Non Directional Beacons Checking

Ján Pitor, Filip Škultéty, Karol Götz [1]

[1]Air transport department, Faculty of Operation and Economics of Transport and Communications, University of Žilina, 010 26 Žilina, Slovak republic

Abstract This paper aims to familiarize experts from other fields with issues of flight check of Non Directional Beacon (NDB) and its assessment. The AT-940 Automatic Flight Inspection System and the aircraft PIPER SENECA are described followed by flight check specifications and procedures. Evaluated were the coverage of NDB Z, NDB ZLA located at Žilina airport and Standard Instrument Approach Procedure for runway 06. The results of evaluation are in paragraph 4. The paper is based on project "Centre of excellence for Air Transport" focused on the impact of air transport on environment photogrammetry, surveillance of electromagnetic compatibility of radio navigation aids and radio communication equipment.

Keywords checking, surveillance, radio navigation aids, radio communication equipment environment, photogrammetry.

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1. Introduction

This paper describes one of the results of scientific research project "Centre of excellence for Air Transport -ITMS 26220120065" focused on the impact of air transport on environment, photogrammetry, surveillance of electromagnetic compatibility of radio navigation aids and radio communication equipment.

The aim of the paper is, apart from the project results and gained knowledge dissemination, to familiarize experts from other fields with issues of procedures for the flight check of communications, navigation and surveillance systems (CNS).

This paper concentrates on flight check of NDBs located at Žilina airport.

2. The AT-940 automatic flight inspection system

The AT-940 Automatic Flight Inspection System is a computer based, fully automatic flight inspection system used for testing, calibration and certification of ground based navigation aids. [1]

The AT-940 has the following capabilities:

- ILS Categories I, II and III
- VOR
- DME
- NDB
- 75 MHz Marker Beacon
- VHF Communications

The AT-940 consists of four primary components (see Figures 1-4)

Figure 1. Signal Processing Unit (SPU)

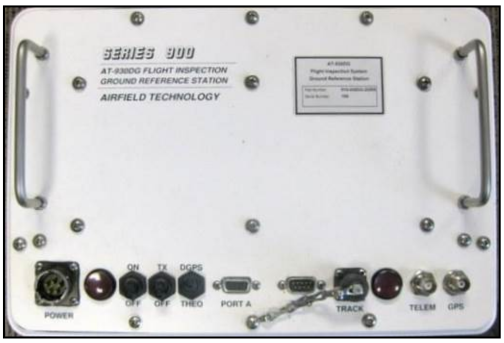

Figure 2. Ground Reference Station (GRS)

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Figure 3. Avionics Sensor Unit (ASU)

Figure 4. Host Computer

The AT-940 airborne equipment consists of the SPU, ASU and associated cables, aircraft antennae and accessories. The AT-940 can operate either in single or dual ASU modes. The airborne equipment receives the radio signals from the navigation aid being inspected and extracts the flight inspection parameters from the receivers for the selected mode of operation. It also receives the GPS corrections being sent from the GRS, and uses this data with its own internal GPS receiver to accurately determine the position of the aircraft antenna. All of this data is then transmitted to a portable computer or "host" either locally through a serial port or to the ground via a telemetry link.

The AT-940 airborne equipment is installed in the aircraft in the compartment behind the rear seats of the aircraft. The AT-940 ground equipment consists of the GRS and associated cables, antennae and accessories. The GRS contains a telemetry transmitter and dual frequency GPS receiver. The GRS is set-up at a known location on an airfield, and provides GPS differential corrections for the airborne GPS receiver over a radio telemetry link.

The host computer records and displays the real time flight inspection data in both graphical and numerical formats on a high resolution colour display. After a flight inspection measurement is completed, the recorded data is saved to the host computers internal hard disk drive. Each measurement is archived as an independent disk file. The computer performs an automatic analysis of common parameters and presents the results on the screen.

When a hard copy is required, recordings may be printed on a portable printer. Previously recorded data may also be displayed and printed for comparison purposes.

2.1. Aircraft's installation

The AT-940 Automatic Flight Inspection System is installed at the airplane **PIPER PA34-220T SENECA** Reg./ MSN: OM-UTC / 3449443. [2]

Figure 5. PIPER PA34-220T Seneca V

PA-34-220T is a twin-engine, piston powered airplane with low-mounted wings and retractable landing gear.
Standard data:

- Gross weight. 2165 kg
- Empty weight. 1548 kg
- Fuel capacity 362 l
- Engines 2x220-hp turbocharged TSIO-360-RB

Performance:

- Top Cruise 197 kts
- Stall 61 kts
- Initial climb rate 1,550 feet per minute
- Ceiling 25,000 feet
- Range 730-820 nautical miles
- Take-off distance 1,707 feet
- Landing distance 2,180 feet

3. Non directional beacons checking

A Non directional Beacon is a low or medium frequency radio beacon that operates in the frequency range 190 to 1,750 kilohertz (kHz). A radio beacon used in conjunction with an Instrument Landing System marker is called a Compass Locator. [3]

3.1. Flight check specifications

Coverage Orbit. Coverage must be evaluated by flying an orbit with the radius equal to the area of intended use.

Standard Instrument Approach Procedure (SIAP). Altitudes flown must be the minimum proposed or published for the segment evaluated, except that the final segment must be flown to 100 ft below the lowest published Minimum descent altitude (MDA).

3.2. Flight check procedures

The primary objectives of flight check are to determine the coverage and quality of the guidance provided by the NDB system and to check for interference from other stations.

These assessments are to be made in all areas where coverage is required and with all operational procedures designed for the NDB, in order to determine the usability of the facility and to ensure that it meets the operational requirements for which it was installed. [4, 5]

Coverage Orbit. Standard service volume coverage is evaluated by flying orbits at the lowest coverage altitude. Facility Maintenance determines the reduced power output of the facility during coverage checks. At facilities where dual transmitters are installed, facility coverage for maximum useable distance may be evaluated by alternating transmitters.

Manoeuvring. Fly an orbit about the facility at the maximum distance specified by the facility classification. The orbit altitude must be 1,500 ft above facility site elevation, or the minimum altitude which will provide 1,000 (2,000 ft in designated mountainous areas) above intervening terrain or obstacles, whichever is higher as determined by map study. Coverage orbits are usually completed counterclockwise, as the ADF navigation needle parks to the right if the signal has an unlock (this is true for mechanical instruments; however, the needle may disappear on electronic displays). Sectors found out of tolerance must be evaluated using orbits at reduced distances or increased altitudes in an attempt to determine facility restrictions. Monitor the facility identification during coverage checks, as the loss of the identifier usually corresponds with the loss of the NDB signal.

Standard Instrument Approach Procedure

Manoeuvring - Periodic Checks. Required coverage evaluations during periodic checks are limited to surveillance checks of any airways, routes or transitions to the extent the aircraft is manoeuvred to position for other required checks, as well as all SIAP final approach segments. For SIAP(s) with a Final Approach Fix (FAF), cross the FAF at the minimum published altitude and descend to at least 100 feet below the minimum descent altitude for that segment. For SIAP(s) without a FAF, fly the final segment from the procedure turn distance at the minimum published procedure turn completion altitude and descend to at least 100 feet below the minimum descent altitude for that segment. In addition, descend to 100 feet below all step-down fix altitudes inside the FAF.

4. The results of evaluation

There are two NDBs at Žilina aerodrome (Z and ZLA, see Figure 6 to 8). Their coverage and Standard Instrument Approach Procedure were evaluated using Seneca aircraft equipped with The AT-940 Automatic Flight Inspection System.
The following flight checks were executed:

- coverage orbit of NDB ZLA, manoeuvring depicted in Figure 6, the results depicted in Figure 9,

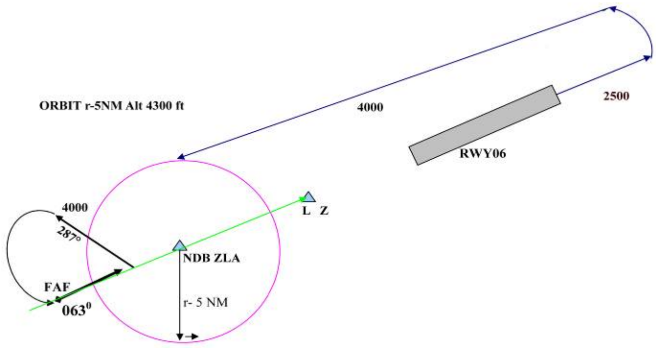

Figure 6. Coverage orbit of NDB ZLA

- coverage orbit of NDB Z, manoeuvring depicted in Fig. 7, the results are in Fig. 10,

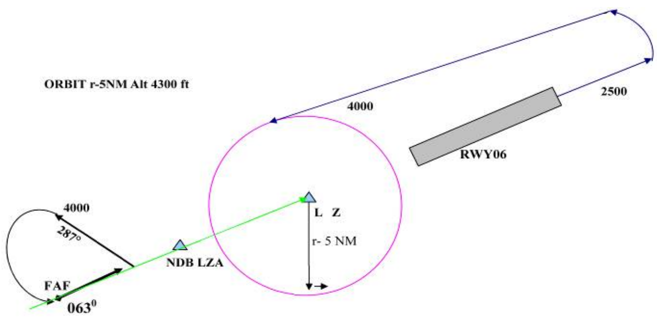

Figure 7. Coverage orbit of NDB Z

- SIAP RWY 06, checked navaids NDB Z and ZLA, manoeuvring depicted in Figure 8, the results depicted in Figs. 11 and 12,

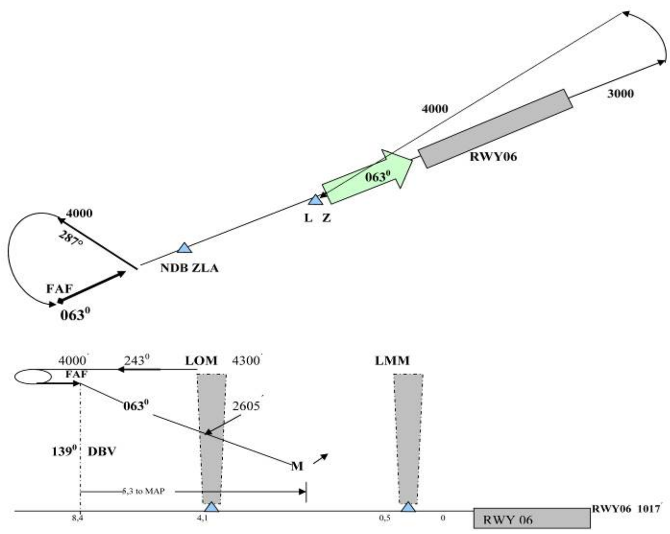

Figure 8. SIAP RWY

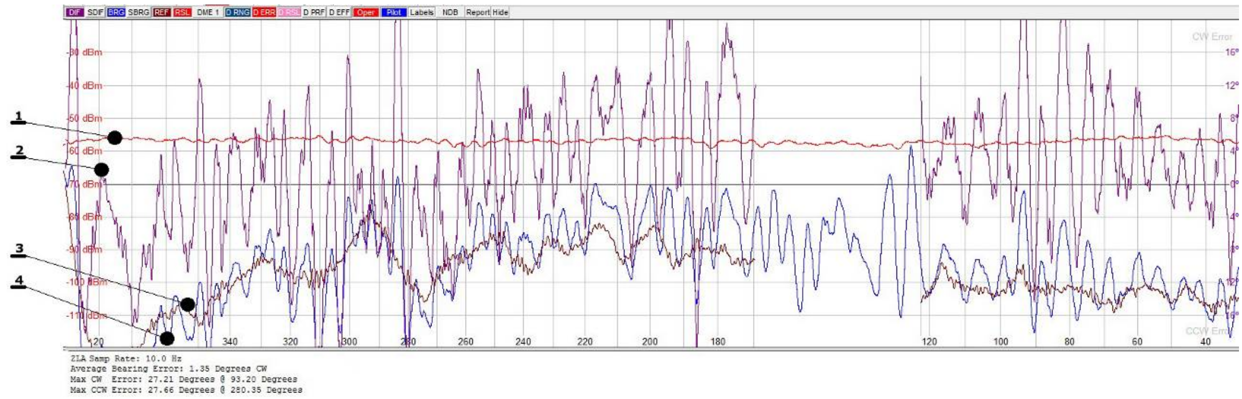

Figure 9. Results of coverage orbit of NDB ZLA

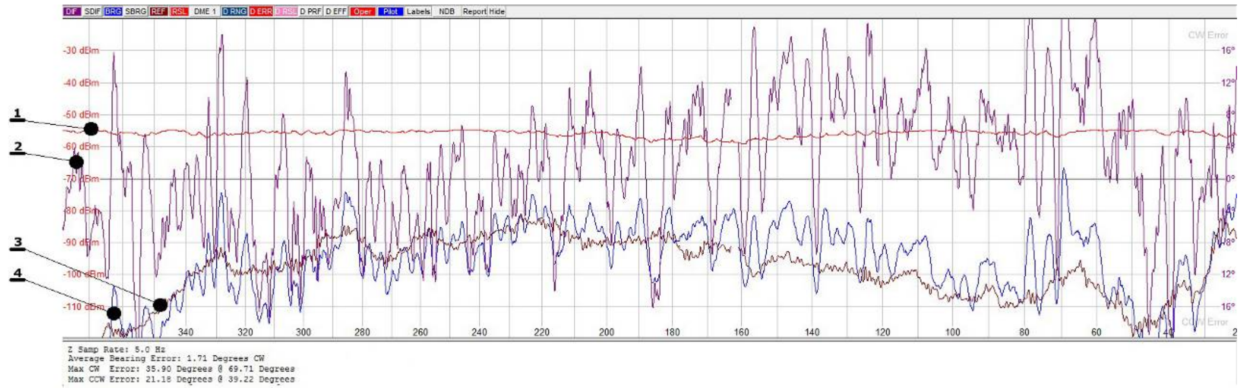

Figure 10. Results of coverage orbit of NDB Z

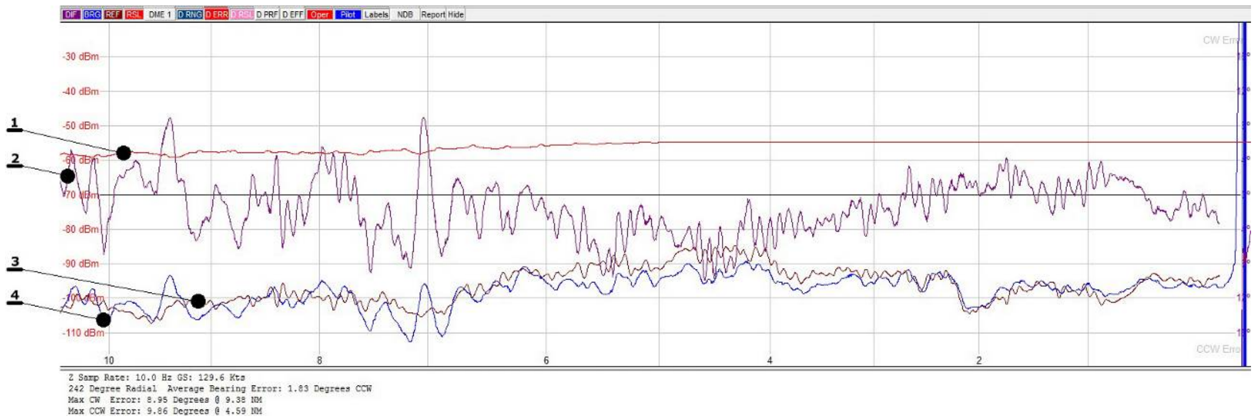

Figure 11. Results of SIAP RWY 06 for NDB Z

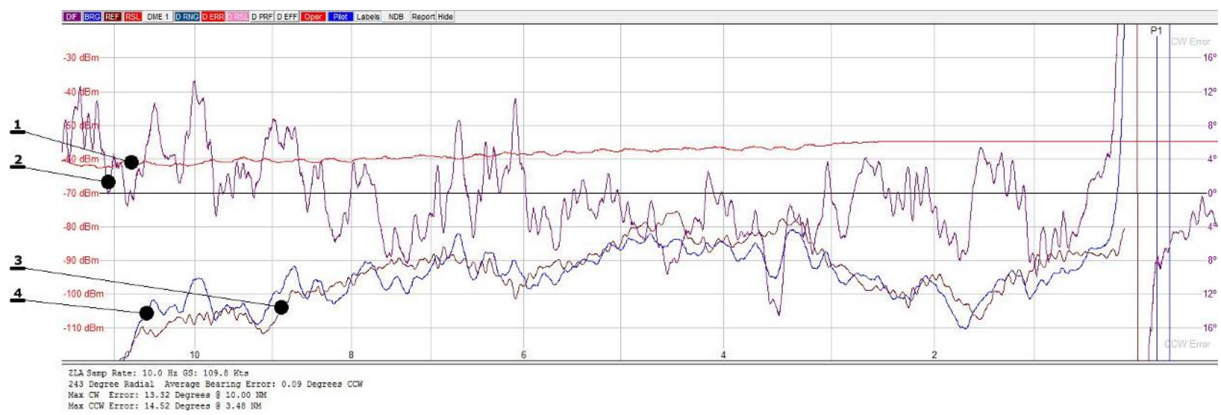

Figure 12. Results of SIAP RWY 06 for NDB ZLA

The legend

1. Received signal level
2. Difference between bearing to NDB (reference value) and measured bearing to NDB,
3. GPS reference (reference value),
4. Measured bearing to NDB.

5. Conclusions

The coverage and Standard Instrument Approach Procedure were evaluated during four flight checks using Seneca aircraft equipped with The AT-940 Automatic Flight Inspection System. The results are not mandatory for Air navigation services provider because they are product of research and development. The University of Žilina is not certified to perform flight checking, The Centre of excellence project is oriented on both the research and development. Such projects are necessary to build information and communication equipment of university laboratories and CNS facilities evaluating system for experimental verification of new knowledge and technology.

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