Radio Frequency Monitoring in the Scope of ICAO and ITU

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ABSTRACT

The rise of wireless communication systems continues to increase the impact of radio signals in almost all aspects of modern life. With this dependence on wireless connectivity, a clean radio-frequency spectrum has become a mandatory prerequisite over the last years. This holds true for various techniques in different frequency bands. Thus, detecting the presence and locating the source of Radio Frequency Interference (RFI) is of particular importance.

The worldwide harmonization and allocation of frequency bands and their respective users is coordinated by the International Telecommunication Union (ITU) in its “Radio Regulations” (R-REG-RR) publication. The process of harmonizing and planning the use of these frequency bands is called spectrum management. An integral part of spectrum management (as defined by ITU) is the monitoring of the radio spectrum. The ITU publishes a dedicated “Handbook on Spectrum Monitoring” (R-HDB-23-2011), which details requirements, processes and tools to be implemented on a national basis. The ITU also incorporates airborne monitoring stations as complementary additions to other types of monitoring stations.

The airborne detection of RFI also is one of the key components of any flight inspection, especially for the frequency bands used for primary aircraft navigation (e.g. VOR/ILS, DME, radar, GNSS, radio altimeter). The International Civil Aviation Organization (ICAO) mandates this via the requirements for flight inspection in its “Manual on Testing of Radio Navigation Aids” (ICAO DOC 8071).

Even though both bodies (ITU and ICAO) attempt to address similar issues, the overall approach differs significantly. This paper will analyze the differences between both bodies regarding the use of airborne systems, and will show how flight inspections can contribute to spectrum monitoring.

INTRODUCTION

Radio Frequency Interference (RFI) denotes any radio frequency emissions affecting a certain usable signal. The effects of RFI on a signal can range from no effect up to a complete denial of service. As radio systems are used in more and more applications, the influence of RFI can be very significant in a wirelessly connected world. This is why RFI has to be taken very seriously in an international context. This paper will compare two international organizations dealing with RFI with respect to the use of measurement aircraft.

On the one hand, this is the International Civil Aviation Organization (ICAO). The ICAO is a specialized agency of the United Nations responsible for ensuring safe and efficient worldwide air traffic. Member states of the ICAO are required to follow international standards in order to allow international civil air traffic. In this domain, RFI primarily affects radio navigation signals, which are detailed in the Annex 10 to the ICAO convention [4]. These "Standards and Recommended Practices" (SARPs) also mandate ICAO member states to perform (periodic) flight inspections of radio navigation aids. More guidance for the required flight inspection can be found in ICAO's DOC8071 [3].

On the other hand, this is the International Telecommunication Union (ITU). The ITU also is a specialized agency of the United Nations, and is responsible for the international harmonization of the RF spectrum. For this purpose, the ITU manages the allocation of different spectrum users to specific radio frequency bands and provides these allocations within their Radio Regulations [2] publication. National regulators of ITU member states then have implement a spectrum management in order to protect the regular users of specific bands. This also includes spectrum monitoring, i.e. the continuous monitoring of the RF spectrum. In its "Handbook Spectrum Monitoring" [1], the ITU defines the spectrum monitoring as "eyes and ears of the spectrum management", in order to "assist in the resolution of electromagnetic spectrum interference". This handbook also includes specific requirements for spectrum monitoring stations, also including mobile airborne stations.

Both organizations (the ICAO and the ITU) work closely together in order to ensure that RF bands vital for civil air transport are protected against interference. However, despite both organizations defining requirements for measurement aircraft, these two domains are currently not directly linked. ICAO-compliant flight inspection aircraft do not necessarily meet the ITU requirements, and ITU-compliant spectrum monitoring aircraft do not necessarily meet the ICAO requirements.

In order to assess this situation further, this paper will compare the requirements of both domains in order to determine how flight inspection aircraft could be used in parallel also for spectrum monitoring.

CHALLENGES

Comparing the ICAO and the ITU, both organizations share technical similarities and a common goal, the international harmonization in their respective domains. However, a closer look at details reveals significant differences. These differences are not ultimately preclusive, but might hinder shared operations.

One example are differences in the vocabulary and the wording. This makes a mutual understanding between both domains harder to achieve, as both parties have to accept these differences and have to adapt themselves. This is related to a slightly different focus between both organizations: the ITU deals with all RF emissions, whereas the ICAO only deals with those signals that civil aircraft rely on. This also results in different approaches in monitoring radio frequency interference. This is why the requirements of the ITU are generally more strict and broad, whereas ICAO requires very specific checks to ensure that a certain navigation aid can be used safely.

This difference between both organizations also become obvious when comparing the resulting reports of a measurement campaign. On the one hand, in the ICAO flight inspection domain, the reports are primarily intended to document that a specific navigation aid has been found to operate within all requirements. In the ITU spectrum monitoring domain on the other hand, a report mainly gathers all information about a detected RFI occurrence, which is then included into a central spectrum monitoring database for a general situational awareness.

Both organizations mandate their member states to implement specific services in order to meet their requirements. This is why the spectrum monitoring and the flight inspection are often organized in different organizations, even if a specific state is member of both organizations. This might put some additional constraints on the interoperability of both domains, because a close collaboration between both administrative bodies might not be foreseen organizationally.

However, while keeping these challenges in mind, flight inspection organizations can provide valuable input to the spectrum monitoring on a technical basis. In order to analyze this in detail, the following section of this paper will analyze the specific requirements of the ITU on airborne spectrum monitoring stations, and how these could be matched with flight inspection aircraft.

ITU REQUIREMENTS

In its handbook on spectrum monitoring [1], the ITU provides operational recommendations, techniques and specific requirements on spectrum monitoring stations. Based on the Radio Regulations [2], this handbook explicitly states the following monitoring tasks to be performed as part of a national spectrum monitoring:

- “monitoring emissions for compliance with frequency assignment conditions”
- “frequency band observations and frequency channel occupancy measurements”
- “investigating cases of interference”
- “identifying and stopping unauthorized emissions”

These tasks can be performed using fixed (i.e. stationary) and mobile (i.e. airborne or vehicle-based) monitoring stations, for which the handbook provides detailed guidance. For airborne monitoring stations, the authors of this paper derived the requirements shown in Table 1.

Table 1: Selected Requirements for an Aircraft Monitoring Station (derived from [1])

#	Section in [1]	Description
(1)	1.1.3	spectrum monitoring system database
(2)	2.2.5	documentation of all observations
(3)	2.4.2.1	determination and recording of precise position
(4)	2.4.2.3.1	frequency compensation for relative velocity
(5)	2.4.2.3.3	flight capability for all weather operations
(6)	2.4.2.3.3	maneuverability and good stability at low speed/altitude
(7)	2.4.2.3.3	adequate load capacity for all necessary equipment and monitoring staff
(8)	2.4.2.3.4	autopilot facilities should permit surveillance operations by pre-planned procedures
(9)	2.4.2.3.4	avionics navigation equipment on board should allow full instrument flight operations
(10)	2.4.2.3.4	independent instantaneous aircraft position and altitude computation system
(11)	2.4.2.3.4	endurance of at least 2 hours in the area under observation in full load conditions
(12)	2.4.2.3.5	antennas integrated into aircraft, incl. certificate of airworthiness
(13)	2.4.2.3.5	direction finder system (either with passive or active airborne antenna systems)
(14)	2.4.2.3.6	all equipment must comply with both ICAO and national regulations
(15)	2.4.2.3.7	automatic determination of position and attitude
(16)	2.4.2.3.7	efficient man-machine interface
(17)	2.5.2.1	remote control of all monitoring equipment
(18)	2.6.1.5	protection from local computer systems
(19)	2.7.5	recurrent calibration of monitoring equipment and antennas at regular intervals
(20)	3.1.3.4	central computer-based man-machine interface
(21)	3.2.2	suitable antennas for different bands, according to monitoring task
(22)	3.2.8.2	distribution system for antenna signals
(23)	3.3.5	monitoring receiver
(24)	3.4	direction finding system
(25)	3.5.1	precise reference frequency standard and common time base
(26)	3.5.2	calibrated measurement of RF level and field strength
(27)	3.5.3	spectrum analyzer for bandwidth measurements
(28)	3.5.5	automated recording of all measurements
(29)	3.6	spectrum monitoring as automated as possible

PROVISIONS IN FLIGHT INSPECTION SYSTEMS

Modern flight inspection aircraft are equipped with a variety of devices in order to meet all requirements of ICAO DOC 8071 [3]. Even though each flight inspection aircraft is individually equipped, this section matches the requirements of the previous section with equipment that has already been installed on specific flight inspection aircraft.

For the installation of an automated flight inspection system (AFIS), a supplemental type certificate (STC) has to be issued by the respective regulator in order to be fully airworthy despite the (massive) modifications and to allow for safe flights under all conditions. Modern AFIS installations even allow using the autopilot for flying arbitrary flight profiles generated by the flight inspection system, as required by the current mission.

Flight inspection systems usually record all measurements on real-time computer systems in order to ensure the correct and precise time stamping of all measurements. The operator can control all sensors via a graphical user interface on a central working station; their measurements are displayed in various forms there, too. The whole flight inspection operation is automated as far as possible and sensible.

In general, flight inspection aircraft use GNSS receivers and inertial technology in order to determine their current position, attitude and time as precisely as possible. The accuracy of the positioning is often enhanced using phase-differential GNSS positioning (PDGNSS or RTK, by using a ground station) or via precise point positioning (PPP, by receiving live data from a service provider).

Flight inspection aircraft usually incorporate a high number of external antennas integrated on the airframes, both above and below the fuselage. These antennas are (together with their signal cables and the corresponding antenna switching) calibrated in order to compensate for measuring RF field strengths. The antenna patterns usually are compensated, too.

Next to the TSO-based navigation receivers, flight inspection systems can also comprise additional receiving equipment like spectrum analyzers, communications receivers and/or direction finders. They are also integrated into the overall system architecture and can be operated remotely via the central operator workstation.

Comparing this already available equipment with the requirements of the previous chapter, it is clear that most of the requirements for an airborne spectrum monitoring platform can already be met by current flight inspection aircraft.

One exception is the requirement to provide a central precise frequency standard, which could for example be used for potential Doppler frequency adjustments. However, as most professional GNSS receivers already provide a 10 MHz reference oscillator output, most flight inspection aircraft generally have a suitable frequency standard available. In addition, most receivers / spectrum analyzers have a corresponding frequency input which is just not necessarily connected at the moment. This is why this requirement could be met with only minor technical changes.

In addition, the central processing software would need to be adapted in order to interface with existing spectrum monitoring databases and to provide reports in an ITU-compatible format. However, as most of the required functionality is already implemented for the flight inspection, the effort to implement the additional software features for spectrum monitoring could be quite limited.

CONCLUSIONS

An extensive analysis proved that the requirements for performing flight inspections (as described in ICAO DOC 8071 [3]) and spectrum monitoring (as described in ITU R-HDB-23-2011 [1]) are similar and in partial agreement. Even though that the nomenclature between both domains are different in details, well-equipped flight inspection aircraft could support the spectrum monitoring as an airborne monitoring station with only minor modifications. This could for example allow for on-demand flights for special spectrum monitoring tasks.

One additional positive aspect could be an improved understanding between aviation and spectrum authorities. If for example RFI is detected during a flight inspection mission, an ITU-compatible description of this event could accelerate further actions by the respective spectrum management authority.

REFERENCES

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