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Flight inspection of aircraft at the University of Zilina

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ABSTRACT
This paper attempts to offer the reader a consistent overview of the flight inspection in the Slovak Republic and the centre of excellence of aviation at the University of Zilina. For the flight inspection, special items have to be taken into consideration when selecting the tested aircraft.

KEYWORDS: accuracy, aircrafts, air transport, flight inspections, ICAO, CNS, ATM safety

1. Introduction to flight inspection

The Aviation System Standards must identify specific requirements based on their operational needs. Appropriately equipped aircraft and helicopters, from service providers or other sources, may be used when required to complete flight inspection requirements. The general characteristics of a flight inspection aircraft should be as follows:

- Equipped for night and instrument flight.
- Sufficient capacity for a flight inspection crew, observers, ground maintenance and/or installation personnel, and required electronic equipment with spares.
- Sufficient range and endurance for a normal mission without reservicing.
- Aerodynamically stable throughout the speed range.
- Low noise and vibration level.
- Adequate and stable electrical system capable of operating the required electronic and recording equipment and other aircraft equipment.
- Wide speed and altitude range to allow the conduct of flight inspections under normal conditions as encountered by the users.
- Appropriate for modifications for flight inspection of new and improved navigation services.

For the flight inspection, special items have to be considered when selecting a test aircraft. The aircraft must have a cabin size where all the equipment can be installed as well as have seats for the inspection personnel that can be easily adjusted. Besides the normal inspection equipment, one has to take into consideration that the systems and the cabin need air conditioning and sufficient electrical power. Certain hot regions, such as the Middle East, require more power for cooling. This causes that generators are required with sufficient electrical power both at 115 Volt AC, 400 Hz and for various DC power supplies (12V, 24V). Additionally, standby power equipment has to be installed in order to make it feasible to shut down the inspection system or to terminate the flight inspection at a defined point if the normal power breaks down.

Another point of concern for the system development is the aircraft skin, because a lot of antennas have to be mounted outside the aircraft and these must not be influenced by each other. The cable channels for the antenna cable, as well as the power and signal cables, have to be separated sufficiently. This normally implies a total separation of aircraft basic instrumentation and flight test instrumentation, which cannot be done completely because some receiver antennas cannot be mounted twice on the aircraft. The aircraft engines may influence the antennas, computers, or other flight

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inspection instrumentation in terms of both electromagnetic interference and vibration. The aircraft itself must be able to reach altitudes up to 10,000 feet at undetermined velocities.

The operation in extreme weather conditions is normally not a basis for selecting an aircraft, but inspecting radio navigation systems in countries near the equator or in very hot and moist or humid areas need special equipment; including, for example, water for the inspection personnel. In the arctic zone, the equipment must work under very cold weather conditions.

Different types of flight inspections – a periodic inspection, site evaluation, commissioning, reconfiguration – have naturally different requirements for the aircraft type and workload. In addition, the type of radio navigation system that has to be checked determines the type of equipment required onboard the aircraft. The number of radio navigation systems that must be flight inspected for a country is another decision basis on which to select one or more aircraft for the flight inspection. As noted previously, some countries do not have their own flight inspection aircraft and crew. These countries have agreements with, for example, the United States to perform the flight inspection. The next table shows the types of aircraft used for flight inspection in different countries.

This is only a small list of countries and aircraft used for flight inspection.

2. Flight inspection in Europe

The flight inspection work is a governmental job. Therefore, each country tries to form a unique flight inspection group. However, some of the countries are very small and have only a few installed radio navigation aids. Each state has its own policy for the flight inspection. As examples, a short description of the flight inspection in Great Britain and Germany follows.

Table 1. Types of aircraft in different countries

Country	Type of aircraft
United States	Convair 580, Sabreliner 80, Sabreliner 40, Beechcraft F-90, Beechcraft BE-300, British Aerospace BAe-125-800.
France	ATR 42
United Kingdom	HS 748 Series 2A Model 238
Netherlands	Fairchild Metro II
Germany	Beechcraft Super King Air 350
Slovak Republic	Let L-410 UVP-E

Source: [own work]

2.1. The Flight Inspection in the United Kingdom

In Great Britain, as in most other countries, the flight inspection is split into military and civil parts. The military flight inspection group is in Boscombe Down near Salisbury. They only test the military radio navigation systems, ground installations, and aircraft systems. For the inspection and testing work they use special equipment adapted to the required accuracy. All military aircraft are cleared to CAT III ILS. For the future landing system, the MLS and DGPS systems would be tested. The main interest for the military groups is the TACAN radio navigation systems because they are also used for tanker aircraft. For this usage the electromagnetic influences have been evaluated and removed. As described for the French military inspection group, in Great Britain also the carriers must be flight inspected.

The civil flight inspection group has its base at Teesside airport and is named CAA (Civil Aviation Authority). Since 1992 this group has been the only civil organization approved to carry out flight tests on radio navigation aids in the United Kingdom.

Presently the CAA delivers their service to each customer needing flight inspection. The CAA uses two HS 748 Series 2A Model 238 turboprop flight calibration aircraft. The inspection equipment was defined by the CAA itself in 1969 and the first redefinition took place in 1987. In 1990 the new system has started working and uses a Hewlett Packard HP9000 computer for the calculation work. A console and a graphical display are the main input and output devices for the system together with a printer, an optical disk, and a 32-channel analogue recorder. The radio navigation receivers transmit their data to the main computer via an RDE (remote data exchange) and a CDE (central data exchange). Each RDE can collect 52 parameters in parallel with the aircraft equipment. Additional radio navigation receivers are installed for the inspection system. Because the general aviation uses mainly two different ILSNOR receivers (BENDIX RNA 3 AF and COLLINS S /RV4), these receivers are also installed in the inspection aircraft to evaluate possible differences between these receivers. The inspection aircraft is also equipped with all other radio navigation receivers as well as with two MLS receivers. For MLS inspection a BENDIX ML301 receiver is installed. The reason for installing a MARCONI CMA2000 receiver relates to special problems during the inspection of the London City Airport.

To calculate a high accuracy flight path, an infrared tracking system MINILIR has to be installed at the inspected airfield. With this radar and a link to the onboard system, the position-fixing equipment can fix the position to within 23 cm and 0.003 degrees of angular displacement. They can also simulate all inspection flights on their ground system, which is equal to the airborne inspection system. Therefore special effects and errors can be analysed on ground.[1]

The CAA has checked ILS, VOR, DVOR, DME, MLS, DMLS, MADGE, TACAN, NDB, SSR, MSSR, SRA, ADSEL, and DABS. Naturally they are also involved in the use and inspection of GPS and DGPS. In the UK, the ILS has to be flight inspected twice a year and about 52 DME and VOR stations must be flight inspected as well. The CAA does the flight inspection for the UK and Ireland.

The following organisations are approved by the CAA to provide Flight Inspection in the UK.

- Cobham Flight Inspection Ltd
- Flight Calibration Services Ltd

Cobham Flight Inspection Ltd are approved to flight inspect the following navigation facilities:

- Instrument Landing Systems (ILS) CAT I, CAT II and CAT III
- Microwave Landing Systems (MLS)
- Distance Measuring Equipment (DME)
- VHF Marker Beacons
- Non-Directional Beacons

Flight Calibration Services Ltd are approved to flight inspect the following navigation facilities:

- Instrument Landing Systems (ILS) CAT I with a nominal Glide-path Angle between 3 and 3.6 degrees.
- Distance Measuring Equipment.

2.2. German Flight Inspection

Until 1993 the German civil flight inspection service was done by the GmFS at the German Air Force field at Lechfeld. In March 1993 a future flight inspection organization was presented to the DFS (Deutsche Flugsicherung), and in 1994 the new DFMG (Deutsche Flugmessgesellschaft) was founded. This private company is a Joint Venture between the DFS and AERODATA. The aim for this cooperation was to reduce the costs of flight inspection in Germany and to increase the efficiency.

The operating base for the flight inspection company changes from Lechfeld to Braunschweig where the AERODATA, the German Federal Aviation Authority, a pilot pool, and 24-hour service of a relatively small – but efficiently operated – airport are situated. The aircraft type changed from a HS748 to a King Air 350. In 1995, the new flight inspection system (FIS) produced by AERODATA, and using GPS as a reference system, was installed into the two King Air aircraft. The instrumentation and installation of the flight inspection system as well as the procedures for flight inspection were changed to improve the efficiency and accuracy of the whole system.

In 1996, preparations for the certification according to ISO 9001 began with the objective to optimise the processes of the DFMG and, if required, to make them transparent to certification authorities and customers. The work began with

- an analysis of the actual situation,
- the development of a quality management handbook,
- a benchmarking process.

These initial activities were to be completed in 1998. A completely new task for the German flight inspection organisation was the marketing of flight inspection services. First positive results were achieved by providing flight inspection services in Switzerland and Austria, the Netherlands and Luxembourg, in Spain, Macedonia, Lithuania, Kiev, Sofia, Bucharest, Macau, Kuwait, Yemen, Sudan and Egypt, and, of course, in Germany.

On 1 October 1997, swisscontrol became a shareholder of the DFMG. At the same time, the company name was changed to FII Flight Inspection International GmbH. On 1 January 1998, Austro Control also became a shareholder of FII. With their accession, both countries gave up their own national flight inspection organisations. [7]

So the FII has three shareholders: AERODATA, swisscontrol and Austro Control. The DFS has close connections with the FII on the basis of a cooperation agreement and can thus be regarded as if it were, de facto, a shareholder. [2]

2.3. The Flight Inspection in the Slovak republic

Flight inspection is performed with modern AERODATA AD-FIS-10 Flight Inspection System capable to flight inspection of:

- ILS CAT I-III
- VOR
- DME
- NDB
- Radars including SSR
- VHF Communications
- PAR
- PAPI

Flight Inspection System Consists of:

- AD Computer
- MO Storage unit
- 2 Special Flight Inspection Navigation Receivers RNA34AF
- 1 Modified DME interrogator
- 1 Modified ADF receiver
- 1 Modified SSR transponder
- Oscilloscope
- Spectrum analyser

Fig. 1. OM – SYI cabin for flight inspection
Source: [6]

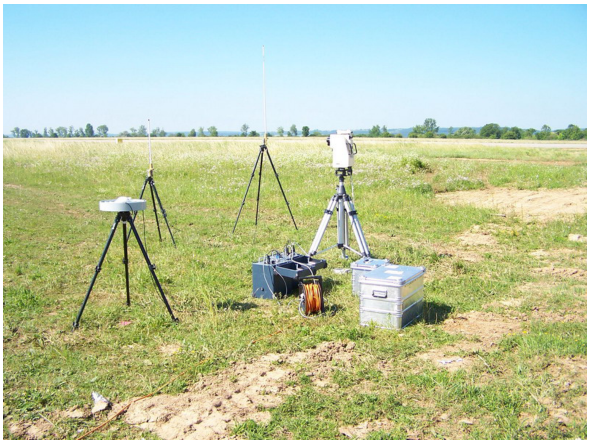

Fig. 2. The ground reference system
Source: [6]

Reference system:
- On-board GPS receiver
- DGPS ground reference station AD – GPSREF – 4
- Laser tracker Aerotrack IBEO Lasertechnik

The ground reference station was designed to receive GPS signals and to transmit GPS data to the airplane for DGPS corrective calculation (GPS errors – atmospheric delays, multipath…,). The GPS receiver is a high precision stand - alone 12 channel receiver by NovAtel, and is used for L 1 frequency 1575.42 MHz C/A code. [3]

The reference station must be built-up exactly at the surveyed position. An improved precision of flight inspection necessary for flight inspection of the ILS is achieved by using a laser tracker. The laser tracker is a highly dynamic – polar locating system used to automatically and continuously determine the position of the reflector placed at the nose of the airplane during the ILS calibration measurement. The laser tracker provides the elevation, azimuth and range information of the approaching aircraft. To avoid a possible lack of precision, the laser tracker must be installed on a solid ground near the threshold of the runway. To define the horizontal reference for all measurements, the laser tracker uses one of the reference reflectors installed at a defined position. If flight inspection with a laser tracker support shall be performed, the location of the laser tracker points, the reference reflector and of all navigation aids on the airfield must be known in the threshold coordinate system. All these parameters can be determined with an airfield survey. Once an airfield survey has been performed and all distances have been evaluated, the laser tracker and reference reflector must be built-up at the exact points for all future inspections.

The measuring range of the system is better than 13 km in good visibility. Fog, rain and snow, as well as steamed up reflectors, will of course reduce the range. However, DGPS technology enables to reduce the required distance of tracking by laser down to approximately 4 km. [4]

2.4. New Research Aircraft at the University of Žilina

This chapter describes our structural funds project oriented at flight inspections systems and the air transport environmental impact. The Flight Inspection mission is comprised of many documents, for example ICAO DOC 8071 vol I, and FAA TI 8200.52.

Technical Requirements

Performance
- ICAO Document 8071
- FAA Flight Inspection Manual OA P8200.1
- UK CAA CAP 670

Capability
- Precision Approach: ILS, MKR (Up to Cat III), MLS, SCAT-1, LAAS, GBAS
- En-Route / Approach: VOR, DME, NDB, TACAN, Loran-C, VDF, UDF, RNAV/ FMS, WAAS, SBAS
- Visual: VASI / PAPI
- Communication: VHF, UHF, HF, SATCOM
- Radar: PSR, PAR, SSR, MSSR

Positioning Reference
- Automatic Position Reference System (APRS) DGPS/ INS/LRF
- Carrier Phase Measurement DGPS -RTK
- Stand-alone GPS or Galileo
- Digital Radio Telemetry Theodolite
- Interface capability to any digital, analogue or manual Position Reference

- Digital maps
  Mechanical design
- Modular and Portable
- Quick disconnect to smaller sections of less than 50 Kg.

3. Conclusion

The improvements in satellite navigation systems like GPS, GLONASS and GALILEO with regard to coverage, accuracy and reliability have cut down the further development and implementation of the new Microwave Landing System MLS. But the application of global navigation systems as the only means of navigation to long range, terminal area and landing is still not yet completely solved. Among others, the most problematic potential risk is that of intentional interference. Thus, most of the conventional navigation systems like INS, VOR, DME and ILS will endure for quite a while.

In this report the function of the conventional radio navigation systems and the problems for testing these systems are described. Especially the different error sources for the en route and terminal area navigation systems are discussed. One of the chapters shows the main radio frequency problems: coverage and multipath and the different measurement methods for these errors. A description of the flight test procedures and flight test methods shows the state of the art for the flight inspection of the actual generation of radio navigation systems. The flight inspection systems and the flight inspection aircraft of different countries used for the testing of radio navigation systems are also outlined. The flight inspection policy changes in many countries, so in this report the authors can only describe their known actual situation of flight inspection policy briefly.

"Flight inspection in a world of change" was the title of the ninth flight inspection symposium and this title characterizes very precisely the problems of flight inspection. Up till replacement the different radio navigation systems like DME, VOR, TACAN, OMEGA, LORAN-C, ILS and MLS have to be inspected.

In the future more and more of these systems will be replaced by the GPS system. Therefore this report describes the function and problems of the GPS and the add-ons like DGPS, LADGPS, WAAS etc. The satellite navigation systems also enable considerable improvements to the flight inspection systems. New systems equipped with differential mode GPS using carrier-phase positioning achieve real-time on-line flight path measurements with errors below 20 cm only. For measurement purposes the mentioned risks of the GNSS are of no significance. If interference occurs the measurements can easily be repeated. [6]

Modern flight inspection systems have reached a higher standard regarding accuracy and automation. Thus, few improvements can be made in the near future.

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