Scientific Journal of Silesian University of Technology. Series Transport
Zeszyty Naukowe Politechniki Śląskiej. Seria Transport

Volume 93 **2016**

p-ISSN: 0209-3324

e-ISSN: 2450-1549

DOI: https://doi.org/10.20858/sjsutst.2016.93.1

Journal homepage: http://sjsutst.polsl.pl

Article citation information:
Fellner, A., Fellner R. Piechoczek E. RNAV GNSS flight validation approach procedures for EPKT RWY27. *Scientific Journal of Silesian University of Technology. Series Transport*. 2016, **93**, 5-11. ISSN: 0209-3324. DOI: https://doi.org/10.20858/sjsutst.2016.93.1.

Andrzej FELLNER[1], Eugeniusz PIECHOCZEK[2], Radosław FELLNER[3]

RNAV GNSS FLIGHT VALIDATION APPROACH PROCEDURES FOR EPKT RWY27

Summary. The purpose of this document is to present evidence of the work carried out as part of the flight validation activities of the RNAV approach involving the instrument flight procedures (IFPs), down to the localizer performance with vertical (LPV) minima, for RWY27 at Katowice Airport (EPKT). The presented material constitutes the second part of the “Preflight validation RNAV GNSS approach procedures for EPKT in the EGNOS APV Mielec” project. The following issues were addressed: flight validation conditions, list of performed approaches, flight path analysis and pilot feedback.
Keywords: flight validation, GNSS, aviation, RNAV, satellite navigation

1. INTRODUCTION

The purpose of this document is to present evidence of the work carried out as part of the flight validation activities of the RNAV approach involving the IFPs, down to the LPV minima, at EPKT for RWY27. The presented material constitutes the second part of

---

[1] Faculty of Transport, Silesian University of Technology, Krasińskiego 13 Street, 40-019 Katowice, Poland. Email: andrzej.fellner@polsl.pl.
[2] Faculty of Transport, Silesian University of Technology, Krasińskiego 13 Street, 40-019 Katowice, Poland. Email: eugeniusz.piechoczek@polsl.pl.
[3] Civil Aviation Personnel Education Centre, Silesian University of Technology, Krasińskiego 13 Street, 40-019 Katowice, Poland. Email: rfellner@wp.pl.

the “Preflight validation RNAV GNSS approach procedures for EPKT in the EGNOS APV Mielec” project. The first part of research was described in a previous article [3].

2. FLIGHT VALIDATION CONDITIONS

According to ICAO standards, the purpose of flight validation is to determine whether a flight procedure is operationally safe, practical and flyable for the target end user [8]. The following guidelines were taken into consideration for conducting the flight validation activities:

- The validation was carried out in daylight hours under visual meteorological conditions (VMCs)
- The final approach segment had to be flown one half of a scale down, at least once
- All segments of the approach were flown at least once (segments common to the LNAV approaches were already flown during the LNAV validation flights)
- The missed approach segment was flown
- A test database containing the RNAV IFP was used
- There was one pilot acting as the flight validation pilot (FVP) and one observer assisting the FVP in the validation process observing the ‘out of cockpit’ environment
- The aircraft used during the flight validation had the appropriate performance capabilities for which the IFP was designed.

The flight validation (FV) was conducted with a Piper Seneca II aircraft. The aircraft is equipped with the appropriate RNAV (area navigation) equipment for conducting LPV guidance operations: a Garmin GNS 430W connected with other required avionics (antenna, course display indicator/vertical display indicator (CDI/VDI)). The complete set allows flying during all phases of flight en route to the precision approaches down to the LPV minima. The IFP to be validated, designed by Pildo and the Polish Air Navigation Services Agency (PANSA), was coded inside a test database produced by Jeppesen and Garmin. The pilots inserted the FV plan inside the FMS-like Garmin device and conducted the trials in the relevant navigation mode using the global positioning system/satellite-based augmentation system (GPS/SBAS) guidance. Guidance during the entire flight, including aircraft positioning, was provided by the CDI/VDI fed by the GNS 430W.

In order to record continuous data and monitor the EGNOS during the campaign, a flight data recording and monitoring system was installed on the aircraft. The system (standalone platform) included a U-blox Antaris 4 GPS/SBAS receiver. A Septentrio PolaRx2 GPS/SBAS receiver was installed on the ground during the flight validation. The receiver was installed at EPKT. The main objective was to collect GPS L1/L2 and EGNOS data, which were post-processing in order to allow for evaluating the local performance of the system. The automatic reports regarding the performance of the signal are included in the “EGNOS performance analysis and SIS analysis” report. This report constitutes a brief overview of the performance of EGNOS SIS (PRN 120) as observed at EPKT over a period of six hours from 14 March at 10:00 until 14 March at 16:20 with a Septentrio PolaRx 2/3 receiver. (Note that, during this period, the EGNOS system was still under test conditions and not yet fully deployed. Therefore, the results serve only as an indication and cannot be used for the final validation.)

Before the flight trials, the local APV-1 availability in the area was simulated using a predictive receiver autonomous integrity monitoring (RAIM) algorithm developed by PildoLabs. The analysis was performed at the ARP, with the following conditions also considered:

- No digital terrain model was used to simulate the local conditions of the area (useful in some environments in order to take into account the masking caused by a mountainous environment)
- The GPS almanac was downloaded from the US Coast Guard Navigation Center website
- The simulation was carried out for a 12-hour data set (from 09:00 to 21:00), with samples every five minutes

The obtained result concerns a 100% APV-1 availability at the threshold coordinates. The estimated horizontal and vertical errors were also estimated. This is presented in Figure 1.

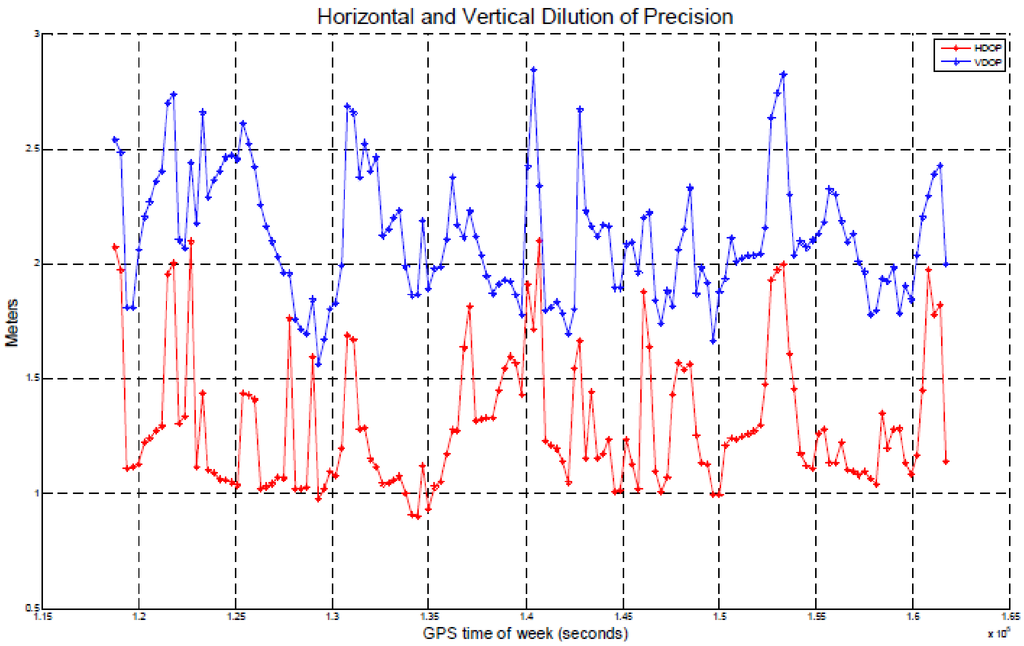

Fig. 1. Dilution of precision for EPKT

These simulations ensured that the EGNOS would enable an APV-1 level of service at EPKT during the entire day.

The data analysis focuses on the data recorded during the flights. The following figures show the trajectories flown during the approaches. The approaches are drawn in conjunction with the tested paths.

Table 1.

Flight validation plan: list of approaches

Appraoch #	Initial segment (IAF - IF)	Intermediate segment (IF - FAP)	Final Approach Segment	Post Flight	Remarks
App1	Fly leg from **KT001 / MLC01** at minimum published altitude	Fly it normally	Fly it normally	Fly the full Missed Approach	Perform a robust test of the vertical profile. Assess de flyability of the procedure. Perform obstacle assessment during missed approach
	From 5000 ft to 3700 ft	from 3700 ft to 3000 ft	Follow the vertical and horizontal profile	MA starts when reaching the minimums	
App2	Fly leg from **KT002 / MLC02** at minimum published altitude	Fly it normally	Fly it half scale below	Fly the first segment of the MA	Perform obstacle assessment evaluation during the final approach segment
	From 5000 ft to 3700 ft	from 3700 ft to 3000 ft	Follow the vertical (HSD below) and horizontal profile	N/A	
App3	Fly leg from **KT003 / MLC 03** at minimum published altitude	Fly it normally	Fly it half scale below	Landing	Perform obstacle assessment. Assess the flyability of the procedure
	From 5000 ft to 3700 ft	from 3700 ft to 3000 ft	Follow the vertical (HSD below) and horizontal profile	N/A	
App4	Fly leg from **KT001 / MLC01** at minimum published altitude	Fly it MOC/2 below published minimum altitude	Fly it half scale right	Fly the first segment of the MA and follow the flight engineer instructions	Perform obstacle assessment
	3200 ft	at 2750 ft	Follow the vertical and horizontal (HSD right) profile	N/A	
App5	Fly leg from **KT002 / MLC02** at minimum published altitude (5000ft)-MOC/2	Fly it MOC/2 below published minimum altitude	Fly it half scale left	Fly the first segment of the MA and follow the flight engineer instructions	Perform obstacle assessment
	3200 ft	at 2750 ft	Follow the vertical and horizontal (HSD left) profile	N/A	

The following figures present the flight trajectories of the demonstrations, together with the waypoints and runway threshold. It can be seen how the aircraft successfully accomplished the operations up to the obstacle clearance altitude/height (OCA/H) values, when either a missed approach or a landing was conducted. In the profile views, the following reference altitudes have been plotted:

- 5,000 ft = the minimum altitude to fly the initial segments of both approaches,
- 1,235 ft = the CAT A LPV minima (OCA) of the procedures,
- 991 ft = the elevation of RWY 27 THR.

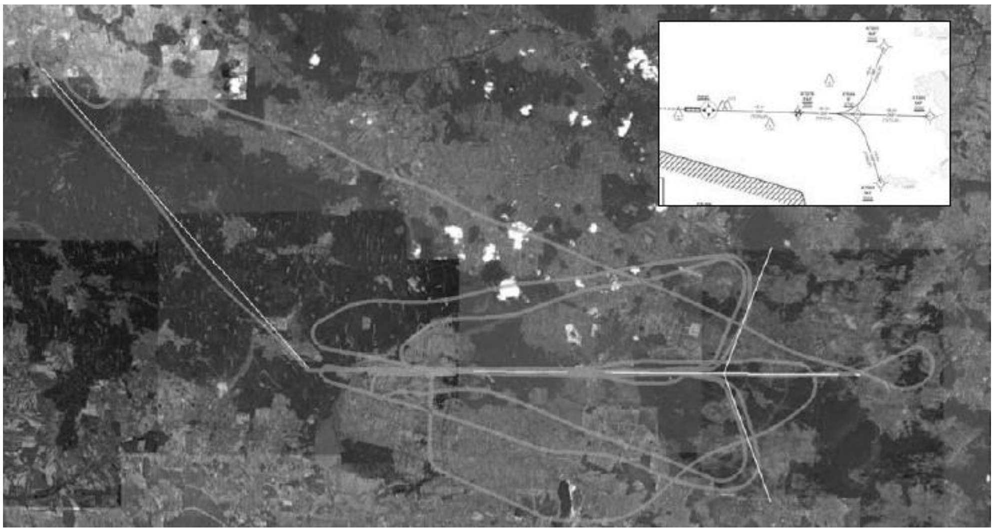

Fig. 2. Plan view of the flight demonstrations

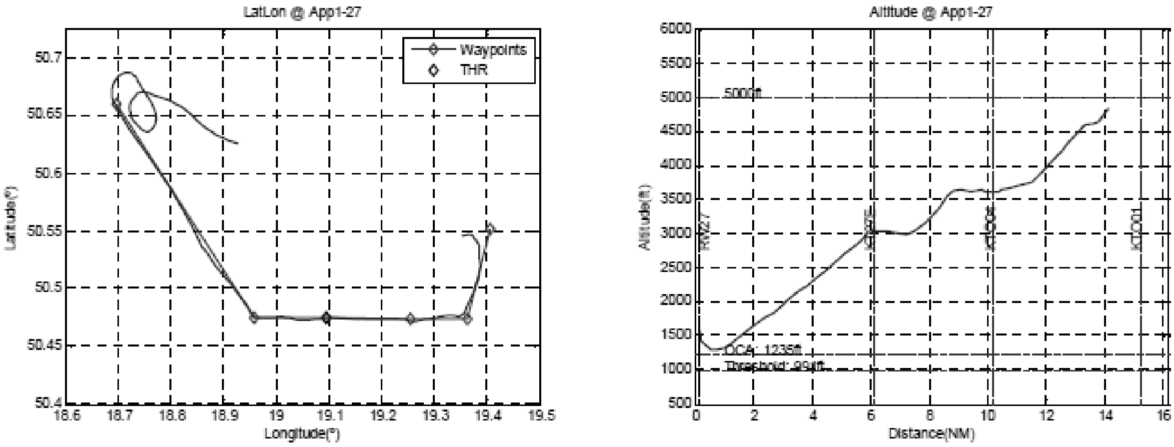

Fig. 3. Plan view of the aircraft flight path and altitude profile
(note: the profile graphs start after KT001 due to the flyby turn performed at this waypoint)

The plan and profile views shown in the above figures are consistent with the specified objectives in the flight validation plan.

3. FLIGHT DEVIATIONS

Establishing flight deviations was necessary. To have a clearer picture of the deviations presented to the pilot during the approaches, the horizontal and vertical deviations have been computed with respect to the desired flight path. The results are presented in the figures in this section. The distances along the vertical axis represent the horizontal or vertical flight technical error (FTE) in metres. The FTE is provided as guidance information to the pilot during the flight, while the NSE and TSE can only be determined using truth references after post-processing the data. Figures located on the left show the deviations of the aircraft during the intermediate and final approach segments, while the figures located on the right side zoom in on the deviations during the FAS. The full-scale deflection (FSD) of the CDI/VDI is also plotted in the figures (cyan colour) when contained in the figure limits, in both the horizontal and the vertical domains. These curves indicate the value of the deviations that the aircraft would have had with respect to the approach path, provided the CDI/VDI needles had been totally deflected. The curves have been calculated using in-house developed tools, in accordance with [2]. As can be seen, the FSDs are not constant and change between being linear and angular along the approach, following the requirements laid down in the minimum operational performance specifications (MOPS).

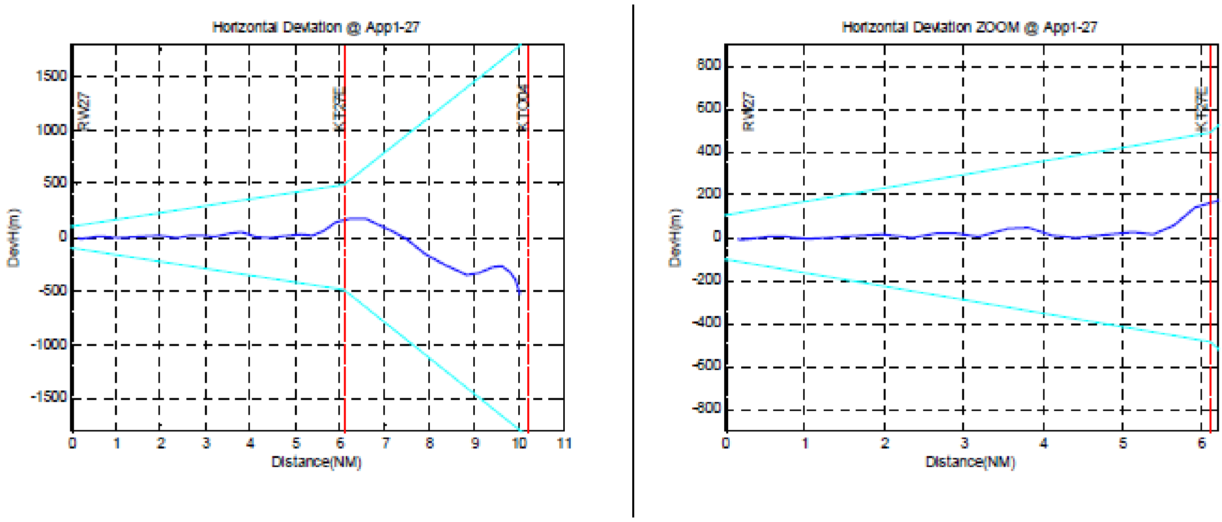

Fig. 4. Horizontal and vertical deviations

The project considered pilot feedback obtained using standard qualitative questionnaires about the flyability of the approaches flown, as included in the ICAO Doc 9906. Assessment of the proposed procedure followed the project's methodology.

4. CONCLUSION

The LPV flight procedures for RWY27 provide tangible operational benefits for airport operators in cases of an inactive instrument landing system. The EGNOS system was capable of providing excellent aircraft guidance, which was appreciated by the pilots. The main outcomes of the validation of the new GNSS procedure are as follows:

- The EGNOS availability performance APV-I was fully achieved during all the approaches
- The coding of the procedure for SBAS is satisfactory
- The horizontal and vertical sensibility of the CDI was successfully tested
- The procedure is safe from the obstacle clearance point of view (it has been flown half scale down the nominal glide path without identifying potential obstacles)

- No significant obstacles were found when overflying the surroundings of the airport either
- The flyability of the procedure was correct

The ground and flight validations were performed successfully. The procedure is published in the AIP of Poland.

References

1. APV SBAS Approach: Concept of Operations 1.0. 28/01/2009.
2. DO-229D. 2006. *Minimum Operational Performance Standards for Global Positioning System/Wide Area Augmentation System Airborne Equipment*. Washington: Radio Technical Commission for Aeronautics.
3. Fellner Andrzej, Radosław Fellner, Eugeniusz Piechoczek. 2015. „Pre-flight validation RNAV GNSS approach procedures for EPKT in "EGNOS APV Mielec project" ". *Scientific Journal of Silesian University of Technology. Series Transport*. 2016, 90, 37-46. ISSN: 0209-3324. DOI: https://doi.org/10.20858/sjsutst.2016.90.4.
4. MIELEC_CA MIELEC Consortium Agreement 1.0.
5. MIELEC D3 GPS NPA and APV-I Procedure Design 2.0.
6. ICAO. 2006. *Doc 8168 Procedures for Air Navigation Services Aircraft Operations. Volume II: Construction of Visual and Instrument Flight Procedures*. Montreal: ICAO.
7. TechPro MIELEC Technical Proposal 1.0.
8. ICAO. 2012. *Doc 9906 Quality Assurance Manual for Flight Procedure Design. Volume 5: Flight Validation of Instrument Flight Procedures*. Montreal: ICAO.

Received 11.08.2016; accepted in revised form 25.10.2016