EGNOS: a big system for small aerodromes

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The work presented in this paper evaluates the benefits and services that EGNOS based navigation can provide to a regional network of aerodromes. The basic enablers for deploying this kind of operations are pointed out, focusing in airport infrastructure but also in required avionics and pilots rating. The regional aerodrome network of Catalonia is now managed by the public company *Aeroports de Catalunya*, jointly with local authorities, under control and supervision of the regional Government of Catalonia, aimed at providing the region with an enhanced and high quality network of aerodromes: between its plans, the modernization of the existing network and the construction of several new regional aerodromes, as well as one business airport. This work also analyses how the benefits of EGNOS for this emerging network can be taken into account in future policies of *Aeroports de Catalunya*. For instance, opportunities for new users such as fire extinguishing and rescue services as well as potential business development (like small air taxi companies) are pointed out. In addition, a new specific procedure design tool is presented. RAPIT (RNAV and APV Procedures Integrated Tool) is a CAD environment software tool specifically developed to assist RNAV and APV procedures design. It is able to manage cartographic and geographic data, making use of modern Digital Terrain Models, as well as obstacle databases. Moreover, it includes some basic drawing tools to assist procedure design. Finally a feasibility study of new EGNOS APV approach procedures is presented for two particular airports of the Catalan secondary airport network.

BIOGRAPHY

Mr Victor Alvarez accumulates more than three years of experience providing support to EUROCONTROL SBAS and GBAS activities. In addition, he has been in charge for some of the activities developed in the frame PiLDo Labs R+D+i department.

Mr Xavier Prats has been working on EGNOS and procedure design activities during the last 6 years, collaborating with PiLDo Labs in several projects for Eurocontrol and the local Government of Catalonia, between others.

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Mr Josep Montolio accumulates more than one year of experience providing support to the development of in-house procedure design tools, and their use for the procedure design and operational analysis for different aerodromes being deployed in the Catalan region.

1 - INTRODUCTION

Major improvements and new challenges will arise from the availability of new Global Navigation Satellite Systems (GNSS) in the next decades. This generic term includes all the systems which allow for the positioning of an aircraft by means of signals received from navigation satellites, as well as the possible (current or future) augmentations to be applied on these systems. Therefore, GNSS stands for a great variety of elements, which basically consist of global constellations of satellites (for instance, GPS and the future Galileo) and the necessary augmentations for them to guarantee the strict security requirements of safe-of-life applications.

As it is well known, the American Global Positioning System (GPS) and the Russian GLONASS are, at present, the unique global navigation systems available. However, these systems, if used in a stand alone basis for navigation do not meet the high accuracy, integrity and continuity levels required for safety-of-life applications, such as civil aviation navigation [1]. In this context augmentation systems are designed in order to meet these high performance requirements.

The two main GPS/GLONASS augmentation systems are the *Satellite* and the *Ground Based Augmentation System* (SBAS and GBAS respectively). In Europe, the augmentation system SBAS is called EGNOS (*European Geostationary Navigation Overlay Service*), while in the USA, the equivalent system is called WAAS (*Wide Area Augmentation System*). In the same way, the LAAS (*Local Area Augmentation System*) in the USA is the European GBAS. Compared with GBAS systems SBAS ones are, at present, in a further stage in the development and certification process. WAAS is already being operational in the USA while EGNOS is currently in its Initial Operation Phase [2]. More information on EGNOS system architecture can be found, for instance in [3-4].
Conventional air radio navigation in continental airspace has been based on a network of fixed ground navigation aids. During the last decade, Area Navigation (RNAV) is being progressively introduced in Europe [5-6]. This new

concept of navigation provides a more flexible en-route structure and departure or approach operations design, although some limitations arise in some demanding environments (for example rich obstacle environments). However, the introduction of RNAV procedures, and in particular those based on EGNOS, will enable IFR navigation at almost no cost in locations where instrumental navigation is poor or even not existing.

In line with previous works [7-8], this paper presents a feasibility study of the benefits and services that EGNOS based navigation can provide to a regional network of aerodromes. The Catalan region is shown as a practical example. On the other hand, the basic enablers for developing this kind of operations will be pointed out, focusing on airport infrastructure but also in required avionics and pilots rating.

Section 2 of this paper presents the Catalan network of airports as well as a brief overview of the general aviation situation in the region. In section 3 basic background in radionavigation aids and aircraft operations is given, pointing out the different types of approach procedures existing for civil aviation. On the other hand, section 4 presents in a glance the software RAPIT (RNAV and APV Procedures Integrated Tool) developed by Pildo Labs which is aimed at giving support in the procedure design process. Finally in section 5 two examples are given presenting approach procedures in two different secondary airports.

2 - GENERAL AND REGIONAL AVIATION IN THE CATALAN REGION

Catalonia is located in the north-east of the Iberian Peninsula and covers an area of approximately 32.000 square kilometres, with a population slightly above 7 million people. It is one of the autonomous communities of Spain, having its own government body: the *Generalitat de Catalunya* (Generalitat in what follows).

General aviation in this region covers a wide and diverse range of activities, some of which are currently growing very rapidly. These activities can be divided in:

- Public services: ambulance, search and rescue, fire extinction, policy and surveillance, etc;
- Aerial works: fumigation, aerial photography and publicity for example;
- Passenger and cargo transport: including aero-taxis, corporate aviation, private transport, packaging, etc;
- Pilot formation and sportive licenses;
- Recreational aviation including private pilots and balloon, gliding or ultralight flights.

The general aviation sector is experiencing an evolution in favour of its development and implantation. Additionally, the growing demand of new travelling services, different from commercial aviation, is opening a new market for current and future operators. In this context, new business models are being developed as well that will open the doors to new clients (fractional ownership, credit card model) that will stimulate the sector even more. Finally, with the apparition of new aircraft models (as the Very Light Jets), more economical than actual ones, it is expected to ease the acquisition of these aircraft from corporations or other groups intending to own their own transport mean.

With the promulgation of the Law 19/2000, of 29 of December [9], commercial and private aviation is intended to be promoted in the region of Catalonia. In this context, it has been edited the Plan of Catalan Airports document (“*Pla d’Aeroports de Catalunya”*) which identifies the creation of a secondary regional aerodrome network oriented to general, regional, sport as well as corporative aviation. This plan evaluates the capabilities of general aviation to generate economical benefits in the region, concluding that this sector should be considered very seriously as a productive one with a very important capacity to grow. Consequently, the Plan tries to establish the basics for the development of the infrastructures that will allow achieving new milestones in general aviation.

2.1 – The Catalan airports network

The Plan of Catalan Airports document states three big axes in the aeronautical development of the region:

- Provide the region with an access network to the air transport;
- Develop base aviation as a progress element;
- Create a first level emergency installations system.

A new revised version of this document has been recently published by the Generalitat [10]. This new document is the instrument that will guide the development of the aerodrome infrastructures under the competence of the Generalitat. This updated version of the document separates aerodrome installations depending on the estimated function to cover:

- Commercial airports: including Barcelona, Girona, Reus and new airports currently under development and/or construction;
- General aviation aerodromes: that will form the so-called ”network of secondary airports”
- Heliports: the document includes the Catalan Heliports Plan, establishing in the same way the guidelines to follow in the next years regarding heliport installations

Figure 1 presents this network of aerodromes in Catalonia showing the current facilities as well as the planned ones. Commercial airports are divided between those with regular international destination (black coloured) and those dedicated to regional flights (green coloured). On the other hand, secondary aerodromes are divided as well between General/Sport Aviation and Auxiliary ones. Apart from these, a new airport intended to host most corporate aviation activities is still in the preliminary development phase. As can be seen in the figure, the total number of secondary aerodromes is 18.

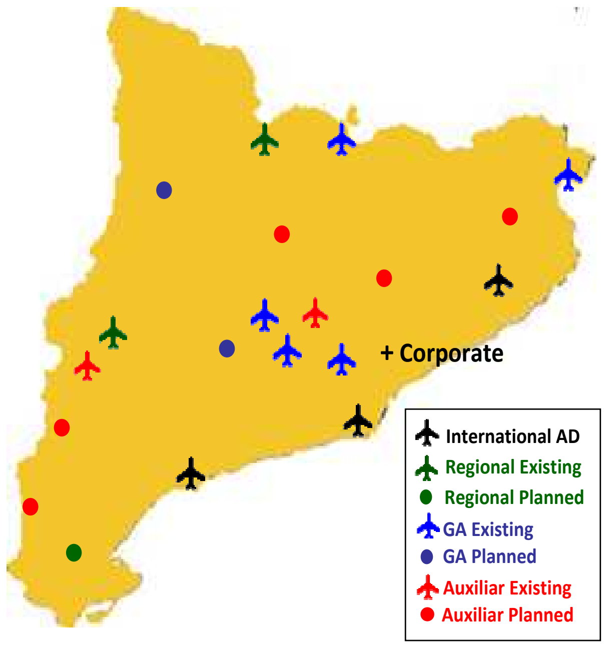

Figure 1: Network of aerodromes in Catalonia *(source: [10])*

The recently created society *Aeroports Públics de Catalunya (Catalonia Public Airports)* will manage the airport infrastructures promoted by the Generalitat government and assume those transferred from the Spanish service provider AENA in the future. Jointly with local authorities, and with the aim of providing the region with and enhanced and high quality network of aerodromes, each one of the regional and secondary airports will be administered by public-private mixed consortiums, involving both the government and local bodies [10].

2.2 – Airport planned investments in Catalonia
The Airports Plan contemplates a series of actuations in each one of the Catalan aerodromes. As a result, the whole planned investments for the current network of General and Sports Aviation aerodromes ascends to 63.7M€. In addition, a total of 23.12M€ are planned to be spent in the development of the new installations that would complete the secondary network of aerodromes. A total amount of 86.82 M€ are hence going to be invested in the secondary network of aerodromes until year 2012 [10]. In addition, very important actuations are planned also in the regional network of commercial airports. This includes the development of three new airports (including the corporative one) and the renovation of the Pyrenees-Andorra one. The planned investments for these installations sum 331.85M€.

The regional network of commercial airports is planned as a response to the growth of low-cost operators and to the forecasts that predict an increase demand of cargo and air taxi services. These airports should therefore be 24 hours operative and guarantee a minimum operability under adverse meteorological conditions. One of the enablers for this is the utilisation of an appropriate navigation system permitting to perform safe approach and landing operations in poor visibility conditions. The conventional ILS system appears as a valid option to accomplish with these requirements in most cases and, in fact, has been selected to provide service to runway 31 of the Lleida-Alguaire airport, which will enter into service during 2008. The installed ILS system has a cost of more than 1 M€.

3 - AIRCRAFT OPERATION AND RADIO-NAVIGATION SYSTEMS

Aircraft flying in civil airspace operate according one of the following rules:

- VFR: Visual Flight Rules
- IFR: Instrumental Flight Rules

VFR navigation is based on external visual references, such as rivers, mountains, roads... This kind of navigation is strictly bond to favourable meteorological conditions (measured in terms of visibility and minimum separation between the aircraft and surrounding clouds) and, as a consequence, its use is almost completely restricted to private or leisure aviation.
On the other hand, an aircraft flying under IFR rules uses several navigation instruments which provide the pilot with information for following its trajectory or navigation route with no need for external visual references. The route to be followed can not be any trajectory, but one which has been previously studied by the competent authorities in air traffic, and conveniently published to let it be known by the users of the air space. Particularly, these trajectories are called procedures (for airport departure, arrival or approach manoeuvres) or airways (for the cruise phase). The design of procedures and airways guarantees the overcoming of obstacles (mountains, buildings...) by means of a secure flight height, as well as the minimum separation between aircrafts using different procedures or airways in the same zone, and finally, it helps managing and directing the air traffic flow in a better way [11-12].

3.1 – Radionavigation systems
Most of the navigation instruments and equipment which support IFR flights use the radiofrequency technology and this is why they are called radionavigation instruments (or equipments). There are several different radionavigation systems and the most used world-wide are the Non Directional Beacon (NDB), the VHF Omnidirectional Ranger (VOR), the Distance Measurement Equipment (DME), the Instrumental Landing System (ILS) and the Microwave Landing System (MLS). It is out of the scope of this document to describe those systems, which are often called as conventional radionavigation systems and for further details one can refer to [13]. Essentially, these systems can be treated as different radiobeacons which give to the user (the pilot) relevant information about his or her relative position to the beacon (which depending on the beacon can be relative distance or relative bearing) enabling the definition of different flight procedures. Among all these systems ILS and MLS should be

highlighted. Both systems, compared to the other conventional ones, are designed only for supporting the final approach phase in a given runway. Another important characteristic is that they are the only ones providing the aircraft with vertical guidance in addition to the lateral information.

3.2 – Approach procedures: Conventional and RNAV

Approach procedures are classified as either precision or non-precision, depending on the performances of the radionavigation aids used. Precision approaches utilize both lateral (localizer) and vertical (glidepath) information, providing a three dimensional guidance to the flying pilot. Nonprecision approaches provide lateral course information only.

The publications depicting instrument approach procedures are commonly referred to by pilots as approach charts. These documents graphically depict the specific procedure to be followed by a pilot for a particular type of approach to a given runway. They depict prescribed altitudes and headings to be flown, as well as obstacles, terrain, and potentially conflicting airspace. In addition, they also list missed approach procedures and commonly-used radio frequencies.

All instrumental approaches have the so called landing minimums which have been established for each approach at a given airport and can vary from runway to runway. Factors which affect these minimums include the type of approach equipment installed, equipment on board the aircraft, runway lighting, aircraft landing airspeed and obstacles in the approach or missed approach paths. Approach landing minimums contain both minimum visibility (measured in terms of Runway Visibility Range or RVR) and minimum altitude requirements that are needed to finish the approach and land into the airport. If those minimum requirements are not meet pilot must execute a missed approach procedure. In non precision approaches altitude requirements are specified with a minimum descent altitude (MDA) which the pilot must remain until the missed approach point (MAPt) is reached. After the MAPt the pilot must continue the approach visually or execute a missed approach.

On the other hand, precision approaches, since they are providing vertical guidance, specify only a decision height or altitude (DH or DA) where the decision of continue the approach visually or start the missed approach procedure must be taken. If standard equipment is used and no penalizing obstacles are found in the approach path, there exist three types of landing categories in function of the precision approach equipment performances and related values are given in table 1.

Category	DA/DH	OCH
CAT-I	DA > 200ft (above terrain)	>800m
CAT-II	DH>100ft	>400m
CAT-III	100ft > DH > 0 ft	<400m

Table 1: Landing categories for conventional precision approaches.

As it was mentioned above, only ILS and MLS provide vertical guidance and therefore, precision approach procedures must be based on either system. Although RNAV navigation is more flexible and efficient it gives only lateral guidance, so only non precision approaches can be defined using that concept. In order to overcome that drawback, in November 2002 a new approach definition was adopted in addition to the existing Non Precision Approaches and Precision Approaches. The new approach procedure is known as APproach with Vertical Guidance (APV) which is defined by an instrument procedure which utilizes lateral and vertical guidance but does not meet the requirements established for precision approach and landing operations.

APV approaches (named LPV as well) can be designed using RNAV systems (giving lateral guidance) in conjunction with vertical guidance provided by a barometric source, for instance (BARO-VNAV approaches). Nevertheless APV approaches give a significant difference when navigation information is provided by GNSS systems, which provide directly lateral and vertical guidance (such as EGNOS system). In a similar way as precision approaches different categories are defined for APV ones, being GNSS APV-I and APV-II approaches the ones offering better performances, similar to those required to execute an ILS CAT-I approach. The main difference remains on less vertical guidance accuracy for APV approaches compared with ILS ones, but this difference is very small if compared with non-precision approaches. APV approaches will enjoy a minima around DA>250ft (above terrain) which is much closer to CAT-I performances than non-precision approach ones.

Summing up, the main advantages of APV approaches, compared with Non Precision Approaches, are:

- Low cost implementation.
- Optimized angle of descent during final approach.
- Lower operation minimas
- Safety improvement due to vertical guidance provided during the final approach segment
- More accurate lateral guidance
- More flexibility when designing the procedure providing as a consequence:
  - Environmental improvements (noise reduction, less fuel consumption...)
  - Possibility to design procedures in montainous areas
  - Better airspace management

In front of Precision Approaches, APV advantages are mainly the low cost of implementing the procedure (ILS or MLS systems are much more expensive and for instance APV SBAS approaches does not need any facility to be installed on ground) and the exibility in the trajectory. On the other hand, APV approaches do not meet the accuracy required for CAT-I, CAT-II and CAT-III operations which are required in much degraded meteorological conditions.

3.3 – State of the art in LPV approaches

Some of the enablers that must be put in place prior to achieve LPV operations in the ECAC zone have already been developed, including between others the publication of the LPV Design Criteria [12] or the Minimum Operational Performance Standards for GPS/SBAS Airborne Equipment [14].

Other enablers are still on-going: the certification of EGNOS is nowadays expected to be completed in 2010, the SBAS Application Safety Case, developed by Eurocontrol, and the Airworthiness Approval and Operational Criteria for LPV, developed by EASA, are still being developed and currently exist as draft versions.

Eurocontrol, with the financial support of the TEN-T funds from the European Union, has launched a number of projects in order to support the implementation of EGNOS LPV operations in some ECAC airports where EGNOS based operations could bring benefits [15]. The objective is to stimulate the introductions of LPV operations and gain experience in the implementation of such procedures.

Being one of PiLDo Labs' objectives the introduction of LPV operations in the mentioned Catalan network of aerodromes, it was decided to develop a software tool with the objective of improving the efficiency of the tasks involved when designing flight operational procedures.

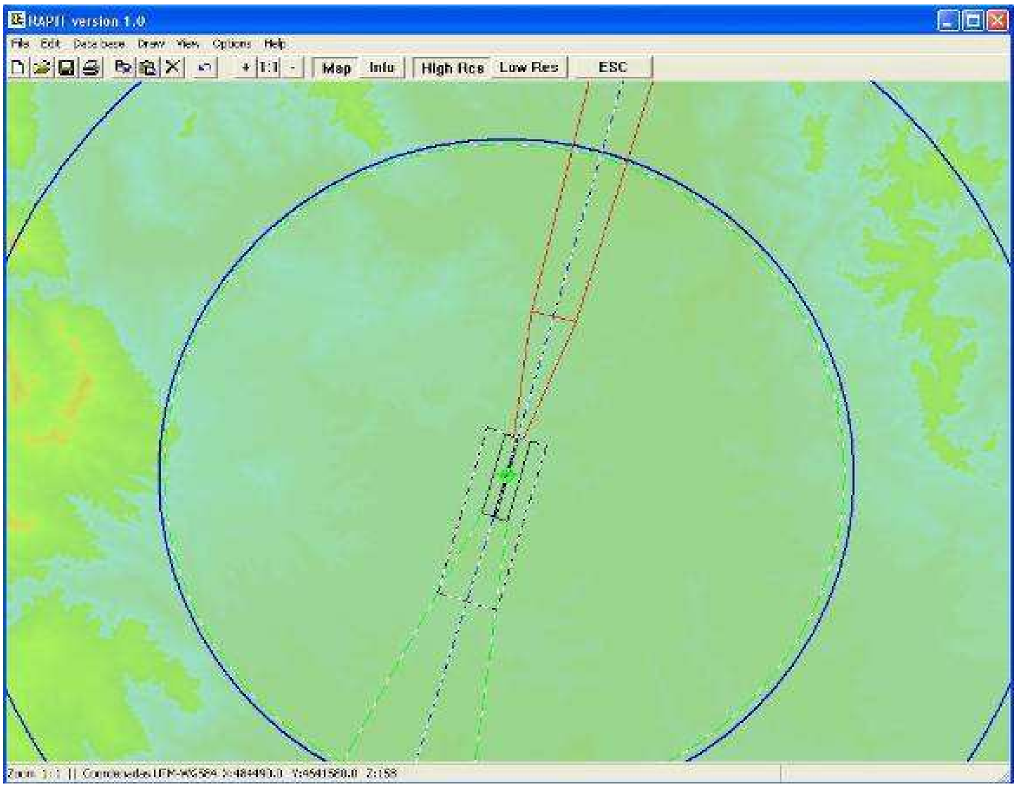

Figure 2: RAPIT's main view *(source: Pildo Labs, RAPIT)*

4 - RNAV AND APV PROCEDURES INTEGRATED TOOL (RAPIT)

RAPIT stands for RNAV and APV Procedures Integrated Tool. This software program is a CAD environment tool specifically designed to assist RNAV and APV procedures design. The tool helps the procedures designed on the required obstacle assessment around the aerodrome area, among other functions.

A very important characteristic of RAPIT is that it uses Digital Terrain Models (DTM) as cartographic source data, improving in this way the accuracy of the data and the easiness of use and implementation of the software. The Catalan Cartographic Institute (ICC) [16] provides several DTM maps of the Catalan region with enough accuracy if used for design procedure purposes. A DTM is a numeric data structure that represents the spatial distribution of the terrain altitude. RAPIT is able to manage two sets of DTM cartography, depending on how far the points of the mesh are located between them. A 200x200 meters mesh can be used for most part of the work, while a 30x30 meters mesh is employed for a more precise identification of obstacle.

As a CAD environment tool, RAPIT offers the user the possibility of drawing and managing a wide range of lines, surfaces and other drawing entities. Furthermore, the tool is able to manage and represent information contained in a series of databases, as for example: artificial obstacles, airports, radio navigation facilities, airways, etc.

RAPIT has been designed in order to easily admitting further functionalities. As an example, one of the latest developments has been the automatic computation of the wind spirals necessary to calculate the protection areas of turns.

5 - EGNOS AND THE NETWORK OF AIRPORTS IN CATALONIA

In section 2 the aeronautical situation of the Catalan region was presented. At present only the three international commercial airports are provided with radionavigation aids that enable IFR approaches in their runways. Barcelona airport is by far the better equipped one with ILS CAT-III systems in all the most frequently used runways. Thus, runways 07L, 07R, 25R, 25L are equipped with this high performance precision approach infrastructure. Runway 02 is most of the time used during night operations and is equipped with a CAT-I ILS while runway 20 is not available to any kind of approach because of its vicinity to Barcelona urban area. On the other hand, Girona and Reus airports have a CAT-I ILS installed in the principal approach runway (runways 20 in Girona and 25 in Reus). All approaches using the complementary threshold (runways 02 in Girona and 07 in Reus) are all non-precision approaches. It is clear that in these airports the benefits that EGNOS could bring are almost nonexistent. In Barcelona the entire infrastructure installed providing approach instrumental guidance is nowadays further more accurate that the performances that EGNOS could achieve. Maybe the introduction of EGNOS approaches could improve environmental issues or provide a backup means of navigation in case of failure of the existing radionavigation aids. In Girona and Reus airports EGNOS could be used perhaps to define LPV approaches in runways 02 and 07 respectively slightly improving the current operation minima in these runway thresholds.

However, as explained at the beginning of this paper, EGNOS navigation was mainly conceived to improve the situation that general aviation and regional and/or secondary airports are experiencing nowadays. In the case of the Catalan network we see that the three main commercial airports would not benefit significantly with the introduction of EGNOS based approaches, but is not at all the case of the remaining 18 airports/aerodromes if we count for the planned facilities as well (see figure 1). The regional, general aviation and auxiliary airports of the Catalan network do not have any infrastructure installed enabling any kind of instrumental procedures to be designed. Therefore, at present, all operations that are carried out in these airports are strictly visual (VFR) operations. This means that if Instrumental Meteorological Conditions (IMC) are meet in these airports any user can operate there. This important restriction is maybe non-important for sportive or leisure flights, but we should keep in mind that general aviation is not only composed by this kind of users. Police or fire fighting units, aerial works aircraft, aerotaxi or private transportation etc. may operate even if VFR conditions are not meet.

It is clear that one of the major issues that are currently stopping the development of general aviation in secondary Catalan aerodromes is the lack of IFR procedures that would enable all weather operations. If no satellite navigation methods were available, but an IFR procedure was to be implanted in some aerodrome or airport, conventional procedures (precision or not precision) would have to be designed. In either case, the installation of ground-based equipment, such as radio aids, would be required. This would unavoidably lead to a considerable economic investment, being much bigger for precision than for not precision procedures. Consequently, the implementation of RNAV and/or LPV procedures in the Catalan network of airports, especially in secondary aerodromes, would yield remarkable improvements. Not only would it provide particular aerodromes with currently non-existing IFR procedures, but it would do it with practically no investment infrastructures. Obviously, some on board equipment would have to be adapted to the new navigation and IFR method, but this is not a serious drawback, in as much as it is a necessary expense when implementing conventional methods as well.

In order to show that those procedures can be a reality in this kind of secondary airports two examples are presented in this work. First of all Igualada-Òdena general aviation aerodrome is studied followed by a more complete study of Lleida-Alguaire regional airport

5.1 – Igualada-Òdena aerodrome

The Igualada-Òdena aerodrome, classified as a sports aviation aerodrome, is located 3 km east of Igualada town, about 50km to Barcelona (see figure 3).

Figure 3: Igualada-Òdena aerodrome *(source: [10])*

During year 2005 and prior to RAPIT software development, a study in this field consisting in the design of an experimental LPV procedure was conducted. The lack of conventional radio navigation aids in the airport surroundings made it an interesting place to test the benefits that EGNOS based operations could bring. The results of this study are fully presented in [17]. The main conclusion of the study was that during the design of the LPV procedure, it was found an important difficulty in the obstacles identification phase. The identification of the natural and artificial obstacles resulted very time-consuming due to the lack of published aeronautic charts for the aerodrome. This limitation encouraged the development of RAPIT and the same study was used as a testing case for the software validation [18].

ICAO document Annex 14 [19] contains standards and recommended practices that prescribe the obstacle limitation surfaces around an airport that define the limits to which objects may project into the airspace. These Annex 14 obstacle limitation surfaces are obviously checked in the planning phase of any procedure design process.

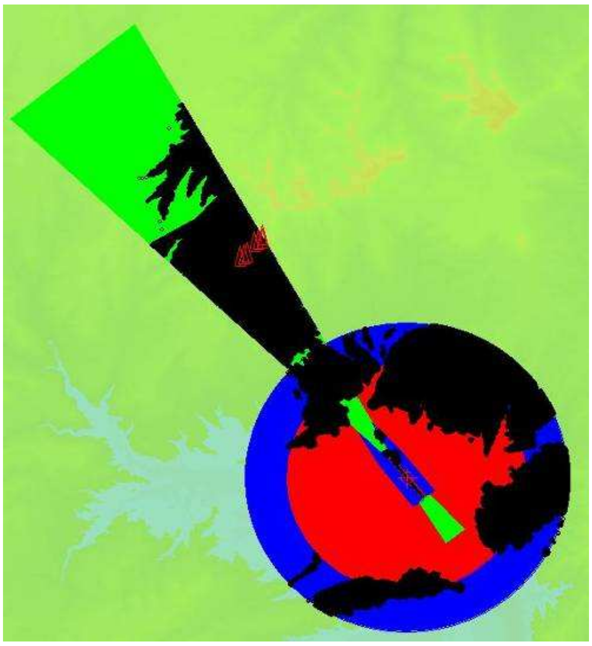

Figure 4: Identification of terrain penetrations with Annex 14 surfaces for Igualada-Òdena airport *(source: Pildo Labs, RAPIT)*

Figure 4 shows theses surfaces when applied over Igualada-Òdena airport. As it can be seen the airport is located in a very challenging surrounding environment and several natural terrain locations pierce the Annex 14 surfaces.

Taking into account all this information a more accurate obstacle study is usually performed in the procedure design process identifying the most critical obstacle and finally computing the Obstacle Clearance Altitude/Height (OCA/H) associated with the approach procedure. The OCA/H is the main figure that will be used in a further stage when computing the airport operational minima. Table 2 shows the OCA/H of the LPV procedure designed for Igualada-Òdena aerodrome.

Aircraft Catefory	OCA	OCH
A	967	632
B	970	635

Table 2: LPV OCA/H for Igualada-Òdena aerodrome

5.2 – Lleida-Alguaire regional airport

The Lleida-Alguaire airport is expected to be operational by the end of year 2008. It has been planned as a regional airport, with optimistic forecasts on low cost companies and cargo transport too, due to the available space in the airport surroundings.

The airport will be located about 15 km North-West from the city of Lleida. Airport specific data is contained in table 3. The airport has a main asphalt runway with a length of 2500 metres by 45 metres wide. The airport will be able to host short and medium commercial passenger transport aircraft.

ARP Coordinates (WGS-84)	**Longitude**	0º31´59.597412´´ E
	Latitude	41º43´46.125´´ N
ARP Ellipsoidal Elevation		392.44 metres
Runway Characteristics	**RWY Ends**	13/31
	Dimensions	2500 x 45 metres

Table 3: Lleida-Alguaire airport information

Regarding radio navigation aids, a VOR/DME and an ILS will be installed. The VOR/DME will not be aligned with the runway centreline, while the ILS system will serve RWY 31. This configuration will allow the definition of the following procedures:

- Standard Instrumental Departures (SIDs) for runways 13/31.
- Standard Terminal Area Routes (STARs) for runways 13/31.
- VOR/DME non-precision approaches for runway 13/31.
- ISL precision approaches for runway 31.

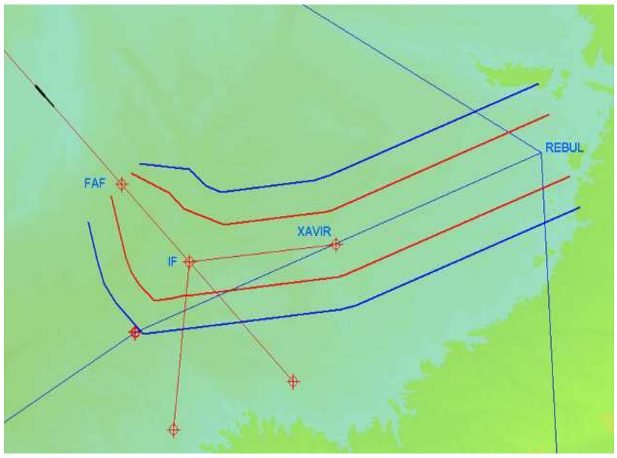

Figure 5: Protection Areas *(source: Pildo Labs, RAPIT)*

With this configuration, an LPV for both runways could be defined. For runway 31, an LPV would serve as back-up for the ILS procedure, while for runway 13, an LPV could provide significant benefits in comparison with the non-precision approach procedure based on the VOR/DME radio aid. In this context, LPV approaches were designed for runways 13 and 31 as well as the associated arrival procedures (STARs).

As it was mentioned above, obstacle clearance is the primary safety consideration in developing instrumental procedures. Each segment of the designed procedure has an associated protection area. The

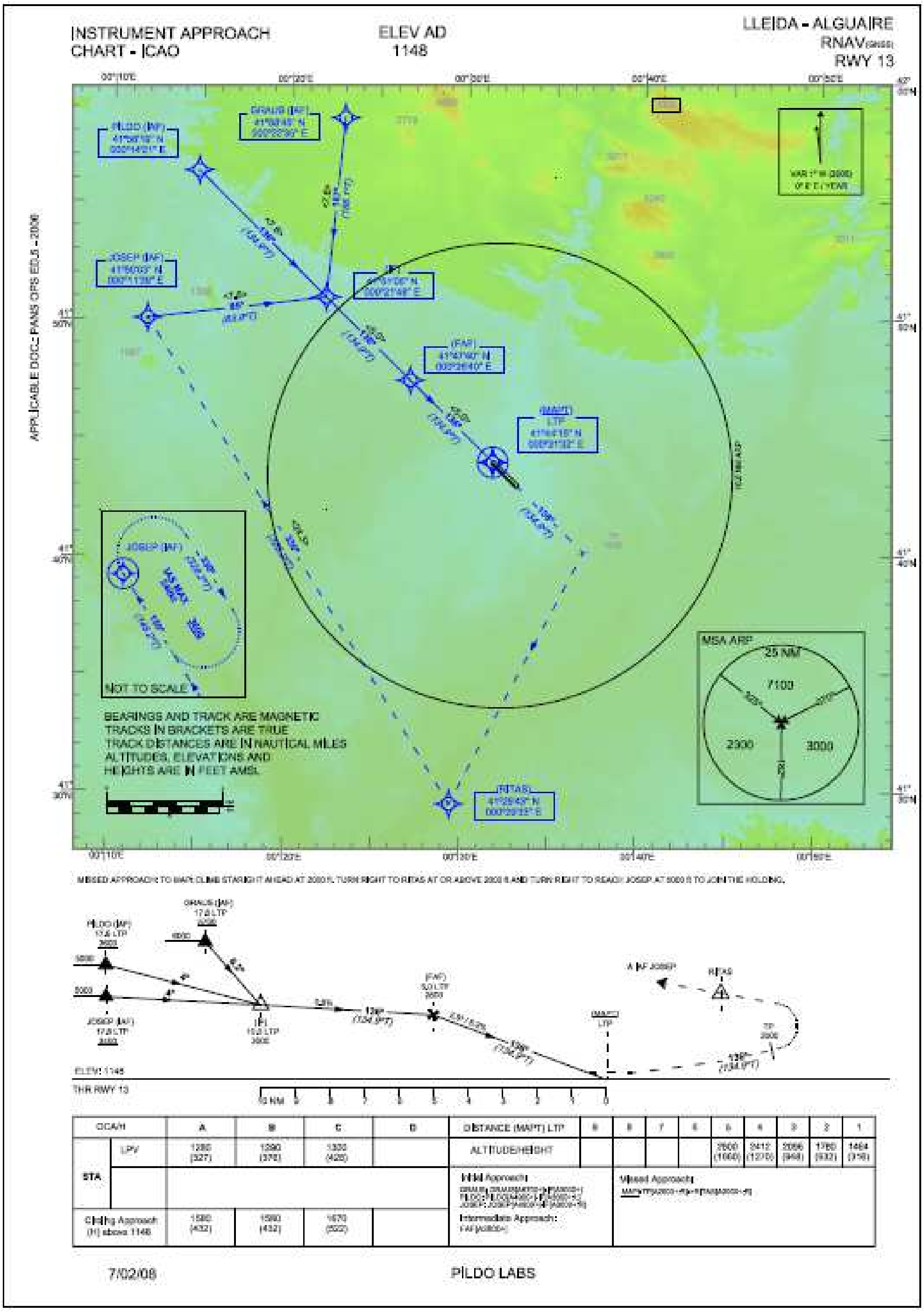

Figure 6: LPV Procedure Approach Chart for RWW 13 *(source: Pildo Labs)*

particular width of the areas as well as the minimum obstacle clearance altitude vary in function of the type of procedure (departure, arrival, approach…), the nature of the segment considered (initial or intermediate in an approach procedure) or the sensor being used for flying the procedure (VOR, DME, GNSS…). In addition, special attention must be given to the Final Approach Segment (FAS) of an approach procedure, where a value of the Obstacle Clearance Altitude or Height (OCA/H) must be computed in order to assess the publication of the Decision Altitude/Height (DA/H) for LPV approaches.

Using RAPIT, the Annex 14 surfaces where defined and all the possible obstacles where identified. Taking advantage of RAPIT ability to create a txt file containing all the identified obstacles, which can directly be read by the Minima Estimator Tool (MET) developed by Eurocontrol [20], the minima of the procedures were easily calculated. In this airport the surrounding obstacle environment

In next steps, the intermediate and initial segments of the approach procedure were designed. STARs ending at each one of the Initial Approach Fixes (IAF) where designed as well. Figure 5 shows the protection areas for a series of transitions between a STAR and the initial and intermediate segments of the LPV RWY 31. Finally, the Missed Approach Procedures for both runways were designed as well.

Figure 6 shows the final LPV approach chart for Lleida-Alguaire RWY 13. The procedure can be joined from three different IAF (JOSEP, PILDO and GRAUS) and the calculated OCH are 327, 376 and 425 feet for aircraft categories A, B and C, respectively.

6 - CONCLUSIONS

The advantages of using EGNOS approaches in small or secondary airports are highlighted in this paper. With the availability of this new satellite based augmentation system all-weather operation will be possible in airports that nowadays can not afford the expensive cost of conventional navigation means. It should be underlined here that these improvements are fully compatible with environmental preserving measures and sustained development criteria, due to its high level of flexibility as well as the intelligent uses which can be derived of such navigation procedures. In this work, a feasibility study of new EGNOS APV approach procedures are presented for two particular airports of the Catalan secondary airport network showing promising and encouraging results.

ACRONYMS AND ABBREVIATIONS

DA/H	Decision Altitude/Height
DME	Distance Measurement Equipment
DTM	Digital Terrain Model
EDCN	Eurocontrol Data Collection Network
EGNOS	European Geostationary Navigation Overaly Service
ESV	EGNOS SIS Validation
FAS	Final Approach Segment
GBAS	Ground Based Augmentation System
GIANT	GNNS Introduction in the Aviation Sector
GNSS	Global Navigation Satellite System
IAF	Initial Approach Fix
ICC	Institut Cartogràfic de Catalunya
ILS	Instrumental Landing System
LPV	Localizer Performance with Vertical Guidance
MET	Minima Estimator Tool
MLS	Microwave Landing System
OCA/H	Obstacle Clearance Altitude/Height
RAPIT	RNAV and APV Procedures Integrated Tool
RNAV	Area Navigation
SBAS	Satellite based Augmentation System
SID	Standard Instrumental Departure
STAR	Standard Arrival
VOR	VHF Omnidirectional Range

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