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Guidance for the preparation of EGNOS National Market Analysis

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ABSTRACT: The objective of this article is to provide some guidance to perform the activities regarding to "The EGNOS country market analysis". Such analyses are necessary during the implementation of EGONS for operational activity. The presented algorithm of proceedings was validated during conducted examinations, of aviation tests in the framework of the SHERPA project (Support ad-Hoc to Eastern Region with Pre-operational Actions on GNSS) under the Agreement Grant No. 287246 with the GSA (European GNSS Agency). Next it was admitted as the European model of conducting analyses of this type in aviation.

1 INTRODUCTION

According to Eurocontrol and EASA guidance, there has been developed a document "EGNOS Poland Market Analysis". It includes research findings concerning analysis of preparing airports and operators (aeroplanes and helicopters) for operational use of EGNOS system. There were first in Poland examinations, conducted by PANSA (Polish Air Navigation Services Agency), which they took to the implementation of LPV GNSS procedures on airports, guarantee safety and high quality of the service. Furthermore, these research was consistent with the expectations of aircraft operators and user of the EGNOS and was conducted in relation to signed by Poland ICAO Resolution A-36/37 concerning the Implementation of PBN (Performance Based Navigation).

Each European ANSP (Air Navigation Services Provider) shall perform a review of airports where LPV approaches would represent a quality improvement in terms of airport accessibility and operation safety. These are the main activities regarding Survey of candidate airports.

Furthermore, new test shall be carried out with aircraft operators, which are interested in of EGNOS system. Priority might be given to those operators with presence in the candidate airport. The assessment of some tangible criteria will allow the best selection after the complete process. This will cover the research of aircraft operators objectives.

The activities will be based on a common approach methodology to be followed by the participating ANSPs in SHERPA when assessing the different feasible scenarios: scenario = airport + aircraft operator. The article contains the following sections:
- description of the proposed implementation methodology
- brief summary of the description of work
- main conclusions after the analysis.

2 METHODOLOGY

The proposed common methodology for the airports and aircraft operator selection (namely "scenarios") is a rational and simple 3-phases process (Fig. 1):

- - Identification and description of potential scenario candidates (airports).
- - Selection of criteria targeting a clear definition of the criteria used to assess each of the potential scenarios identified, based on the criteria proposed in this document or including any additional aspect under ANSP consideration for the final scenario selection.
- - Assessment based on the selected list parameters/criteria. Each potential scenario shall be assessed justifying the selection of the best or most beneficial "final scenario" in which LPV procedures were published.

During the assessment of the different "scenarios" following the proposed methodology, the ANSPs will be able to evaluate the implications and benefits derived from the implementation of LPV procedures in each of them such as minima reduction, increased accessibility, continuous horizontal/vertical guidance, noise and emissions reduction, etc. This evaluation process will be the basis for the justification of the final selected scenario.

These activities must be performed in close co-operation with all the stakeholders such as Aircraft Operators, ANSPs, Regulators and Airports.

During the assessment of the different "scenarios" following the proposed methodology, the PANSA will be able to evaluate the implications and benefits derived from the implementation of LPV procedures in each of them such as minima reduction, increased accessibility, continuous horizontal or/and vertical guidance, noise and emissions reduction, etc. This evaluation process will be the basis for the justification of the final selected scenario. These activities also must be performed in close co-operation with all the stakeholders such as Aircraft Operators, PANSA, Regulators and Airports.

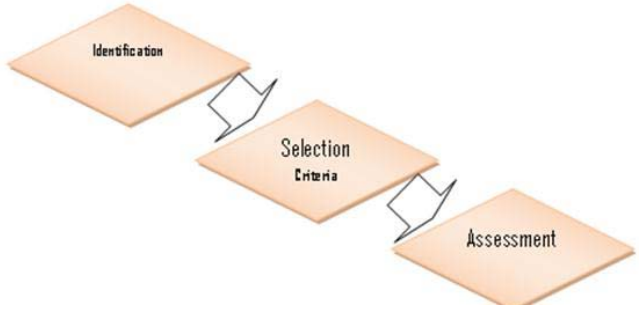

Figure 1. Methodology's phases

3 PHASE 1- IDENTIFICATION

Identification as one of the main objectives of SHERPA project is to support Eastern European countries through the set up of a regional working group and to understand the actions to be undertaken by their relevant stakeholders (ANSPs, Regulators and Aircraft Operators) in support to EGNOS adoption, the first step in the process is identification of some State airports and aircraft operators where LPV approaches implementation and its later operation will represent tangible benefits.

They assumed that PANSA should generate the list of potential candidates of the script (airports and operators of the plane) to be subsequently assessed. In principle, pairs of aircraft operators and airports where the first ones operate in would be the preference. The identification of candidates should be done taking into account organizational, technical and institutional requirements similar, but not limited to, the following ones:

- National strategic objectives,
- Aircraft operator requests,
- PBN implementation plans and airspace concept,
- ATM operational requirements,
- Environmental policy directives.

As part of the SHERPA project, a Polish National Implementation Team was established.

Figure 2. National Implementation Team

3.1 *Airports*

Each ANSP shall identify and analyse which are the most suitable airports/aerodromes in its State to be included in the list of candidates. This preliminary identification should be based on above parameters or even on some other specific national criteria that could be proposed and explained by each National Implementation Team.

For identification purposes, each ANSP should provide all the relevant information of the pre-selected airports. The information of each airport shall be presented in a specific form that is detailed below. This survey form aims to summarize the information, ease the process and gather the relevant data of the candidate airports in a coordinated manner for all the SHERPA ANSP partners.

The candidate airports shall fulfil minimum technical requirements, at least in terms of physical characteristics (runway shall be classified as instrumental according to ICAO Annex 14, ATS/AFIS

should be present, etc.). This first phase will be completed when a reasonable number of candidate airports are identified by the corresponding survey forms.

PANSA identified and analyzed most appropriate airports, landing field in Poland, which were included in the list of candidates. This preliminary identification was based on mentioned above parameters, specific domestic criteria and is accepted in the Polish Team (National Implementation Team). For the purposes of the PANSA identification he is providing with all essential information of the pre-selected airports. The information for every airport was presented in the assumed form - below specified tables for six airports. The candidate airports (Katowice EPKT, Kraków EPKK, Rzeszów EPRZ, Warszawa-Chopina EPWA, Wrocław EPWR, Warszawa- Modlin EPMO, Mielec EPML) shall fulfill minimum technical requirements, at least in terms of physical characteristics (e.g. table 1. runway shall be classified as instrumental according to ICAO Annex 14, ATS/AFIS should be present, etc.). This form of the examination is aspiring for summarizing the information, to relieve the process and to collect essential data of airports of the candidate in the coordinated way for the entire SHERPA ANSP partners.

Table 1. Identification chart for airports – example of Rzeszów Airport (ICAO: EPRZ, IATA: RZE)

		Name	RZESZOW - JASIONKA
		ICAO code	EPRZ
		IATA code	RZE
Airport's overview			
International airport, located in Jasionka 8 km west of center of Rzeszow.			
Location		Jasionka	
Traffic		Schedule, Nonschedule, General Aviation	
RWYs layout		RWY 09-27	
Taxiway		2 Taxiways, CONC/ASPH	
RWY		09	27
Main parameters	Magnetic [deg]	91.16°	271.20°
	Dimensions [m]	3200 x 45	3200 x 45
	IFR/VFR	IFR/VFR	IFR/VFR
	Lightning	THR, REDL, RENL	THR, REDL, RENL
Navigation	PA		ILS Cat I
	NPA	DVOR/DME	DVOR/DME, NDB
Equipment	App lightning system	SALS, PAPI 3°	ALPA-ATA Cat I, PAPI 2,9°
	Approach aids	DVOR/DME, NDB	DVOR/DME, NDB
	RVR measurement available	Yes	Yes
Traffic (2011) by Rzeszów airport	Movements	→	12357
	IFR/VFR [%]		b.d.
	Commercial flights		b.d.
	People/Load %		491325 / b.d.
	A/C types used for schedule flights		AT5, AT7, B735, B738, B767, CR7, J32
ATS			
	Aerodrome Control	DELIVERY MON-SUN 0600-2100 LTC TOWER H24	
	TWR Opening	H24	
Obstacle Clearance Height (OCH)		RWY 27	

Cat. Of ACFT (AD 2 EPRZ 6-1-1)		A	B	C	D
	Cat I	60	60	60	60
Straight-in	Loc- DME	110	110	110	110
Circling OCH ALL		135	155	200	210

RWY 09

Cat. Of ACFT (AD 2 EPRZ 6-2-1)	A	B	C	D
Straight-in	125	125	125	125
Circling OCH ALL	135	155	200	210

Noise footprint	NIL
Meteo relevant data	AIP POLAND AD 2 EPRZ 1-5 (AD 2.11)
Visual Segment Surface (VSS)	AERODROME OBSTACLE CHART (AIP POLAND AD 2 EPRZ 2-1-1)
Expected APV benefits	Backup for ILS,

3.2 *Aircraft operators*

Similarly to section 2, to make a good identification of aircraft operators, it is essential to collect enough information of the ones with potential interest in EGNOS based operations. This is a crucial activity to be developed by each of the National Implementation Teams in order to survey the different aircraft operators and obtain the required feedback from them to assess the interest and capabilities to be included in SHERPA as candidates.

It is very important to aware regarding current and projected RNAV capabilities onboard the aircraft operating at the airport of interest. Including, though not restricted, to the following:

- Aircraft equipment and navigation capabilities.
- Airworthiness and operational approval,
- Current experience with RNP APCH procedures,
- Operator requirements and preferences for RNP APCH procedures,
- Plans in terms of future equipage and operational approval.

The information of each identified aircraft operator shall be presented in a specific form that is detailed below. This survey form aims to summarize the information, ease the process and gather the rele-vant data of the candidate aircraft operators in a co-ordinated manner for all the SHERPA ANSP partners.

Table 2. Identification chart for aircraft operator – example of Royal Star Aero

Name	P.P.H.U. Royal-Star Krzysztof Pawelek
Location	Drogowców 7, 39-200 Dębica, Poland
Area of business	Training, Aerotaxi, Repair
Contact point	ul. Lotniskowa 16, 39-300 Mielec, Poland

Operator's overview

Business profile:

- Manufacture of aircraft components and engine parts.
- Design and construction of flight simulators.
- Major repair and overhaul of engines for Lycoming, Continental.
- Major repair and overhaul of propellers for McCauley, Hartzell, Sensenich.
- Production of refrigeration equipment and components for aviation industry.
- **Training of pilots:** PPL (A), CPL (A), Air Transport Pilot License ATPL (A).
- **PART-147: Training for mechanic's license:** A. A1 (Airplane - turbine engines), A. A2 Airplane piston engines), A. A4 Helicopter piston engines, B1.B1.2 Airplane piston engines

Fleet (number and type)	4 x Cessna 152	PZL M20	PA34-200T	PA28R-201T
Company size	LARGE			
Movements	~30			
National airports operated	MIELEC – EPML			

Questionnaire

Q1	**How many aircraft of your fleet are equipped for RNAV NPA, APV Baro or APV SBAS approach?** **2**
Q2	**Do you have certified GPS receivers onboard the aircraft? List the types (e.g. TSO-C129a, TSO-C145a, TSO-C146a):** **M20 - TSO-C129a , PA-34 - TSO-C146a**
Q3	**Does the aircraft have an airworthiness approval for the use of GPS and/or EGNOS in the approach phase of flight? Which type of operation?** **Yes. Enroute, terminal and , NPA and APV approaches**
Q4	**Do you intend to upgrade the navigation equipment of aircraft which are not equipped for any type of RNAV approach mentioned in the first question?** **Yes**
Q5	**Do you have any plans to sign new a/c purchases? If yes, are these new a/c suitably equipped for RNAV approaches? Which ones (NPA, APV Baro, APV SBAS)?** **APV SBAS**
Q6	**Which type of approach are you most interested in with respect to your present or future navigation equipment – APV Baro or APV SBAS ?** **APV SBAS**
Q7	**Do you have already any experiences with RNAV approaches? At which airports and what are your experiences?** **Yes. During APV approaches evaluation at EPML, EPKT airports**
Q8	**Which national airport (or runway) would you consider to have the highest priority for RNAV approach implementation?** **All certified**
Q9	**Do you consider having sufficient information and documentation about RNAV approaches operations and aircraft certification?** **Yes**

Polish team we know, that is very important it aware regarding current and projected RNAV capa-

bilities onboard the aircraft operating at the airport of interest. Including, though not restricted, to the following: aircraft equipment and navigation capabilities, airworthiness and operational approval, current experience with RNP APCH procedures, operator requirements and preferences for RNP APCH procedures, plans in terms of future equipage and operational approval e.g. Aircraft operator Royal Star Aero (Table 2).

4 PHASE 2 - SELECTION CRITERIA

This is the core section of this guidance document due to the direct application of the contents included here. It describes the main criteria to be taken into account by the participating PANSA, when evaluating the identified scenarios (airports +aircraft operators) and the selection of the "best" one.

After the identification and presentation, through the specific forms, of the potential scenario candidates ("airports" where LPV approaches bring tangible benefits and "aircraft operators" with potential interests on EGNOS based operations), next step is the definition of the scenario selection criteria.

The proposed criteria to be used by the participating PANSA come from the well-known key benefits that the EGNOS adoption brings for aviation in operational, safety, economical and environmental aspects within the Performance Based Navigation (PBN) concept.

Airport capabilities shall be studied to determine whether APV SBAS operations can be implemented on specific aerodromes. These criteria are detailed in the following subsection. Five areas are considered to group the proposed criteria based on EGNOS benefits for the assessment of the candidate airports: operational, safety, economical, environmental, capabilities

Some operational criteria that would represent benefits in the adoption of LPV approaches are:
- LPV is particularly attractive to runways not equipped with ILS, although also it could;
- be used as back-up of ILS. EGNOS provides lower operational minima on non ILS;
- runways and one achievable minima estimation is suggested;
- EGNOS allows to perform instrument approaches with vertical guidance (APV) based on SBAS down to LPV minima to airports which currently only provide NPA or visual approaches;
- a minimum of physical aerodrome infrastructure (runway, taxiway, approach lighting etc.) and CNS Systems are required.;
- it provides increased accessibility at airports with weather/terrain constraints. Improving lateral guidance and proposing vertical guidance, creating a direct approach that does not currently exist with standard navigation resources;
- meteorological data such as wind statistics, cloud ceiling and RVR per runway end are required;
- the airports with existing high OCH (over 500ft) are specially preferred;
- the existence of ATC/ATS services and the airport traffic and number and distribution of flight operations, must also be studied;
- the Visual Segment Surface (VSS) has to be assessed since its penetration may represent an obstacle for the publication of the RNP APCH procedures;
- a possible reduction in the decision height and lowering the slope on the final approach;
- the possibility to implement advanced procedures (e.g. curved approaches) and the integration of the new procedure into the terminal area impact.

Of relevant interest are the criteria regarding safety, for example:
- LPV is able to reduce Controlled Flights Into Terrain (CFIT) accidents, because it provides vertical guidance and situational awareness to pilots;
- It also provides better precision in low altitude routes such as for helicopters.

From an economical point of view criteria could be:
- LPV improves the attractiveness of airports not equipped with ILS to new airlines (e.g. major airlines, regional aviation, business aviation, general aviation, cargo aviation, aerial works, helicopters, etc).
- APV/SBAS allows enhancing accessibility (% of avoidable disruptions) flights that can land at the intended destination.
- EGNOS could reduce and rationalize ground navigation infrastructure with cost reduction in maintenance of ground infrastructure and conventional navigation aids (e.g. NDB, VOR and ILS).

Finally, there are environmental parameters than can be included for the selection process:
- noise reduction in populated areas.
- LPV provides more efficient approaches and time and fuel saving.

The proposed criteria based on EGNOS benefits for the assessment of the candidate aircraft operators are listed below:
- It will be very positive assessed if the aircraft operator operates at the airport under study;
- fleet composition of aircraft operator will inform about availability of a target type of aircraft to be selected for SHERPA project;
- it will be taken into account if there is any LPV equipped aircraft;
- the aircraft operator investment plan is important due to several costs the process involves: equipment upgrade, certification, procedure design, training, manuals update, etc.
- the traffic at a specific airport giving detailed information of movements and composition (people/load).
- if the aircraft operator use advanced landing procedures.
- time saving estimation after adoption of APV/SBAS approach procedures.
- fuel saving estimation after adoption of APV/SBAS approach procedures.
- the operation of LPV approaches is done through low cost and high performance avionics available for all users.

A set of these criteria shall be selected and presented using a specific *Criteria form* (see next section 5). In order to complete this phase, the definition of *weights* of all these criteria (between 0-100% depending on the importance or priority given to each of them by the ANSP) shall be performed.

5 PHASE 3 – ASSESSMENT

Based on a benchmark analysis methodology (mark + weight), each of the criterion will be assessed and justified for each airport and aircraft operator based on the information provided for each of them. So, the outcomes of the final scenario selection process will be totally based on valuable, objective and justified decisions.

The assessment process consists of 3 sub-phases as follows:
- To define and explain the marks to be applied;/
- To perform a benchmark analysis using prior data justifying the evaluation;
- To select the final scenario (Airport+Aircraft Operator) by means of an overall vision.

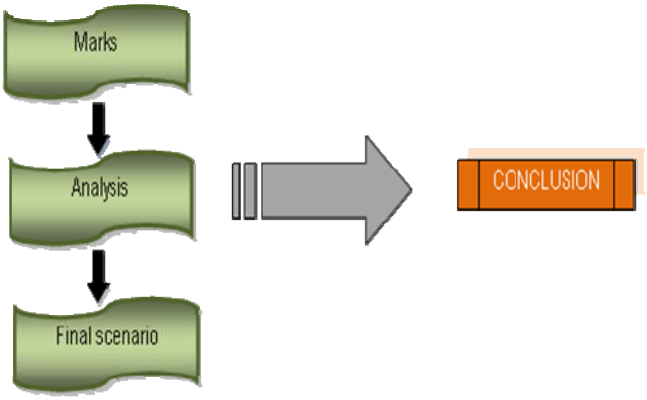

Figure 2. Assessment's phases

Inputs from Phase 1 (identified candidates) and Phase 2 (selection criteria) are combined to perform the assessment and obtain the results as the conclusion of the analysis. See detailed explanations in the following sub-sections about the mentioned 3 sub-phases and one final example for clarification purposes.

The first step to perform a consistent benchmark analysis is to define the marks to be assigned to each parameter or criterion. For marks, a simple approach would be using a scale from 0 to 10 points depending of the full, partial or non compliance of the parameter:
- Full compliance or "yes" - **10 points**.
- Partial compliance: **X points** (to be assessed from 0 to 10).
- Non compliance or "no" - **0 points**.

In the case of partial compliance, it is expected a threshold definition to guide the mark assignment. For example table 3:

Table 3. Threshold definition example

Traffic (number/distribution)[10]	Mark
X> 1×10^6/20/80	0
X> 1×10^6/80/20	1
500×10^3/20/80>X>100×10^3/20/80	3
500×10^3/80/20>X>100×10^3/80/20	4
100×10^3/20/80>X>50×10^3/20/80	6
100×10^3/80/20>X>50×10^3/80/20	7
X<50×10^3/20/80	9
X<50×10^3/80/20	10

[1] Traffic: number of operations/year and distribution of people/load in %.

The assignment of marks in case of partial compliance should be detailed and justified by each ANSP (Poland – PANSA). At this point, the mark and the weight (previously assigned) to each criterion shall be justified in order to understand the conditions of each scenario and be able to check the similarities and differences among the partners.

The analysis consists of using the forms presented in section 3 and applying the corresponding marks and weights for all the criteria. Crossing marks with the assigned weights will result in a specific figure to assess the feasibility of the LPV implementation for each individual airport and aircraft operator. This process shall be repeated for all the airport and aircraft operator candidates, paying special attention in crossing data, due to the aircraft operator criteria form shall analyse the corresponding aircraft operator together with a specific airport. In order to ease the completion of this task, the use of an Excel spreadsheet is suggested.

As explained before, this analysis shall be completed with a rationale justification of criteria, marks and weights selected in each case. This process shall be repeated for all the airport (for example Katowice EPKT – table 4) and aircraft operator candidates (for example AIRCOM – table 5), paying special attention in crossing data, due to the aircraft operator criteria form shall analyses the corresponding aircraft operator together with a specific airport (Poland: Katowice EPKT, Kraków EPKK, Rzeszów EPRZ, Warszawa EPWA, Wrocław EPWR, Modlin EPMO, Mielec EPML).

[10] Traffic: number of operations/year and distribution of people/load in %.

Table 4. Model result of conducted analyses for the airport EPKT Katowice

AIRPORT EPKT			
OPERATIONAL			
CRITERIA	WEIGHT	RUNWAY	
		07	25
RWY without ILS?	70	10	0
Only NPA or visual APCH?	80	10	0
Physical infrastructure (RWY, Taxiways, Lighting)?	60	10	10
Minimum CNS Systems?	70	8	8
Weather/terrain constraints?	90	7	7
OCH ≥ 500 ft?	20	2	2
ATC/ATS services?	40	10	10
Traffic(number/distribution)	20	7	7
VSS penetration?	80	10	10
Operational minima	10	8	8
SAFETY			
CFIT accidents?	100	7	2
Low altitude routes?	10	0	0
ECONOMICAL			
Interest of new aircraft operators?	80	10	10
Accessibility	60	6	8
Maintenance ground navigation systems high cost	90	0	10
ENVIRONMENTAL			
Noise impact?	30	0	0
Time and fuel saving?	70	10	10
CAPABILITIES			
Aerodrome infrastructure	60	10	10
Meteorological conditions	90	8	8
GNSS infrastructure	10	0	0
Integration of new procedure	20	10	10
TOTAL		88,3	78,5

Table 5. Model result of conducted analyses for the aircraft operator AIRCOM

2.3.2. Aircraft Operator criteria form

AIRCOM

CRITERIA	WEIGHT	AIRPORT NAME						
		EPRZ	EPKK	EPKT	EPWA	EPMO	EPML	EPWR
Operation at proposed airport?	100	5	10	10	10	4	6	5
Fleet composition?	90	4	6	8	8	3	5	4
LPV equipped A/C?	60	4	6	8	10	3	6	4
Upgrade investment foreseen?	80	10	2	10	10	1	5	5
Cost SBAS avionics	70	4	4	10	8	2	6	3
Movements?	30	7	7	9	8	3	5	3
People/Load (%)	20	5	7	8	8	3	3	3
Advanced procedures?	70	3	8	8	8	1	3	1
Time saving estimated?	80	5	5	8	9	3	5	4
Fuel saving estimated?	90	9	9	9	9	3	4	4
Strategic plans	40	4	6	9	9	3	5	3
Involvement local actors	50	2	4	10	10	4	7	5
Other user's interest	20	1	1	9	9	6	6	5
TOTAL		41,9	49,2	71,8	71,4	27,12	51,00	38,50

6 FINAL SCENARIO

Final scenario shall be selected as the best choice of "airport + aircraft operator" after crossing all information forms (table 6). This table presents the outcome of the study and states that RWY 29 of EPWA Airport and RWY 09 of EPKT Airport, are the best option for implementing a new LPV approach. Including above analyses, they distinguished one pair: EPKT (Airport) – AIRCOM (aircraft operator).

Table 6. Final scenario summary

AIRPORT	RUNWAY				AIRCRAFT OPERATOR	
					LOCAL AIRLINE OF POLAND	POLAND AIRCRAFTS
EPRZ	*9*	*27*				
	77,9	**62,9**			**44,0**	**41,9**
EPKK	*7*	*25*				
	87,8	**72,8**			**38,5**	**49,2**
EPKT	*9*	*27*				
	80,3	**65,3**			**54,7**	**71,8**
EPWA	*11*	*29*	*15*	*33*		
	69,5	**84,5**	**84,5**	**69,5**	**46,5**	**71,4**

7 CONCLUSION

This section lists the sequence of actions required to complete the SHERPA activities by each ANSP (in the case of Poland it was PANSA):

1 Make a list of airports and aircraft operators candidates fulfilling the forms with relevant information that appear in section 3.
2 Define the criteria that will be used to assess the feasibility of the LPV implementation. Using one airport form and one aircraft operator form. Particular criteria could be included by the ANSP if necessary.
3 To define the weight of each criterion and justify the decision.
4 To allocate one mark to each criterion defined in section 4.
5 Asses using benchmark analysis methodology all the airport and aircraft operator candidates.
6 Present results of the benchmark analysis.
7 Include any other national specific criteria (if any) and justify it and its mark.
8 Select the best scenario based on the final results.
9 Present main conclusions and outcomes of the analysis.

The "EGNOS Poland Market Analysis" was drawn up on the basis of the "Guidance for the preparation of EGNOS National Market Analysis based on the survey of candidate airports and aircraft operators". It is the first document drawn up by PANSA in SHERPA Project.

Other information as difficulties, implementation plan details, lessons learned, etc., will be useful and interesting for further analysis. Special mention to benefits that can be reached like:

- Improve safety.
- Reduce risk of CFIT.
- Stabilised approach.
- Saving costs for ground navaids maintenance.
- Fewer building constraints.
- Develop and improve services.
- Avoidance of delay and diversion.
- Reduced operational minima.

Conducted examinations showed, that:

- EGNOS must assure required by ICAO: accuracy, integrity availability, continuity in Poland;
- GNSS is lacking domestic regulations concerning the application;

– All responsible institutions must in the employed and coordinated way join in into the process of implementing GNSS;
– The part of the fleet only has an essential avionics.

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