Short and Efficient Flight Inspection Profiles - How Much Diversity is Acceptable?

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Mike Spanner trained in Flight Inspection with the UK CAA Flight Calibration Unit, starting in December 1982 at Stansted Airport and moved to Teesside to help set up the Strategic Business Unit CAA-Flight Calibration Service in 1993. He trained as a Navigational Aid Inspector and gained qualifications in 1995. Mike subsequently acted as deputy manager of Flight Inspection within the role 'Operations Support Manager' from April 1998 for both Civil and Military Tasking. In January 2000 he transferred to Aerodata (systems) in Germany to join the Marketing Department. This role had primary responsibility for the World marketing of Flight Inspection Systems. In July 2001 returned to current post as Manager Flight Inspection for Flight Precision, with specific responsibilities for tasking, operational issues and personal management of the Flight Inspectors. The role demands liaison with all customers on operational matters and approvals and has the delegated authority from the UKK CAA to approve Flight Inspector for their tasks.

ABSTRACT

The modern flight inspection environment demands that the inspection aircraft is actually on task for the minimum amount of time. Driven solely by economic grounds, there is a balance between the safe management of a navigational aid and the economic impact of flight inspection operations. The drivers for reduced impact are varied and not just the commercialisation of Flight Inspection Organisations. The need to carryout night inspections is an example, but even this environment has an impact on the ground station staff, that supports the inspection. In many cases entry to certain airspace areas is restricted for operational reasons and this places more demand on the inspection team to be efficient in the use of the time allocated.

Each of these factors drive the need to assess constantly the types and numbers of flight inspections for each facility, with an underlying requirement to ensure that the facility performs to international standards. The guidelines published in ICAO Doc 8071 suggest the parameters to be measured, but it is left to the individual flight inspection organisation to determine the best profiles for each facility. The choice and variation of individual runs can lead to interpreting the results of an inspection in different ways and can potentially lead to discussions on the suitability of a navigational aid when inspected by different organisations.

This paper seeks to invite discussion that compares types of inspections from different countries and in particular the differences that may result. An Inspection Category system linked to traditional Inspection Types is also presented that allows focus to be made of the Flight Inspection task. Within an inspection type, assessment is made of the applicability of different measurement methods and the variations of results that may be expected. A conclusion is proposed that seeks to find a way to reduce the impact of Flight Inspection for other facility users, but maintain a balance of technical and operational oversight.

Why do we do it?

In looking at Flight Inspection in the context of efficiency one should really start by asking the basic question of Why? Over many years thousands of hours have been spent flying aircraft towards, away from, over and around Navigation Facilities. Even now, a new concept of 'under' can be seen with the extensive use of GPS for navigation. But what does all this information give us? Are we doing it to satisfy our need inquisitive nature as engineers, or for other more esoteric reasons?

Many years ago in the days of valve technology, engineers spent a great deal of time trying to design and perfect stable systems. However, given the basic building blocks that within them had finite lives measured in thousands of hours, it was in evitable that the Mean Time Between Failure was comparatively low. Such unserviceabilities involve 'soft' failures that could go unnoticed by clever monitor systems, if indeed such systems were in place. Given such a background, one can see the reason for effective cross checking of the real Signal in Space (SiS) as a safety net to ensure a given system was performing to specifications.

The experiences of the early systems lead to particular sets of standards to which we in the Flight Inspection community now accept as the definitive requirements. Various committees sit and discuss ways of ensuring developing technologies are tested and inspected to a satisfactory level. But what is a 'satisfactory' level and are the tests applicable in all cases?

The continued improvement of equipment over the years, with the virtual retirement of valves and early transistor circuits has led to a much more stable equipment design. This is also true of the environment in which equipment is expected to work- there is now widespread use of temperature and climate controlled equipment rooms. Cable and distribution networks have benefited over time from re-engineering and improvement as knowledge of their shortfalls has increased. Ground based monitor systems are more stable and sophisticated (including provision, in some cases, of specialist test vehicles). Thus the need for regular airborne testing could be questioned.

The real answer to the title question is, of course, that ICAO mandates that Flight Inspection shall be carried out [Annex 10 Volume 1 para 2.7]. But on what basis is the mandate still valid? There are many reasons why it is still deemed necessary to continue the work of Flight Inspection; to discuss this aspect would be outside the scope of this paper. However, to summarise, I would group all reasons into three categories:

- Assessment of Facility Performance against published standards
- Safety Assurance of Service Provision
- Technical Analysis of the Facility over time

Each category has a distinct role in the life cycle of the equipment, but also each link with one another. In Figure 1, 'F' could represent the Facility and the associated actions that need to take place around it in order to provide a safe service, or could equally be an 'F' for Flight Inspection and the services provided by the Flight Inspection team.

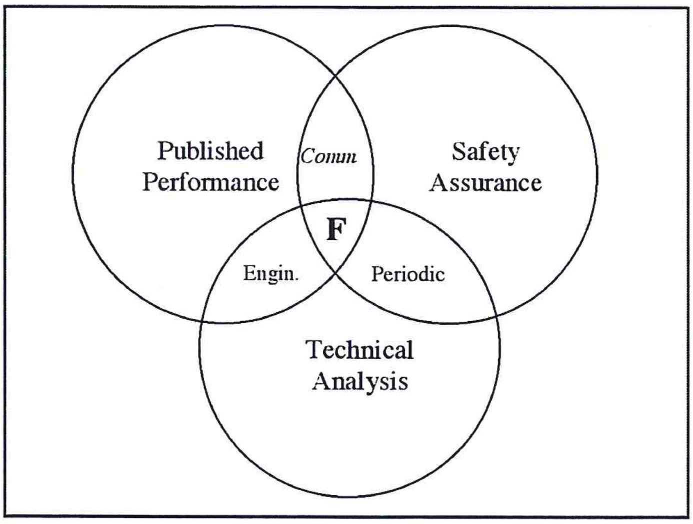

Figure 1: Relationship of Proposed Inspection Category to traditional Inspection Types.

In practical terms, Annex 10 defines the requirements for the Published Performance; DOC 8071 provides guidance in applying techniques to allow the Technical Analysis of the Facility, whilst Safety Assurance is left rather loosely in the hands of Individual States to determine how this action is completed. The interpretation of 'Comm' (Commissioning), 'Engin' (Engineering) and Periodic types of Flight Inspection is also left open to interpretation and varies considerably throughout the World. The following paragraphs expand on the three inspection types, as many other papers can be found discussing areas associated with Category types.

How do we do it?

The rather simplistic answer is that we take a measurement tool and simply measure. The tool of choice is an aircraft (of many different designs), fitted with a system (of many different designs) capable of recording and presenting information. Each crewed by experienced staff (but not of a common standard) capable of making informed decisions about the performance of a Navigational Aid. Recording systems of some sort are essential these days in being able to provide 'documentary evidence' of the conduct of a Flight Inspection mission. What is also emerging is the need to show traceability of the results taken in air to Internationally Recognised measurement standards (e.g. National Physical Laboratories). In this respect our measurement tool is a sophisticated 'Transfer Standard'.

How we measure, what we measure, and how we assess the results is an area that - although covered in part in DOC 8071 - still leaves many areas open to discussion. The ever present discussions on Threshold Crossing Height, how to measure the real Glidepath (what is it really?) and other such subjects provide plenty of food for thought. Even where parameters seem simple to measure, different organisations can lead to different conclusions about the results. Take the example of two standard Flight Inspection receivers measuring the same VOR station. Figure 2 shows at least 3% difference in results of 9960 Hz measurements and up to 2% in 30 Hz, whilst back at base and connected to the trusty test set, both receivers read the same[1].

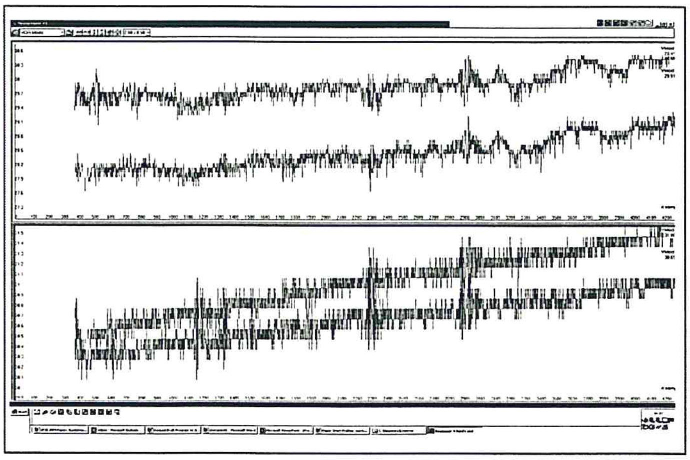

Figure 2: Modulation Depths using 'calibrated' receivers.

These areas lead to the possibility that a facility may, or may not, meet internationally laid down standards, depending on which receiver was used at the time. Similar effects of inconsistent results may be observed in calculating range errors when either using an interrogator designed for TACAN or DME for standard DME measurements.

[1]This is thought to be due to the VOR switching frequency/signal shape and the Receiver sampling frequency. Interestingly, when changing transmitter on the ground, the effects are reversed!

DOC 8071 goes some way to improve the potential variability of measurements by introducing the idea of 'Measurement Uncertainty'. Although great effort may be undertaken by a Flight Inspection Organisation to define how it thinks it may be measuring and to what accuracy (or standard), it is almost impossible to cover every eventuality in real life.

Even given the perfect measuring tool, it is still possible to 'measure' the facility under inspection in many different ways. There are so many variations that listing the differences and commenting on them would not be of practical use (but perhaps should be a discussion forum within ICASC or ICAO?). However there are several themes that may be bought from such study work to allow the discussion to continue.

- Frequency of Inspection
- Types of Manoeuvres
- Checked Parameters
- Subjective Assessment of Flyability

Frequency of Inspection

It is evident that even within Europe, one cannot find a 'standard' set of rules followed for each type of facility, or indeed which type of inspection should be carried out given a particular set of circumstances. In general, it is common for those facilities used for Precision Approach to be checked 2 or 3 times per year, with Enroute aids ranging from 12 monthly, 18 monthly or even 60 monthly. The generic pattern follows good sound engineering principles:

Commissioning/Categorisation - on installation of the equipment, re-engineering of major components (e.g. Antenna systems) and is a comprehensive test of the system operation. This set of tests should ensure that the facility meets the standards required for its published performance and demonstrates sufficient safety assurance for the operation of the equipment. In this context, not only the standard operation of the facility is checked, but also that failure modes are captured by their respective monitors.

Periodic - A generic test of the facility to demonstrate that the continued operation of the equipment is safe, whilst also providing on-going technical monitoring of the systems stability. The variation of tests performed under the 'periodic' heading is most widespread, with some facilities receiving a cursory 'fly by' check and others a near commissioning type regime. It is in this area that an exploration of the types of individual runs performed can lead to great efficiency of operation, whilst still maintaining a satisfactory level of safe-ty assurance and technical information for trend monitoring. The frequency of Periodic Inspections is subject of discussion since DOC 8071 was issued at 4th Edition, as defined periodicities were removed, allowing facility operators or regulators to be more flexible in defining what is right for that particular installation.

Engineering - Special flights of non-specific types as determined by the relevant authorities who have an interest in the facility. As there may be more than one party falling into this category, there is no need to define facility specific profiles or tests. This may however change with the introduction of PRNAV procedures. A new type of inspection may be required that looks at the use of a particular navigational facility in the context of its operational environment, rather than its present technical one.

Types of Manoeuvres

Within each type of inspection there is the possibility of a variety of individual manoeuvres that may be performed to meet the operational and technical assessment criteria. Once again, variations exist between countries but in this case the extent of variation is more limited. After all, an aeroplane can only be flown forward, up or down thus limiting the possibilities. In general, all manoeuvres can be categorised into three main sub headings:

- Radial (which can also be a Level run or Slice)
- Orbit or Partial Orbit
- Approach

It is of note that in order to be efficient in the collection of data to evaluate a particular facility, it is very common practice to combine several measurements into one measurement run. Typically, an approach might start as a level run, convert into a full approach whilst variations in the facility causes certain monitor conditions to be functioned, followed directly by a final approach phase. In such circumstances many technical parameters can be tested in a very short time.

There are one or two classic measurements made on ILS facilities that can be performed in a variety of ways. Although a full technical analysis of, for example, Glidepath Angle and Width may be performed by an Approach run using 3 approaches taking on average 20 minutes, a Radial manoeuvre can furnish the same data in one 7 minute run. Equally, it is possible to calculate the Localiser sector width and alignment angle in a similarly short time. Less variation is possible on facilities supporting airways or area navigation, it is essentially a case of assessing what the facility is trying to support in terms of navigation and performing an appropriate set of manoeuvres- provided a minimum set of technical runs are also performed.

Checked Parameters

Here there is plenty of scope for difference to exist! If one was to look into the criticality of each parameter it was possible to measure with modern Flight Inspection Systems, there are probably only one or two items that need our attention from a Safety Assurance perspective. From a technical viewpoint however, there is never enough data to satisfy our need to understand not only the facility performance, but also more increasingly these days, the environment in which the facility is operating.

With any facility, accuracy of guidance, both absolute and derived (control motion noise and path following error using convenient terms borrowed from MLS) are the primary parameters that are the most critical. All other system related parameters of technical interest, but not of paramount importance. This view may be tempered by the fact that certain secondary parameter 'real life' effects cause the facility performance to be degraded where one would not immediately expect such an effect to happen. The most documented effect is the high modulation depths experienced on some localisers causing deterioration in the clearance regions.

Operational coverage of a facility, although not usually a parameter that causes detrimental effects in areas that would lead to safety implications, is one that is becoming increasingly important in its own right. In terms of the Flight Inspection more demands are placed on the accuracy of such measurements. This is due to the increasing congestion within the radio frequency environment restricting the range that facilities are permitted to radiate to. With ever more complex software based prediction tools giving Facility Operators the confidence that their systems meet those more stringent conditions, the Flight Inspection provider must similarly match the increasing technical test expectations.

Subjective Assessment of Flyability

Whilst the technical analysis of a facility is the domain of a technically trained engineer, the Flyability of a Facility is open to much interpretation. Technical assessments may be standardised using specifications for facility performance, measurement techniques and results analysis. Operational assessments rely on Pilots using their own skills and, in general, standard aircraft equipment to ascertain whether a facility is performing adequately. There is the possibility of such an assessment involving 'gut feeling', rather than have a firm basis, however as a final check of a system is an important one. When checking a system performance against a 'standard' what additional quality or safety controls are in place to capture the effect that has not yet been documented? A facility may be technically perfect according to Annex 10 standards, but actually not provide a 'safe' or adequate service. It is the duty of the Flight Inspection team (both Pilots and Technical staff) to be vigilant for such instance and promulgate the information effectively.

What does it all mean?

Flight Inspection has to provide more than just a need to satisfy the mandated requirements of Annex 10. The role a particular organisation plays may vary between countries but essentially the basic service is to ensure that facilities radiate safely and provide an adequate service for users. In the increasingly demanding environment within which we work, efforts should be made to reduce the impact of Flight Inspection without significantly reducing the safety role that the service provides. The environment in this case is multi faceted: Radio spectrum, Pollution (Noise, Fuel), Airspace Usage- giving an increasingly complex set of challenges to the Flight Inspection team.

Effective measures should be in place during a facilities life cycle to try and reduce the number of individual test runs required for the continued operation of that facility. The Flight Inspection organisation, regulators, facility operators should all be working together to ensure that the time spent 'on task' is used as effectively as possible. One stepwise approach could be look closely at what is really required for a Periodic check- do we really need to collect all that data, or is it just 'nice to have'? A commissioning inspection should not just provide technical confirmation that a facility meets the required standards, but also 'transfer standards' that allow shorter runs to be performed during periodic inspections. Greater co-ordination between ground engineers and flight inspectors could allow more correlation data to be used to reduce the Flight Inspection requirement to a minimum. Each individual run should be used to the maximum to extract as much information at one time.

In Conclusion

The useful guidance material in DOC 8071 could be augmented by definitions of minimum and maximum expected inspection periodicities for each facility (or even parameter), allowing more efficient Periodic type inspections. Such a review could also determine the minimum run types expected, allowing some uniformity across the World in the base case. It is highly probable that we do the minimum anyway, but it might be that through evolution we are doing more than is really required just because 'we've always done it that way'.

At a time when every organisation in the world is trying to be more efficient, we in the Flight Inspection community should also not ignore the real opportunities we have to contribute to reducing the impact of Inspections, without losing the extensive benefits of the work we carryout.