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A Case Study: Third Party Performance-Based Navigation Instrument Flight Procedure Design Regulations at the Federal Aviation Administration, the Civil Aviation Safety Authority of Australia, and the Civil Aviation Authority of New Zealand

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A CASE STUDY: THIRD PARTY PERFORMANCE-BASED NAVIGATION INSTRUMENT FLIGHT PROCEDURE DESIGN REGULATIONS AT THE FEDERAL AVIATION ADMINISTRATION, THE CIVIL AVIATION SAFETY AUTHORITY OF AUSTRALIA, AND THE CIVIL AVIATION AUTHORITY OF NEW ZEALAND

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INTRODUCTION

The Instrument Flight Procedure (IFP) [A listing of all acronyms and definitions is provided in Appendix A] is an essential component to the aviation system. Every day and during every flight, thousands of aircraft around the world are flying instrument departure, arrival, or approach procedures (International Civil Aviation Organization, 2008). Historically, Civil Aviation Authorities (CAA) have relied on internal resources to produce and implement (develop, publish, flight inspect, perform quality assurance functions, and maintain) IFPs (Federal Aviation Administration, 2009). Today safety, access, environmental and capacity concerns have, in some cases, driven the demand for Performance-Based Navigation (PBN) IFPs beyond the capability or production capacity of many CAAs. Accordingly, commercial entities, referred to as Third Party Instrument Flight Procedure Designers (TPIFPD), have responded to the demand with service and product offerings to fill the need. Because of the potential entry for multiple TPIFPDs in the short-term, there is concern that the production of high-performance PBN IFPs by TPIFPDs is sensitive to the need for definitive regulatory guidance and oversight (Hughes, FAA OKs Outsourcing of RNP Design, 2007).

The introduction of TPIFPD products and services into the aviation system will bring both new opportunities and demands to PBN IFP production and implementation. Applying what the industry has learned from the past, an explicit, clear, and authoritative set of regulatory material must be identified to ensure an orderly and safe transition for TPIFPDs. The Civil Aviation Authority of New Zealand (CAANZ), the Civil Aviation

Safety Authority of Australia (CASA), and the Federal Aviation Administration (FAA) have all endeavored to create regulatory material to address this need. Unfortunately for TPIFPDs this regulatory material has not been harmonized or standardized to ensure consistency and means of compliance.

This paper presents a preliminary qualitative case study of TPIFPD operations and oversight requirements as defined by FAA Draft Advisory Circular 90-TPA, CASA CAR Part 173, and CAANZ CAR Part 173. While each of the aforementioned CAAs have established regulatory material on the subject it was the goal of this study to compare and contrast existing requirements to support the harmonization and fortification of future regulatory material on the subject.

Author Background

The author of the study has been involved in PBN IFP since 2006. It is important to note that the earliest regulatory material analyzed in this study was published in December of 2004. Since beginning work in PBN IFP, the author has been directly involved with the implementation and deployment of PBN IFP in seven countries including Canada, the United States, Peru, Panama, Ecuador, Australia, and China. In addition to practical experience, the author's participation was requested to support the development of TPIFPD regulatory material in the Third Party Instrument Flight Procedure Working Group (TPIWG) group with the FAA. The participation in government/industry working groups has provided the author with significant insight into the process, requirements, and thought processes at regulatory agencies. In addition to participating in working groups related to the subject, the author has also been mentored by the primary author of the original TPIFPD requirements. Though the cumulative time of three years in the space is limited, when compared to the total amount of time the regulatory guidance has been around, four years, the author's three years in the field makes up for nearly seventy five percent of the total applied experience available.

PBN Background

The accuracy of satellite navigation (SATNAV) is the cornerstone of performance-based navigation. The SATNAV system exists today in the National Airspace System (NAS) as a combination of the Global Positioning System (GPS), Wide Area Augmentation System (WAAS), and Local Area Augmentation System (LAAS) (Federal Aviation Administration, 2000). The importance of the SATNAV system to performance-based navigation cannot be understated. The capabilities of performance-based navigation are severely restricted without the accuracy, reliability, and availability of SATNAV sources (Federal Aviation Administration, 2000).

Due to the performance and benefits associated with satellite navigation, the International Civil Aviation Organization (ICAO) and the FAA are pursuing the transition to satellite navigation (Federal Aviation Administration, 2000). The result of this combined effort is the universal Global Navigation Satellite System (GNSS) (Federal Aviation Administration, 2000). As a part of the long-term development of GNSS the FAA is expediting the development of a common technical capability and implementation method for satellite navigation in the United States, Canada, and Mexico (Federal Aviation Administration, 2000). This plan will ultimately create the North American Satellite Augmentation System (NASAS). The NASAS will support GPS implementation throughout the region including the further application of WAAS capability tailored to each region and LAAS sites where they are needed for precise terminal navigation (Federal Aviation Administration, 2000). The benefits associated with the NASAS include decreased costs associated with maintaining the current ground-based navigation infrastructure and the standardization of WAAS and LAAS service (Federal Aviation Administration, 2000).

Area Navigation

The first of two concepts that define performance-based navigation is aRea Navigation (RNAV). RNAV is defined by the Aeronautical Information Manual as, "A method of navigation which permits aircraft operation on any desired flight path within the coverage of station-referenced navigation aids or within the limits of the capability of self-contained aids, or a combination of these (Federal Aviation Administration, 2008, p. 539)." RNAV guidance can be divided into two components, lateral navigation (LNAV) and vertical navigation (VNAV). LNAV and VNAV are functions of RNAV equipment that provides lateral or vertical guidance to a profile or path (Federal Aviation Administration, 2008). Current RNAV capable equipment includes Flight Management Systems (FMS) and panel-mount GPSs (Federal Aviation Administration, 2003). FMS, the RNAV technology found on commercial airliners today, "is an integrated suite of sensors, receivers, and computers, coupled with a navigation database (Federal Aviation Administration, 2008, p. 522)." The purpose of a FMS is to provide performance and RNAV guidance to displays and automatic flight control systems by assimilating several navigation sources including GPS, Distance Measuring Equipment (DME), Very High Frequency Omni-directional Range (VOR), Localizer (LOC), and Inertial Reference Unit (IRU) (Federal Aviation Administration, 2008). Normally, FMSs rely upon GPS and/or two or more DME stations to determine aircraft location. Often, other navigation inputs may be incorporated dependent upon aircraft equipment and FMS system architecture (Federal Aviation Administration, 2008).

Required Navigation Performance

Not all navigation systems are created equal. The accuracy to which a navigation system is capable of determining its position is dependent upon the type and number of navigation sources the system uses to calculate its position. Some of the more common types of navigation system sources discussed in the Aeronautical Information Manual (AIM) are GPS, DME, VOR, LOC, IRU and each of these offer differing levels of navigation accuracy (Federal Aviation Administration, 2008). In addition to varying navigation systems, aircraft configuration also varies greatly. The combined result of heterogeneous aircraft configuration and navigation systems is nonstandard navigation performance.

The standardization of navigation performance is essential to taking advantage of RNAV benefits and capabilities. While the cost and complexity of implementing a common navigation system in the NAS is prohibitive, the cost and complexity of requiring common navigation system performance is attainable (Dodd, Jobanek, & Li, 2001). The standardization of navigation performance is known as Required Navigation Performance (RNP) and is the second concept that defines performance-based navigation. The Aeronautical Information Manual states, “RNP is intended to provide a single performance standard for aircraft manufacturers, airspace designers, pilots, controllers, and international aviation authorities (Federal Aviation Administration, 2008, p. 517).” In regards to aircraft configuration the AIM goes on further to state, “When RNP is specified a combination of systems may be used, provided the aircraft can achieve the required navigation performance (Federal Aviation Administration, 2008, p. 517).” RNP is not a new piece of hardware requiring installation onboard an aircraft or a type of navigation aid. RNP is a method of containing aircraft within specified airspace using existing navigation systems to a high degree of reliability and repeatability (Federal Aviation Administration, n.d.). The designation of airspace or specific navigation procedure for RNP use is characterized by affixing a numeric value to RNP (Federal Aviation Administration, n.d.). The standard levels of RNP in the United States are RNP-2, RNP-1, and RNP-0.3 (Federal Aviation Administration, 2008). An RNP-*x* designation requires the total navigation system error to remain within ± *x* nautical miles laterally from the track centerline 95 percent of the time.

Required Navigation Performance Area Navigation

The resulting combination of RNAV and RNP is known as Required Navigation Performance aRea NAVigation (RNP RNAV) and is the method of navigation that will provide the results for performance-based navigation (Bradley & Meyer, 2001). The application and operation of RNP and RNP RNAV are significantly different. The primary difference between the two is the requirement for monitoring and airspace containment. RNP operations do not require airborne monitoring to ensure accuracy (Bradley & Meyer, 2001). Instead, RNP operations rely on specific operationally tested sensors or air traffic management (ATM) to guarantee accuracy (Bradley & Meyer, 2001). Alternatively, RNP RNAV operations require significantly more monitoring of navigation performance including containment integrity, containment continuity, and a containment region equal to two times the RNP value (Federal Aviation Administration, 2003). Additionally, an RNP RNAV system is required to alert the flight crew in the event of loss of RNP in their primary field of view. The net result of stringent containment requirements for RNP RNAV is navigation performance where the probability of un-annunciated deviation of greater than 2 x RNP is less than 1×10^{-5} (Bradley & Meyer, 2001). The benefits associated with the RNP RNAV containment region include the ability to provide safety assessments for separation and obstacle clearance (Bradley & Meyer, 2001).

Purpose of the Study

The purpose of this case study is to compare and contrast the regulatory requirements for PBN TPIFPDs, hereafter referred to as TPIFPD, working with the FAA, CASA, and CAANZ to support the development and harmonization of future regulatory material. Additionally, this study investigates the conflicts between the aforementioned regulatory guidance materials to determine if it is possible for a TPIFPD to be compliant with all requirements simultaneously.

REVIEW OF THE LITERATURE

Introduction

The concepts supporting TPIFPD are unique to the aviation industry and even rarer for other industries due to the intangible nature of TPIFPD deliverables. The introduction of advanced concepts such as PBN makes this specific area of regulatory study a prime candidate for qualitative analysis. No other directly or indirectly related academic studies were identified to support the subject area. To support the assertion that the demand for PBN IFP exceeds the supply and therefore the need for TPIFPD, industry publications were reviewed to evaluate the PBN benefits.

Aviation Challenges

During the past twenty years air traffic in the National Airspace System (NAS) has grown at an enormous rate. In 2001, 486.3 million passengers enplaned at the 32 large hub airports (Federal Aviation Administration, 2003). Current projections show enplanements at these airports increasing by 68 percent to 818.5 million by 2020 (Federal Aviation Administration, 2003). The rate air-traffic is growing is greater than the growth of capacity in airports or airspace (Federal Aviation Administration, 2003). Some limiting factors of capacity and efficiency in the NAS are the technologies and methods used for navigation. Due to these navigation limitations and many other restrictions the entire NAS suffers flight delays, schedule disruptions, passenger and operator inconveniences, and inefficient flight operations (Federal Aviation Administration, 2003). In response to the need for greater airspace capacity, safety, and efficiency the industry has defined universal navigation concepts and applications based on performance standards rather than specific technologies and equipment configurations (Federal Aviation Administration, 2003). The performance-based concepts that will improve domestic airline navigation in the NAS are RNAV and RNP. By 2020 the FAA intends to accomplish the long-term goal of implementing performance-based navigation throughout the NAS (Federal Aviation Administration, 2003). The realization of this goal requires an NAS where RNP operations are available in nearly all airspace and SATNAV is the primary navigation infrastructure (Federal Aviation Administration, 2003).

Increased Safety

The way that performance-based navigation improves domestic airline safety is evident in a study completed by Flight Safety Foundation. They found that 141 accidents could have been prevented over a 20-year period through the addition of precision approach capability to airports that currently have non-precision approaches (Dodd, Jobanek, & Li, 2001). Today, the Instrument Landing System (ILS) provides the majority of precision approach guidance. An ILS provides lateral and vertical navigation through localizer (lateral guidance) and glideslope (vertical guidance) transmitters located at the end of the approach runway (Federal Aviation Administration, 2008). The most important benefit of a precision approach is that it ensures vertical and lateral obstacle clearance (Dodd, Jobanek, & Li, 2001). This not only prevents Controlled Flight Into Terrain (CFIT) but also aids the pilot in establishing and maintaining a stabilized approach. If a pilot follows the ILS guidance correctly they will arrive at the beginning of the runway, configured to land, and have flown a stabilized approach (Dodd, Jobanek, &

Li, 2001). A stabilized approach is an important factor in preventing loss of control or CFIT. A precision approach is more conducive to a stabilized approach due to the positive lateral and vertical guidance provided (Dodd, Jobanek, & Li, 2001). The major limitation of implementing additional ILS precision approaches is the cost of installation and maintenance of such a facility. Even in situations where the funding exists to install an ILS, the system is limited by terrain (Dodd, Jobanek, & Li, 2001).

A non-precision approach, while less costly and easier to implement, does not provide vertical guidance to the pilot. Lateral course guidance is provided by the navigation signal the approach is based upon (Dodd, Jobanek, & Li, 2001). Vertical obstacle clearance and descent planning is usually accomplished by sole reference to the barometric altimeter. During a non-precision approach the pilot must maintain an altitude that is not below the minimum descent altitude (MDA) until the runway is visually identified (Dodd, Jobanek, & Li, 2001). The challenges related to a non-precision approach after sighting the runway are aircraft location, altitude, and configuration. A majority of non-precision instrument approach procedures do not have course guidance aligned directly with the centerline of the runway. This may cause the pilot to execute a series of turns to align the aircraft correctly. Furthermore, if the runway is sighted at a distance and altitude close to the airport it is likely that the pilot will have to abort the approach due to lack of time, altitude, or distance required to stabilize the approach (Dodd, Jobanek, & Li, 2001). For the reasons discussed above, the workload associated with a non-precision approach may challenge the most seasoned pilot or overload the inexperienced or fatigued pilot (Dodd, Jobanek, & Li, 2001).

Performance-based navigation is the solution to a lack of precision approaches and the perils of a non-precision approach. An RNP RNAV enabled FMS has the capability to provide the accurate and reliable three-dimensional navigation necessary for precision-like approaches without the cost and infrastructure of the ILS system (Dodd, Jobanek, & Li, 2001). Alaska Airlines was the first domestic airline to take advantage of RNP precision approach capability (Hughes, Will RNP Proliferate?, 2005). The first RNP RNAV procedure, developed for Juneau International Airport, allows Alaska airlines to accomplish a precision approach down the Gastineau Channel to Runway 26. This channel is known for its steeply rising terrain on either side. Due to steeply rising terrain near the airport, Runway 26 is not served by an ILS approach nor can one be installed (Hughes, Will RNP Proliferate?, 2005). This procedure and many more developed by the carrier make use of the airline's Boeing 737-400s, -700s, -800s, and -900s (Hughes, Will RNP Proliferate?, 2005). These aircraft have dual FMSs enhanced with software that allow them to monitor sensor inputs in real time and achieve navigation performance equivalent to RNP-0.11 (Hughes, Will RNP Proliferate?, 2005). Alaska Airlines now has 12 RNP approaches and 15 departures in use statewide (Hughes, Will RNP Proliferate?, 2005).

Increased Efficiency

The RNP RNAV approaches Alaska uses to operate with greater safety into high, mountainous airports also increase on-time performance and efficiency by permitting operations in lower visibility than previously possible (Hughes, Will RNP Proliferate?, 2005). Performance-based navigation provides efficiency benefits that affect terminal, en-route, and approach operations. The sum of these improvements provides a total efficiency increase for domestic airlines. Generally speaking, performance-based navigation increases efficiency in the NAS by providing consistent, accurate, repeatable performance, and the ability to meet stringent aircraft separation requirements (Federal Aviation Administration, 2004). The standardization of performance-based navigation eliminates the need for wide separation standards, special handling by Air Traffic Control (ATC), and considerations for different aircraft performance. This consistent, accurate, and repeatable performance of performance-based navigation yields a benefit to all aircraft flying in the NAS (Federal Aviation Administration, 2004). Greater accuracy leads to more precise airspace protection. Increased consistency reduces controller workload. Standardized performance allows the implementation of procedures that may not have been otherwise developed (Federal Aviation Administration, 2004). Additionally, the linear guidance performance-based navigation provides is accurate enough to support existing lateral separation and provide increased capacity (Federal Aviation Administration, 2004).

The efficiency benefits of performance-based navigation in the terminal environment include support for complex terminal operations, guided departures, and extended departure and arrival procedures (Federal Aviation Administration, 2004). A complex terminal operation is defined as a procedure involving multiple legs, descents, and turns. Attempting to accomplish such a procedure with ILS guidance systems is impossible due to the reduction in accuracy as distance increases from the Navigation Aid (NAVAID) and the fact that most NAVAIDs do not provide accurate curved-path guidance (Federal Aviation Administration, 2004). A guided departure or arrival procedure is a form of a complex terminal operation and is not significantly different from the procedures in use today. The major difference is that performance-based navigation departure and arrival procedures are available to all airports whereas existing procedures require the specific installation of NAVAIDs (Federal Aviation Administration, 2004). The implementation of performance-based navigation in the terminal environment will result in more efficient use of airspace through better use of arrival and departure corridors (Federal Aviation Administration, 2003). This improved efficiency is achieved by relocating the entry and exit points of Standard Instrument Departure (SID) procedures and Standard Terminal Arrival (STAR) procedures without relocating ground-based NAVAIDs (Federal Aviation Administration, 2003). RNP RNAV SIDs and STARs improve efficiency by reducing communication errors, taking advantage of three-dimensional navigation performance of FMSs, and enabling simultaneous independent departures during instrument meteorological conditions (Federal Aviation Administration, 2003).

In the en route environment performance-based navigation will increase domestic airline efficiency through flexible routing options. Performance-based navigation provides the capability for an increased number of air traffic routes and direct routing. This increased capability in the en route environment is a direct result of the precision and containment capability of performance-based navigation. New RNAV routes based on a series of waypoints, known as Q routes, will provide efficiency and flexibility in the NAS (Federal Aviation Administration, 2003). Q routes do not rely upon ground-based NAVAIDs and therefore permit aircraft operation along routes and altitudes that would not have been otherwise feasible (Federal Aviation Administration, 2003). The goal of creating a series of Q routes is to eventually convert them to RNP-2 and initiate a reduction in route spacing. The condensing of route spacing will allow further route development and flexibility in the NAS (Federal Aviation Administration, 2003). In addition to Q routes, the introduction of parallel offset routes will allow aircraft to fly a specified offset distance from an existing route (Federal Aviation Administration, 2003). This procedure, known as en route parallel offset, will provide the opportunity for improved en route trajectories, reduced in-trail restrictions, reduced departure delays, reduced block times, reduced workload, and greater access to existing routes (Federal Aviation Administration, 2003).

The benefits of RNAV routing can already be seen at Atlanta International Airport where RNAV departures have increased the number departures and decreased complex radio transmissions (Withers). The striking improvement can be seen in six-hour radar plots of departing traffic from Atlanta International. Before RNAV headings and altitudes were assigned by ATC, and departures required significant voice transmissions (Withers). After the implementation of RNAV routing at Atlanta International headings, altitudes, and speeds were automated, and voice transmissions were reduced 30-50% (Withers). Performance-based navigation will also increase the capability of direct routing, where aircraft fly non-published routes along a direct path between two route points (Federal Aviation Administration, 2004). Direct routing, otherwise known as free flight, will provide a large increase in efficiency due to unconstrained routing options (Federal Aviation Administration, 2004). Between the combinations of RNAV routes, parallel offsets, and free flight performance-based navigation will have a significant effect on the efficiency of domestic airline operations in the en route environment.

Most, if not all, approach environments will gain from the general efficiency benefits of performance-based navigation. At airports where there are closely spaced runways, environmental constraints, conflicting traffic flows, or outages of ILS and other NAVAIDs performance-based navigation procedures will have a significant effect on increasing efficiency (Federal Aviation Administration, 2003).

At airports with closely spaced runways, RNP Parallel Approach Transition (RPAT) will provide greater arrival rates during marginal weather (Federal Aviation Administration, 2003). Due to the improved linear accuracy of performance-based navigation, RPAT procedures allow for the parallel approach of two aircraft in weather conditions that would have otherwise prevented simultaneous independent parallel approaches (Federal Aviation Administration, 2003).

Environmental constraints, such as the ones experienced by Boston’s Runway 4L will also be solved by performance-based navigation procedures. This runway is currently accessible via a circle-to-land procedure that requires several tight radius turns that are impossible to accomplish with a transport or regional jet (Federal Aviation Administration, 2003). RNP RNAV procedures, using other than straight-in segments, and accurate VNAV guidance will avoid noise-sensitive areas and streamline arrivals to Runway 4L (Federal Aviation Administration, 2003).

Conflicting traffic flows are another source of inefficiency in the terminal environment. Currently, Newark and LaGuardia have approaches to runways constrained by adjacent traffic flows and airspace (Federal Aviation Administration, 2003). Another example of traffic conflict in the approach environment occurs between departures at Chicago O’Hare and an adjacent approach path into Midway airport (Federal Aviation Administration, 2003). Conflicting traffic in these situations can be reduced and efficiency improved through RNP RNAV procedures using RNP values less than 0.3 and curved approach segments.

An additional terminal environment where performance-based navigation will improve efficiency is Long Beach, California. The airport is served by a single ILS approach that is scheduled to be taken out of service (Federal Aviation Administration, 2003). By removing the ILS, the Long Beach airport will only be served by a non-precision approach with high minima. Here is a situation where the implementation of an RNP RNAV approach with VNAV guidance would provide a solution to an otherwise bleak situation (Federal Aviation Administration, 2003). Eventually it is the goal of the FAA to develop new precision approaches at airports or for runways that are not currently served by an approach (Federal Aviation Administration, 2003).

Increased Airport Access

Perhaps the most intriguing capability of performance-based navigation is the increased access to terrain-challenged airports. Earlier this year Qantas Airlines began operating Boeing 737s with RNP .1 capability into Queenstown, New Zealand (Hughes, Will RNP Proliferate?, 2005). The approach allows Qantas aircraft to fly a precision RNP RNAV approach to a decision altitude (DA(H)) of 280 feet (Hughes, Will RNP Proliferate?, 2005). This RNP RNAV procedure allows Qantas to get into the airport with 3,320-foot lower ceilings than rival Air New Zealand (Hughes, Will RNP Proliferate?, 2005). The reason Qantas can achieve such lower weather minimums on an approach to Queenstown is due to the flexible approach paths and accuracy provided by performance-based navigation. The terrain surrounding Queensland is not unlike the terrain Alaska Airlines found at Juneau. The increased accuracy and flexibility for curved path routing of performance-based navigation provides the ability to route aircraft around terrain obstacles. While domestic airlines have been slow to adopt RNP RNAV procedures, Canadian airline WestJet has spent the last several years setting up 80 RNP procedures to airports challenged by terrain or lack of instrument approaches (Hughes, Will RNP Proliferate?, 2005). Such an example of an approach WestJet is flying occurs at Kelowna Airport in British Columbia. The airport is situated at 1,409 feet and terrain rises to 8,700 feet within 25 miles (Hughes, Will RNP Proliferate?, 2005). WestJet can fly an RNP RNAV approach to this airport with a 340 foot DA. Prior to the RNP RNAV approaches, Kelowna was often unavailable to WestJet due to low ceilings and visibilities (Federal Aviation Administration, 2003).

Implementation

Airlines and Air Navigation Service Providers (ANSP) have recognized the benefits of PBN and are moving rapidly to deploy PBN IFPD. Most notably, Southwest Airlines (SWA) and Air Services Australia (ASA) have taken the lead for the airline and ANSP implementation effort respectively. In 2007, SWA committed to installing RNP avionics and software on all 520 aircraft and contracted a TPIFPD to deploy tailored procedures to 63 airports in their network (Hughes, Southwest Makes a Massive Commitment to RNP, 2007). In 2009, ASA contracted a TPIFPD to deploy the world's first nationwide PBN network which will include procedures at up to 28 major airports over five years (Thomas, 2009).

The FAA has also recognized the importance of PBN and has identified it as a cornerstone of the Next Generation Air Transportation System (NextGen) (Federal Aviation Administration, FAA's Next Gen Implementation Plan 2009). Specifically, the FAA has drafted a detailed roadmap that supports the planning and collaboration processes required for deploying PBN at the busiest 35 airports in the NAS (Federal Aviation Administration, 2006). As recently as September of 2009, the FAA authorized the first third-party instrument flight procedure design firms Jeppesen and Naverus to deploy IFP in the NAS (Seattle Times Business Staff, 2009). The combination of airlines, ANSPs, and regulators engaging PBN in the magnitude and scale as they have is indicative of the demand and need for the deployment of these types of procedures globally.

METHODOLOGY

Initially, TPIFPD regulations were reviewed from three different CAAs; CASA as the first regulatory material to support approval of PBN TPIFPD, the FAA as the most recent CAA to offer guidance on the subject, and CAANZ as the most comprehensive. The research was designed to identify each CAA's requirements associated with PBN TPIFPD and the similarities and differences among them. It was also the intent of the study to determine if it was possible for TPIFPDs to comply with all requirements simultaneously.

A review of the literature discussed in the previous section revealed that there was a definitive need for analysis of TPIFPD regulatory material to support the implementation of PBN IFP. A defining feature of this study is the comparison of all three leading regulatory guidance on the subject from the perspective of a TPIFPD regarding the certification, operation, training, and qualification requirements.

Theoretical Framework

The theoretical framework chosen for this research was a case study using grounded theory. Using publically available documents and a matrix comparison tool, as found in Appendix B, this method allowed for the direct comparison of the different regulatory material sets. Using the PBN TPIFPD regulatory material from the CAA, FAA, and CASA interrelating categories of requirements were created to analyze applicability of PBN TPIFPD.

A qualitative study of TPIFPD requirements in the form of a direct document comparison may enhance current literature on TPIFPD through the impact of viewing the requirements in a different structure. This perspective could provide a provocative method for research in a field that is emerging. The value of this research lies in its ability to clarify regulatory issues of TPIFPD.

Research Questions

The following research questions were used to guide the inquiry of the study.

1. How are TPIFPD requirements defined?
2. What are the relationships between FAA, CASA, and CAANZ TPIFPD regulatory material?
3. Is it possible for a TPIFPD to comply with all requirements simultaneously?

Documents

The following sections describe the documents used in the study. The three regulatory sets initially identified for this study represent a majority of the emerging TPIFPD requirements to have practical application. Since the research is a case study by direct document comparison, the document background and general history are central to the understandings that develop in the review, a brief description of each document is provided before data collection is discussed.

Australia: CASA CAR Part 173

CASA Part 173 is regulation developed to cover the requirements for the certification of designers of instrument approach and departure procedures, including the qualifications and training required for persons engaged in IFPD; the procedures to be used by organizations in the conduct of design work; and provisions for on-going maintenance of procedures. The determination of instrument flight procedures was originally a CASA responsibility under 1988 Civil Aviation Regulation (CAR) 178 (Civil Aviation Safety Authority of Australia, 2004). CASR Part 173 is further supported by the Manual of Standards (MOS) and three related advisory circulars. The combination of these elements, Regulation, MOS, and Advisory Circulars make up the guidance material that support the design and implementation of all instrument flight procedure design, PBN and conventional. The regulation applies to all instrument flight procedure designers.

New Zealand: CAANZ CAR Part 173

CAANZ Part 173 is regulation that prescribes rules governing the certification and operation of organizations that provide services for the design and maintenance of instrument flight procedures; and the technical standards for the design of instrument flight procedures. Part 173 aims to ensure that the design, maintenance, and promulgation of instrument flight procedures intended for use by aircraft operating under instrument flight rules (IFR) in the New Zealand Flight Information Region (NZFIR) meet or exceed the International Civil Aviation Organization standards and recommended practices for instrument flight procedures. The regulation applies to all instrument flight procedure designers (Civil Aviation Authority of New Zealand, 2008).

United States: FAA Draft Advisory Circular 90-TPA

FAA Draft Advisory Circular 90-TPA provides approval guidance material for third party sources to become authorized for the design, development and implementation of Title 14 of the Code of Federal Regulations (CFR) Part 97 Area Navigation Required Navigation Performance instrument approach procedures with Special Aircraft and Aircrew Authorization Required (SAAAR). The Advisory Circular only applies to TPIFPD (Federal Aviation Administration, 2009).

FINDINGS

In total, 810 individual TPIFPD requirements were analyzed. A requirement is defined as a concept/element separated by paragraph or content. The requirements were distributed with CASA making up 45% (367), CAANZ with 35% or (283), and FAA with 20% (160). Commonality amongst the requirements was further investigated. The FAA and CAANZ share 13% common requirements, FAA and CASA share 13% common requirements, CAANZ and CASA share 11% common requirements. When all three requirements are compared against another, the FAA, CAANZ, and CASA share only 5% common requirements.

Analysis by Topic

The requirements can be divided into five main topics: general, certification, operating, design criteria, and qualifications. These five topics can be further divided into 40 subtopics. For the purposes and scope of this paper, the sub-topics were grouped into logical sets for analysis. Set groupings are described in each Topic level discussion.

General

The General Topic area was defined as the requirements that define or set the structure for the operations as a whole. Content that can be found in the general section includes background information and administrative functions for operations. From a high-level perspective, the General Topic area shared the highest level of commonality amongst the three sets of regulatory material. The sub-topics were grouped into six Sets for analysis; purpose, related regulations, definitions, related documents, background, and certificates.

FAA vs CASA

The FAA and CASA requirements share many common elements, though certainly the CASA material contains extensive requirements from the perspective of the breadth of material covered. While the FAA regulatory material focuses on the history, background, and related documents, the CASA regulatory material defines practical guidance for the operations as a whole.

Purpose

The purpose section of both CASA and the FAA requirements define the structure for which the requirements apply. The most notable difference is the fact that the FAA requirements are advisory in nature. This difference manifests itself in the weaker stance from the FAA document, “Service providers may elect to use the guidance in this Advisory Circular or follow an alternative method, provided that the method is acceptable /approved to/by the FAA (Federal Aviation Administration, 2009, p. 1).”

Related Regulations

The FAA Advisory Circular is the only document that specifically calls out related regulations as a part of the requirements. The specific regulation referenced by the Advisory Circular is 14 CFR Part 97. Most notable about 14 CFR Part is section 97.20, which describes the relationship between the Orders and Forms related to IFPD. Specifically, standard instrument approach procedure and associated data documented on related FAA Forms are incorporated by reference. The incorporation by reference effectively makes all IFPD equivalent to publication of a rule in the Federal Register and CFR.

Definitions

The definitions sub-topic set between CASA and FAA does not contain many notable differences other than the fact that the majority of the definitions related to the CASA requirements are absent in the FAA Advisory circular. This difference is expected due to the nature of regulation versus Advisory Circular.

Related Documents

Absent in the CASA regulation is a listing of related documents. The listing of related documents effectively increases the scope of the FAA requirements by reference to the related documents. From a TPIFPD perspective, this makes compliance with the FAA requirements a far more challenging task.

Background

Absent in the CASA regulation is a description of a background of IFPD. Though this does not have a tangible effect on the requirements as a whole, it does provide further insight into the purpose of the requirements from the FAA perspective.

Certificates

The mechanism authorizing TPIFPD in Australia is a procedure design certificate. This procedure design certificate is applicable to any entity providing services, including the state ANSP. Due to the incorporation by reference described above, the FAA's mechanism is a Letter of Authorization (LOA). Other than this major difference, the FAA and CASA requirements related to Certificates are largely similar and focus on the administrative elements.

FAA vs CAANZ

The FAA and CAANZ requirements from the General Topic level could not be more different. CAANZ requirements can be characterized as deliberate and instructive while the FAA material provided limited information on the content related to the administrative functions of operations for TPIFPD.

Purpose

The purpose section of both CAANZ and the FAA requirements define the structure for which the requirements apply. The most notable difference is the fact that the FAA requirements are advisory in nature.

Related Regulations

The FAA Advisory Circular is the only document that specifically calls out related regulations as a part of the requirements.

Definitions

Absent from CAANZ Part 173 is a list of related definitions. This appears to be more of a document structure issue as definitions are provided throughout the rule as terms are used.

Related Documents

Absent in the CAANZ regulation is a listing of related documents. The listing of related documents effectively increases the scope of the FAA requirements by reference to the related documents..

Background

Absent in the CAANZ regulation is a description of a background of IFPD.

Certificates

The mechanism authorizing TPIFPD in New Zealand is a procedure design certificate. This procedure design certificate is applicable to any entity providing services, including the state ANSP. Due to the incorporation by reference described above, the FAA's mechanism is a Letter of Authorization (LOA). Other than this major difference, the FAA and CAANZ requirements related to Certificates are largely similar and focus on the administrative elements.

CASA vs CAANZ

Not surprisingly, CASA and CAANZ share the greatest similarities in TPIFPD requirements. It certainly appears that the CASA requirements have had a significant effect on the structure and operation of the CASA requirements.

Purpose

The purpose section of both CASA and the CAANZ requirements define the structure for which the requirements apply. Other than minor scope differences, the purpose section of both CASA and CAANZ are largely similar.

Related Regulations

The Related Regulations sub-topic set is absent in both CASA and CAANZ regulation.

Definitions

Absent from CAANZ Part 173 is a list of related definitions. This appears more of a document structure issue, as definitions are provided throughout the rule as terms are used.

Related Documents

Absent from both CAANZ and CASA is a listing of related documents.

Background

Background information does not specifically exist in the CASA or CAANZ requirements.

Certificates

The mechanism authorizing TPIFPD in Australia and New Zealand is a procedure design certificate. The differences in the issuance of a procedure design certificate for CAANZ versus CASA is primarily related to administration and does not materially affect the authorization of a TPIFPD.

Certification

The Certification Topic area was defined as the requirements that define or set the standards for certifying TPIFPD. Content that can be found in the Certification section includes the general operating requirements of a TPIFPD. This Topic makes up the bulk of the operations requirements for TPIFPD and defines the general day-to-day operations. The sub-topics were grouped into ten Sets for analysis; personnel, organization, chief designer, training, reference materials, design, validation, records, safety management system, and operations manual.

FAA vs CASA

In any comparison of Certification topic level related to the FAA regulatory material it becomes quite clear that the FAA requirements are still in their developmental phase of maturity. The level of detail and complexity for the CASA requirements are significantly more developed than the FAA.

Personnel

Specific requirements related to personnel are absent from the FAA Advisory Circular. This difference is primarily a document structure/organization issue as functional requirements for personnel are described elsewhere throughout the document.

Organization

Organizational structure requirements are absent from the FAA Advisory circular. CASA requirements focus on functional requirements and quantity of personnel.

Chief Designer

The Chief Designer is identified as key in the final issuance and authorization of IFPD for CASA. This function is highlighted as the TPIFPD has the final authorization to issue the instrument flight procedure in Australia and the Chief Designer is held ultimately responsible. In the FAA's case, the final issuance of the IFPD is executed by the FAA.

Training

Training requirements are defined in a separate Appendix of the FAA Advisory Circular. In comparison, the CASA requirements are very high-level and are ultimately at the discretion of the design organization.

Reference Materials

The requirement for reference materials is nearly identical between the FAA and CASA, with the only difference being access to state specific materials.

Design

Absent from FAA requirements is specific design authorization definitions. This difference is to be expected as the authorization under CASA is procedure design specific while FAA authorization is only related to PBN IFPD.

Validation

CASA IFPD validation activities are defined in detail within CASA Part 173 while the FAA Advisory Circular references an external document (Notice 8260.66: Flight Validation of Satellite-Based Performance-Based Navigation Instrument Flight Procedures). The differences between Notice 8260.66 and CASA Part 173 is significant, to be expected, as an entire document has been created to define flight validation requirements. The specific differences are between 8260.66 and the related sections of CASA Part 173 are outside the scope of this document.

Records

The record keeping requirements between FAA and CASA are very similar with CASA providing a detailed description of record keeping requirements while the FAA details a list of requirements in relationship to the associated documents (FAA Order 8260.19).

Safety Management System

Safety Management System requirements differ significantly between CASA and the FAA. Specifically, the FAA description of a Safety Management System for a TPIFPD exists only in the Draft Advisory Circular while CASA dedicated a separate Advisory Circular and further guidance material on the subject.

Operations Manual

The concept of an Operations Manual is nearly identical between the FAA and CASA. In the CASA example, the requirements are broad and address the operation as a whole, while the FAA requirement addresses individual elements specific to daily operations. This appears more to of a document structure difference than functional requirement disparity.

FAA vs CAANZ

Again with the differences in regulatory maturity, it was easy to see how the development of the Certification requirements could certainly be more definitive and directive with the CAANZ requirements. The CAANZ requirements have a level of detail and definition that defines a standard the FAA material has not yet reached. Of the common elements, the Operations Manual appears to be the driving element between these two regulatory material sets.

Personnel

Specific requirements related to personnel are absent from the FAA Advisory Circular. This difference is primarily a document structure/organization issue as functional requirements for personnel are described elsewhere throughout the document.

Organization

Organizational structure requirements are absent from the FAA Advisory circular. CAANZ requirements focus on functional requirements and quantity of personnel.

Chief Designer

The Chief Designer is identified as the key concept in the final issuance and authorization of IFPD for CAANZ as described above.

Training

Training requirements are defined in a separate Appendix of the FAA Advisory Circular. In comparison, the CAANZ requirements are very high-level and are ultimately at the discretion of the design organization.

Reference Materials

The requirement for reference materials is nearly identical between the FAA and CAANZ, with the only difference being access to state specific materials.

Design

Absent from FAA requirements is specific design authorization definitions. This difference is to be expected as the authorization under CAANZ is procedure design specific while FAA authorization is only related to PBN IFPD.

Validation

CASA IFPD validation activities are defined in detail within CAANZ Part 173 while the FAA Advisory Circular references an external document (Notice 8260.66) as described above.

Records

The record keeping requirements between FAA and CAANZ are very similar with CAANZ providing a detailed description of record keeping requirements while the FAA details a list of requirements in relationship to the associated documents (FAA Order 8260.19).

Safety Management System

Safety Management System requirements differ significantly between CAANZ and the FAA. Specifically, the FAA description of a Safety Management System for a TPIFPD exists only in the Draft Advisory Circular while CAANZ dedicated a separate Advisory Circular and further guidance material on the subject.

Operations Manual

The concept of an Operations Manual is nearly identical between the FAA and CAANZ. However, the CAANZ requirements organize the requirements in relationship to the regulation. Compliance with the regulation for CAANZ is to be demonstrated through an exposition while FAA requirements identify the Operations Manual as the central compliance vehicle.

CASA vs CAANZ

The differences in Certification requirements between the CASA and CAANZ define past and present of TPIFPD authorization. CAANZ represents the most comprehensive and definitive set of requirements for certification on the whole. The clarity of the requirements lends themselves well to a high quality and high fidelity TPIFPD operation. The CASA requirements also have a technical depth that defines the standard but does not reflect the state of the art procedure design tools.

Personnel

Personnel requirements are identical between CASA and CAANZ.

Organization

Organizational requirements are nearly identical between CASA and CAANZ. The primary difference is associated with the method by which the Chief Designer is authorized. CAANZ recognizes the Chief Designer as the primary entity while CASA recognizes the entire company as a whole.

Chief Designer

The Chief Designer is identified as the key concept in the final issuance and authorization of IFPD for CASA and CAANZ. This function is highlighted as the TPIFPD has the final authorization to issue the instrument flight procedure in both Australia and New Zealand.

Training

Training requirements are very similar between CAANZ and CASA, with CAANZ providing specific requirements differentiating authorized designers from those in training.

Reference Materials

The requirement for reference materials is nearly identical between the CAANZ and CASA, with the only difference being access to state specific materials.

Design

Design function and authorization between CAANZ and CASA are very similar; however CAANZ requires the specific use of procedures applicable to New Zealand while CASA leaves this function to the authorized designer.

Validation

CASA IFPD validation activities are defined in detail within CASA Part 173 and CAANZ Part 173.

Records

The record keeping requirements between CAANZ and CASA are identical.

Safety Management System

Safety Management System requirements differ slightly between CAANZ and CASA. CASA defines the requirements for a Safety Management System in a separate Advisory Circular while CAANZ takes a combined approached by defining the SMS requirements specific to IFPD in Part 173 and a separate Advisory Circular.

Operations Manual

The concept of an Operations Manual is complementary between CAANZ and CASA. CAANZ requirement for an Operations Manual is defined under a continuing compliance requirement as the company exposition.

Operating Requirements

The Operating Topic area was defined as the requirements that define or set the ongoing requirements beyond certification that define TPIFPD. Content that can be found in the Operating section includes the general oversight and operation as defined by the associated state of operation. This Topic defines the general provisions for the oversight of the associated CAA. The sub-topics were grouped into two Sets for analysis; oversight and qualification.

FAA vs CASA

In the Operating Topic level it is clear that the FAA and CASA share a common concept of oversight functionality. While CASA's oversight requirements and description provide a definitive framework for operations, the FAA material appears to point the guidance towards a yet to be developed regulatory material.

Oversight

The primary difference in oversight requirement between FAA and CASA is the authorization mechanism. As the FAA provides a LOA and CASA a certificate, the oversight process varies in a level of equivalency related to the level of authorization granted. Oversight by the FAA is conducted in accordance with two additional Orders (1100.61 and 8000.86) while CASA conducts their oversight as defined by a specific section related defined in CASA Part 173.

Transfer of Maintenance

The transfer of maintenance for an instrument flight procedure is absent from FAA requirements while CASA defines maintenance transfer requirements. This difference is expected as FAA requirements do not permit maintenance transfer without forfeiture of the letter of authorization.

FAA vs CAANZ

The differences between the FAA and CAANZ could not be clearer in this topic area. Here again we find the CAANZ has definitive, concise, and complete descriptions of the requirements and the associated definitions while the FAA guidance fails to provide the background or support that is needed to adequately address the technical detail for oversight purposes.

Oversight

The primary difference in oversight requirement between FAA and CAANZ is the authorization mechanism as described above.

Transfer of Maintenance

The transfer of maintenance for an instrument flight procedure is absent from FAA requirements while CASA defines maintenance transfer requirements as described above.

CASA vs CAANZ

CASA and CAANZ share near identical regulatory mechanisms that define oversight and operating requirements. This Topic area appears to be the most common element shared between CASA and CAANZ and it appears that it would be possible to meet both requirements simultaneously under the provisions of the topic.

Oversight

Oversight requirements and function between the CAANZ and FAA are quite similar with CASA providing more detail related to the powers and function of the oversight process.

Transfer of Maintenance

The transfer of maintenance for an instrument flight procedure is nearly identical between CAANZ and CASA, each providing a similar process for the transfer of procedure maintenance.

Design Criteria

The Design Criteria Topic area was defined as the requirements that define or set the criteria for the design of PBN IFP. Content that can be found in the section includes state and international guidance on the initial construction and maintenance of IFP.

FAA vs CASA

The primary difference that defines the requirements between FAA and CASA is the state standard for IFP construction. CASA has defined the standard to be within the

ICAO and Australian Manual of Standards, while FAA guidance relies upon the US Standard for Terminal Instrument Flight Procedure Design (TERPS).

FAA vs CAANZ

The differences between CAANZ and FAA are related again to the state design standards. In this case, CAANZ requires strict ICAO standards while the FAA requires compliance with TERPS requirements.

CASA vs CAANZ

Both CASA and CAANZ require compliance with ICAO standards, however, CASA requires additional compliance with their state developed Manual of Standards.

Qualifications

The Qualifications Topic area was defined as the requirements that define the experience and training of qualified procedure designers. Content that can be found in the topic define or set standards for minimum requirements for procedure designers acting on behalf of a TPIFPD to design procedures.

FAA vs CASA

In this topic area, the FAA has a more definitive set of regulatory guidance material while CASA definitions are left to further to the TPFIPD to define. This is one area where the maturity of the FAA regulatory material is more advanced than CASA due to the additional knowledge level developed in the interim.

FAA vs CAANZ

In this topic area, CAANZ provides definitive regulatory guidance that supports the development and clarity of requirements for qualification of authorized procedure designers to a level that is higher than the FAA.

CASA vs CAANZ

The difference between CASA and CAANZ highlight a philosophical difference in regulatory content development. CAANZ provides a prescriptive definition of qualification requirements while CASA leaves their regulatory material up to the interpretation of the TPIFPD.

CONCLUSIONS & RECOMMENDATIONS

The purpose of this case study is to compare and contrast the regulatory requirements for PBN TPIFPDs working with the FAA, CASA, and CAANZ to support the development and harmonization of future regulatory material. Additionally, this study investigated the conflicts between the aforementioned regulatory guidance materials to determine if it is possible for a TPIFPD to be compliant with all requirements simultaneously.

Conclusions

Three research questions were identified as central to this study. These questions are reviewed below.

1. How are TPIFPD requirements defined?

TPIFPD requirements are defined through a number of different regulatory mechanisms including Regulation, Order, Notice, and Advisory Circular. The most challenging aspect for TPIFPD is tracing the relationship between the numerous related documents that comprise the total requirements package. This study evaluated the core requirements for TPIFPD, though it was clear that the requirements extended further. Many of the requirements identified were linked to existing documents not specifically written for the purpose of TPIFPD. This specific area requires further investigation and review.

2. What are the relationships between FAA, CASA, and CAANZ PBN TPIFPD regulatory material?

At the Topic level, the FAA, CASA and CAANZ all shared a common structure and content. This is an encouraging trend as commonality along the structural level indicates that a common set of requirements could be harmonized in the future. The greatest challenge facing commonality amongst the different regulatory material is the mechanisms that enable authorization of TPIFPD. Functional differences will continue to exist until a common mechanism is identified and defined.

3. Is it possible for a TPIFPD to comply with all requirements simultaneously?

The findings of this study indicated that the current regulatory material share a small fraction of their functional requirements amongst one another, though at a principle level they share nearly all. This disparity in functional requirements makes it extremely challenging for a TPIFPD to comply simultaneously with all requirements without having individual, separate, and parallel processes to comply with each set of requirements.

Recommendations

The lack of commonality of requirements at the functional level creates a system where the development of IFPDs are hindered by the complex system of requirements individual to the state of authorization. At the highest level a common mechanism for TPIFPD should be recognized as the method for authorizing third parties to conduct traditionally governmental functions. Therefore, it is the recommendation to issue IFPD operating certificates similar to air carrier operating certificates. To support the issuance of operating certificates, a common set of function requirements should be developed. ICAO has already begun this effort with the issuance of the 9906 Series Documents. Currently the 9906 Series addresses operational requirements and details training but does not yet address guidance on how states can authorize TPIFPD (International Civil Aviation Organization, 2008).

APPENDICES

Appendix A

Acronyms and Definitions

Acronym	Definition
AC	Advisory Circular
AIM	Aeronautical Information Manual
ANSP	Air Navigation Service Provider
ASA	Airservices Australia
ATM	Air Traffic Management
CAA	Civil Aviation Authority
CAANZ	Civil Aviation Authority of New Zealand
CAR	Civil Aviation Regulation
CASA	Civil Aviation Safety Authority of Australia
CFIT	Controlled Flight Into Terrain
CFR	Code of Federal Regulation
DA	Decision Altitude
DME	Distance Measuring Equipment
FAA	Federal Aviation Administration
FMS	Flight Management System
GNSS	Global Navigation Satellite System
GPS	Global Positioning System

ICAO	International Civil Aviation Organization
IFP	Instrument Flight Procedure
IFPD	Instrument Flight Procedure Design
ILS	Instrument Landing System
IRU	Inertial Reference Unit
LAAS	Local Area Augmentation System
LNAV	Lateral Navigation
LOA	Letter of Authorization
LOC	Localizer
MDA	Minimum Descent Altitude
NAS	National Airspace System
NASAS	North American Satellite Augmentation System
NAVAID	Navigation Aid
PBN	Performance-based Navigation
RNAV	Area Navigation
RNP	Required Navigation Performance
RNP RNAV	Required Navigation Performance Area Navigation
RPAT	RNP Parallel Approach Transition
SAAAR	Special Aircrew and Aircraft Authorization Required
SATNAV	Satellite Navigation
SID	Standard Instrument Departure
STAR	Standard Terminal Arrival
SWA	Southwest Airlines

TPIFPD	Third Party Instrument Flight Procedure Design
VNAV	Vertical Navigation
VOR	Very high frequency Omni-directional Range
WAAS	Wide Area Augmentation System .

Appendix B

Regulatory Guidance Comparison Matrix

RESERVED

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