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HOW TO USE A PUBLIC TRANSPORTATION AIRCRAFT FOR FLIGHT INSPECTION OF THE RADIONAVIGATION AIDS
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ABSTRACT

The primary concern of a Flight Inspection Operator is the availability of a suitable platform to perform the requested tasks.
The definition of the operator's needs and consequently of the aircraft characteristics is the first step toward the selection of the right model among the several ones existing.
Unfortunately, the aviation market does not offer specific 'Flight Inspection' machines, so the necessity arises to transform a passenger aircraft by the removal of its typical commercial items (seats, overhead bins…) and by installing the calibration benches.
Integration with basic avionics, antennas fitting, impact on aircraft characteristics and performance are the main subjects to be analyzed.
The cost of acquisition, of the study and the realization of the required modifications, combined with a usually low aircraft utilization lead to a very high operating cost per hour.
A solution to lower this cost consists in operating a public transportation aircraft for Flight Inspection through a removable calibration installation.
STNA presents here its experience in this field.

BACKGROUND

Operators know that, in the very delicate task of Flight Inspection, the success of their action is based upon various parameters.
The quality, the technology and the reliability of the tools they use are mostly a warranty of their success. Among these tools, one can highlight the calibration bench and the aircraft. These two elements are the most expensive in term of purchase and operation.

The calibration benches all have the same architecture: receivers for acquisition of the different navaids signals, a trajectography system and a calculator for computing, treatment of data and Man Machine Interface. Of course the technology, the dimensions, the capacity, ... are different from one system to another.
This paper does not address the calibration bench whose choice is relatively indifferent, but the aircraft used for Flight Inspection (or calibration).

Each state or organization in charge of Flight Inspection has its own constraints that will determine its Flight Inspection policy.

Among these constraints, we can note the area of the country, the number of navaids to check, the number of procedures to check, the human and financial capabilities, the geographical isolation, ...
In this way, the USA with thousands of VOR, ILS, and GNSS procedures will not require the same means as Mauritius Island for example. But all the states or organizations, small or large, rich or modest, have the same commitments towards the quality of the Flight Inspection.

Among the different Flight Inspection policies, we can identify :
- The state or organization has its own Flight Inspection teams and fleet (this is our case in France).
- The state or organization subcontracts its Flight Inspection operations to another state or organization.
- The state or organization shares (with other states) equipment, aircraft, personnel, ...
There are of course other possibilities, this list is not exhaustive.

Most of us would like to have our own equipment and Flight Inspection personnel, to have the maximum of flexibility and be able to intervene immediately however scheduled or whatever the task may be. But this luxury has a price, especially the one of the aircraft. A small twin-prop such as a Beech 200 costs about 5 to 6 million $.

Nowadays companies propose to buy a share of an aircraft for private transportation, this is the timesharing in aeronautics.

This principle can be envisaged as an alternative for states or organization that would have a limited need for a Flight Inspection aircraft. Then they transform for some days or weeks a year a public transportation aircraft into a Flight Inspection aircraft.

AIRCRAFT CHARACTERISTICS

All aircraft can be modified into a Flight Inspection aircraft at a reasonable cost, whatever the size.

However it is essential to be aware of aircraft characteristics related to these specific missions in order to choose the one that better fits to operator's needs and provides enough flexibility for future requirements. These particular needs will limit the choice of an aircraft. The operational aspects in Flight Inspection cannot be satisfactory treated without having a look to the platform acting in this field.

The STNA (Service Technique de la Navigation Aérienne) is in charge of the Flight Inspection (we use the term calibration) of the radio navigation aids on the French territory. This includes the Metropole (France mainland) and overseas territories : New-Caledonia (east of Australia), Polynesia (Pacific ocean), Caribbean, Guyana (South America), La Reunion (east of Madagascar in Indian ocean), Saint Pierre et Miquelon (east of Canada).

We face the problem of periodically flight inspecting the few radio navigation aids of these overseas territories that can be situated at more than 10 000 Nm from our home base.
Our calibration bench can be easily transported by plane and can be installed on any aircraft outfitted for Flight Inspection. The problem then was to choose the aircraft type.

Our constraints are as follows :
- Most of the typical Flight Inspection patterns (except for ferry flights) are made at low altitude. the twin-prop is the best fitted aircraft for these operations, it

presents an excellent safety and a low fuel consumption compared to a jet.
- The operational performances of the aircraft must authorize accessibility to any kind of airfields, the autonomy and range will be sufficient to avoid multiple refueling which is a loss of time especially on main airfields.
- The dimensions of the aircraft must be sufficient to assure a good stability on the patterns even in moderate or severe turbulence, which is key for the quality of the measurements. The length of the plane is important too for a proper location of the calibration antennas ; it's easier to solve a problem of interference between antennas on a larger plane than on a short one.
- Concerning the ergonomics and cabin layout, with sufficient dimension you can take more people onboard with no limitation on autonomy or range, trainees for example or specialists or observers for a special operation or expertise.
The comfort of the operators and pilots are not negligible, especially when you plan to flight inspect a maximum of navaids in a minimum of time to minimize the operating cost and to fit with the availability of the aircraft.
- The availability in 28VDC must be sufficient (for our calibration bench, about 40A), with easy access and an electrical on ground self-sufficiency is advisable (APU or equivalent).
- A cargo door to facilitate and accelerate the loading and unloading of the calibration bench is highly recommended. This minimizes the time necessary to change the configuration of the aircraft (passengers transport, Flight Inspection, cargo transport, ...) to about 1 hour. Aircraft versatility for secondary missions must be in the specifications of the aircraft.
-The operating cost must be as low as possible.
- Maintenance and reliability are to be considered. A JAR 25 (or FAR 25) aircraft generally fits these requirements.
- The design and the approval of a typical modification for Flight Inspection is a long and expensive process. We look for an aircraft used worldwide so we could have a unique engineering order for all our locations.
- The product support must be efficient to provide all necessary solutions during the design period. The manufacturer must be more than a supplier, he must act as a partner.
- The realization of the modification can be done by any qualified maintenance center during a C check for example to reduce costs.

For all these reasons, we choose the ATR 42.

Actually we have an ATR 42 for France (we also fly once a year to Saint Pierre et Miquelon for flight Inspection). This modification for the aircraft is permanent because the aircraft is dedicated to flight inspection. We also have modified 3 ATR 42 (2 in New-Caledonia and 1 in Cuba) for specific and limited missions.

The ATR product support has always been resourceful at any phase of the project, design, approval and realization.

DESCRIPTION OF THE MODIFICATION

On a definitive (or permanent) modification, when the aircraft is strictly intended to Flight Inspection, we impose a complete segregation between the aircraft navigation systems and the calibration's one.
This separation avoids any common mode failure between systems and assures that a fault on the calibration installation will have no consequence on the aircraft's reliability.
The plane is equipped with its own antennas for calibration, its own AHRS, its own ADC, its own radio transceivers,

... The aircraft system could be used as backup in case of failure on the calibration systems to ensure a continuity of the service.
The aircraft is fitted with extra equipment, optical trajectography, laser tracking, ... only used in our case for backup of the DGPS.
This permanent modification is more expensive and creates extra weight and extra drag that slightly modify the aircraft limitations and performances. These limitations are incompatible for a generally used as public transportation aircraft and our requirements.
Our aircraft in France received this modification and is dedicated to Flight Inspection.

For a specific and limited use, we can have modifications for a low cost and a very low impact on the aircraft performance (Flight Inspection represents a small percentage of the total flight hours of the plane).
We use through couplers the signals coming from the aircraft antennas. We only add antennas for signals that don't exist basically on the aircraft.

The realization of the modification is a three-stages operation :
- Technical modifications to realize to allow the installation and the operation of the calibration bench.
- Supplements to flight manual and maintenance manual, to describe limitations and procedures for the use of a calibration bench.
- Justifications of non-interference on the onboard electrical and avionics systems.

TECHNICAL MODIFICATIONS

Integration of the bench in the aircraft

The mechanical characteristics of our bench are :
- Weight 170 Kg
- Dimensions L*H*l 1,23*1,23*0,55 m

The bench is designed to be fastened on the seat rails.
Two or three seats on the front of the cabin are removed to install the calibration bench. The operator can sit down on the first seat next to the bench.

Power supply

The power consumption is less than 40A under 28 VDC.
The bench is supplied through two existing plugs (in rack 90 VU, connections 268 VC and 269 VC) "ferry INS". These plugs are used during delivery flights from the manufacture in Toulouse to airline bases to supply some specific ferry kits, inertial systems, HF transceivers, ...

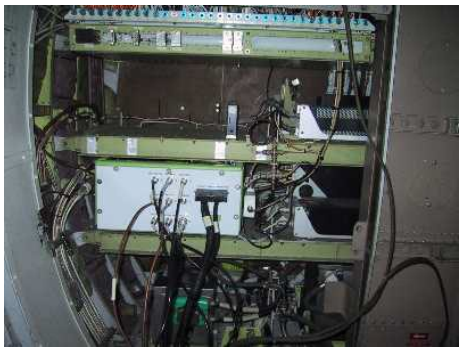
A circuit breaker in the cockpit allows an isolation of the calibration equipment as required

Antennas

The calibration bench can use signals coming from aircraft antennas through couplers or from specific calibration antennas.
We favor the use of couplers in a limited modification, but if the signal does not exist or is too low to be divided, we have to install specific antennas.

Aircraft antennas

All the signals or parameters necessary for the bench pass through a junction panel that is installed in the avionics rack of the ATR between cockpit and cargo zone. The calibration bench is connected to this junction panel to receive the signals.



From aircraft antennas we use :
- 1 VOR/LOC (signal taken from coupler)
- 1 MARKER (signal taken from coupler)
- 1 DME 2 (no coupler is possible), we use the DME2 antenna during the calibration flights. This antenna is normally used for DME2 transponder, during calibration flights, the aircraft has only one DME antenna. Most of the ATR have two DME antennas. In case there is only one, we have to install a second one. Then covered by an ATR Service Bulletin.

DME1, GLIDE, VHF1 and VHF2 do not pass through the junction panel.

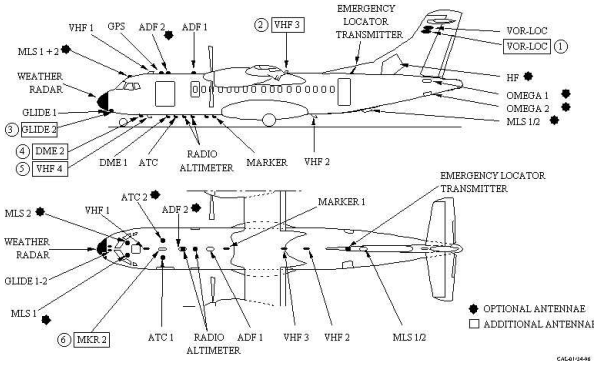
Specific antenna

We have to install :
- 1 GLIDE antenna CHELTON 17-21 with two outputs, this antenna is installed next to the existing one (see picture).
The low output signals level of the GLIDE antenna does not permit the use of a coupler.

- 1 GPS antenna L1/L2 for DGPS and phase tracking SENSOR with integrated amplifier (P/N S67-1575-96).
- The VHF1 antenna is replaced with a VHF1/UHF1 antenna STAREC 3271 with a duplexer STAREC 1378. The UHF1 channel is dedicated to the DGPS data-link trajectography.
- 1 VHF4/UHF2 antenna for the VHF transmission of optical data-link trajectography and a spare UHF

transmission of DGPS data-link. We use the same antenna STAREC 3271 and duplexer STAREC 1378.
- An optional VHF3 antenna for communication between the calibration operator and the ground maintenance. If the traffic on the airfield is not important, this communication can be done using the VHF1 or the VHF2 transceiver.

The wires coming from the antennas are connected on the junction panel.



Information shared by the bench and the aircraft

The bench receives as inputs :
- The attitude information of the aircraft, Heading, Pitch and Roll (Synchro).
- The reference signal (26 V, 400 Hz) of AHRS (Attitude and Heading Reference System).
- The flag cap (Validity + 28 V).

The bench provides as outputs :
- Analogic information to an indicator situated in the cockpit (guidance display for the pilot during calibration) :
    - LOC deviation
    - Flag LOC
    - GLIDE deviation
    - Flag GLIDE
- Discrete information to two warning lights :
    - Shifted approach
    - GPS guidance

The attitude parameters come from AHRS N° 2.

All this information transits through the junction panel.

VHF communication

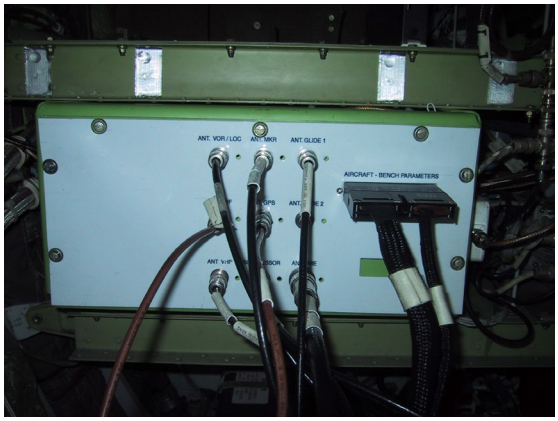
The calibration operator must be able to talk with the pilots via the intercom unit. He must be able also to communicate on the VHF 1 or 2 and optionally on a third VHF with the ground maintenance.
On the ATR 42 we use the functionality of the 3 channels RCAU (Radio Control Audio Unit), 2 channels are for the pilots and one for the operator, this third channel is normally used by the mechanic or the navigator in the cockpit.
There is an ATR SB to describe the installation of the 3 channels RCAU .

Integration of a guidance display in the cockpit

ILS-like information is sent from the bench to an analogic (or digital) display in the cockpit. This guides the pilot on specific patterns during calibration flights.

Junction panel

This panel is installed in the avionics rack of the ATR. It centralizes all the interfaces between the bench and the aircraft :
- Antennas signals.
- Aircraft parameters.
- Parameters for the guidance display.
- VHF radio connections.



A special cable-set is connected before each calibration campaign between the bench and the junction panel. It is fixed on the aircraft's floor.

Supplements to flight manual and maintenance manual

These are required to cover permanent and limited modifications of the aircraft due to the calibration installation.

- Effects on weight and balance.
- Effects on power supply.
- Effects on the use of the aircraft equipment.
- Impacts on the documentation :
  - Flight manual (supplements for calibration procedures).
  - Operating manual (supplements for calibration procedures).
  - Maintenance documentation (inspection of specific antennas, ...).

Test and approval

The purpose is to check that operating the calibration bench has no effect on the power supply (no rejection) and on the avionics of the aircraft.
The functioning of all the aircraft's systems, VHF, LOC, ILS, VOR, DME, ADF, HSI, RMI, Audio, Transponders, ... with and without the calibration bench operating will be checked.
Also the lack of interference between the two installations (aircraft and calibration) will be checked.

CONCLUSION

The cooperation between ATR, as aircraft manufacturer, and DGAC-STNA as operator and as airworthiness authority led to develop easy-to-apply modifications to transform a passenger aircraft into a Flight Inspection one.
These modifications permits to offer more opportunities for operators through a dramatic reduction of non recurring costs.