RADIO NAVIGATION SYSTEMS FOR PRECISION APPROACH TO LANDING AT THE AIRPORT SLIAČ

Matej BABULJAK, Milan DŽUNDA, Natália KOTIANOVÁ*
Faculty of Aeronautics, Technical university of Košice, Rampová 7, 041 21 Košice, Slovak Republic
**Corresponding author*. natalia.kotianova@tuke.sk

Summary. In our diploma thesis we have dealt with radio and navigation systems for precision approach for landing at the airport Sliač. In the first chapters we dealt with radio navigation systems used in aviation in general, a description of the approach, precision approach the first category, the procedures approach ICAO maps that are published in Aip SR. In the following chapters we show exact specifications NDB and instrument landing system ILS used at the airport Sliač. In this work we wanted to introduce to the reader the general knowledge of the systems used in air navigation and highlight their irreplaceable function in aviation.

Keywords: Instrument Landing System, VHF Omnidirectional Range, Non Directional Beacon Distance, Measuring Equipment, Aeronautical Information Publication

1. INTRODUCTION

Our diploma thesis is Radio navigation systems for precision approach for landing at the airport Sliač. This topic is a very important issue in the aviation for small, as well as large transport airplanes. That was the reason why in our work we will precisely deal with this issue.

According to the quality of approach we can distinguish: precision approach, non - precision approach, circling and visual approach. In our case, the precision approach devices are: ILS (instrument landing system), MLS (Microwave Landing System) and PAR (Precision Approach Radar). Their advantage is that they provide information to the pilot of the directional and vertical guidance. There are also devices that do not provide an electronic glideslope: VOR (very high frequency omnidirectional radio range), NDB (Non-directional beacon), ILS without GP and surveillance radar SRE (Surveillance radar equipment). At the airport Sliač these devices are located: ILS CAT / T2, VOR / DME, NDB, DME, OM, MM.

2. APPROACH ACCORDING TO THE DEVICES USED IN AVIATION

Visual flight rules (VFR) are a set of regulations under which a pilot operates an aircraft in weather conditions generally clear enough to allow the pilot to see where the aircraft is going. Specifically, the weather must be better than basic VFR weather minima, i.e. in visual meteorological conditions (VMC), as specified in the rules of the relevant aviation authority. The pilot must be able to operate the aircraft with visual reference to the ground, and by visually avoiding obstructions and other aircraft.[1]

2.1. Instrument flight rules (IFR)

It permits an aircraft to operate in instrument meteorological conditions (IMC) in contrast to VFR. IFR flight depends upon flying by reference to instruments in the flight deck, and navigation is accomplished by reference to electronic signals.[1]

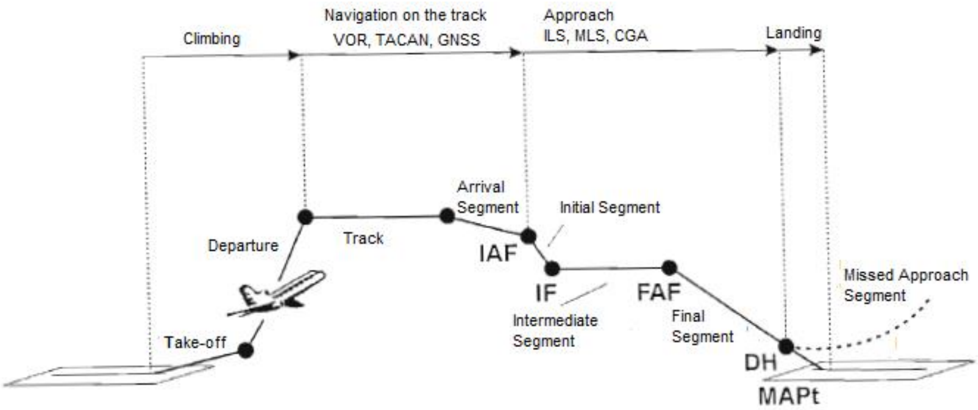

Figure 1 Approach Segments [2]

Where: IAF – Initial approach fix, IF – Intermediate fix, FAF – Final approach fix, DH/DA – Decision hight/Decision altitude, MAPt – Missed approach point

3. CATEGORIES OF APPROACH AND LANDING

Pilot has to know his radio navigational flight position. The more precious navigational devices are the more precious position of the plane is given for the pilot. Different types of instrument approaches are given by the quality of instrument equipment. We distinguish four types of approach in civil aviation:

a) Precision Approach
b) Non – Precision Approach
c) Circling Approach
d) Visual Approach [2]

4. AERODROME GEOGRAPHICAL AND ADMINISTRATIVE DATA OF SLIAČ AIRPORT

Table 1 The main characteristics of Sliač airport [3]

Geographical position (Lat/Long)	483817.094N 0190802.834E On the axis of THR RWY 18/36, 1 200 m THR RWY 36.
Elevation / Reference temperature	318 m/ 26,8 ℃
Magnetic variation (date) / annual change	3.9167 dg (2010)/ 0,09
Observed flight rules	IFR VFR
ICAO code	LZSL
IATA code	SLD
Organisation	Letisko Sliač, a.s.
Operational hours	TIMSH
Time Zone	UTC+1
City	Sliač
Direction and distance from city	315 ˚, 3,5 km from the spa building Sliač – bath house.

Figure 2 Building Sliač airport[4]

5. APPROACH AND LANDING OPERATIONS USING INSTRUMENT APPROACH PROCERUDES

Instrument approach and landing operations are classified as follow:

- Non-precision approach and landing operations. An instrument approach and landing which utilizes lateral guidance but does not utilize vertical guidance.
- Approach and landing operations with vertical guidance. An instrument approach and landing which utilizes lateral and vertical guidance but does not meet the requirements established for precision approach and landing operations.
- Precision approach and landing operations. An instrument approach and landing using precision lateral and vertical guidance with minima as determined by the category of operation. [5]

Lateral and vertical guidance refers to the guidance provided either by:

a) a ground-based navigation aid; or

b) computer generated navigation data.

Categories of precision approach and landing operations:

- Category I (CAT I) operation. A precision instrument approach and landing with:

a) a decision height not lower than 60 m (200 ft); and

b) with either a visibility not less than 800 m or a runway visual range not less than 550 m.

- Category II (CAT II) operation. A precision instrument approach and landing with:

a) a decision height lower than 60 m (200 ft), but not lower than 30 m (100 ft); and

b) a runway visual range not less than 300 m.

- Category III A (CAT III A) operation. A precision instrument approach and landing with:

a) a decision height lower than 30 m (100 ft) or no decision height; and

b) a runway visual range not less than 175 m.

- Category III B (CAT III B) operation. A precision instrument approach and landing with:

a) a decision height lower than 15 m (50 ft), or no decision height; and

b) a runway visual range less than 175 m but not less than 50 m.

- Category IIIC (CAT IIIC) operation. A precision instrument approach and landing with no decision height and no runway visual range limitations.[5]

6. SYSTEM DESCRIPTION ILS

Instrument Landing System (ILS) is the international standard system for approach and landing guidance for more than 40 years up till now. ILS was adopted by ICAO (International Civil Aviation Organization) in 1947. Because of the worldwide-adopted ICAO's performance specifications, any ILS-equipped aircraft can expect satisfactory operation from the system at any airport equipped with an ILS installation.[6]

A complete Instrument Landing System comprises:

• A LOCALIZER system, producing a radio course to furnish lateral guidance to the airport runway.
• A GLIDE PATH system, producing a radio course to furnish vertical guidance down the correct descent angle to the runway.
• MARKER BEACONS, to provide accurate radio fixes along the approach course.
• DME (Distance Measuring Equipment) to provide a continuous reading of the distance.

The layout of a typical ILS airport installation is shown below.[5]

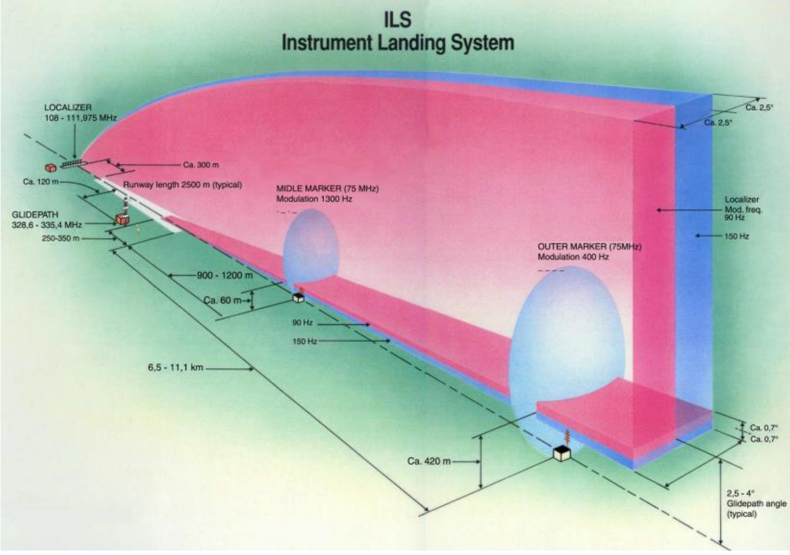

Figure 3 Description ILS (Instrument Landing System).[6]

6.1. Localizer

The antenna array of the ILS localizer transmitter is located on the extension of the centre line of the instrument runway of an airfield, but is located far enough from the stop end of the runway to prevent it being a collision hazard. The Localizer (LLZ/LOC), which provides lateral guidance, produces a course formed by the intersection of two antenna radiation patterns of equal amplitudes. One pattern is modulated by 90 Hz and the other by 150 Hz. The "course" is the vertical plane where the 90 Hz and 150 Hz modulations are equal. The signals received by the airborne receiver will produce a "fly right" indication for the pilot when the aircraft is to the left of the course in the predominately 90 Hz region. Similarly, a "fly left" indication will be produced for the pilot on the opposite side of the course in the predominately 150 Hz region. The system also furnishes information outside the front course area in the form of full fly-left or full flyright indications (CLEARANCE).
All localizer installations transmit a station identification (Ident) in Morse code at periodic intervals. This is a 1020 Hz tone that is keyed to form the basic station identifier. The localizer is designed to provide a signal at a minimum distance of 25 nautical miles (46.3km) within +/-10 degrees, and at a minimum distance of 17 nautical miles (31.5km) between +/- 10 and +/- 35 degrees from the front course line.[2][7]

6.2. Glide Path

The Glide Path (GP/GS) produces two amplitude modulated radiation patterns in the vertical plane, which intercept at the descent angle, namely the glide path angle. Below the 150 Hz predominates giving a "fly up" indication. Above the glide path angle a "fly down" indication will be produced by the 90 Hz predominance. The GP is sited about 300 m behind the runway threshold to give the 15 to

18 m threshold crossing height. The glide path angle is about 3.0°. To shape the glide path signal, ground plane reflection from an area in front of the antenna array is necessary. The glide path site may be located on either side of the runway, but the most reliable operation will be obtained if the site is selected on terrain least obstructed by taxiways, aircraft holding aprons, parking ramps, buildings, power lines etc. The site should offer the widest area of smooth ground with possibilities of levelling without excessive physical or economical effort, if indeed levelling is deemed necessary.
The glide path antenna system should be located at a distance of 75-200 m from the runway centre line. The distance from the runway threshold is a function of several factors upon which establishment of the optimum operational conditions depend.[2][7]

These factors are:
1. The glide path angle.
2. Threshold crossing height requirements.
3. Obstruction clearance requirements
4. The slope of the terrain in front of the antenna system.
5. The extent of smooth terrain in the site area and beyond the threshold.

6.3. Marker Beacons

The marker beacon (MB) system comprises two or three beacons, with fan-shaped vertical radiation patterns. The function of the "outer marker" located 4 to 7 nautical miles from the runway threshold is normally to signal the start of the descent.[2][7]

7. FUNCTIONAL ANALYSIS OF ILS APPROACH AND LANDING

An ILS procedure begins with the transition from en route flight to final approach. This may be accomplished by departing from the last VHF Omni Range (VOR) navigation station of the en route flight on a radial that will intercept the localizer course approximately 7 to 10 nautical miles from the runway. The aircraft intercepts the localizer course in level flight at an altitude (specified by the approach plate of the pilot's flight manual) and distance that place the aircraft below the glide path. This allows the pilot to become stabilized on the localizer course before starting descent. The pilot continues level flight although the glide path indicator reads full-scale fly-up. As the aircraft intercepts the glide path sector, the indicator starts to move towards centre, and the pilot then makes the necessary power and trim adjustments to give a rate of descent consistent with the glide path angle. As he reaches the centre of the glide path, he receives the aural keying and visual flashing of the 75 MHz Outer Marker beacons. The approach plate indicates the proper altitude at which the glide path intercepts the outer marker for the specific facility being used. If he notes any significant deviation from the published value, before starting his decent he must determine whether an improper altimeter setting or a malfunction of some parts of the system causes the discrepancy. With a normal interception he is assured at this point that the key elements are working properly and he can safely begin his descent. An important check at this stage, or even earlier, is to positively identify the localizer by listening to the transmitted Morse-code ident. Descent from the Outer Marker involves keeping both Localizer and Glide path indicators centred by making small changes in heading and in rate of descent. Wind shear and turbulence during descent can cause deviations that must be corrected. If the approach is being made to Category I weather minima (which can be down to 60 meters above airport level with 800 meters Runway Visual Range at a fully equipped airport), the pilot must have in view an element of the approach lights, runway lights or markings by the time he reaches his minima descent altitude. If he reaches this decision height and does not have adequate visual reference, he must abort the approach and execute a missed-approach procedure. This usually involves a climb-out to a navigational fix where Air Traffic Control (ATC) can instruct him further. With the ground in sight the pilot continues his rate of descent until reaching a height of about 20 meters above runway elevation, he then slows his rate of descent so that he will further approach the runway on an exponential flight path. The touchdown should be near the runway centreline and at a suitable longitudinal distance beyond the point where the glide path intersects the runway. This distance varies with the performance characteristics of the aircraft. The final portion of the landing begins with touchdown and ends with the deceleration of the aircraft to taxi speed or when the aircraft turns off the runway to enter a taxiway.[2]

8. OTHER RADIO NAVIGATION SYSTEMS AT THE AIEPORT SLIAČ

The Navigation Radio Beacon Transmitter of the type NAVYRA – M is determined for use as the en route and approach navigation non-directional radio beacon (NDB) to allow the landing procedure in the radio navigational system of the air force. This navigation system may fully replace the presently used NDBs that are used in the Air Force of Slovak Republic Armed Forces (TDV-60, TDV-100). The radio beacon design is suitable for both the stationary and the mobile use. The system may be controlled locally or remotely to different distances according to the need by help of the used modems.[8]

The NAVYRA-M equipment has been developed as a modernized full alternative to replace the present radio beacons that are in service in the air force of Army of SR with the objective to increase the operating comfort, quality and stability of the operating parameters. This radio beacon has been designed on the basis of the most advanced design components available from the world's famous producers and the technologies that meet the demanding requirements for use in the air navigation. The equipment is designed for the use both in the armed forces and the civil aviation and meets the requirements of the ICAO International Standards. Its operating properties are comparable with the equivalent equipment that is used in the NATO armed forces.[8]

The VHF Ommi – directional Range (VOR) was adopted as the standard short range navigation aid in 1960 by ICAO. It produces 360 radials/tracks at 1˚spacing which are aligned in relation to magnetic north at the VOR location. It is practically free from static interference and is not affected by sky-waves, which enables it to be used day and night. When the VOR frequency is paired with a co – located Distance Measuring Equipment (DME) an instantaneous range and bearing (Rho – Theta) fix is obtained. The equipment operates within the frequency range of 108 – 117,95 MHz.

Radio beacons in the past contributed mainly to increase safety in civil aviation pilots and facilitate navigation. Today, these devices are obsolete, their actual operation and maintenance are costly, for this reason, in some countries their replacement has already started.[5][6]

In detail, we mainly dealt with ILS equipment used at the airport Sliač, because our aim was to specify it precisely. It is the precision approach device for landing. The main advantage of this device is that it continuously provides information of the vertical and horizontal position of the plane for the flight crew, which is very important especially in the final phase of the flight.

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