SAFETY ASPECTS OF APPROACH PROCEDURES DESIGN APPLYING THE GNSS

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The graduation thesis "SAFETY ASPECTS OF APPROACH PROCEDURES DESIGN APPLYING THE GNSS" solves current issues of safety aspects at construction of instrument approaches RNAV with using technical GNSS devices. Thesis focuses on standard procedure of non precision approach according to these navigation devices and describes principles of theirs construction. The main aim of thesis is to unify requirements of safety aspects by the construction of approach RNAV GNSS. The end of thesis is dedicated to specific values of safety aspects for procedures based on primary GNSS receiver.

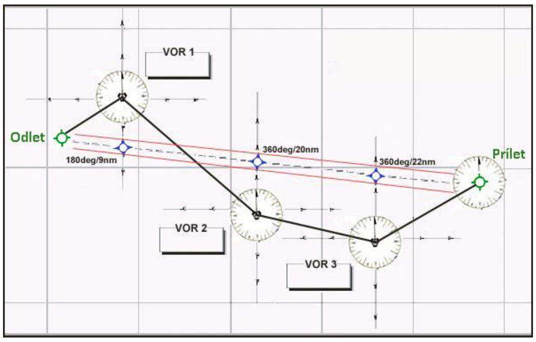
K e y w o r d s: safety aspects, approach, RNAV, GNSS, RNP

1 INTRODUCTION

This thesis deals with the topic of safety aspects of approach procedures design applying GNSS. With technical development satellite navigation systems are affordable, cheaper and they are more accurate than traditional navigation systems. The accuracy reaching levels which could be use for risk phases of flight such as departure and landing procedures. This thesis deals with short history of RNAV system, describes non-precision approach procedures with GNSS, construction and design procedures for approach and safety aspects of this procedures.

2 RNAV

Area navigation (RNAV). Area navigation is a navigation method which allows an aircraft to choose any course within a network of navigation beacons, rather than navigating directly to and from the beacons. This allow flight into airports without conventional navigation add. This method reducing flight distances consequently is reduced fuel consumption.



Img. 1 Area navigation (RNAV)

Global navigation satellite system (GNSS). GNSS is a satellite navigation system with global coverage, Today we have two fully functional systems with global coverage the firs is American GPS and Russian GLONASS. There are many regional satellite systems which could reach the global coverage within 10 years, like Chinese Beidu and European Galileo.

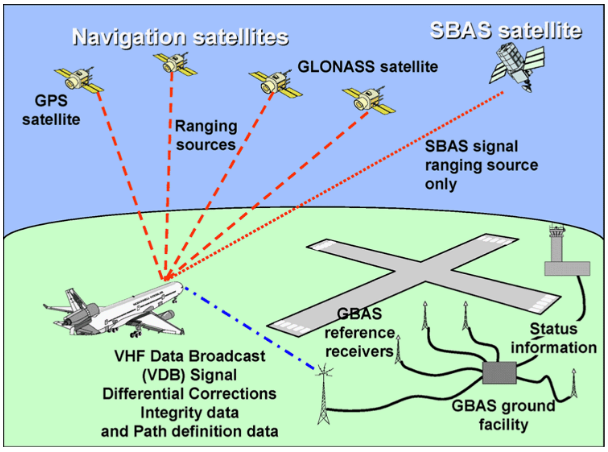
Receiver autonomous integrity monitoring (RAIM). When more satellites are available than needed there will be available more pseudoranges which can allow for this system computing position and find the differs from the expected value.

3 APPROACHES

3.1 RNAV compatible approaches

Types of approaches usable with area navigation (RNAV) are:

- DME/DME
- VOR/DME
- FMS/RNAV
- NPA
- APV Baro
- APV SBAS
- GNSS GBAS



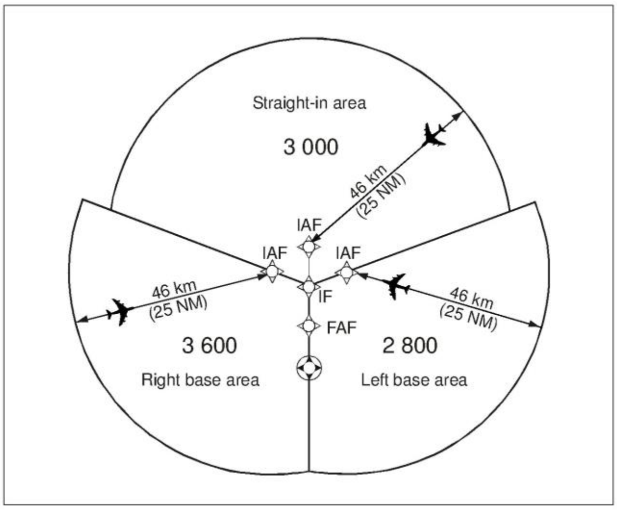
Img. 2 GNSS with GBAS and SBAS

3.2 Non-precision approach – basic GNSS

Non-precision approach based on basic GNSS system is affordable and simple solution for everyone who want to upgrade the plane oportunities. This kind of approach is very similar to traditional a approach. Main differences are in terminology and displayed information in the control unit.

3.3 Construction criteria for RNAV GNSS

Terminal arrival altitude (TAA) – this is the lowest altitude which provide clearance of 300m (1000ft) above all obstacles in an arc of a circle defined by a 46 km (25 NM) radius centred on the initial approach fix (IAF). Where TAA is combined it could be defined as 360 degrees around intermediate fix (IF).



Img. 3 Typical TAA

Initial approach segment

This segment is using to switching en route flight to approach phase of flight. This segment usually starting in IAF and ending in IF.

Intermediate approach segment

The intermediate segment consists of two components:

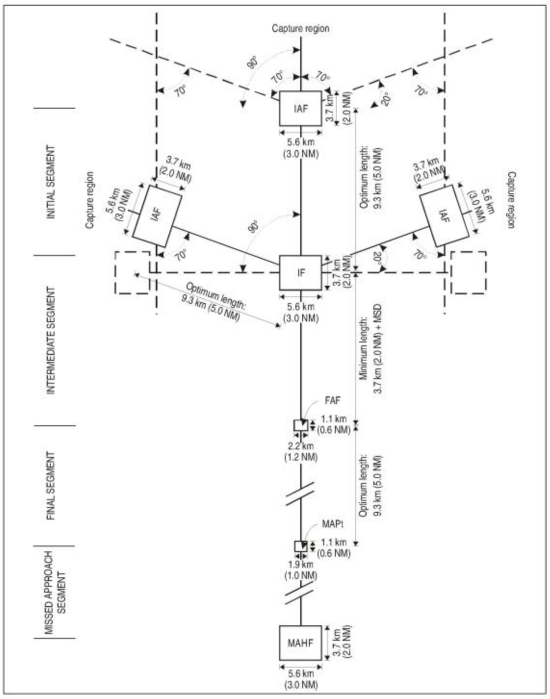
- a turning component abeam the IF
- straight component immediately before the final approach fix (FAF)

Final approach segment

The final approach segment for a GNSS approach will begin at a named waypoint normally located 9.3 km (5.0 NM) from the runway threshold.

Missed approach segment

For basic GNSS receivers, sequencing of the guidance past the MAPt activates transition of the CDI sensitivity and RAIM alert limit to terminal mode (1.9 km (1.0 NM))



Img. 4 Basic GNSS RNAV approach

4 SAFETY ASPECTS OF CONSTRUCTION

It is very important that the safety standards were applied in construction for approach procedures. They providing enough space for eliminate possible errors.

4.1 Categories of aircraft

The most significant factor in aircraft performance is speed. According to this there are five categories of typical aircraft:

- Category A — less than 169 km/h (91 kt) indicated airspeed (IAS)
- Category B — 169 km/h (91 kt) or more but less than 224 km/h (121 kt) IAS
- Category C — 224 km/h (121 kt) or more but less than 261 km/h (141 kt) IAS
- Category D — 261 km/h (141 kt) or more but less than 307 km/h (166 kt) IAS
- Category E — 307 km/h (166 kt) or more but less than 391 km/h (211 kt) IAS
- Category H —"Helicopters".

4.2 Obstacle clearance altitude/height (OCA/H)

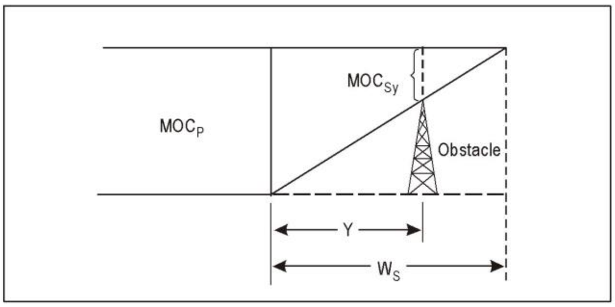
OCA/H is calculated for every approach procedure, according to aircraft category. This information is published on the instrument approach chart.

4.3 Operational minima

In general, minima are developed by adding the effect of a number of operational factors to OCA/H to produce, in the case of precision approaches, decision altitude (DA) or decision height (DH) and, in the case of non-precision approaches, minimum descent altitude (MDA) or minimum descent height (MDH).

4.4 Obstacle clearance (MOC)

Full obstacle clearance is providing in primary area, when the secondary are is available obstacle clearance is reducing linearly from full clearance to zero.



Img. 5 MOC in primary and secondary area

4.5 Radius to fix turn (RF turn)

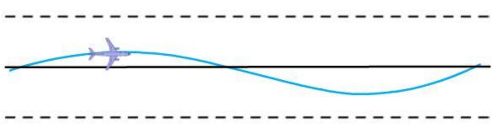
A radius to fix turn is a method for turn construction applicable RNAV with constant radius circular path defined by the:

- tangential point at the end of the turn
- centre of the turn
- turn radius
- XTT value
- buffer value (BV),

4.6 Errors

Flight technical error (FTE)

FTE is the difference between accuracy of real and indicated position of aircraft.



Img. 6 Flight technical error

Path definition error (PDA)

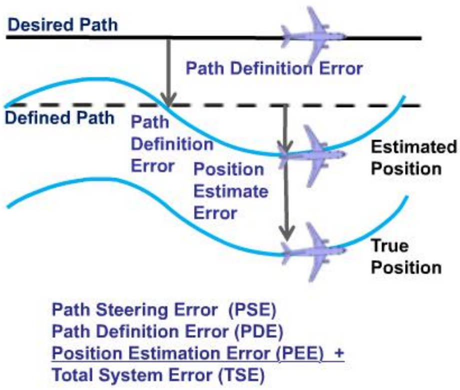
PDA is caused by differences between designer plans and coding procedures.

Path steering error (PSE)

PSE is the sum of display error and flight technical error (FTE)

Position estimate error (PEE)

PEE is the difference between true position and estimated position.



Img. 7 Total system error

4.7 Buffer value

Buffer value is additional design criteria for RNP 4, basic RNP 1, RNP APCH, RNAV 1, RNAV 2 and RNAV 5, based upon the aircraft characteristics (speed, manoeuvrability, etc.) and the phase of flight (pilot reaction time, time of exposure, etc.)

4.8 Cross-track tolerance (XTT), Along-track tolerance (ATT)

ATT is a fix tolerance along the nominal track resulting from the airborne and ground equipment tolerances. XTT is a fix tolerance measured perpendicularly to the nominal track resulting from the airborne and ground equipment tolerances and the flight technical tolerance (FTT).

4.9 Area semi-width (½ A/W)

The ½ A/W of the obstacle clearance area in all RNAV and RNP applications (except RNP AR) is based upon the following:

$$\frac{1}{2} A/W = 1.5 \cdot XTT + BV \qquad (1)$$

5 XTT, ATT, Area semi-width for RNP applications

- RNP 4

En-route/STAR/SID (> 56 km from airport)		
XTT	ATT	½ A/W
7.41 km	5.93 km	14.82 km

- RNAV 5

En-route /STAR/SID (> 56 km from airport)		
XTT	ATT	½ A/W
4.65 km	3.72 km	10.69 km

- Basic RNP 1

STAR/SID (> 56 km from airport)		
XTT	ATT	½ A/W
1.85 km	1.48 km	6.48 km

STAR/SID (< 56 km from airport)		
XTT	ATT	½ A/W
1.85 km	1.48 km	4.63 km

SID (< 28 km from airport)		
XTT	ATT	½ A/W
1.85 km	1.48 km	3.70 km

- RNAV 1 and RNAV 2

Let po trati/STAR/SID (> 56 km od letiska)		
XTT	ATT	½ A/W
3.7 km	2.96 km	9.26 km

STAR/IF/IAF/SID (< 56 km od letiska)		
XTT	ATT	½ A/W
1.85 km	1.48 km	4.63 km

SID (< 28 km od letiska)		
XTT	ATT	½ A/W
1.85 km	1.48 km	3.70 km

5 CONCLUSION

This thesis discusses about safety aspects of RNAV procedures based on basic GNSS. Will help to understand basic terminology for those who wish study this issue. These types of approach could be able to fully replace the conventional methods of navigation in the near future. Safety regulations are very important for reducing risks during the application of approach procedure, and to maintain the reputation of flying as the safest way to travelling.

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