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European Global Navigation Satellite Systems Agency

EGNOS

Guidelines for ANSP/Airports and Aircraft Operators for LPV implementation

The following document provides a set of generic guidelines for Air Navigation Service Providers (ANSPs), Airport Operators and Aircraft Operators within the European Civil Aviation Conference (ECAC) area to facilitate the operational implementation of Localizer Performance with Vertical guidance (LPV) operations. It has been prepared by European Satellite Services Provider S.A.S. (ESSP SAS) under its EGNOS Service Provision Contract with the European Global Navigation Satellite Systems Agency (GSA).

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1 INTRODUCTION

1.1 Purpose and Scope of the Document

The aim of the present generic guidelines is to provide high level material for Air Navigation Service Providers (ANSPs) and Aircraft Operators within the European Civil Aviation Conference (ECAC) area to facilitate the operational implementation of RNP APCH procedures down to LPV minima, which could be as low as 200 ft, with the aim to ensure harmonized solutions and a common approach according to the Single European Sky (SES) Regulation.

1.1.1 Reference Documents

[RD-1]	ICAO Doc 9613 - Performance Based Navigation (PBN) Manual
[RD-2]	ICAO Annex 4 – Aeronautical Charts
[RD-3]	ICAO Annex 6 - Operation of aircraft
[RD-4]	ICAO Annex 10 - Aeronautical Telecommunications
[RD-5]	ICAO Annex 14 - Aerodromes
[RD-6]	ICAO Annex 15 - Aeronautical Information Services
[RD-7]	ICAO Doc 8168 - Procedures for Air Navigation Services Aircraft Operations PANS OPS, Sixth Edition, 2014.
[RD-8]	ICAO Doc 9906 - Quality Assurance Manual for Flight Procedure Design, First Edition, 2009.
[RD-9]	ICAO EUR RNP APCH Guidance Material (EUR Doc 025)
[RD-10]	RTCA/EurocaeDO200A/ED-76 Standards for Processing Aeronautical Data
[RD-11]	RTCA DO-229D Minimum Operational Performance Standards for Global Positioning System/Wide Area Augmentation System Airborne equipment.
[RD-12]	FAA AC90-107 - Guidance for Localizer Performance with Vertical Guidance and Localizer Performance without Vertical Guidance Approach Operations in the U.S. National Airspace System
[RD-13]	FAA AC 20-138B - Airworthiness Approval of Positioning and Navigation Systems
[RD-14]	EASA E-TSO 145c – Airborne Navigation Sensors Using the GPS Augmented by SBAS
[RD-15]	EASA E-TSO 146c Stand-Alone Airborne Navigation Equipment Using the GPS Augmented by SBAS
[RD-16]	EASAAMC 20-28 - Airworthiness Approval and Operational Criteria for RNAV GNSS approach operation to LPV minima using SBAS
[RD-17]	Regulation (EC) No 216/2008 on common rules in the field of civil aviation and establishing a European Aviation Safety Agency, plus applicable amendments
[RD-18]	EASA Regulation No 965/2012 laying down technical requirements and administrative procedures related to air operations (AIR-OPS), plus applicable amendments.
[RD-19]	Annex to ED Decision 2014/015/R “Acceptable Means of Compliance (AMC) and Guidance Material (GM) to Part-CAT”, Consolidated version — Issue 2, 24 April 2014

[RD-20]	Regulation (EC) No 549/2004 laying down the framework for the creation of the single European sky (the framework Regulation), plus applicable amendments.
[RD-21]	Regulation (EC) No 550/2004 on the provision of air navigation services in the single European sky (the service provision Regulation), plus applicable amendments.
[RD-22]	Regulation (EC) No 551/2004 on the organisation and use of the airspace in the single European sky (the airspace Regulation), plus applicable amendments.
[RD-23]	Regulation (EC) No 552/2004 on the interoperability of the European Air Traffic Management network (the interoperability Regulation), plus applicable amendments.
[RD-24]	Regulation (EU) No 1035/2011 laying down common requirements for the provision of air navigation services, plus applicable amendments
[RD-25]	EUROCONTROL "APV SBAS Approach - Concept of Operations", Final Draft, 28/01/09.
[RD-26]	ACCEPTA Pioneer Airlines Development Report, Ref: ACCEPTA_WP2-RC-D2.0.2, Issue: 3.0, 27/03/14
[RD-27]	HEDGE Certification Roadmap, D1.2, 04/08/10
[RD-28]	GIANT-2 Certification and Standardisation, Ref: GIANT-2_WP2-RC-D2.1, 06/10/09
[RD-29]	SHERPA Workshop, EASA presentations, Gliwice, Poland, 30/Jan/2013
[RD-30]	EGNOS Safety of Life (SoL) Service Definition Document (SDD)

2 EGNOS

2.1 What is EGNOS?

The European Geostationary Navigation Overlay Service (EGNOS) is Europe's first venture into satellite navigation. It was developed by the European Space Agency (ESA) under a tripartite agreement between the European Commission (EC), the European Organisation for the Safety of Air Navigation (EUROCONTROL) and the European Space Agency (ESA). In April 2009, the ownership of the EGNOS assets was transferred from the ESA to the European Commission which manages and finances the EGNOS Service Provision through the European GNSS Agency (GSA).

EGNOS is the European Satellite-Based Augmentation System (SBAS) that complements the GPS system. It broadcast, on the GPS L1 frequency, integrity messages in real-time, providing information on the health of the GPS constellation. In addition, correction data improves the accuracy of the current GPS services from about 10 m to about 2 m in the horizontal dimension. The EGNOS Service Area includes all European States and has the system-inherent capability to be extended to other regions, such as the European Union (EU) neighbouring countries, North Africa and more generally regions within the coverage of three geostationary satellites being used to transmit the EGNOS signal.

EGNOS is the first element of the European satellite-navigation strategy and a major stepping-stone towards Galileo, Europe's own global navigation satellite system (GNSS) for the future.

2.2 EGNOS system description

EGNOS is divided into four functional segments:

1) The ground segment is composed of the following stations/centres which are mainly distributed in Europe and are interconnected between themselves through a land network.

- 39 (Ranging and Integrity Monitoring Stations, RIMS): receive the satellite signals and send this information to the Master Control Centres (MCC).
- 4 MCC (control and processing centres) receive the information from the RIMS stations and generate correction messages to improve satellite signal accuracy and information messages on the status of the satellites (integrity). The MCC acts as the EGNOS system 'brain'.
- 6 Navigation Land Earth Stations (NLES), stations that access the geostationary satellites: they receive the correction messages from the Central Processing Facilities (CPFs) for the upload of the data stream

to the geostationary satellites and the generation of the GPS-like signal. This data is then transmitted to the European users via the geostationary Satellites.

2) EGNOS support segment. In addition to the previously mentioned stations/centres, the system has other ground support installations that perform the activities of system operations planning and performance assessment.

3) The Space Segment is composed of three geostationary satellites:

- Two Inmarsat satellites in the EGNOS operational platform transmitting the operational Signal-In-Space (SiS) to be used by EGNOS users: INMARSAT 3F2 AOR-E (PRN-120) and INMARSAT 4F2 EMEA (PRN-126).
- An ASTRA satellite as part of the EGNOS TEST Platform broadcasting the TEST SIS: ASTRASES-5 (PRN-136).

4) User segment: set of EGNOS (or SBAS) receivers developed for various types of users.

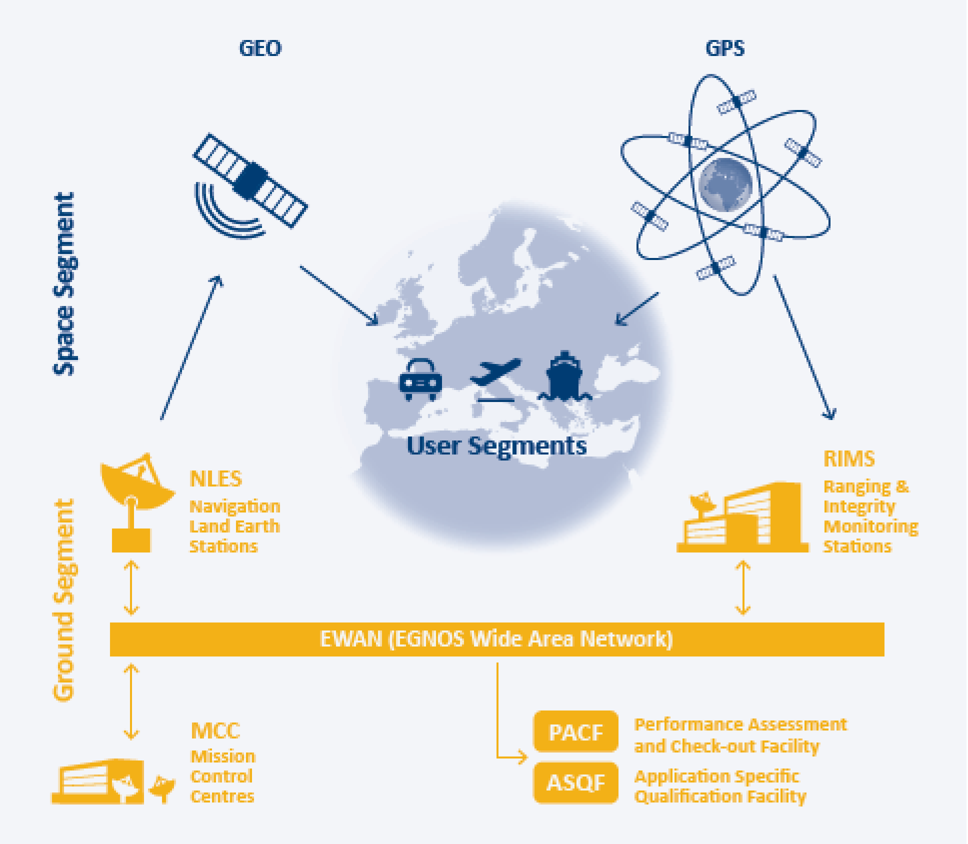

Figure 2-1 EGNOS elements[1]

2.3 EGNOS Signal Provision

Since April 2009, The European Commission has awarded the EGNOS service provision (ESP) to the ESSP. The ESSP is committed to the following main objectives in the course of the ESP Contract:

- EGNOS Service Provision, Operations and maintenance (including network connectivity and geostationary transponder leases)
- The EGNOS signal and data provision for Open Service (OS), Safety of Life Service (SoL) and EGNOS Data Access Service (EDAS) Service.
- The support to the European Commission and the European GNSS Agency (GSA) for the implementation and promotion of enabling actions for the EGNOS signal and services mainly in the civil aviation market, but also taking into account new application markets such as maritime, rail, precision agriculture or surveying.

The ESSP is contracted by the GSA to ensure the operation, maintenance and more generally the EGNOS Service Provision in the frame of a contract for the period 2014-2021.

2.4 EGNOS Services

EGNOS offers all users of satellite radio navigation high-performance navigation and positioning services. The three services available are:

- Open Service (OS)
- Safety-of-Life (SoL) Service
- EGNOS Data Access Service (EDAS)

For the EGNOS Open Service, the signal-in-space is continuously available since October 2009. EGNOS Open Service provides unprecedented positioning precision by improving the accuracy of GPS.

The continuing monitoring of the augmentation signal shows it improves the accuracy of GPS to within one to two meters and is available more than 99 percent of the time. By comparison, someone using a GPS receiver that is not EGNOS enabled can only be sure of his position to within 17 meters[2].

[1] Additional information: http://egnos-user-support.essp-sas.eu/new_egnos_ops/content/about-egnos --- http://egnos-portal.gsa.europa.eu

Since March the 2nd **2011**, the EGNOS **Safety-of-Life Service** has been declared available for use, after the Certification of the ESSP as an Air Navigation Service Provider (ANSP).

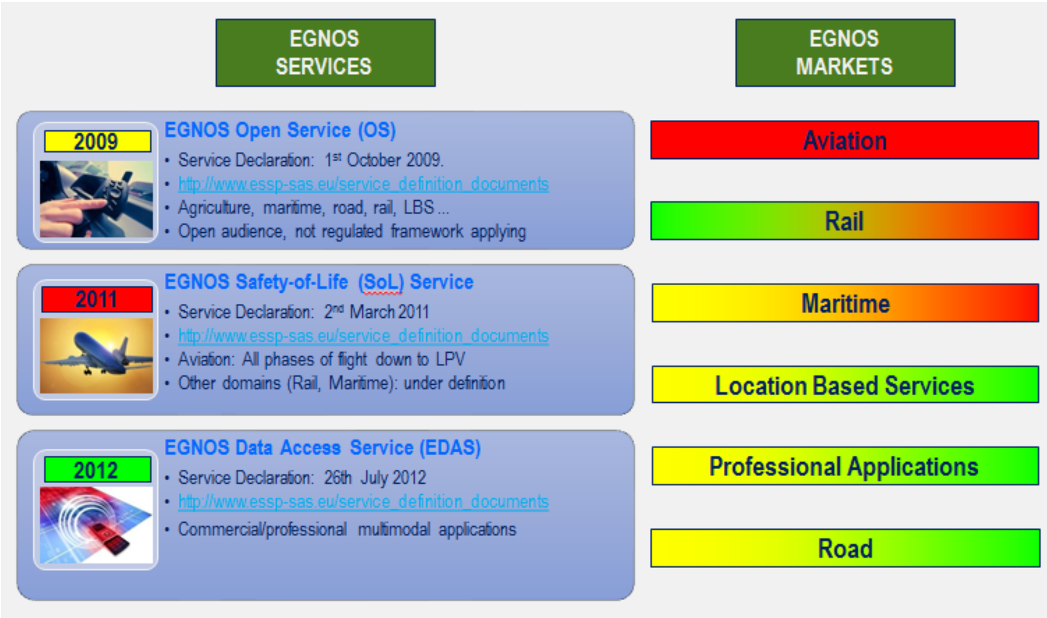

Figure 2-2 EGNOS Services and Market

The detailed performance of each EGNOS service is described in the corresponding associated Service Definition Document [RD-30] available at http://egnos-user-support.essp-sas.eu/new_egnos_ops/sites/default/files/library/official_docs/egnos_sol_sdd_in_force.

[2] http://www.gps.gov/technical/ps

2.5 EGNOS Service Provision Scenario (Who does what)

The following figure shows the EGNOS Service Provision scenario including the relationships among the key actors:

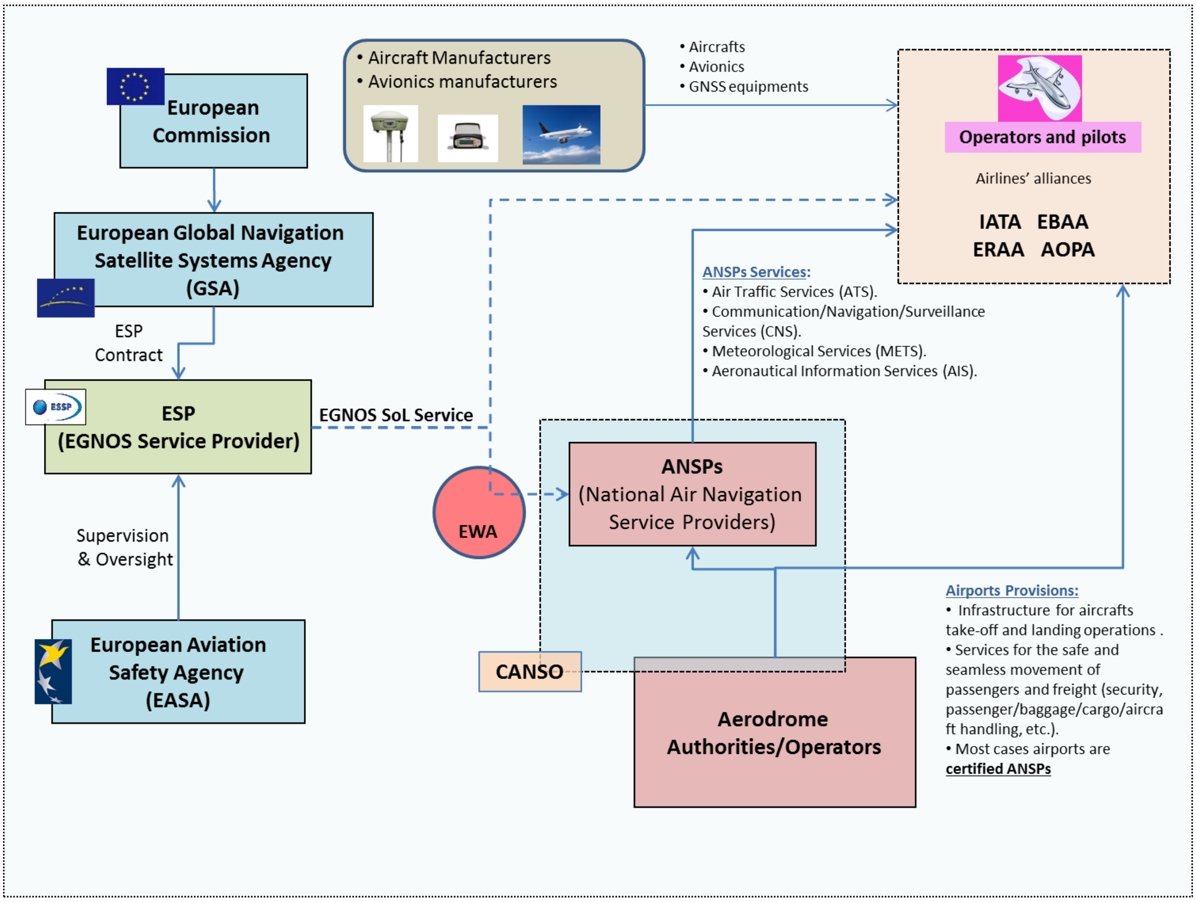

Figure 2-3 EGNOS SoL Service Provision Key Actors

Air Navigation Service Providers (ANSPs): are public or private entities providing air navigation services, under the framework of the Single European Sky and subject to the relevant authority oversight, for the general air traffic in the European Air Traffic Management Network (EATMN); where 'air navigation services' means:

- ATS (Air Traffic Services): the flight information services, alerting services, air traffic advisory services and ATC services (area, approach and aerodrome control services);
- CNS: communication, navigation and surveillance services;
- Meteorological services for air navigation;
- Aeronautical information services;

EGNOS Service Provider (ESP): This role is successfully performed by the ESSP in the frame of the current ESP contract with the GSA. It requires an Air Navigation Service Provider (ANSP) certification in the frame of the SES regulations and subject to the corresponding applicable provisions to deliver the EGNOS Navigation Service under the oversight of EASA.

The European GNSS Agency (GSA)[3], an official European Union Agency, is responsible for:

- Preparing for the successful commercialisation and exploitation of the systems, with a view to smooth functioning, seamless service provision and high market penetration;
- Ensuring the security accreditation of the system and the establishment and operation of the Galileo Security Monitoring Centres;
- Accomplishing other tasks entrusted to it by the European Commission, such as managing EU GNSS Framework Programme Research and Innovation (Horizon 2020), the promotion of satellite navigation applications and services, and ensuring the certification of the systems' components.

In addition, under delegation from the European Commission, the GSA assumed responsibility for the operations and service provision for the EGNOS Programme in 2013, and will take up these responsibilities for the Galileo Programme from 2017.

Civil Air Navigation Services Organization (CANSO)[4]: is the global voice of the companies that provide air traffic control, and represents the interests of Air Navigation Service Providers (ANSPs) worldwide. CANSO members are responsible for supporting over 85% of world air traffic, and through its Workgroups, members share information and develop new policies, with the ultimate aim of improving air navigation services on the ground and in the air. CANSO also represents its members' views in major regulatory and industry forums, including at the International Civil Aviation Organization (ICAO), where it has official Observer status.

Airports Authorities/operators: are public or private entities managing the required infrastructure for aircraft take-off and landing operations and all required and associated services (security, passenger/baggage/cargo/aircraft handling, etc.) for the safe and seamless movement of passengers and freight and their connection to different transport means.

[3] http://www.gsa.europa.eu

[4] ESSP is a CANSO silver member.

Most of the European airports are owned by local, regional, or national government bodies, usually managing the associated air navigation services as certified ANSPs.

Nonetheless there is a growing trend to lease the airport to private corporations who manage the airport's operation which is the case on a number of airports/aerodromes in the United Kingdom and increasingly in some other countries such as Norway or Spain. Then the air navigation services are either obtained from an existing certified ANSP or provided on its own (fulfilling the corresponding SES requirements to become certified as ANSPs and authorized to provide the corresponding services).

<u>Operators' and pilots' related most relevant organizations:</u>

Main airlines' alliances: Oneworld, Skyteam and Star Alliance, gathering the main commercial operators offering end-to-end worldwide coverage to the users by sharing their services under a mutual business beneficial scheme.

International Air Transport Association[5] (IATA): is the most relevant international industry trade group of airlines headquartered in Montreal, Quebec, Canada.

IATA's mission is to represent, lead, and serve the airline industry. IATA represents some 240 airlines comprising 84% of scheduled international air traffic, IATA is present in over 150 countries covered through 101 offices around the globe.

European Business Aviation Association[6] (EBAA): is a non-profit association based in Belgium that has existed since 1977. Its 500 member companies span all aspects of the business aviation sector in Europe and elsewhere. The EBAA's aim is to promote excellence and professionalism amongst its members and to ensure that business aviation is properly recognized as a vital sector of the European Economy. EBAA represents corporate operators, commercial operators, manufacturers, airports, fixed-base operators, and business aviation service providers.

EBAA focuses on creating an environment that fosters business aviation in Europe and around the world, and is one the few entities recognized by the European authorities as representing business aviation in Europe.

Other European national aviation associations encompassed by the EBAA include: BBGA (British & General Aviation Association), EBAA France, EBAA Switzerland, GBAA (German Business Aviation Association), IBAA (Italian Business Aviation Association) and NAOA (Norwegian Aircraft Operators Association).

[5] http://www.iata.org

[6] http://www.ebaa.org

The European Regions Airline Association[7] (ERAA): Founded in 1980, ERAA is a non-profit trade association representing some 200 companies involved in European air transport, including airlines, airframe and engine manufacturers, airports, suppliers and service providers from all over Europe which annually carry 70.6m passengers on 1.6m flights to 426 destinations in 61 European countries.

The Association promotes the interests of intra-European airlines by lobbying the European Commission and other European regulatory bodies on policy matters, promoting the social and economic importance of air transport and its environmental commitments, holding an annual conference and other networking events, publishing a monthly journal and providing expert advice and guidance on all air transport regulatory matters.

The Aircraft Owners and Pilots Association[8] (AOPA): is a Frederick, Maryland-based American non-profit political organization that advocates for general aviation.

AOPA exists to serve the interests of its members as aircraft owners and pilots, and to promote the economy, safety, utility, and popularity of flight in general aviation aircraft.

With 384,915 members in 2012, AOPA is the largest aviation association in the world, being affiliated with other similar organizations in other countries though membership in the International Council of Aircraft Owner and Pilot Associations (IAOPA).

Aircraft Manufacturers: where the main players are: Airbus (EU) and Boeing (US) for commercial aviation, Bombardier (CA), Embraer (BR) and ATR (EU) for Regional Aviation, Cessna (US), Dassault (FR), Gulfstream (US), Beechcraft (US) for Business Aviation and Cessna (US), Piper (US), Cirrus (US) and Diamond (AU) for General Aviation.

GNSS Receiver manufacturers: where we could highlight the main players, concerning the GNSS market, in line with: Honeywell (US), Rockwell Collins (US), Universal Avionics (US), CMC Electronics (CA) and Thales Avionics (FR) for Commercial Aviation and Garmin (US), Avidyne (US), Aspen Avionics (US), Honeywell (US) for General Aviation.

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[7] http://www.eraa.org

[8] http://www.aopa.org

2.6 EGNOS SoL Service

The EGNOS SoL Service consists of signals for timing and positioning intended for most transport applications in different domains. The SoL service is based on integrity data provided through the EGNOS satellite signal.

The main objective of the EGNOS SoL service, available from the 2nd of March, 2011, is to support civil aviation operations down to LPV (Localiser Performance with Vertical guidance) minima.

In order to provide the SoL Service, the EGNOS system has been designed so that the EGNOS SiS is compliant to the ICAO SARPs Annex 10 Aeronautical Telecommunications Vol I [RD-4] to be used in all phases of flight from en-route, terminal and approach operations (RNP APCH procedures down to LPV as low as 200 ft).

Additional information about the EGNOS Safety-of-Life (SoL) Service can be found at the EGNOS SoL Service Definition Document [RD-30] available at http://egnos-user-support.essp-sas.eu/new_egnos_ops/sites/default/files/library/official_docs/egnos_sol_sdd_in_force.pdf.

3 RNP APCH DOWN TO LPV MINIMA WITHIN THE ICAO CONTEXT (WHAT)

3.1 RNP Approach Procedures

The Performance Based Navigation (PBN) concept, published within the Performance-Based Navigation (PBN) Manual (Doc 9613). - 4th edition, 2013, defines performance requirements for aircraft navigating on an ATS route, terminal procedure or in a designated airspace.

Through the application of Area Navigation (RNAV) and Required Navigation Performance (RNP) specifications, PBN provides the means for flexible routes and terminal procedures helping the global aviation community to reduce aviation congestion, save fuel, protect the environment and maintain reliable, all-weather operations, even at the most challenging airports. It provides ANSP and operators with greater flexibility and better operating returns while increasing the safety of regional and national airspace systems.

GNSS is identified as a key enabler for most of the navigation specifications defined. Notably SBAS and therefore EGNOS is a key enabler for procedures based on the RNP APCH Navigation Specification. The following figure shows in a schematic way the ICAO PBN Navigation Specification classification included in the PBN manual.

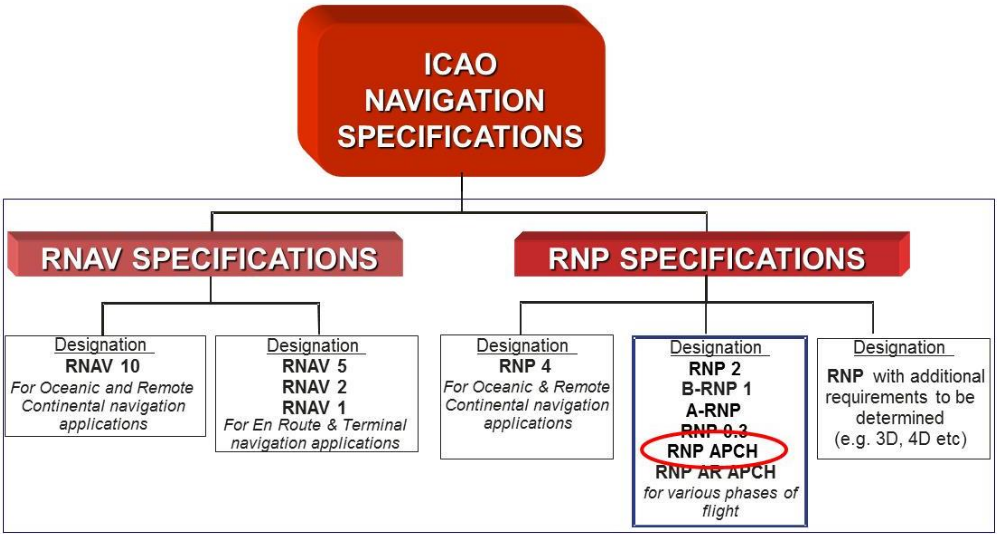

Figure 3-1 Navigation Specification according to the PBN Manual

RNP APCH procedures allow four minima lines: LP, LNAV, LNAV/VNAV and LPV. The RNP APCH procedures are published on charts with the title RNAV (GNSS) RWY XX.

The following figure shows the different types of approach operations included within the RNP APCH navigation specification.

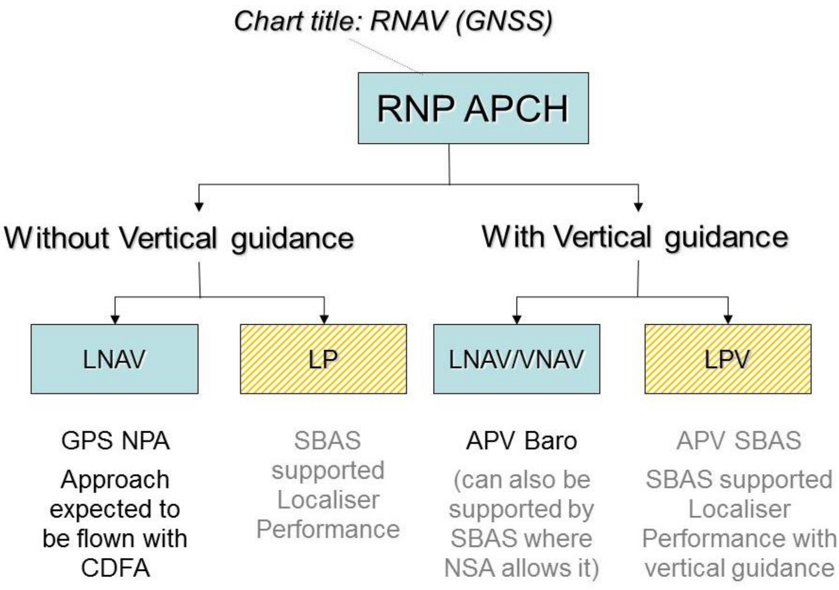

Figure 3-.2. RNP APPROACH minima

Within the ECAC area EGNOS is the only navigation system supporting for RNP APCH procedures down to LPV minima.

3.2 Safety of Life Service Levels

The Service Levels defined within the EGNOS SoL Service Definition Document[9] are as follows:

- NPA (Non-Precision Approach operations): supporting PBN navigation specifications other than RNP APCH, not only for approaches but also for other phases of flight.
- APV-I (Approach operations with Vertical Guidance): supporting PBN navigation specification RNP APCH down to LPV minima (DH) as low as 250 ft in compliance with APV-I Performance Requirements of ICAO Annex 10[10].
- LPV-200: supporting PBN navigation specification RNP APCH down to LPV minima (DH) as low as 200 ft., in compliance with Category I precision approach Performance Requirements of ICAO Annex 10[11].

[9] The Service Definition Document [RD-30] contains the commitment maps for the different Service Levels.

[10] ICAO Annex 10 – Vol I – Chapter 3, Table 3.7.2.4-1 Signal in space performance requirements – Typical operation Approach operations with vertical guidance (APV-I).

It is important to highlight that the user cannot choose between one service level or the other. The avionics receiver will use the unique signal available, monitoring the performance according to the required minimum performance for the intended operation.

3.3 The new ICAO Approach Classification

ICAO Annex 6 [RD-3], since the last amendment, provides new definitions for Approach Procedure with Vertical guidance (APV) as well as for the Precision Approach (PA) procedure:

> "*Approach procedure with vertical guidance (APV). A performance-based navigation (PBN) instrument approach procedure designed for 3D instrument approach operations Type A.*"

> "*Precision approach (PA) procedure. An instrument approach procedure based on navigation systems (ILS, MLS, GLS and SBAS Cat I) designed for 3D instrument approach operations Type A or B.*"

Therefore, SBAS is an enabler for both approach procedures with vertical guidance (APV) and for precision approach (PA) procedures that can be based on the SBAS navigation system.

The types of instrument approach operations can be Type A and Type B, defined in ICAO Annex 6 [RD-3] as follows:

> "*Instrument approach operations shall be classified based on the designed lowest operating minima below which an approach operation shall only be continued with the required visual reference as follows:*
>
> > *a) Type A: a minimum descent height or decision height at or above 75 m (250 ft); and*
> >
> > *b) Type B: a decision height below 75 m (250 ft). Type B instrument approach operations are categorized as:*
> >
> > > *1) Category I (CAT I): a decision height not lower than 60 m (200 ft) and with either a visibility not less than 800 m or a runway visual range not less than 550 m;*"

[11] ICAO Annex 10 – Vol I – Chapter 3, Table 3.7.2.4-1 Signal in space performance requirements – Typical operation Category I precision approach.

Consequently an operation making use of the LPV-200 capability is a precision approach procedure which corresponds to a 3D instrument approach operation (since it is based on both horizontal and vertical guidance) of:

- Type A if DH ≥ 250 ft
- Type B if DH < 250 ft

New Approach Classification

Domain	Document	Aspect					
Approach Operations	Annex 6	Classification	Type A (>= 250')		Type B: CAT I (>= 200')	CAT II (>= 100')	CAT III (<100')
		Method	2D	3D			
		Minima	MDA/H	DA/H*			
Approach Runways	Annex 14	M(DA/H) >= VMC	Non Instrument RWY				
		M(DA/H) >= 250' Visibility=1 000m	Non Precision Approach RWY				
		DA/H >= 200' Visibility>=800m or RVR >= 550m	Precision Approach RWY, Category I				
		DA/H >= 100' RVR >= 300m	Precision Approach RWY, Category II				
		DA/H >= 0' RVR >= 0m	Precision Approach RWY, Category III (A, B & C)				
System Performance Procedures	Annex 10 PANS-OPS Vol. II	NPA	NDB, Lctr, LOC, VOR, Azimuth, GNSS				
		APV		GNSS/Baro/SBAS			
		PA		ILS, MLS, SBAS, GBAS			

Figure 3-3 - ICAO Approach Classification (ICAO State letter AN 11/1.1-12/40)

4 LPV IMPLEMENTATION DRIVERS (WHY)

4.1 ICAO Assembly Resolution

The ICAO Resolution A37-11 [12](2010) urges States to complete a PBN implementation plan as a matter of urgency to achieve:

- Implementation of RNAV and RNP operations (where required) for en-route and terminal areas according to established timelines and intermediate milestones.
- Implementation of approach procedures with vertical guidance (APV) (Baro-VNAV and/or SBAS), including LNAV-only minima, for all instrument runway ends, either as the primary approach or as a back-up for precision approaches by 2016 with intermediate milestones as follows: 30 per cent by 2010, 70 per cent by 2014; and
- Implementation of straight-in LNAV-only procedures, as an exception to 2) above, for instrument runways at aerodromes where there is no local altimeter setting available and where there are no aircraft suitably equipped for APV operations with a maximum certificated take-off mass of 5.700 kg or more.

4.2 EASA NPA 2015-01 (Former PBN Implementing Rule)

The Notice of Proposed Amendment (NPA) 2015-01 “Performance-Based Navigation (PBN) implementation in the European Air Traffic Management Network (EATMN)”, RMT.0639 — 19.1.2015, issued by EASA, addresses the safety, interoperability, proportionality and coordination issues related to the implementation of Performance Based Navigation (PBN) within European airspace.

The specific objective is to ensure a safe, efficient and harmonised implementation of specific PBN specifications and functionality in the European ATM Network (EATMN). In achieving this objective, the proposal, which extends the PBN implementation requirements beyond the 24 EU aerodromes as required by the Regulation (EU) No 716/2014 — ‘Pilot Common Project’, mitigates the risks associated with a non-harmonised implementation, thus ensuring a smooth transition to PBN operations, fully supporting the implementation of the European Air Traffic Management Master Plan. The proposal builds on the accepted conclusions defining the navigation specifications and functionality that should be implemented in the European

[12] Superseding and amendingICAO 36th Assembly Resolution A36-23.
http://www.icao.int/safety/pbn/PBN%20references/Assembly%20Resolution%2037-11_%20PBN%20global%20goals.pdf

airspace, resulting from a previous European Commission mandate issued to EUROCONTROL for the preparation of a Single European Sky interoperability Implementing Regulation for PBN.

This NPA proposes that Air Traffic Service Providers (ATSPs) and aerodrome operators implement:

- PBN Standard Instrument Departure (SID)/Standard Instrument Arrival (STAR) and Air Traffic Service (ATS) routes as required to meet locally defined performance objectives that conform to RNP1 performance requirements as of December 2018; and
- PBN approach procedures with vertical guidance (APV) (RNP APCH) at all instrument runway ends where there are currently only non-precision approach procedures published before January 2024.

Aircraft operators wishing to operate these routes and procedures will be required to ensure that their aircraft and flight crew are approved for PBN operations.

This proposal is expected to increase safety, improve harmonisation of PBN operation and be consistent with the ATM Functionality AF 1 — 'Extended AMAN and PBN in high density TMAs; of Commission Implementing Regulation (EU) No 716/2014 — 'Pilot Common Project'.

The foreseen publication date of the EASA Decision on the NPA 2015-01 is Q4 2015.

4.3 LPV implementing Benefits

LPV approaches enabled by EGNOS SoL service, provide the following general benefits compared to approaches based on conventional navigation aids (NPA or ILS Cat I):

- Minima reduction, down to 250 ft. or as low as 200 ft. based on the Safety of Life LPV 200 service level capability which can allow successful approaches in conditions that would otherwise disrupt operations compared to conventional NPAs and therefore increase accessibility.
- Supports ILS Cat I look-alike operations without the need for a ground-based final approach system on the airfield or in case of ILS Cat I approach unavailability.
- Safety increases because vertical guidance is provided to the aircrew during the approach. This makes the approach easier to fly and reduces the risk of controlled flight into terrain (CFIT).

- Operational Benefits:
  - Reduces trajectory dispersion (predictability and noise footprint reduction).
  - CDA/CDFA techniques (fuel consumption reduction and noise footprint reduction).
  - More flexible use of airspace.
  - LPVs offer straight-in approaches in some cases where this is not otherwise possible with conventional NPAs and they also allow the offset (angle) as in some ILS approaches.
  - LPVs offer the potential to remove circling approaches.
- Infrastructure rationalization:
  - LPV approaches will be most beneficial at runway-ends where there is no ILS already available.
  - Potentially enabling VOR, NDB, ILS removal reducing the associated installation / maintenance costs (in accordance with airlines equipage and/or interests).
- Limited impact on user avionics:
  - SBAS receivers are currently available.
  - Limited impact on the FMS.
- Low training requirements for flight crews.

4.4 Benefits of early adopters

The EC/GSA through ESSP is actively promoting the widespread use of EGNOS for aviation applications by sponsoring the early adopters with ad-hoc funding schemes (with EC/GSA funding). There is a two-fold approach:

- ANSPs can have financial and technical support for the publication of the first LPV procedures in a given airfield.
- Aircraft operators can have financial and technical support for the upgrade, certification and operational approval of (part of their fleet) to perform flight operations based on EGNOS (e.g. LPV approach).

5 LPV IMPLEMENTATION REGULATORY FRAMEWORK (HOW)

As the EGNOS SoL service is an enabler for Safety-of-Life (SoL) applications, a regulated framework under the appropriate Supervisory Authority oversight is required.

In the case of the EGNOS based operations, as a Civil Aviation application, the associated regulatory framework is established by the Single European Sky (SES) regulations.

5.1 Single European Sky (SES)

The Single European Sky (SES) legislative package consists of the following four basic Regulations (SES I) plus one amending regulation (SES II):

- **Regulation (EC) No. 549/2004**[13] of 10 March 2004 laying down the framework for the creation of the single European sky;
- **Regulation (EC) No. 550/2004**[14]of 10 March 2004 on the provision of air navigation services in the single European sky; Complemented by**:**
    - RE (EC) No 482/2008[15] of 30 May 2008 establishing a software safety assurance system to be implemented by air navigation service providers and amending Annex II to Regulation (EC) No 2096/2005.
    - RE (EU) No 691/2010 [16]of 29 July 2010 laying down a performance scheme for air navigation services and network functions and amending Regulation (EC) No2096/2005 laying down common requirements for the provision of air navigation services.
    - RE (EU) No 1035/2011 [17]of 17 October 2011 laying down common requirements for the provision of air navigation services and amending Regulations (EC) No482/2008 and (EU) No 691/2010.
    - RE (EU) No 1034/2011[18] of 17 October 2011 on safety oversight in air traffic management and air navigation services and amending Regulation (EU) No691/2010.

[13] http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CONSLEG:2004R0549:20091204:EN:PDF

[14] http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CONSLEG:2004R0550:20091204:EN:PDF

[15] http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2008:141:0005:0010:EN:PDF

[16] http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2010:201:0001:0022:EN:PDF

[17] http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2011:271:0023:0041:EN:PDF

[18] http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2011:271:0015:0022:EN:PDF

- **Regulation (EC) No. 551/2004**[19] of 10 March 2004 on the organization and use of the airspace in the single European sky;
- **Regulation (EC) No. 552/2004**[20] of 10 March 2004 on the interoperability of the European Air Traffic Management network.
- **Regulation (EC) No 1070/2009**[21] of 21 October 2009 amending Regulations (EC) No 549/2004, (EC) No 550/2004, (EC) No 551/2004 and (EC) No 552/2004 in order to improve the performance and sustainability of the European aviation system).

5.2 CS-ATM Service and Operators related regulatory processes

This section does not intend to complete an in-depth analysis of all regulatory requirements applying but summarizing the most relevant processes and applicable references to be taken into account by the corresponding actors.

Notably, CS ATM regulatory process for implementing LPV approach procedures is included in section 2.5 and aircraft operator's regulatory is included in section 3.

5.3 EGNOS Service Provider regulatory processes

RNP APCH procedures flown to LPV minima rely on the use of GPS augmented by SBAS. The European Geostationary Navigation Overlay Service (EGNOS) is the European SBAS.

As EGNOS is a Pan-European Service used by other ANSPs and aircraft and provided by an organization established in the territory of the EU Member States it is subject to the SES Regulations

The EGNOS service is provided by the European Satellite Services Provider (ESSP). EASA, according to its role within the Regulation (EC) 1108/2009, is the competent authority for the oversight of ESSP as the EGNOS certified service provider.

After being certified as an ANSP, the ESSP submitted in July 2010 the Declaration of Verification (DoV) for the EGNOS system as required by Regulation (EC) 552/2004.

The SoL service introduction within the EATMN was demonstrated to be safe according to Regulation (EC) 1034/2011.

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[19] http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CONSLEG:2004R0551:20091204:EN:PDF

[20] http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32004R0552&from=en

[21] http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:300:0034:0050:en:PDF

The following figure summarizes in a schematic way the role and area of activity of each involved actor and the most relevant interactions in the current LPV implementation scenario including the EGNOS final users.

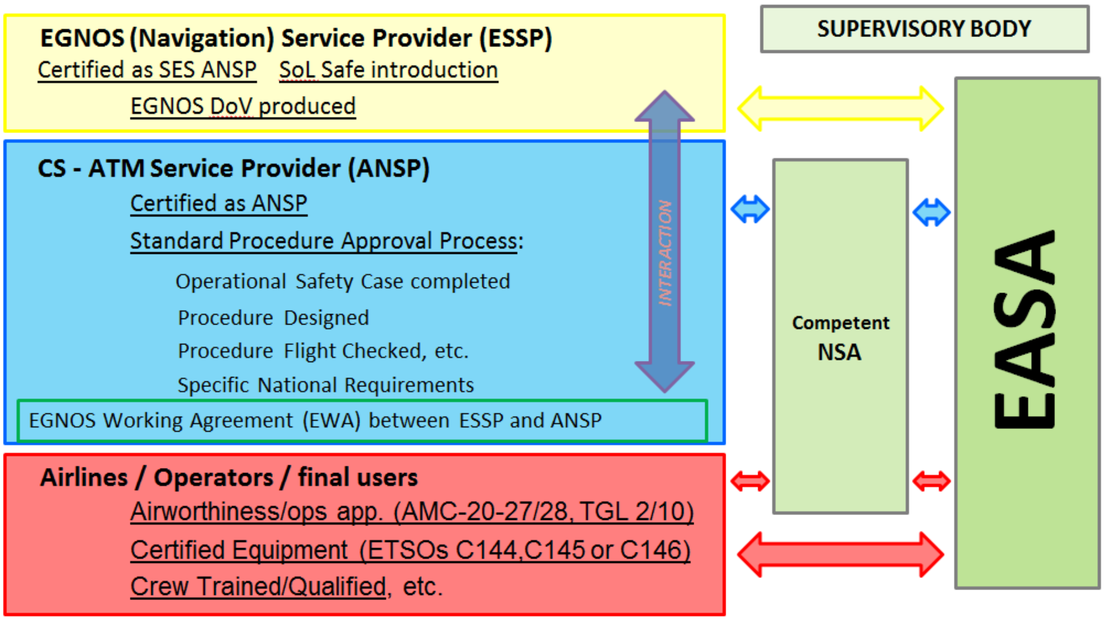

Figure 5-1. LPV implementation framework

5.4 EGNOS Working Agreement (EWA) with the ESSP

Once the EGNOS SoL Service was declared available on the 2nd March 2011, Air Navigation Service Providers (ANSPs) were enabled to start the process for the implementation of EGNOS based operations, in particular vertically guided approach procedures based on EGNOS (LPV approaches).

European ANSPs planning to implement such navigation services should, according to Regulation CE 550/2004 and 1035/2011, first sign an EWA with the EGNOS service provider, ESSP, and cover the corresponding requirements from the corresponding National Supervisory Authority (NSA), as indicated in the previous section.

Although a specific ANSP or airport is not directly responsible of the GNSS navigation signal (GPS or EGNOS) when a LPV approach procedure is implemented, it is necessary to consider the impact in the overall service provided.

Basically, the EWAs are free of charge bilateral working arrangements between ESSP and European ATS/ANSPs defining all needed interfaces between these entities.

The EWA is a facilitator for EGNOS implementation helping to:

- Comply with applicable regulation;
- Provide support to ANSPs implementing EGNOS-based operations;
- Formalize the working interfaces between ESSP and ANSPs as an evidence for the NSA;
- Ensure a fair and equitable treatment for all European ANSP proposing a harmonized approach.

The EWA[22] provides a harmonized and consolidated approach for the implementation of operations based on RNP APCH down to LPV minima. On the basis of the experience provided by the 36 EWAs already signed (September 2015) the average signature process takes around two months. The following map shows the current status (September 2015) in terms of operational and planned LPV approaches.

[22] ESSP Mailbox for EGNOS Working Agreements EGNOS-working-agreement@essp-sas.eu

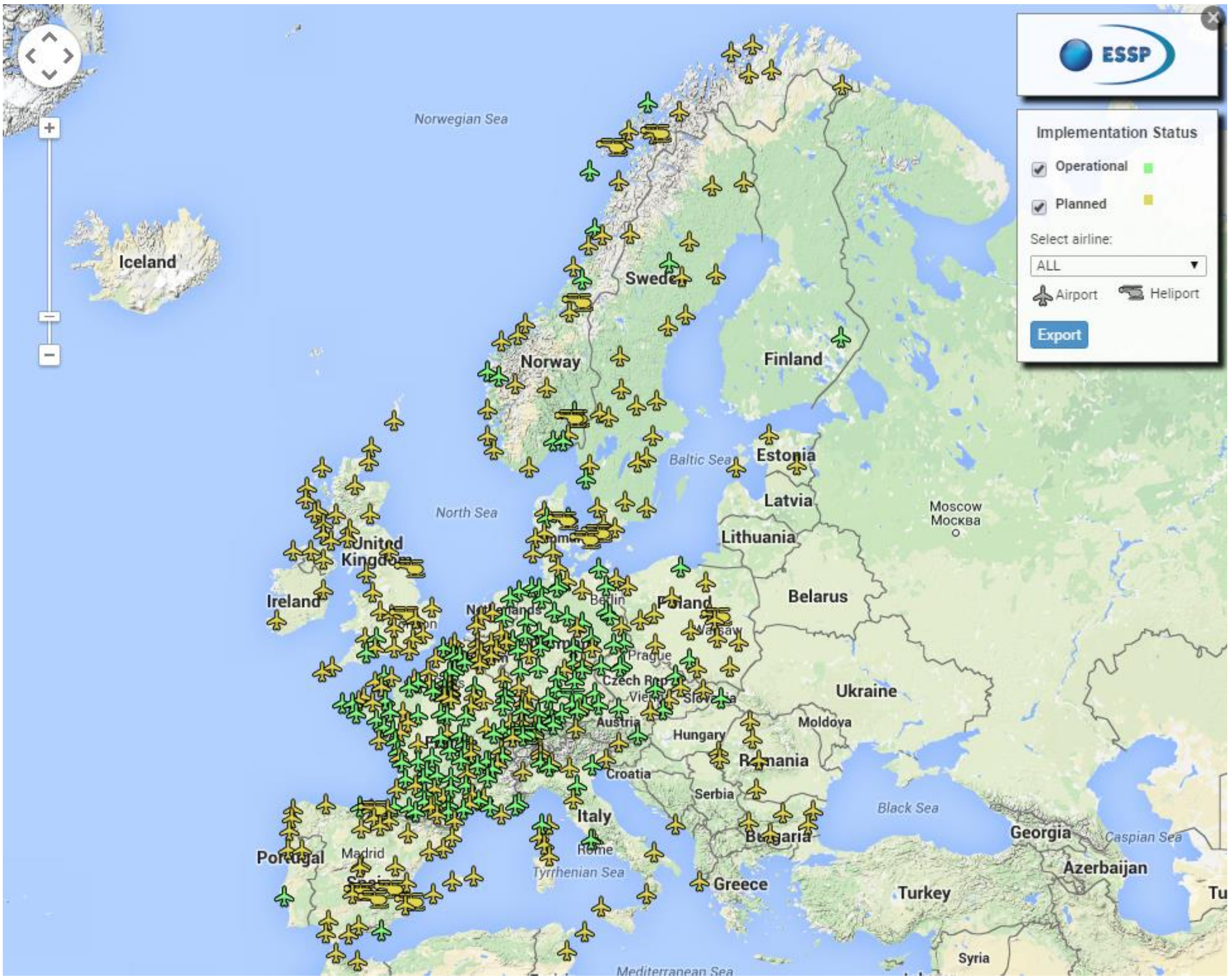

Figure 5-2. EGNOS implementation status in European Airports by September 2015 (http://egnos-user-support.essp-sas.eu).

- **Non EU States approach**

The EGNOS implementation in a non-EU country should be driven by:

a) Agreement/decision/discussion at State level (between the non-EU country and the European Union) clarifying the framework for the use of EGNOS SoL Service (SES applicability, financial and liability scheme, etc.) and ensuring the mutual recognition of the corresponding civil aviation regulatory requirements (level of safety, quality, etc.).

b) EWA with ANSPs: Only when the previous agreement is reached and ESSP is requested by the EC/GSA to do so, ESSP could enter into a EWA with the corresponding country/organization.

Any use of the SiS outside of this framework would be understood as an Open Service application in the non-EU country on its own risk.

6 GUIDELINES FOR ANSPS AND AIRPORTS

This section provides guidelines for ANSPs within the ECAC area to implement RNP APCH procedures down to LPV minima as low as 200 ft. under the Single European Sky framework.

The guidance provided is intended to be used as a baseline and could be duly adjusted considering the internal ANSP/airport organization.

The approval of the GNSS-based procedures will be the responsibility of the corresponding National Supervisory Authority.

It is important to highlight that there is only one concept of operation for RNP APCH to LPV. Two sets of procedure design criteria are available for the design of such procedures depending on the EGNOS Service Level to be used. The minimum EGNOS performance required for flying the approach will depend on the criteria used for the design. The minimum performances required are available in the navigation database (VAL value in the FAS DB).

6.1 Required processes / activities for RNP APCH implementation

The processes to be followed by an ANSP to implement LPV procedures are included in the ICAO EUR Doc. 025 [RD-9]. The main steps are:

1. **RNP APCH Pre-implementation activities (Process 1)**
   - 5.2.1. General
   - 5.2.2.Activity 1: The background to RNP APCH implementation
   - 5.2.3. Activity 2: Create the implementation project team
   - 5.2.4. Activity 3: Agree project objectives, scope and timescale
   - 5.2.5. Activity 4: Survey of candidate airports
   - 5.2.6. Activity 5: Assessment of Airport Capabilities
   - 5.2.7. Activity 6: Survey of Traffic Characteristics and Aircraft Operators
   - 5.2.8. Activity 7: ATC and NOTAM services
   - 5.2.9. Activity 8: Benefits and costs for RNP APCH implementation
   - 5.2.10. Activity 9: Choose which type of RNP APCH to implement

2. RNP APCH Implementation (Process 2)

- 5.3.1 General
- 5.3.2. Activity 10: Procedure design
- 5.3.3. Activity 11: Validation of expected benefits
- 5.3.4. Activity 12: Local Safety Case
- 5.3.5. Gate: Final decision to implement
- 5.3.6. Activity 13: Procedure validation
- 5.3.7. Activity 14: ATC Handling of Mixed-Mode Operations
- 5.3.8. Activity 15: AIS Requirements
- 5.3.9. Activity 16: Navigation Database
- 5.3.10. Activity 17: Training Requirements
- 5.3.11. Activity 18: Final Review before implementation
- 5.3.12. Activity 19: Introduction into service

3. RNP APCH Post implementation Process

- 5.3.13. Activity 20: Post-implementation activities

The following figure shows the previously depicted process in flowchart format mapped to ICAO PBN implementation methodology [RD-1].

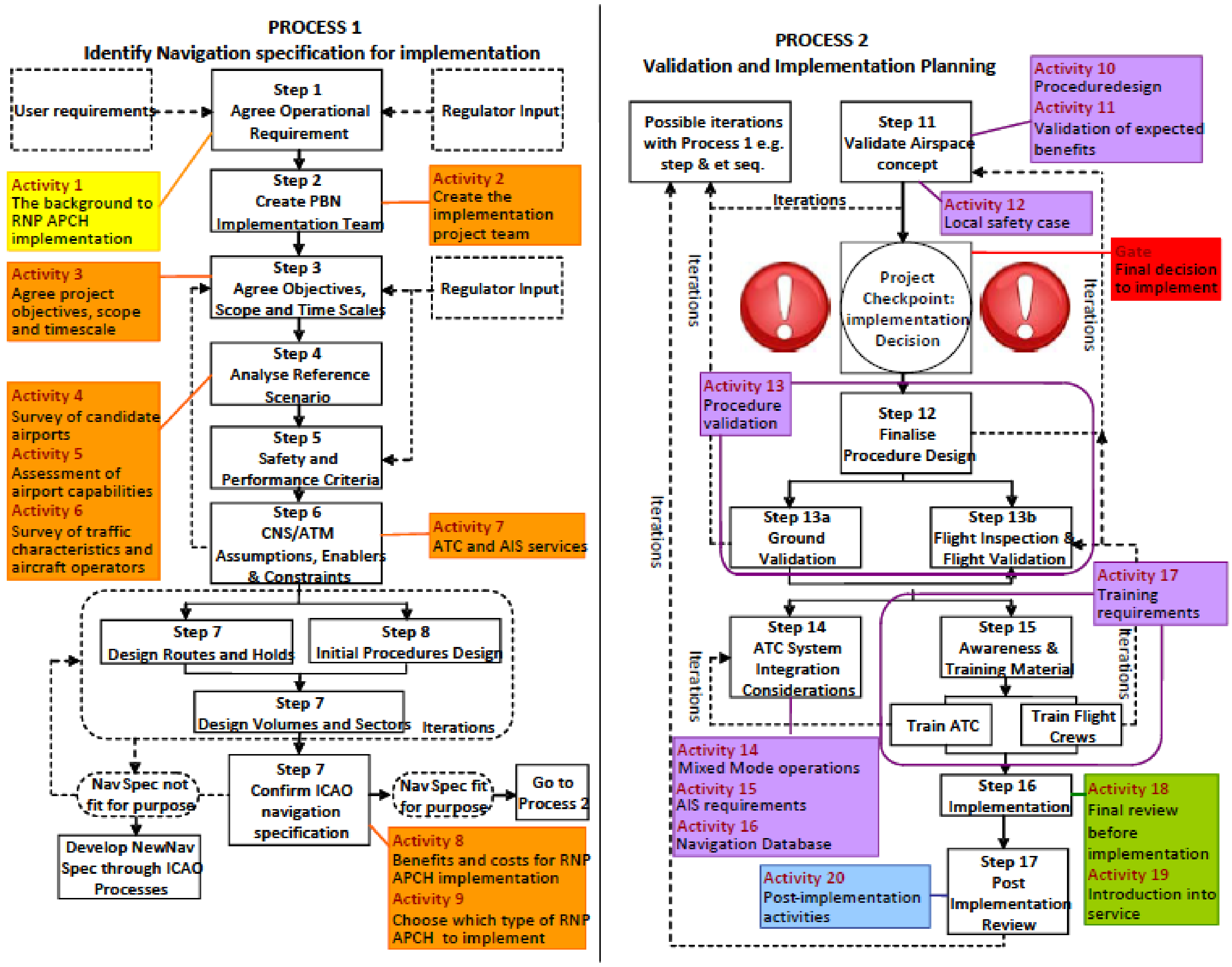

Figure 6-1. Activity mapping to ICAO implementation steps. Source: ICAO EUR Doc.025

6.2 Taking Operational Advantage of the LPV-200 Service Level

6.2.1 Concept of Operations

The Concept of Operations for the LPV-200 service level is the same as the one for any LPV procedure, i.e. the "APV SBAS Approach – Concept of Operations" [RD-26]. The final descent from FAF to DA/H is performed in the same manner as for current LPV with the only exception being that the DH can be as low as 200 ft above the runway threshold provided a number of conditions are met (e.g. obstacles, runway category, etc.).

6.2.2 Runway requirements

ICAO Annex 14 [RD-5] provides definitions for runway-types:

"*a) Non-precision approach runway. A runway served by visual aids and non-visual aid(s) intended for landing operations following an instrument approach operation type A and a visibility not less than 1 000 m.*"

"*b) Precision approach runway, category I. A runway served by visual aids and non-visual aid(s) intended for landing operations following an instrument approach operation type B with a decision height (DH) not lower than 60 m (200 ft) and either a visibility not less than 800 m or a runway visual range not less than 550 m.*"

As a consequence, LPV-200 service level based operations:

- With DH ≥ 250 ft (Type A instrument approach operation) can be promulgated at both category I precision approach runway-ends and non-precision approach runways.
- With DH < 250 ft (Type B instrument approach operation) can <u>only</u> be promulgated at <u>category I precision approach runway-ends</u>.

6.2.3 Instrument Approach Procedures

The design criteria for [NPA, APV and] precision approach category I procedures are described in ICAO Doc 8168 – PANS-OPS [RD-7]. According to the Section 3, Chapter 5 of the Volume II within this document, a procedure based on LPV-200 service[23] may be constructed fully equivalent to ILS Category I since the same Obstacle Assessment Surfaces (OAS) has to be used.

The declaration of the EGNOS LPV-200 service level will mean that new LPV procedure design criteria can be used to design LPV procedures, enabling lower minima. Existing LPV procedures (based on APV 1 procedure design criteria will remain valid).

[23] LPV 200 service is not mentioned in ICAO Doc 8168 PANS OPS. It uses the following terms: SBAS Category I may be constructed using the ILS Category I CRM and/or the ILS Category I OAS.

The procedure designer will have to decide either to implement an APV I operation (using the SBAS APV I OAS) or an LPV-200 based operation (using the SBAS Category I OAS, which in practice are the ILS Category I OAS) based on a number of considerations such as runway category, obstacle environment, location in the periphery of the EGNOS service area, etc. Not always the SBAS Category I OAS would lead to lower OCA/H than SBAS APV I OAS since the former is not derived from the latter.

The LPV-200 based procedures will be published on approach charts titled RNAV(GNSS) – as current LPV approaches. From December 2022, ICAO expects all RNP APCH procedures will only be titled 'RNP'.

An LPV-200 based operation will be published as an LPV line of minima in the minima box. Therefore, it is not possible to publish APV SBAS (APV-I) and LPV-200 based operations (as two minima lines) in the same chart since only one LPV minima line is possible on a chart – either being calculated based on APV-I or LPV-200 services levels.

6.2.4 Final Approach Segment Data Block

The procedure designer must enter a value of 35 in the VAL[24] field (m) for LPV-200 based operations when using the EUROCONTROL (or any other) tool to derive the Cyclic Redundancy Check (CRC) for data integrity.

6.2.5 Approach Lighting

According to the section AMC5 CAT.OP.MPA.110 Aerodrome operating minima included in the EASA AMC/GM to Part-CATs [RD-19] applicable to AIR-OPS Regulation [RD-18], it is possible to implement LPV approaches with DH as low as 200 ft without an Approach Lighting System (ALS). However, if available/feasible, the better the ALS, the lower RVR is required.

[24] For more details about VAL/HAL, see SDD [RD-30] available at http://egnos-user-support.essp-sas.eu/new_egnos_ops/sites/default/files/library/official_docs/egnos_sol_sdd_in_force

6.2.6 Procedure Validation

The validation process, as part of the process for the ANSP to implement the operations, and as described in ICAO Doc 9906 [RD-8], for a LPV-200 based operation, is the same as for current LPV procedures.

6.2.7 Safety Assessment

There is no difference resulting from the implementation of LPV-200 based procedures, so the safety assessment, as part of the process for the ANSP to implement the operations, has to be carried out as for current RNP APCH procedures down to LPV minima since the concept of operations is the same.

6.2.8 ATC Procedures

There is no additional requirement or change on ATC procedures as a result of the implementation of the LPV-200 based procedures. The approaches down to DH as low as 200 ft will still be titled RNAV(GNSS) or RNP rwy xx, and the pilot will request the approach based on the title of the chart.

6.2.9 NOTAM

The EGNOS Service Provider needs to know which specific type of LPV is promulgated at each aerodrome and runway-end, either APV-I based operation (VAL = 50 m) or LPV-200 based operation (VAL = 35 m). This information must be used by the EGNOS Service Provider as a driver for both specific ANSP communications and NOTAM proposal purposes.

The criteria would be as follows:

- If VPL is predicted to be > 50 m at a given aerodrome, then LPVs are unavailable irrespectively of their service level (APV-I based or LPV-200 based) → NOTAM proposal issued;
- If VPL is predicted to be > 35 m but ≤ 50 m at a given aerodrome, then only LPVs based on LPV-200 are unavailable (and APV-I based are therefore available) → NOTAM proposal issued only in case LPV (LPV-200 based) are published.
- If VPL is predicted to be ≤ 35 m at a given aerodrome, then no LPV is unavailable (and no NOTAM proposal is issued by ESSP).

6.2.10 Taking advantage of the LPV-200 service at runway-ends with existing RNAV (GNSS) approach procedures with LPV minima

Once the LPV-200 service level is declared operational, in the case where there is already an RNAV(GNSS) approach procedure down to LPV minima for a given runway-end, the ANSP may revise the procedure to consider the EGNOS LPV-200 service. . In order to achieve minima lower than 250ft the procedure will need to be redesigned using different criteria in accordance with ICAO Doc 8168 PANS OPS [RD-7].

It is the responsibility of States to promulgate OCA/H values for each Instrument Approach Procedure, while it is the responsibility of operators to develop operational minima (DA/H) by adding the effect of a number of operational factors to the OCA/H, as stated in ICAO Annex 6 [RD-3], Chapter 4.2.8:

"The State of the Operator shall require that the operator establish aerodrome operating minima for each aerodrome to be used in operations and shall approve the method of determination of such minima. Such minima shall not be lower than any that may be established for such aerodromes by the State of the Aerodrome, except when specifically approved by that State.

Note.— This Standard does not require the State of the Aerodrome to establish aerodrome operating minima."

Therefore, the suggested criteria to be considered by the ANSP, in close cooperation with the main aerodrome operators, are as follows:

1. A precision approach runway-end will be required if it is expected that operators establish a DH lower than 250 ft. If the DH[25] is above 250 ft a non-precision approach runway-end may suffice.

2. The commitment area published in the SDD document [RD-30] is wider for APV-I service level than for LPV-200 service level. Aerodromes located within the APV-I service level area will have high EGNOS availability with VPL ≤ 50m, and aerodromes located within the LPV-200 service level area will have high EGNOS availability with VPL ≤ 35m. At the edge of both EGNOS SoL service areas, the availability may vary depending on the service to be used. Consequently a State may design SBAS based procedures with with either one or the other set of

[25] This is according to ICAO Annex 6 definitions where Type A/B distinction is related to the DH, and not the OCH. Nevertheless the ANSP/Airport has no responsibility over the DH, but the OCH. To be precise with the later, if the OCH is above 250 ft, DH cannot be expected to be lower than 250 ft either, and a non-precision approach runway-end may suffice.

alert limits (e.g. APV-I based when close to the edge of the LPV-200 service area, and LPV-200 based within this area[26]).

3. The existing SBAS based approach procedures (based on APV-I service level) will have to be redesigned if LPV-200 service is going to be used (final approach, initial and intermediate segments of the missed approach) using the SBAS Category I OAS (equivalent to ILS Category I OAS).

4. It is advisable to confirm with operators that the attainable DH is effectively reduced with the approach designed based on LPV-200 capability, in comparison with the existing SBAS based procedure (based on APV-I service level), and therefore airport accessibility is improved.

In principle, the reviewed approach procedure should undergo the same validation process as a new one so as to be eventually published in the State-AIP.

It is important to highlight that, when it is intended to use an SBAS based approach procedure to parallel runways, simultaneously with ILS, MLS, GBAS or another SBAS based approach procedure, additional criteria shall be applied as stated in Amendment 6 to ICAO Doc 8168 [RD-3], section 5.6, though according to current ICAO standards (ICAO DOC 9643 Manual on Simultaneous Operations on Parallel or near parallel Instrument Runways -SOIR), only ILS is approved to support dependant and independent parallel runway operations.

[26] The Safety of Life Service Definition Document [RD-30] includes the commitment maps for both Service Levels.

7 GUIDELINES FOR AIRCRAFT OPERATORS

7.1 Guidelines for Aircraft Operators to Implement RNP APCH down to LPV Capability

7.1.1 Introduction

These guidelines describe the various steps that have to be accomplished by an aircraft operator (airplane or helicopter) to realize operational capability for Localizer Performance with Vertical guidance (LPV) operations.

The overall process comprises the associated three main steps:

1. Aircraft modification, upgrade and airworthiness re-certification;
2. Operational approval;
3. Introduction of the capability into the operation.

Each step is broken down into lower level items and tasks in order to support the conversion project.

The generic and overall flowchart for the work described is as follows:

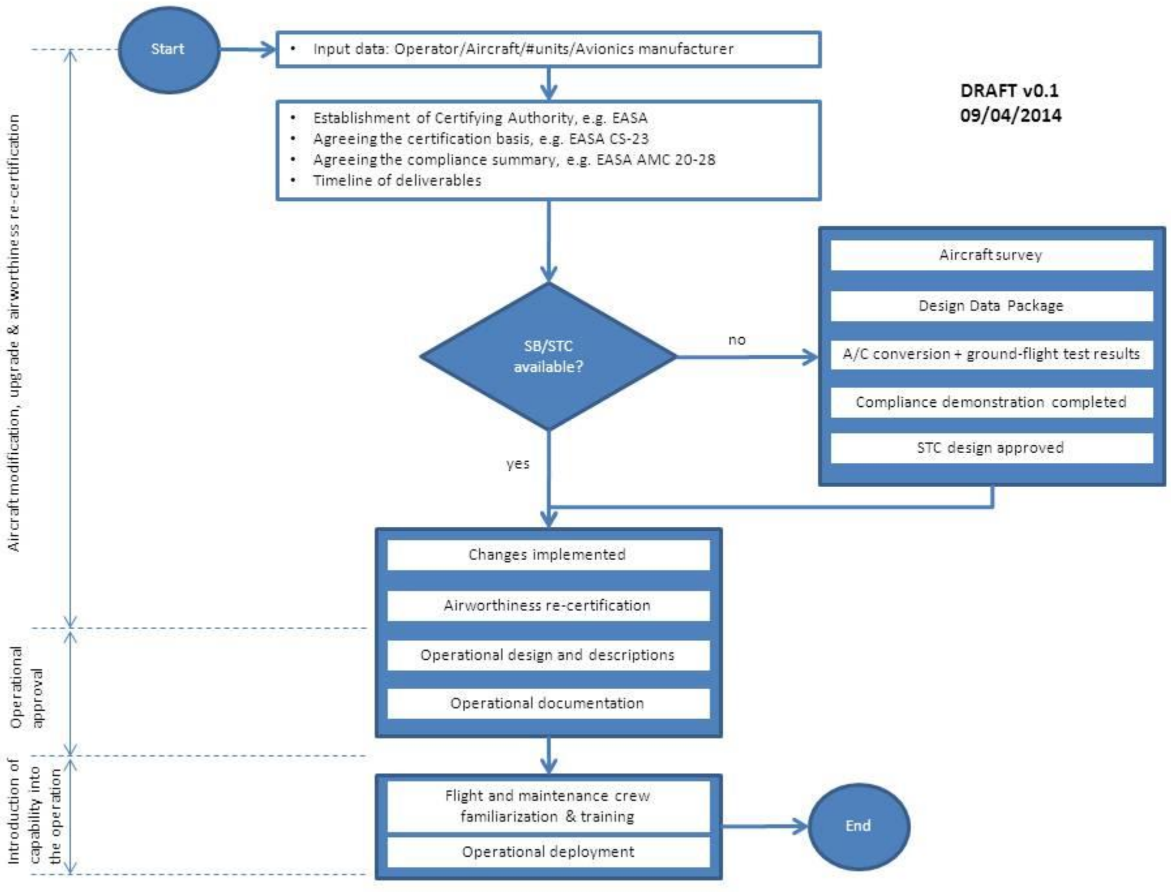

Figure 7-1 Overall process of the LPV capability implementation

7.1.2 Aircraft modification, upgrade and airworthiness re-certification

The work associated with the aircraft involves the following main tasks:

1. Establishing the Certifying Authority
2. Agreeing the certification basis
3. Agreeing the compliance summary
4. Timeline of deliverables
5. System design and engineering descriptions (specific SB / STC)
6. Operational design and descriptions
7. First article conversion and verifications
8. Establishing/delivering the certification documentation

7.1.2.1 *Establishing the Certifying Authority*

Establishing the Certification Authority (the Authority) will determine with whom the certification/compliance basis for the aircraft changes and subsequent re-certification must be discussed and agreed. “Establishing” the authority typically involves contacting the authority and agreeing the specific project to fall under the Authority’s jurisdiction and competence. In response, the Authority will open a dossier on the specific project and assign a timeline to its completion, based on available resources and competences. This timeline will become the driver and reference in the remainder of the work.

Typically and by default, the Authority is the National Aviation Authority-NSA of the country where the operator is legally vested or where the aircraft in question is registered. But exceptions occur, for example where the Authority requests delegation of the project to another national Authority, because of workload reasons, or for reasons of specific competence. In such a case, the agreement on a project dossier and timeline may be complicated by the fact the delegated authority will work under priorities assigned by dossiers from his specific national obligation. The bottom line is that establishing the Certifying Authority must be undertaken early in the process, since timing of all other tasks may become contingent on timeslots that can be agreed with the Authority.

In practice, the certifying authority is the National Supervisory Authority (NSA), e.g. AESA in Spain, or EASA, or even a combined approach: EASA responsible for the airworthiness certification and the NSA in charge of the operational approval.

7.1.2.2 *Agreeing the certification basis*

A discussion is undertaken with the Authority on the certification basis for the modification in question.
In general, any function implemented by way of ‘equipment’ (as opposed to aircraft design/construction and power plant) will require airworthiness approval per the criteria set forth in **Subpart F (Equipment)** of the respective European Aviation Safety Agency (EASA) **Certification Specification** (CS)[27].

The “default” paragraphs of Subpart F that must be considered will be:

1. Perform the intended functions, including function placarding and annunciation, coverage by operational manuals, etc. (Subpart F, paragraph .1301)
2. To assure absence of interference by the newly created situation, radiated as well as conducted in terms of any affects that such interference might cause (Subpart F, paragraph .1431)

[27] Large Aeroplanes: CS-25; Normal, Utility, Aerobatic, and Commuter Category Aeroplanes: CS-23, etc.
http://www.easa.europa.eu/agency-measures/certification-specifications.php

3. To preserve safety to the original extent, i.e. absence or change of unsafety factors introduced by the modification and demonstration that the probability of occurrence of any [new] unsafety is acceptably remote (Subpart F, paragraph .1309).

There may be one or two other paragraphs declared applicable, subject to discussion with the Authority.

The Authority may propose other and different certification requirements for the specific category of aircraft and/or operation, based on his understanding of the scope of the change. But the discussion will lead to a level of agreement which decides the certification basis, so that compliance with those requirements will be what it takes to achieve an installation that will be approvable from the airworthiness perspective.

This agreement will be documented, so that there is an undisputable compliance basis, applicable to the specific LPV function, the aircraft type in question and their operation, beyond any doubt.

7.1.2.3 *Agreeing the compliance summary*

Once the certification basis has been agreed, the next discussion concerns **the means of demonstrating compliance with the certification basis.**

In the case of LPV, the European EASA has performed work to explain the specifics of the function in context of the main CS paragraphs. The corresponding document is:

- EASA "Airworthiness Approval and Operational Criteria related to Area Navigation for Global Navigation Satellite System approach operation to Localiser Performance with Vertical guidance minima using Satellite Based Augmentation System", Acceptable Means of Compliance (**AMC) 20-28**[28], 24 Sep 2012[29].

This document provides guidance on the general aspects of changing an aircraft avionics installation, the LPV functionality specifically, as well as its operation. In fact, this document provides an à priori explanation of the data package, methods and measurements that should be acceptable for demonstrating compliance with the certification requirements.

[28] http://www.easa.europa.eu/agency-measures/docs/agency-decisions/2012/2012-014-R/Annex%20II%20-%20AMC%2020-28.pdf

[29] The EASA AMC 20-28 includes airworthiness as well as operational approval criteria for RNP APCH down to LPV. This AMC will be updated as described in the EASA NPA 2013-25, section 2.5.29.6 and Opinion No 03/2015 section 2.8. The new issue A of AMC 20-28 will be limited to airworthiness approval aspects whereas the operational aspects are transposed into the AIR-OPS rules. The proposed amendments to AMC 20-28 (Draft EASA Decision) are included in section 3.19 of the NPA 2013-25 that will finally be included in the NAV section of the EASA CS-ACNS. .

Also and nevertheless, the Authority will have to concur with this document to form part of the certification basis while the discussion may lead to some form of interpretation, requiring different or additional means.

The final agreement on materials and data to be submitted is captured and summarized in a document ('checklist') to be used in the demonstration campaign for verifying that all agreed materials and data ('deliverables') are provided.

7.1.2.4 *Timeline of deliverables*

A timeline will be agreed to those deliverables, so that both the applicant and the Authority may schedule the necessary resources.

7.1.2.5 *System design and engineering descriptions (specific SB / STC)*

Typically, the data to be submitted in demonstrating compliance will comprise a design data package showing the aircraft installation (or any revisions) particularly the electrical installation (with a view to wire sizes, electrical circuit breakers, racking and cooling, etc.) in order to provide evidence of proper electrical loading (normal bus and battery), wire sizes and electrical currents to be expected (with a view wire protection), cooling fan performance with a view to equipment operation and thermal protections, mechanical installation (with a view to vibration, rack loading, weight distribution, etc.)

In addition, data substantiating the flight deck interfaces, annunciations, crew interactions, labels and placards, will have to be included. Particular attention is also placed on absence of interference, in the sense that any newly installed or modified equipment, and or wiring must be analysed and demonstrated to not cause radio interference (radiated and/or conducted) in excess of what was the case before the modification.

A typical set of engineering files as a result of the design may be:

- Engineering descriptions and associated job cards.
- Drawings.
- Wires list.
- Installation kit parts list(s) (if any).
- Installation part list (if any).

Equipment installed will have to conform to aviation standards, such as European Technical Standard Order (E-TSO)[30] in order to meet the requirement of the EASA CS. The Authority may call for additional specific information (from EASA AMC 20-28) to be comprised in the data package.

Practically speaking, the LPV function requires function (software) changes to primarily the Flight Management System (FMS), plus downstream changes to the display systems (annunciations, possibly deviation pointer symbology) and upstream changes associated with the fact that GNSS (GPS) Position Velocity Time information must be augmented by way of Satellite Based Augmentation System (SBAS) – such as EGNOS -, as well as any associated input/output changes to the associated systems. In terms of actual hardware and wiring changes, usually only the GPS antenna may be affected, since SBAS reception requires a bandwidth somewhat different from the ordinary GPS reception, so that a different antenna may[31] have to be installed.

As a result, hardware, racking and wiring changes should ordinarily not be required, but the design data package will have to substantiate that.

A **detailed upfront survey** of the existing aircraft installations will be part of the effort in order to validate the original data package and to assure that the assumptions in the assessment of the certification requirements and the design of the change orders are correct.

The resulting change to implement the LPV capability in the aircraft installation and its certification is supplementary to its type certificate. This change is classified as a **major change** and can be implemented in the form of a **Supplemental Type Certificate** (STC) or a **Service Bulletin** (SB).

[30] ETSO-C145c Airborne Navigation Sensors Using the Global Positioning System (GPS) Augmented by the Satellite Based Augmentation System.

http://easa.europa.eu/agency-measures/docs/certification-specifications/CS-ETSO/Annex%20II%20-%20ETSOs.pdf#page=59

ETSO-C146c Stand-Alone Airborne Navigation Equipment Using the Global Positioning System (GPS) Augmented by the Satellite Based Augmentation System.

http://easa.europa.eu/agency-measures/docs/certification-specifications/CS-ETSO/Annex%20II%20-%20ETSOs.pdf#page=63

[31] Some aircraft may have the proper antenna to start with.

7.1.2.6 *Operational design and descriptions*

As a result of the previous task, another set of documents will also be produced:

- Instructions for Continued Airworthiness (ICA).
- Aircraft Flight Manual / Aircraft Operation Manual Supplement.
- FCOM supplement (if any).
- MEL Supplement (if any).

Specific operational information associated with the intended aircraft operation will have to be captured in the Aircraft Operating Manual (AOM) or whichever equivalent document the operator elects to use.

Flight crew operational procedures will have to be indicated or adapted associated with:

- Planning the flight to the destination including prevailing minimums;
- Applicable flight procedures for conducting an LPV operation to be available for the destination;
- Alternate planning (assuming actual minimums below lowest minimums for the available LPV);
- System availability either per Minimum Equipment List (MEL) or other governing document for the operation, including missed approach operation and diversion;
- Flight crew proficiency and qualifications needed for the specific (LPV) operation.

7.1.2.7 *First aircraft version and verifications*

Assuming agreement on the above, a first aircraft will be converted following the design data package provided. Also flight operational amendments will be carried through, so that a complete modification is established along the lines of what had been agreed with the Authority. This first aircraft is then used to demonstrate proper operation, absence of interference, etc. A demonstration flight operation to validate the work may have to be included, dependent on what has been found agreeable with the Authority.

From the demonstrations, a report is established documenting the findings and possible deviations, which is submitted as part of the compliance to the Authority to provide evidence of proper conversion and operation.

7.1.2.8 *Establishing/delivering the certification documentation*

Following the first article conversion and verifications, the results are summarized in a concluding report consistent with the compliance summary and timeline, for delivery to the Authority.

7.1.3 Operational approval

The operation of new functions must be integrated with the existing aircraft functions and standard operating procedures, providing that an airworthy installation and functions compliant with the requirements for LPV such as per the EASA AMC 20-28 is given. Evidence to that effect must be shown to the Authority so as to gain operational approval.

Granting an operational approval is responsibility of the National Supervisory Authority. For CAT operators, the process involves changes to their current operating procedures, their operation manuals and training programs together with a formal application to their authority while, for NCC/NCO, this could simply imply changes to their Operating Handbooks and providing evidence to their authority that the appropriate training has been undertaken.

For the moment, AMC 20-28 is the current reference document providing EASA operational requirements for the use of LPVs although this will change with the upcoming Regulation. LPVs and other PBN specifications will be soon considered as standard practices becoming part of the IR license of pilots and standard operators' procedures by default. These changes are currently reflected in EASA Opinion 03/2015 which has been addressed to the EC to amend the corresponding Commission Regulations by August 2016.

These changes will eliminate the burden to apply for an SPA and will incorporate LPV operational requirements from AMC 20-28 into the AIR-OPS. However, operators will still be required to put the necessary operational procedures in place and amend accordingly their operational manuals to obtain the approval from their authorities, as it happens nowadays with other instrument approach procedures.

There are three main set of actions that the operator must complete to receive approval once the aircraft airworthiness requirements from previous sections have been met:

1. Amend the operational procedures and corresponding manuals to account for this type of operations.

   As it happens with other approach procedures which are operated under IFR, there are certain operational criteria which apply to the use of LPVs. The way the installed equipment is operated must be in accordance with the AFM or POH. For example, the MEL should be amended to identify the minimum equipment necessary to satisfy these LPV approach operations and the operator should determine the operational characteristics of the procedure to be flown, which must be reflected on the Operational Manual.

2. Update the training and checking programs and train the crew accordingly.

   Until the previously mentioned EC regulation introduces PBN in the standard IR license, operators willing to make use of LPVs will need to provide the necessary training, briefings and guidance material to their flight crew. The training program should be structured to provide sufficient theoretical and practical training using a simulator, training device, or line training in an aircraft, in the concept of RNAV GNSS and RNP approaches and the use of the aircraft's approach system in such operations.

3. Submit a formal application to the competent authority.

   Once the previous actions are completed, the operator must elaborate a written (SPA) proposal to the regulator with evidences of these changes. These evidences are normally extracts from the AFM or POH and STC or SB documentation for the airworthiness part and extracts from the Operational Manuals and copies of ATOs/PTOs training for the operational part.

   Once the NSA evaluates the application and agrees that the requirements are met, the operational approval is given via an amendment to the OM, an Ops Spec associated with the AOC, or a LOA in the case of non-commercial operator.

7.1.4 Introduction of the capability into the operation

The capabilities achieved in the way described must be introduced into the flight dispatch practice so that they can be applied in daily flight planning. Since it is likely that the aircraft in the fleet will be modified over a period of time, a degree of difference varying from partial provisions to operational capability between individual tail numbers will exist during that period.

Dispatch, flight operations and maintenance must be advised of these differences so that the proper function and performance capability may be applied in flight planning and flight execution. Appropriate communications must be put in place to inform and coordinate the necessary offices.

7.1.5 Annex – Definitions

- Supplemental Type Certificate (STC)

  Any additions, omissions or alterations to the aircraft's certified layout, built-in equipment, airframe and engines, initiated by any party other than the type certificate holder, need an approved supplementary ("supplemental" in FAA terminology) type certificate, or STC. STCs are applied due to either the type certificate holder's refusal (frequently due to economics) or its inability to meet some owners' requirements. STCs are frequently raised for out-of-production aircraft types conversions to fit new roles. Before STCs are issued, procedures similar to type certificate changes for new variants are followed, likely including thorough flight tests. STCs belong to the STC holder and are generally more restrictive than type certificate changes.

- Service Bulletin (SB)

  With increasing in-service experience, the type certificate holder may find ways to improve the original design resulting in either lower maintenance costs or increased performance. These improvements (normally involving some alterations) are suggested through service bulletins to their customers as optional (and may be extra cost) items. The customers may exercise their discretion whether or not to incorporate the bulletins. Sometimes SBs can become mandated by relevant Airworthiness Directives (ADs).

7.2 Taking Operational Advantage of the LPV-200 Service Level

7.2.1 Avionics upgrade for LPV-200 based operations

The avionics upgrade is performed to implement the LPV capability to minima that can be as low as 200 ft. There is no specific upgrade to implement the LPV-200 feature, as only LPV feature exists in avionics, not distinguishing between SoL Service Leves. The avionic will monitor the performance according to the minimum performance required for the intended operation. However, there can be limitations on the certification of the aircraft preventing operations down to a certain height associated with other systems such as the TAWS described below.

7.2.2 Terrain Awareness Warning System

Operationally, according to the EASA AMC/GM to Part-CAT within AIR-OPS [RD-18], Section AMC1 CAT.IDE.A.150[32], there is no specific requirement for Terrain Awareness Warning System (TAWS) as a result of the implementation of LPV-200 since the requirement applies to LPV (including those with a DH as low as 200 ft).

Nevertheless due to historical reasons, some aircraft could have a DH limitation to 250ft as a result of the EASA policy applied as follows:

> In the case of commercial operators, CAT.IDE.A.150 requires the installation of a Class A TAWS for turbine-powered aeroplanes (and Class B TAWS for reciprocating-engine-powered aeroplanes) having an MCTOM of more than 5 700 kg or an MOPSC of more than nine[33] while it is not mandated to NCC/NCO.

> Regarding LPV airworthiness requirements, AMC 20-28 requires the capability to provide an alert for excessive downward deviation from the glide path where operational regulations require the use of a Class A TAWS (the case of CAT.IDE.A.150 explained above) or a Class A TAWS is installed (the case of operators which decided to install it although it was not required). In addition, it clarifies that if the

[32] The same applies to non-commercial operators as stated in AMC1 NCC.IDE.A.135 and AMC1 NCO.IDE.A.130

[33] EASA has published a Terms of Reference ToR OPS.078 (a) & (b) (RMT.0371 & RMT.0372) proposing that the TAWS requirement is extended also to all turbine-powered aeroplanes with an MTOW of less than 5 700 kg and with a MOPSC of more than 5 and not more than 9, which is in line with the recommendation given by ICAO in Annex 6, Part I, paragraph 6.15.5.

alert is not provided by the TAWS system, the alert should have equivalent effect to that provided by a TAWS system.

As EASA didn't want to jeopardise the implementation of LPVs, an internal policy memo was drafted to grant relief from this requirement provided that the applicant established a plan for development of the necessary changes and the AFM would contain a limitation that, for EASA approved aircraft, the decision altitude would be limited to 250ft (i.e. no making use of LPV-200 service level), which is the case of various aircraft models nowadays. This policy was applied and agreed with manufacturers as documented in Certification Review Items (CRIs) issued for many certification projects.

7.2.3 Airworthiness and operational approval for LPV-200 based operations

The same criteria apply to the airworthiness approval of aircraft avionics to conduct LPV-200 based or APV-I based operations. Therefore, aircraft with an existing airworthiness approval (AMC 20-28) do not require an additional approval for LPV-200 based operations, unless the Aircraft Flight Manual (AFM or POH) includes a specific limitation stating that the DH cannot be lower than a certain threshold. The future EASA CS-ACNS Navigation section (CS-ACNS.NAV) will include the airworthiness aspects currently in AMC 20-28.

Regarding the operational approval, aircraft with an existing operational approval (AMC 20-28) do not require an additional approval for LPV-200 based operations, unless the current operational approval is limited to a higher DH by the corresponding National Supervisory Authority (NSA). Operational provisions of AMC 20-28 will be transferred to the AIR-OPS (applicable by August 2016).

Moreover, according to proposed amendments to AMC/GM to EASA AIR-OPS Part SPA as described in the EASA Opinion 2015-03, RNP APCH capability (to any minima, i.e. LNAV, LNAV/VNAV, LP or LPV – including LPV-200) will be part of the standard pilot instrument rating and will no longer require specific operational approval.

7.2.4 Navigation Database

The declaration of LPV-200 service level will enable the promulgation of LPV approach with the operators' establishment of operational minima DH as low as 200 ft. The procedure including the FAS data-block is encoded in the aircraft database. What distinguishes the coding of an LPV procedure designed according to LPV 200 and the one for a procedure designed according to APV 1 design criteria is the value of the Vertical Alert Limit (VAL). For APV 1, VAL equals 50 m whereas for LPV-200 VAL = 35 m.

7.2.5 Pilot rating for LPV-200 based operations

The Flight Crew Training is addressed in section 10.2 of the AMC 20-28.

> *The Flight Crew should receive appropriate training, briefings and guidance material in order to safely conduct an LPV approach. This material and training should cover both normal and abnormal procedures. Standard training and checking should include LPV approach procedures. Based on this, the operator should determine what constitutes a qualified crew.*
>
> *The operator should ensure that during line operations Flight Crew can perform assigned duties reliably and expeditiously for each procedure to be flown in:*
>
> > *a) normal operations: and*
> >
> > *b) abnormal operations.*
>
> *A training program should be structured to provide sufficient theoretical and practical training. An example training syllabus is described in APPENDIX 4.*

The flight crew training syllabus in Appendix 4 could have to be amended[34] to reflect the fact the minima can be as low as 200 ft.

Once the pilot training for instrument rating (IR) is revised (as described in the Part FCL provisions proposed by the EASA NPA 2013-25 and later EASA Opinion 2015-03), a pilot holding an IR does not need any additional specific training or license to perform LPV approaches down to a DH of 200 ft.

7.2.6 Aircraft contingency procedures

In case of a reduced EGNOS service level, the reversionary mode for an LPV (either VAL = 50 m or VAL = 35 m) approach would be LNAV or LNAV/VNAV (prior to the FAF) or LNAV (after the aircraft passes the FAF).

7.2.7 Implementing LPV-200 capability in current LPV-capable aircraft

An aircraft meeting the airworthiness requirements for flying LPV approaches (AMC 20-28) does not need to meet any additional requirement to fly down to DH as low as 200 ft (unless otherwise specified in the AFM or POH).

The AMC 20-28 is the current relevant document for operational approval. The only aspect to assess is whether the corresponding NSA has imposed any limitation of the DH. In such a case, when implementing the LPV-200 based operation, an amendment of the operational approval for RNP APCH would be required if the current operational approval is limited to a DH of 250 ft.

The declaration of LPV-200 capability will have no impact from the user perspective. An SBAS receiver will monitor EGNOS performance against the Alarm Limits coded in the database (FAS DB), where the VAL can be 35 m instead of 50 m. It is necessary to check the relevant parts and sections of the Operations Manual (e.g. Aircraft Operations Manual, check lists, training of crew) to take account of the operating procedures detailed in Appendix 3 of the AMC 20-28, in case there is a specific limitation on the DH.

A non-LPV-capable aircraft can perform a direct upgrade to LPV capability to minima as low as 200 ft provided the AMC 20-28 requirements are fulfilled and no limitations are imposed by the corresponding NSA.

7.3 Navigation Database

7.3.1 Data Providers

Navigation data published with the procedure will meet the requirements of ICAO Annex 15. Operators are required to ensure the quality, accuracy and integrity of the data loaded into their avionics. This is done through the navigation data provider holding a Type 2 Letter of Acceptance (LoA) or equivalent. The LoA is issued by EASA in accordance with EASA Opinion Nr. 01/2005 on “The Acceptance of Navigation Data Suppliers”. The FAA also issues such Type 2 LoAs in accordance with AC 20-153, while Transport Canada issues an Acknowledgment Letter of an Aeronautical Data Process using the same basis. The EASA and FAA LoAs and the Transport Canada Acknowledgement Letter are all seen to be equivalent.

The standards for Processing Aeronautical Data are published in EUROCAE/RTCA document ED-76/DO 200A which contains guidance about the processes to be applied by the data provider.

8 LIST OF ACRONYMS

AIP	Aeronautical Information Publication
AFM	Aircraft Flicht Manual
ALS	Approach Lighting System
AMC	Acceptance Means of Compliance
AML	Approved Model List
ANSP	Air Navigation Service Provider
APV	Approach with Vertical guidance
ATC	Air Traffic Control
ATS	Air Traffic Services
CAA	Civil Aviation Authority
CBA	Cost Benefit Analysis
CDA / CDFA	Continuous Descent Approach / Constant Descent Final Approach
CDO/CCO	Continuous Descent Operations / Continuous Climb Operations
CFIT	Controlled Flight Into Terrain
CNS	Communications, Navigation and Surveillance
CPF	Central Processing Facility
CRC	Cyclic Redundancy Check
DB	Database
DH	Decision Height
DoV	Declaration of Verification
EASA	European Aviation Safety Agency
EATMN	European Air Traffic Management Network
EBAA	European Business Aviation Association
EC	European Commission
ECAC	European Civil Aviation Conference
EDAS	EGNOS Data Access Service
EGNOS	European Geostationary Navigation Overlay Service
EMA	EGNOS Multimodal Adoption
ESA	European Space Agency
ESP	EGNOS Service Provider
ESSP	European Satellite Services Provider

EU	European Union
EUROCONTROL	European Organisation for the Safety of Air Navigation
EWA	EGNOS Working Agreement
FAA	Federal Aviation Administration
FAF	Final Approach Fix
FAS DB	Final Approach Segment Data Block
FMS	Flight Management System
GBAS	Ground Based Augmentation System
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
GSA	European GNSS Agency
IAP	Instrument Approach Procedure
IATA	International Air Transport Association
ICAO	International Civil Aviation Organization
ILS	Instrument Landing System
IR	Implementing Rule
ISG	Interoperability Steering Group
LoA	Letter of Acceptance
LPV	Localiser Performance with Vertical guidance
MCC	Master Control Centre
MEDA	Euro - Mediterranean Partnership region
MLS	Microwave Landing System
NLES	Navigation Land Earth Station
NPA	Non-Precision Approach
NSA	National Supervisory Authority
NSG	Navigation Steering Group
OAS	Obstacle Assessment Surface
OCA/H	Obstacle Clearance Altitude/Height
OEM	Original Equipment Manufacturer
OS	Open Service
PBN	Performance Based Navigation
POH	Pilot Operating Handbook
RAD	Regulatory Approach Document

RAISG	RNAV Approach Implementation Sub-Group
RIMS	Ranging and Integrity Monitoring Stations
RNP APCH	RNP Approach
SBAS	Satellite Based Augmentation System
SDD	Service Definition Document
SID	Standard Instrument Departure
SES	Single European Sky
SoL	Safety of Life
SOU	System Operations Unit
SPU	Service Provision unit
STAR	Standard Instrument Arrival
STC	Supplemental Type Certificate
TAWS	Terrain Awareness Warning System
VAL	Vertical Alert Limit
VPL	Vertical Protection Level
WBS	Work Breakdown Structure
WP	Work Package

Table 1. List of acronyms

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