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PRE-FLIGHT VALIDATION RNAV GNSS APPROACH PROCEDURES FOR EPKT IN „EGNOS APV MIELEC PROJECT"

Summary. The purpose of this document is to show evidence of the work carried out as part of the pre-flight flight validation activities of one RNAV approach Instrument Flight Procedures (IFP), down to LPV minima, at Katowice Airport (EPKT). The document is a deliverable of the TEN-T funded project "Support to the EGNOS APV Operational Implementation – APV MIELEC".
Keywords: flight validation, GNSS, aviation, RNAV, satellite navigation

1. INTRODUCION

In accordance with ICAO Assembly resolution 37-11 technological developments in aviation, especially in approaches and validations, will be determined by the need to implement navigation procedures based on characteristics (Performance Based Navigation – PBN) and GBAS system. Partial implementation approach procedures RNAV and RNP contained in Performance-Based Navigation (PBN) Manual is planned by 2016. EASA plans implementation of PBN Standard Instrument Departure (SID) / Standard Instrument Arrival (STAR) 2018., And PBN approach procedures with vertical guidance (APV) (RNP APCH) to 2024. PBN means Area Navigation (RNAV) based on requirement for performance

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monitoring and alerting (Required Navigation Performance RNP) for aircraft operating along an air traffic service route, on an instrument approach procedure or in a designated airspace [4]. For example, RNP 1 operations require the Lateral and Longitudinal Total System Error (TSE) to be within +/– 1 nautical mile for at least 95% of flight time and on-board performance monitoring, alerting capability and high integrity navigation databases. With regard to RNP approaches (RNP APCH) the TSE shall be +/– 0,3 nautical mile for at least 95% of flight time for the Final Approach Segment and on-board performance monitoring, alerting capability and high integrity navigation databases are required [3].

2. BACKGROUND ON RNAV APPROACHES

Area Navigation (RNAV) is defined as a method of navigation that permits aircraft operation on any desired course within the coverage of station-referenced navigation signals or within the limits of a self contained system capability, or a combination of these. RNAV was developed to provide more lateral freedom and thus more complete use of available airspace. This method of navigation does not require a track directly to or from any specific radio navigation aid, and has three principal applications:

1. A route structure can be organized between any given departure and arrival point to reduce flight distance and traffic separation;
2. Aircraft can be flown into terminal areas on varied pre-programmed arrival and departure paths to expedite traffic flow;
3. Instrument approaches can be developed and certified at certain airports, without local instrument landing aids at that airport.

Focusing on the last point, RNAV approaches can have several descent minima depending on the kind of RNAV approach to be flown:

- RNAV (GNSS) NPA (Non Precision Approach): an approach without vertical guidance flown to the LNAV MDA/H (Lateral Navigation Minimum Descent Altitude/Height);
- APV Baro (Approach with Barometric Vertical guidance): an approach with barometric vertical guidance flown to the LNAV/VNAV DA/H. APV Baro is a vertically guided approach that can be flown by modern aircraft with VNAV (Vertical Navigation) functionality using barometric inputs. Most Boeing and Airbus aircraft already have this capability meaning that a large part of the fleet is already equipped;
- APV SBAS (Satellite Based Augmentation System): An approach with geometric vertical and lateral guidance flown to the LPV DA/H (Decision Altitude/Decision Height). APV SBAS is supported by satellite based augmentation systems such as WAAS (Wide Area Augmentation System) in the US and EGNOS (European Geostationary Navigation Overlay System) in Europe to provide lateral and vertical guidance. equivalent to an ILS localizer and the vertical guidance is provided against a geometrical path in space rather than a barometric altitude.

The 36th ICAO Assembly in 2007 passed a resolution encouraging States to implement approach procedures with vertical guidance (Baro-VNAV and/or SBAS) for all instrument runway ends, either as the primary approach or as a back-up for precision approaches by 2016.

The use of the European SBAS system – EGNOS – presents a feasible solution to APV approaches.

The use of the European SBAS system – EGNOS – presents a feasible solution to APV approaches:

- Navigation system specifically designed for approach operations;
- Europe coverage;
- High accuracy and integrity;
- Requires no infrastructure on the aerodromes themselves;
- Supports autopilot coupling;
- Standalone avionics possible thereby minimising retrofit costs.

The ESSP (European Satellite Service Provider) has officially declared the start of the EGNOS Safety-of-Life Service as of today, March 2nd 2011, following EC authorization to provide the service.

Intensive scientific and technological progress in aviation and flight approaches has been recognized in Poland. Polish Civil Aviation Authority are interested in the implementation of RNAV approaches in the short term into some of their airports. However, unlike to USA, France or Germany, in Poland, IFR navigation based on basic GNSS like GPS (Global Positioning System) is not currently accepted. The Polish Air Navigation Services Agency (PANSA) participates in this study by providing reports of the EGNOS SIS performance using a receiver installed on-ground. Royal Star Aero participates in the flight validation campaign directly by providing an aircraft. The pilots involved are IFR (Instrumental Flight Rules) licensed and are Royal Star Aero staff too.

3. PRE-FLIGHT VALIDATION RNAV GNSS APPROACH PROCEDURES

Research was conducted within the framework of the “Support to the EGNOS APV Operational Implementation – APV MIELEC” programme. Firstly, to the project were chosen two airports: Mielec Airport (EPML) as General Aviation airport and Katowice Airport (EPKT). During preparation to validation it turned out that EPML does not meet the requirements adopted in project and its infrastructure is unprepared to performing validation. That is why only EPKT was fully fledged participant at these project. Pre-flight validation was performed in line with ICAO Doc 9906 volume 5 “Validation of Instrument Flight Procedures”, which provides guidance for conducting validation of instrument flight procedures, including safety, flyability and design accuracy [8].

Table 1

List of waypoints

Waypoints list				
Fixes	WP	Coordinates (WGS84)		
IAF	KT001	503305,92 N	0192423,32 E	50.55164 N, 19.40648 E
	KT002	502823,46 N	0192930,64 E	50.47318 N, 19.49184 E
	KT003	502342,71 N	0192420,00 E	50.3952 N, 19.40556 E
IF	KT004	502824,67 N	0192141,05 E	50.47352 N, 19.3614 E
FAP	KT27E	502825,63 N	0191515,99 E	50.47379 N, 19.25444 E
LTP	RW27	502827,19 N	0190538,65 E	50.47422 N, 19.09407 E
	KTMA1	502828,37 N	0185730,00 E	50.47455 N, 18.95833 E
	KTMA2	503936,46N	0184148,88 E	50.66013 N, 18.69691 E

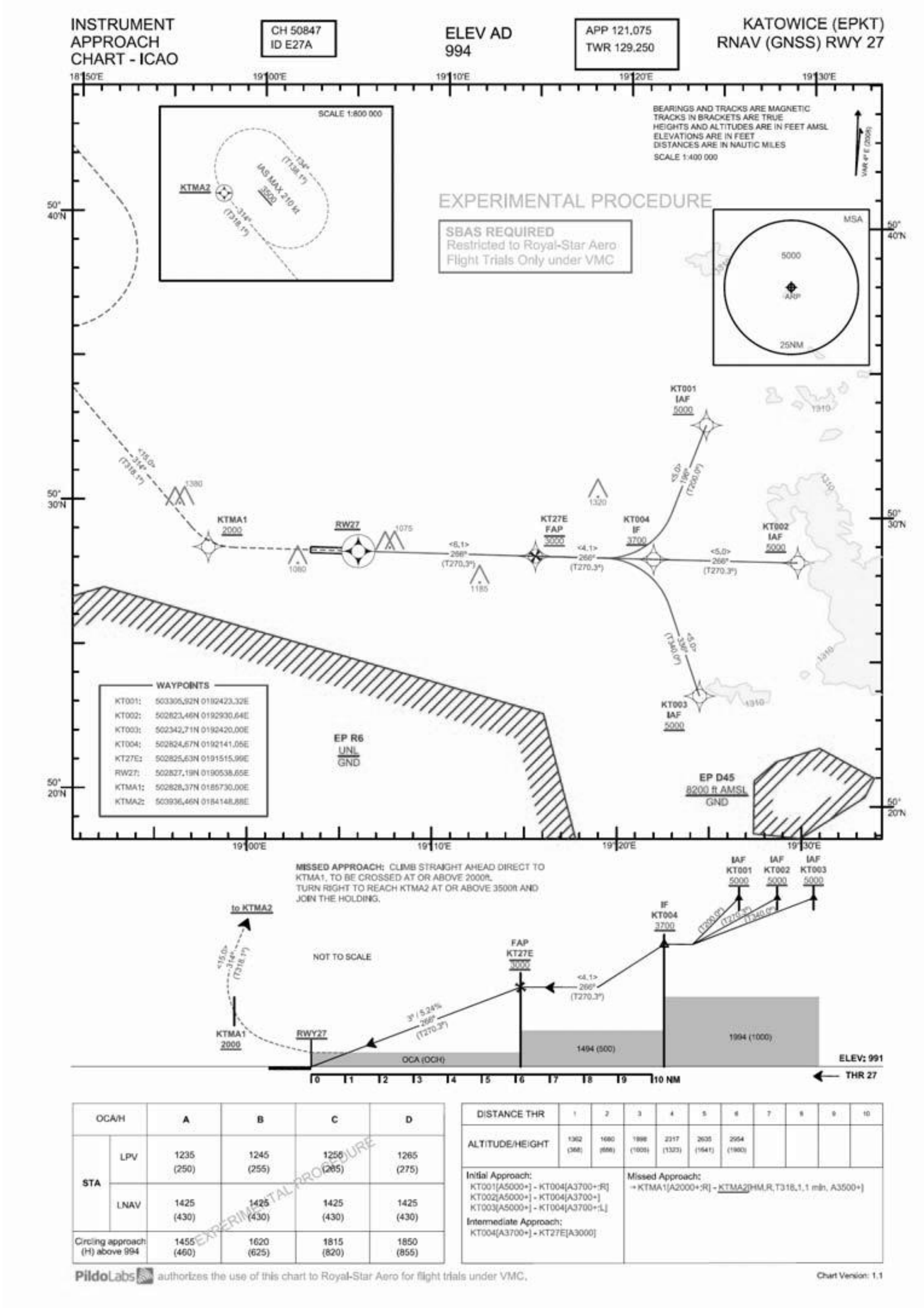


Fig. 1. Procedure chart designed for EPKT

Table 2

Path terminators

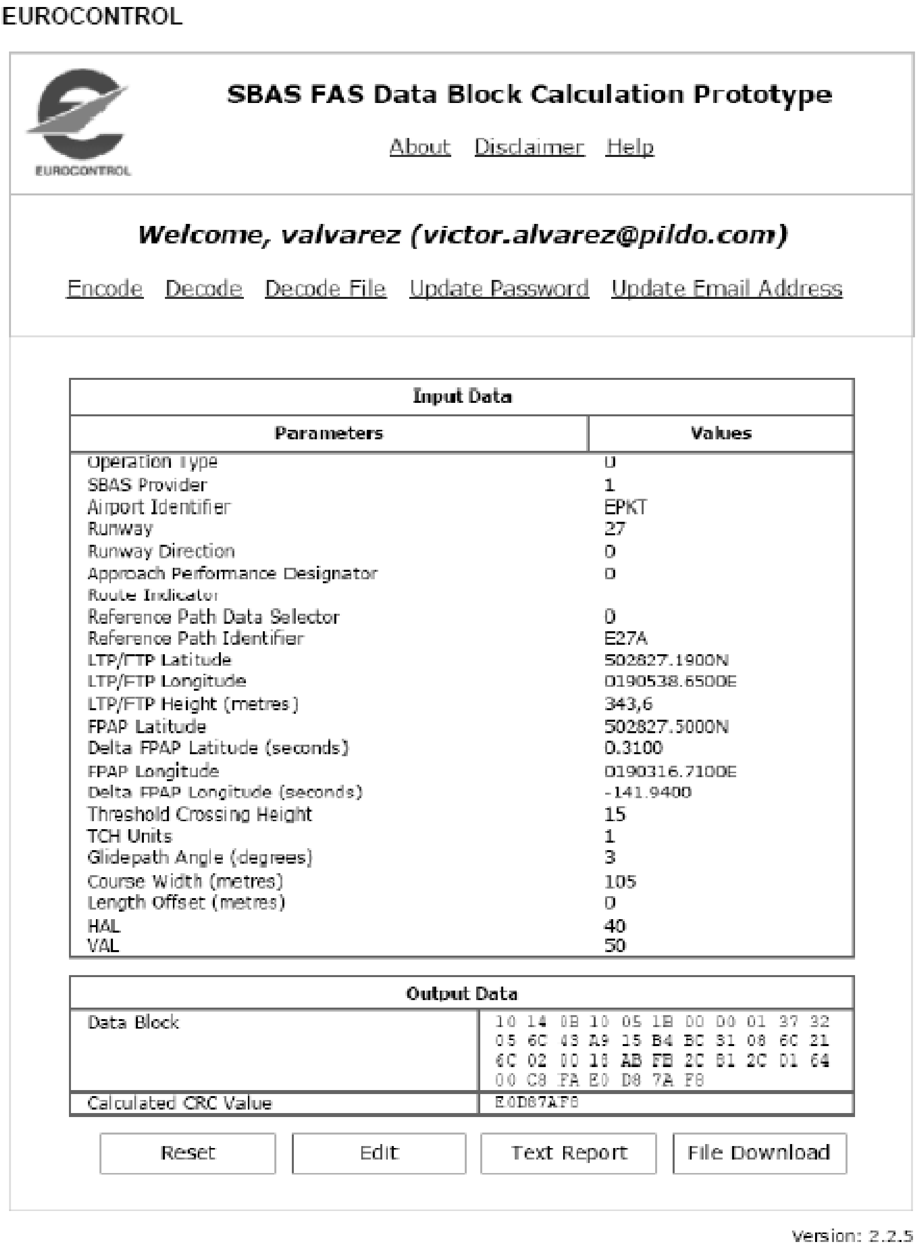
APPROACH / MISSED APPROACH FROM IAF KT001			
Formal Description	**Short description**	**Expected Path Terminator**	**Flyover required**
KT001 at or above 5000ft	KT001[A5000+]	IF	N
To KT004 at or above 3700ft, turn right	KT004[A3700+;R]	TF	N
To KT27E at 3000ft	KT27E[A3000]	TF	N
To RW27	RW27[A1041+]	TF	Y
MISSED APPROACH			
Direct to KTMA1 at or above 2000ft, turn right	→ KTMA1[A2000+;R]	DF	N
To KTMA2{HM,R,T318.1, 1min} at or above 3500ft	KTMA2[R]	TF	Y

APPROACH / MISSED APPROACH FROM IAF KT002			
Formal Description	**Short description**	**Expected Path Terminator**	**Flyover required**
KT002 at or above 5000ft	KT002[A5000+]	IF	N
To KT004 at or above 3700ft	KT004[A3700+]	TF	N
To KT27E at 3000ft	KT27E[A3000]	TF	N
To RWY27	RWY27[A1041+]	TF	Y
MISSED APPROACH			
Direct to KTMA1 at or above 2000ft, turn right	→ KTMA1[A2000+;R]	DF	N
To KTMA2{HM,R,T318.1, 1min} at or above 3500ft	KTMA2[R]	TF	Y

APPROACH / MISSED APPROACH FROM IAF KT003			
Formal Description	**Short description**	**Expected Path Terminator**	**Flyover required**
KT003 at or above 5000ft	KT003[A5000+]	IF	N
To KT004 at or above 3700ft, turn left	KT004[A3700+;L]	TF	N
To KT27E at 3000ft	KT27E[A3000]	TF	N
To RWY27	RWY27[A1041+]	TF	Y
MISSED APPROACH			
Direct to KTMA1 at or above 2000ft, turn right	→ KTMA1[A2000+;R]	DF	N
To KTMA2{HM,R,T318.1, 1min} at or above 3500ft	KTMA2[R]	TF	Y

The review of the IFP (Instrument Flight Procedure) design package has been performed together with PANSA and PILDO. The main outcomes are:

- It has been confirmed the application of the criteria specified in PANS-OPS [7];
- It has been confirmed the data accuracy and integrity;
- The Terrain maps used (Digital Terrain Model from SRTM with 90 m accuracy) are accepted by Polish Authorities;
- The controlled obstacles around the airport were provided by the airport. They were accepted by PANSA for the design.



EUROCONTROL

SBAS FAS Data Block Calculation Prototype

About Disclaimer Help

Welcome, valvarez (victor.alvarez@pildo.com)

Encode Decode Decode File Update Password Update Email Address

Input Data	
Parameters	**Values**
Operation Type	0
SBAS Provider	1
Airport Identifier	EPKT
Runway	27
Runway Direction	0
Approach Performance Designator	0
Route Indicator	
Reference Path Data Selector	0
Reference Path Identifier	E27A
LTP/FTP Latitude	502827.1900N
LTP/FTP Longitude	0190538.6500E
LTP/FTP Height (metres)	343,6
FPAP Latitude	502827.5000N
Delta FPAP Latitude (seconds)	0.3100
FPAP Longitude	0190316.7100E
Delta FPAP Longitude (seconds)	-141.9400
Threshold Crossing Height	15
TCH Units	1
Glidepath Angle (degrees)	3
Course Width (metres)	105
Length Offset (metres)	0
HAL	40
VAL	50

Output Data	
Data Block	10 14 0B 10 05 1B 00 D0 01 37 32 05 6C 43 A9 15 B4 BC 31 08 6C 21 6C 02 00 18 AB FB 2C B1 2C D1 64 00 C8 FA E0 D8 7A F8
Calculated CRC Value	E0D87AF8

Reset Edit Text Report File Download

Version: 2.2.5

Fig. 2. Final Approach Segment datablock input data

The reviewers involved realised that one of the obstacles (ID#79) was not well referenced. This entailed a substantial reduction of the LPV (Localizer Performance with Vertical guidance) minima value. The charts were corrected accordingly prior to the flight trials.

There is a slight deviation of the criteria concerning the position where the FPAP (Flight Path Alignment Point) has been located. In Katowice the ILS localizer (LOC) is located more than 305 meters from THR09. Thus the position of the FPAP should be the one specified in the following Fig. 4.

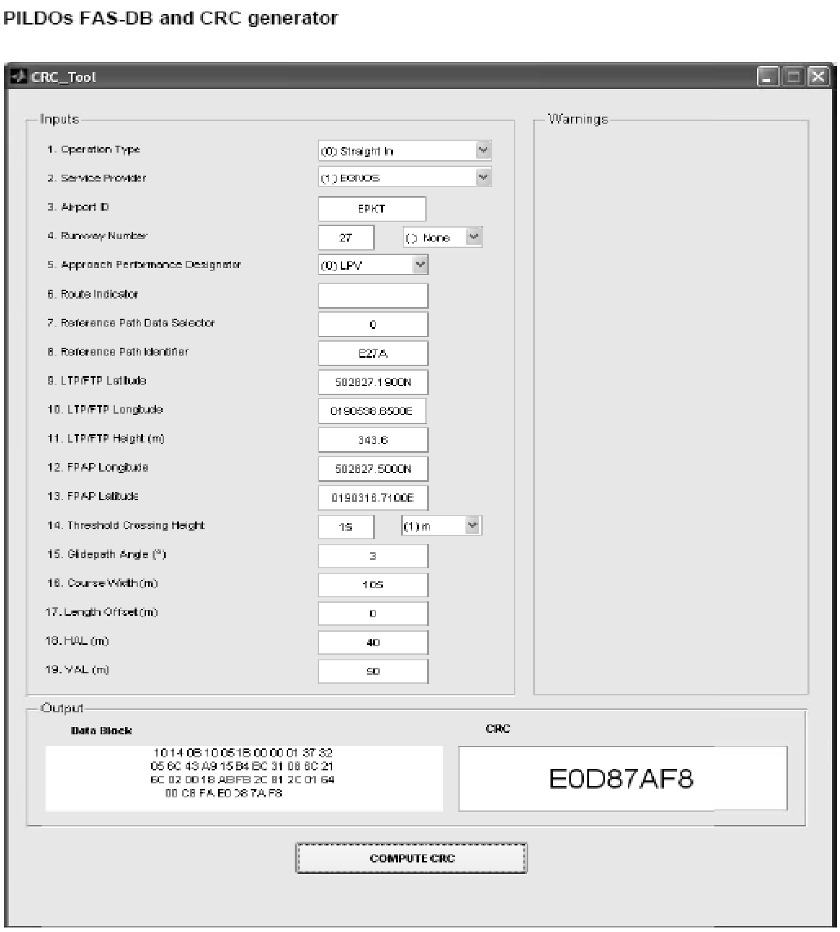


Fig. 3. Procedure chart for EPKT

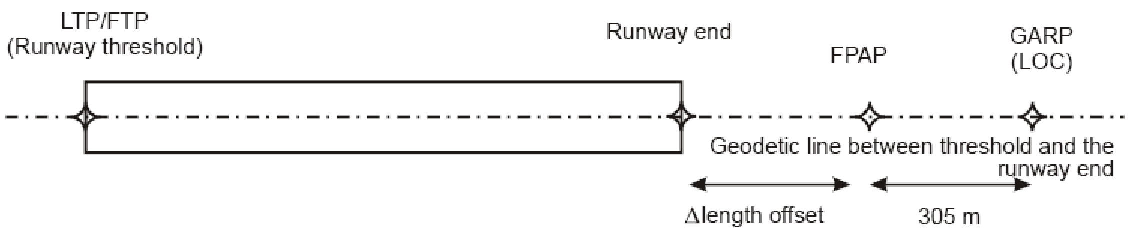


Fig. 4. FPAP location, ILS localizer more than 305 m from the runway end

The codification performed considered that the localizer was located at 305 m. Therefore the FPAP was coded in threshold 09 (THR09) position, being the length offset nil. However, it is not an important issue operationally speaking. The horizontal deviations that the pilot obtains are not exactly the same that the ones that would be obtained flying the existing ILS (Instrumental Landing System) procedure. Fig. 4 shows this small difference.

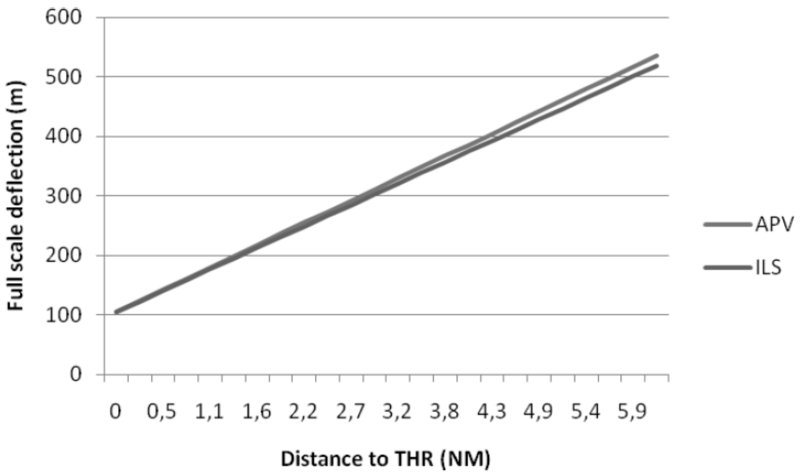


Fig. 5. Difference between the Full Scale Deflection of the ILS with respect to the APV

A Jeppesen coding screenshot is provided in order to validate the coding of the database used in the aircraft. Furthermore, it is provided two screenshots with the results of the CRC (Cyclic Redundancy Check) generation and Final Approach Segment Datablock:

- One using the online application developed by EUROCONTROL;
- Another using the in-house tool developed by PILDO LABS in accordance with DO-229D.

Effective Date: 31-Aug-2010
As Of Date: 31-Aug-2010

Jeppesen
SID/STAR/Terminal Procedure Report for
To Rwy, Sensor not specified - R27
Location: Katowice, Poland

Report Date: 31-Aug-2010
ReportTime: 10:41:13 AM

Area: EEU Apt ID: EPKT Airport: Pyrzowice Airline Code: Arinc Output: No
Term Proc Type: APRRS Term Proc ID: R27 Helicopter: No Level of Service(s): LPV (A), LNAV (A)
Term Proc Climb Gradient:

Route Type: APA Transition Ident: KT002 Transition Req: Transition ICAO: EP GPS: A MSA Ident: MSA Type: MSA ICAO: MSA Same Desig:
Transition Climb Gradient:

Seq	Path Term	Fix Ident	Fix Type	Fix Desc	Fix ICAO	TD	TV	Rec'd Navaid Type	Rec'd Navaid Ident	Theta	RHO	Outbound Course	T/M	Distance Route	Distance Leg	ATC Ind	Precision Alt GS Intcpt	Precision Alt At Fix	NP Alt From Alt	NP Alt To Alt	Trans	Arc Based On Ident	Arc Based On Radius	Dir	RNP	TCH	Speed Limit/ Desc	Vert Angle (minus)
10	IF	KT002	P	E A	EP		N								000.0				+ 5000		BYAT							
20	TF	KT004	P	EE B	EP		N								005.0				+ 3700									

Route Type: APA Transition Ident: KT001 Transition Req: Transition ICAO: EP GPS: A MSA Ident: MSA Type: MSA ICAO: MSA Same Desig:
Transition Climb Gradient:

Seq	Path Term	Fix Ident	Fix Type	Fix Desc	Fix ICAO	TD	TV	Rec'd Navaid Type	Rec'd Navaid Ident	Theta	RHO	Outbound Course	T/M	Distance Route	Distance Leg	ATC Ind	Precision Alt GS Intcpt	Precision Alt At Fix	NP Alt From Alt	NP Alt To Alt	Trans	Arc Based On Ident	Arc Based On Radius	Dir	RNP	TCH	Speed Limit/ Desc	Vert Angle (minus)
10	IF	KT001	P	E A	EP		N								000.0				+ 5000		BYAT							
20	TF	KT004	P	EE B	EP		N								005.0				+ 3700									

Route Type: APA Transition Ident: KT003 Transition Req: Transition ICAO: EP GPS: A MSA Ident: MSA Type: MSA ICAO: MSA Same Desig:
Transition Climb Gradient:

Seq	Path Term	Fix Ident	Fix Type	Fix Desc	Fix ICAO	TD	TV	Rec'd Navaid Type	Rec'd Navaid Ident	Theta	RHO	Outbound Course	T/M	Distance Route	Distance Leg	ATC Ind	Precision Alt GS Intcpt	Precision Alt At Fix	NP Alt From Alt	NP Alt To Alt	Trans	Arc Based On Ident	Arc Based On Radius	Dir	RNP	TCH	Speed Limit/ Desc	Vert Angle (minus)
10	IF	KT003	P	E A	EP		N								000.0				+ 5000		BYAT							
20	TF	KT004	P	EE B	EP		N								005.0				+ 3700									

Route Type: APR Transition Ident: Final Transition Req: Transition ICAO: GPS: A MSA Ident: EPKT MSA Type: A MSA ICAO: EP MSA Same Desig:
Transition Climb Gradient:

Seq	Path Term	Fix Ident	Fix Type	Fix Desc	Fix ICAO	TD	TV	Rec'd Navaid Type	Rec'd Navaid Ident	Theta	RHO	Outbound Course	T/M	Distance Route	Distance Leg	ATC Ind	Precision Alt GS Intcpt	Precision Alt At Fix	NP Alt From Alt	NP Alt To Alt	Trans	Arc Based On Ident	Arc Based On Radius	Dir	RNP	TCH	Speed Limit/ Desc	Vert Angle (minus)
10	IF	KT004	P	E I	EP		N								000.0				+ 3700		BYAT							
20	TF	KT27E	P	E F	EP		N					266.0	M	004.1	004.1				0 3000									
30	TF	27	G	GY M	EP		N					266.0	M	006.1	006.1				0 1041							50		3.00
40	DF	KTMA1	P	E M	EP		N								005.2				+ 2000									
50	TF	KTMA2	P	EY	EP		N								015.0				+ 3500									
60	HM	KTMA2	P	EE H	EP	R	N					314.0	M	1.00T	000.0												- 210	

 Database of Record: JAD Production (DEN) Page 1 of 1

Fig. 6. Jeppesen screenshots

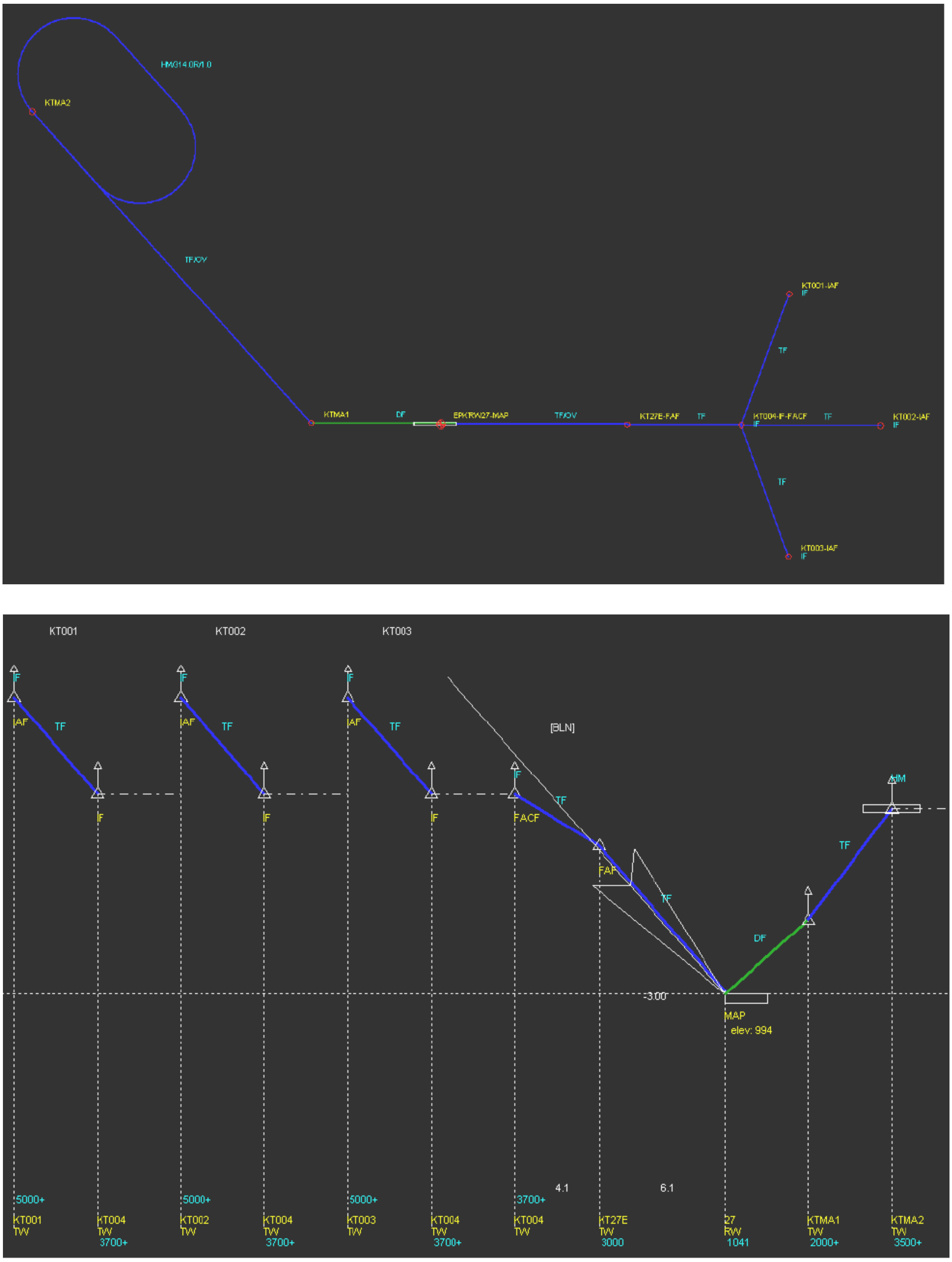


Fig. 7. Jeppesen screenshots

4. CONCLUSION

Intensive scientific and technological progress in aviation raises the need of using simulators in training of pilots and air traffic controllers new RNAV and RNP procedures. Such procedures are recommended by ICAO, as well as EUROCONTROL and EASA. That is why these organizations are working on implementation Performance-Based Navigation. Research project "Support to the EGNOS APV Operational Implementation – APV MIELEC" proved that pre-flight validation of specific types of precision approach at Polish airport is possible. It shows that implementation RNAV GNSS approaches requires:

- geodesic survey of navigation points (also waypoints);
- implementation of NPA at General Aviation airports and aerodromes requires possession of a lights system;
- system of RNAV GNSS approaches must be designed and manufactured by overlines method on the standard radionavigation systems (NDB, ILS).

Nowadays, approach procedures in Poland are designed by PANSA, which are also responsible for include them into Aeronautical Information Publication (AIO Poland).

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