)	V	VHF RTF
B	LPV (APV w/SBAS)	F	ADF	J3	FANS 1/A - VDL Mode A	L	ILS	P2	RCP240 (CPDLC)	W	RVSM
C	LORAN C	G	GNSS	J4	FANS 1/A - VDL Mode 2	M1	RTF - Inmarsat	P3	RCP400 (Satvoice)	X	MNPS
D	DME	H	HF RTF	J5	FANS 1/A - Satcom Inmarsat	M2	RTF - MTSAT	R	PBN	Y	8.33 kHz VHF

ICAO Flight Plan Field 18							
A1	RNAV 10 (RNP10)	B6	RNAV 5 - LORANC	D2	RNAV1 - GNSS	O3	RNP1 - DME/DME
B1	RNAV 5 - All	C1	RNAV2 - All	D3	RNAV1 - DME/DME	O4	RNP1 - DME/DME/IRU
B2	RNAV 5 - GNSS	C2	RNAV2 - GNSS	D4	RNAV1 - DME/DME/IRU	S1	RNP APCH
B3	RNAV 5 - DME/DME	C3	RNAV2 - DME/DME	L1	RNP 4	S2	RNP APCH w/ BARO VNAV
B4	RNAV 5 - VOR/DME	C4	RNAV2 - DME/DME/IRU	O1	RNP1 - All	T1	RNP AR APCH With RF
B5	RNAV 5 - INS or IRS	D1	RNAV1 - All	O2	RNP1 - GNSS	T2	RNP AR APCH Without RF

ICAO Flight Plan Field 10b					
N	No surveillance equipment	L	Mode S AC id. ADS-B	U1	ADS-B Out cap. using UAT
A	Mode A	P	Mode S Pres Alt No AC ID	U2	ADS-B Out and In cap. UAT
C	Mode A and Mode C	S	Mode S Pres Alt and AC ID	V1	ADS-B Out cap. VDL Mode 4
E	Mode S AC id. Ext Sq	X	Mode S No Pres Alt No AC ID	V2	ADS-B Out/In cap. VDL Mode 4
H	Mode S AC id. Enh Surv	B1	ADS-B w/ 1090MHz ADS-B Out	D1	ADS-C with FANS 1/A cap.
I	Mode S AC id. No Pres Alt	B2	ADS-B 1090 MHz ADS-B Out/In	G1	ADS-C with ATN cap

Note:
Shaded filing codes indicate capability

B.3 Data Communications Flight Plan Mappings

FANS 1/A Domestic – Tower Services Flight Plan Mapping

Legacy NAS Slant Filings									
REDUCED VERTICAL SEPARATION MINIMUM (RVSM)									
/H	Any nav. capability with failed transponder or failed Mode C			/Z	RNAV, no GNSS, and transponder with Mode C				
/W	No GNSS, no RNAV, and transponder with Mode C			/L	GNSS and transponder with Mode C				
NO RVSM									
No DME		*DME*		*TACAN*		*RNAV, No GNSS*		*GNSS*	
/X	No transponder	/D	No transponder	/M	No transponder	/Y	No transponder	/V	No transponder
/T	Transponder with no Mode C	/B	Transponder with no Mode C	/N	Transponder with no Mode C	/C	Transponder with no Mode C	/S	Transponder with no Mode C
/U	Transponder with Mode C	/A	Transponder with Mode C	/P	Transponder with Mode C	/I	Transponder with Mode C	/G	Transponder with Mode C

ICAO Flight Plan Field 10a											
N	No Capabilities	E1	ACARS - FMC WPR	I	INS	J6	FANS 1/A - Satcom MTSAT	M3	RTF - Iridium	T	TACAN
S	Standard	E2	ACARS - D-FIS	J1	ATN - VDL Mode 2	J7	FANS 1/A - Satcom Iridium	O	VOR	U	UHF RTF
A	GBAS Landing System	E3	ACARS - PDC	J2	FANS 1/A - HFDL	K	MLS	P1	RCP400 (CPDLC)	V	VHF RTF
B	LPV (APV w/SBAS)	F	ADF	J3	FANS 1/A - VDL Mode A	L	ILS	P2	RCP240 (CPDLC)	W	RVSM
C	LORAN C	G	GNSS	J4	FANS 1/A - VDL Mode 2	M1	RTF - Inmarsat	P3	RCP400 (Satvoice)	X	MNPS
D	DME	H	HF RTF	J5	FANS 1/A - Satcom Inmarsat	M2	RTF - MTSAT	R	PBN	Y	8.33 kHz VHF

ICAO Flight Plan Field 18							
A1	RNAV 10 (RNP10)	B6	RNAV 5 - LORANC	D2	RNAV1 - GNSS	O3	RNP1 - DME/DME
B1	RNAV 5 - All	C1	RNAV2 - All	D3	RNAV1 - DME/DME	O4	RNP1 - DME/DME/IRU
B2	RNAV 5 - GNSS	C2	RNAV2 - GNSS	D4	RNAV1 - DME/DME/IRU	S1	RNP APCH
B3	RNAV 5 - DME/DME	C3	RNAV2 - DME/DME	L1	RNP 4	S2	RNP APCH w/ BARO VNAV
B4	RNAV 5 - VOR/DME	C4	RNAV2 - DME/DME/IRU	O1	RNP1 - All	T1	RNP AR APCH With RF
B5	RNAV 5 - INS or IRS	D1	RNAV1 - All	O2	RNP1 - GNSS	T2	RNP AR APCH Without RF

ICAO Flight Plan Field 10b					
N	No surveillance equipment	L	Mode S AC id. ADS-B	U1	ADS-B Out cap. using UAT
A	Mode A	P	Mode S Pres Alt No AC ID	U2	ADS-B Out and In cap. UAT
C	Mode A and Mode C	S	Mode S Pres Alt and AC ID	V1	ADS-B Out cap. VDL Mode 4
E	Mode S AC id. Ext Sq	X	Mode S No Pres Alt No AC ID	V2	ADS-B Out/In cap. VDL Mode 4
H	Mode S AC id. Enh Surv	B1	ADS-B w/ 1090MHz ADS-B Out	D1	ADS-C with FANS 1/A cap.
I	Mode S AC id. No Pres Alt	B2	ADS-B 1090 MHz ADS-B Out/In	G1	ADS-C with ATN cap

Note:
Shaded filing codes indicate capability

FANS 1/A Domestic – En Route Services Flight Plan Mapping

Legacy NAS Slant Filings									
REDUCED VERTICAL SEPARATION MINIMUM (RVSM)									
/H	Any nav. capability with failed transponder or failed Mode C			/Z	RNAV, no GNSS, and transponder with Mode C				
/W	No GNSS, no RNAV, and transponder with Mode C			/L	GNSS and transponder with Mode C				
NO RVSM									
No DME		*DME*		*TACAN*		*RNAV, No GNSS*		*GNSS*	
/X	No transponder	/D	No transponder	/M	No transponder	/Y	No transponder	/V	No transponder
/T	Transponder with no Mode C	/B	Transponder with no Mode C	/N	Transponder with no Mode C	/C	Transponder with no Mode C	/S	Transponder with no Mode C
/U	Transponder with Mode C	/A	Transponder with Mode C	/P	Transponder with Mode C	/I	Transponder with Mode C	/G	Transponder with Mode C

ICAO Flight Plan Field 10a											
N	No Capabilities	E1	ACARS - FMC WPR	I	INS	J6	FANS 1/A - Satcom MTSAT	M3	RTF - Iridium	T	TACAN
S	Standard	E2	ACARS - D-FIS	J1	ATN - VDL Mode 2	J7	FANS 1/A - Satcom Iridium	O	VOR	U	UHF RTF
A	GBAS Landing System	E3	ACARS - PDC	J2	FANS 1/A - HFDL	K	MLS	P1	RCP400 (CPDLC)	V	VHF RTF
B	LPV (APV w/SBAS)	F	ADF	J3	FANS 1/A - VDL Mode A	L	ILS	P2	RCP240 (CPDLC)	W	RVSM
C	LORAN C	G	GNSS	J4	FANS 1/A - VDL Mode 2	M1	RTF - Inmarsat	P3	RCP400 (Satvoice)	X	MNPS
D	DME	H	HF RTF	J5	FANS 1/A - Satcom Inmarsat	M2	RTF - MTSAT	R	PBN	Y	8.33 kHz VHF

ICAO Flight Plan Field 18							
A1	RNAV 10 (RNP10)	B6	RNAV 5 - LORANC	D2	RNAV1 - GNSS	O3	RNP1 - DME/DME
B1	RNAV 5 - All	C1	RNAV2 - All	D3	RNAV1 - DME/DME	O4	RNP1 - DME/DME/IRU
B2	RNAV 5 - GNSS	C2	RNAV2 - GNSS	D4	RNAV1 - DME/DME/IRU	S1	RNP APCH
B3	RNAV 5 - DME/DME	C3	RNAV2 - DME/DME	L1	RNP 4	S2	RNP APCH w/ BARO VNAV
B4	RNAV 5 - VOR/DME	C4	RNAV2 - DME/DME/IRU	O1	RNP1 - All	T1	RNP AR APCH With RF
B5	RNAV 5 - INS or IRS	D1	RNAV1 - All	O2	RNP1 - GNSS	T2	RNP AR APCH Without RF

ICAO Flight Plan Field 10b					
N	No surveillance equipment	L	Mode S AC id. ADS-B	U1	ADS-B Out cap. using UAT
A	Mode A	P	Mode S Pres Alt No AC ID	U2	ADS-B Out and In cap. UAT
C	Mode A and Mode C	S	Mode S Pres Alt and AC ID	V1	ADS-B Out cap. VDL Mode 4
E	Mode S AC id. Ext Sq	X	Mode S No Pres Alt No AC ID	V2	ADS-B Out/In cap. VDL Mode 4
H	Mode S AC id. Enh Surv	B1	ADS-B w/ 1090MHz ADS-B Out	D1	ADS-C with FANS 1/A cap.
I	Mode S AC id. No Pres Alt	B2	ADS-B 1090 MHz ADS-B Out/In	G1	ADS-C with ATN cap

Note:
Shaded filing codes indicate capability

FANS 1/A Oceanic Flight Plan Mapping

Legacy NAS Slant Filings									
REDUCED VERTICAL SEPARATION MINIMUM (RVSM)									
/H	Any nav. capability with failed transponder or failed Mode C			/Z	RNAV, no GNSS, and transponder with Mode C				
/W	No GNSS, no RNAV, and transponder with Mode C			/L	GNSS and transponder with Mode C				
NO RVSM									
No DME		*DME*		*TACAN*		*RNAV, No GNSS*		*GNSS*	
/X	No transponder	/D	No transponder	/M	No transponder	/Y	No transponder	/V	No transponder
/T	Transponder with no Mode C	/B	Transponder with no Mode C	/N	Transponder with no Mode C	/C	Transponder with no Mode C	/S	Transponder with no Mode C
/U	Transponder with Mode C	/A	Transponder with Mode C	/P	Transponder with Mode C	/I	Transponder with Mode C	/G	Transponder with Mode C

ICAO Flight Plan Field 10a											
N	No Capabilities	E1	ACARS - FMC WPR	I	INS	J6	FANS 1/A - Satcom MTSAT	M3	RTF - Iridium	T	TACAN
S	Standard	E2	ACARS - D-FIS	J1	ATN - VDL Mode 2	J7	FANS 1/A - Satcom Iridium	O	VOR	U	UHF RTF
A	GBAS Landing System	E3	ACARS - PDC	J2	FANS 1/A - HFDL	K	MLS	P1	RCP400 (CPDLC)	V	VHF RTF
B	LPV (APV w/SBAS)	F	ADF	J3	FANS 1/A - VDL Mode A	L	ILS	P2	RCP240 (CPDLC)	W	RVSM
C	LORAN C	G	GNSS	J4	FANS 1/A - VDL Mode 2	M1	RTF - Inmarsat	P3	RCP400 (Satvoice)	X	MNPS
D	DME	H	HF RTF	J5	FANS 1/A - Satcom Inmarsat	M2	RTF - MTSAT	R	PBN	Y	8.33 kHz VHF

ICAO Flight Plan Field 18							
A1	RNAV 10 (RNP10)	B6	RNAV 5 - LORANC	D2	RNAV1 - GNSS	O3	RNP1 - DME/DME
B1	RNAV 5 - All	C1	RNAV2 - All	D3	RNAV1 - DME/DME	O4	RNP1 - DME/DME/IRU
B2	RNAV 5 - GNSS	C2	RNAV2 - GNSS	D4	RNAV1 - DME/DME/IRU	S1	RNP APCH
B3	RNAV 5 - DME/DME	C3	RNAV2 - DME/DME	L1	RNP 4	S2	RNP APCH w/ BARO VNAV
B4	RNAV 5 - VOR/DME	C4	RNAV2 - DME/DME/IRU	O1	RNP1 - All	T1	RNP AR APCH With RF
B5	RNAV 5 - INS or IRS	D1	RNAV1 - All	O2	RNP1 - GNSS	T2	RNP AR APCH Without RF

ICAO Flight Plan Field 10b					
N	No surveillance equipment	L	Mode S AC id. ADS-B	U1	ADS-B Out cap. using UAT
A	Mode A	P	Mode S Pres Alt No AC ID	U2	ADS-B Out and In cap. UAT
C	Mode A and Mode C	S	Mode S Pres Alt and AC ID	V1	ADS-B Out cap. VDL Mode 4
E	Mode S AC id. Ext Sq	X	Mode S No Pres Alt No AC ID	V2	ADS-B Out/In cap. VDL Mode 4
H	Mode S AC id. Enh Surv	B1	ADS-B w/ 1090MHz ADS-B Out	D1	ADS-C with FANS 1/A cap.
I	Mode S AC id. No Pres Alt	B2	ADS-B 1090 MHz ADS-B Out/In	G1	ADS-C with ATN cap

Note:
Shaded filing codes indicate capability

Appendix C Airplane Labels and Abbreviations

C.1 Airplane Labels

Labels	Airplane Names
A109	AgustaWestland AW109
A139	AgustaWestland AW139
A21N	Airbus A321neo
A306	Airbus A300-600
A310	Airbus A310
A319	Airbus A319
A320	Airbus A320
A321	Airbus A321
A332	Airbus A330-200
A333	Airbus A330-300
A359	Airbus A350-900
A35K	Airbus A350-1000
A388	Airbus A380-800
AT43	ATR42-300
AT72	ATR72-200
B350	Beechcraft King Air 350
B38M	Boeing 737 MAX 8
B39M	Boeing 737 MAX 9
B407	Bell 407, Bell RH-70 Arapaho
B429	Bell 429 Global Ranger
B712	Boeing 717-200
B722	Boeing 727-200
B737	Boeing 737-700
B738	Boeing 737-800
B739	Boeing 737-900
B744	Boeing 747-400
B748	Boeing 747-8
B752	Boeing 757-200
B762	Boeing 767-200, KC-46, KC-767
B763	Boeing 767-300
B772	Boeing 777-200, 777-200ER
B77L	Boeing 777-200LR, 777F
B77W	Boeing 777-300ER

Labels	Airplane Names
B788	Boeing 787-8
B789	Boeing 787-9
BCS1	Airbus A220-100, Bombardier BD-500 CSeries CS100
BE20	Beechcraft King Air 200
BE35	Beechcraft 35 Bonanza
BE36	Beechcraft 36 Bonanza
BE58	Beechcraft 58 Baron
BE9L	Beechcraft King Air 90
C172	Cessna 172
C182	Cessna 182
C208	Cessna 208 Caravan
C210	Cessna 210
C25B	Cessna 525A Citation CJ2
C402	Cessna 402
C46	Curtiss C-46 Commando
C525	Cessna 525 Citation CJ1
C560	Cessna 560 Citation V
C56X	Cessna 560XL Citation Excel
C68A	Cessna 680A Citation Latitude
CL30	Bombardier BD-100 Challenger 300
CL35	Bombardier BD-100 Challenger 350
CL60	Bombardier CL-600 Challenger 600, Challenger 650
CRJ2	Bombardier CRJ200, CRJ440; CL-600 Challenger 800, Challenger 850
CRJ7	Bombardier CRJ550, CRJ700, CL-600 Challenger 870
CRJ9	Bombardier CRJ705, CRJ900, CL-600 Challenger 890
DC93	McDonnell Douglas DC-9-30
DH8D	Bombardier DHC-8-400 Dash 8
E135	Embraer ERJ135
E145	Embraer ERJ145
E170	Embraer ERJ170-100, E170
E190	Embraer ERJ190, E190
E55P	Embraer EMB505 Phenom 300
E75L	Embraer ERJ170-200, E175 Long Wing
E75S	Embraer ERJ170-200, E175 Short Wing
EC35	Airbus Helicopters (Eurocopter) EC-135, EC-635
EC45	Airbus Helicopters (Eurocopter) EC-145, EC-645
EC55	Airbus Helicopters (Eurocopter) EC-155

Labels	Airplane Names
F2TH	Dassault Falcon 2000
F900	Dassault Falcon 900
FA7X	Dassault Falcon 7X
GL5T	Bombardier BD-700 Global 5000
GLEX	Bombardier BD-700 Global Express 6000
GLF4	Gulfstream IV, IV-SP, G350, G450
GLF5	Gulfstream V, V-SP, G500, G550
GLF6	Gulfstream G650
H25B	Beechcraft Hawker 750, 800, 850, 900
LJ35	Learjet 35, 36
M20P	Mooney 201, 205, M20
MD10	McDonnell Douglas MD-10
MD11	McDonnell Douglas MD-11
MD83	McDonnell Douglas MD-83
P28A	Piper PA-28 Cherokee 140, 160, 180, Warrior, Archer
PA32	Piper PA-32 Cherokee Six, Lance, Saratoga
PC12	Pilatus PC-12
R22	Robinson R22
R44	Robinson R44
S76	Sikorsky S-76
S92	Sikorsky S-92
SR22	Cirrus SR22

C.2 Acronyms and Abbreviations

Term	Definition
AAM	Advanced Air Mobility
AAtS	Aircraft Access to SWIM
AC	Advisory Circular
ADS-B	Automatic Dependent Surveillance-Broadcast
AGL	Above Ground Level
AID	Aircraft Interface Device
AIRB	Situational Awareness-Airborne
AIRS Eval	ADS-B In Retrofit Spacing Evaluation
AMOC	Alternative Means of Compliance
APV	Approach Procedure with Vertical Guidance
AR	Authorization Required
ASA	Aircraft Surveillance Applications
ATM	Air Traffic Management
ATOP	Advanced Technologies and Oceanic Procedures
BARO	Barometric
CAASD	Center for Advanced Aviation System Development
CAS	CDTI Assisted Separation
CAT	Category
CAVS	CDTI Assisted Visual Separation [on Approach]
CDTI	Cockpit Display of Traffic Information
CFR	Code of Federal Regulations
COVID-19	Coronavirus Disease of 2019
CPDLC	Controller Pilot Data Link Communications
C-PNT	Complementary Position, Navigation, and Timing
CRJ	Canadair Regional Jet
CVS	Combined Vision Systems
CY	Calendar Year
DA	Decision Altitude
Data Comm	Data Communications
DCIS	Data Communications Integrated Services
DFMC	Dual Frequency Multi Constellation

Term	Definition
DH	Decision Height
DME	Distance Measuring Equipment
DP	Departure Procedures
EFB	Electronic Flight Bag
EFVS	Enhanced Flight Vision Systems
EoR	Established on RNP
EPP	Extended Projected Profile
FAA	Federal Aviation Administration
FANS	Future Air Navigation System
FIS-B	Flight Information Service-Broadcast
FMC	Flight Management Computer
FMS	Flight Management System
FSIMS	Flight Standards Information Management System
FY	Fiscal Year
GA	General Aviation
GAST	GBAS Approach Service Type
GBAS	Ground Based Augmentation System
GLS	GBAS Landing System
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
HLA	High Level Airspace
HSpec	Helicopter Specification
HUD	Head-up Display
HWD	Head Worn Display
IAP	Instrument Approach Procedure
ICAO	International Civil Aviation Organization
IFE	Inflight Entertainment
IFR	Instrument Flight Rules
ILS	Instrument Landing System
IM	Interval Management
IRU	Inertial Reference Unit
ITP	In-Trail Procedures

Term	Definition
KCLE	Cleveland Hopkins International Airport
KPHX	Phoenix Sky Harbor International Airport
KSEA	Seattle–Tacoma International Airport
LNAV	Lateral Navigation
LOA	Letter of Authorization
LPV	Localizer Performance with Vertical Guidance
LRNS	Long Range Navigation Systems
MARS	Multiple Airport Route Separation
MCL	Minimum Capability List
MDA	Minimum Descent Altitude
MFMC	Multi Frequency Multi Constellation
MHz	Megahertz
MLS	Microwave Landing System
MMR	Multi-mode Receiver
MSL	Mean Sea Level
MSpec	Management Specification
NAS	National Airspace System
NASA	National Aeronautics and Space Administration
NAT	North Atlantic Track
NB	Narrow-body
NextGen	Next Generation Air Transportation System
NGSS	Next Generation Satellite System
NOTA	No OpSpec Template Available
NSIP	NextGen Segment Implementation Plan
OAV	Operator Aircraft Viewer
OEM	Original Equipment Manufacturer
Ops	Operations
OpSpec(s)	Operations Specification(s)
PBN	Performance Based Navigation
RCP	Required Communications Performance
RF	Radius to Fix
RFI	Radio Frequency Interference

Term	**Definition**
RJ	Regional Jet
RNAV	Area Navigation
RNP	Required Navigation Performance
RSP	Required Surveillance Performance
RTCA	Radio Technical Commission for Aeronautics
SA	Situational Awareness
SA	Selective Availability
SATCOM	Satellite Communications
SBAS	Space Based Augmentation System
SBS	Surveillance and Broadcast Services
SEC	Securities and Exchange Commission
SFA	Special Flight Authorizations
STAR	Standard Terminal Arrivals
SURF	Situational Awareness – Surface
SWIM	System Wide Information Management
TBO	Trajectory Based Operations
TF	Track to Fix
TIS-B	Traffic Information Service-Broadcast
TP	Turboprop
TSO	Technical Standard Order
U.S.	United States
UAM	Urban Air Mobility
UAS	Unmanned Aircraft Systems
UAT	Universal Access Transceiver
UPS	United Parcel Service
VDL	VHF Data Link
VFR	Visual Flight Rules
VHF	Very High Frequency
VNAV	Vertical Navigation
w/	With
WAAS	Wide Area Augmentation System
WB	Wide-body

Term	Definition
WebOPSS	Web-based Operations Safety System

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