Solution to the Problem of Civil Aviation VHF Band Radio Frequency Interference by Using Flight Inspection Aircraft

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BIOGRAPHY (IES)

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ABSTRACT

With the sustained and rapid development of Chinese economy, more and more new TV stations and radio stations have been built. Due to some equipment or man-made reasons, some radiation signals from broadcasting stations has been spread into civil aviation communication and navigation bands, which results in seriously affects on the operation safety of civil aviation. In order to monitor the air radio environment and locate the possible interference source, two calibration aircrafts with the ability of radio frequency interference (RFI) monitoring has been introduced into the Flight Inspection Center of CAAC (CFIC) to carry out a number of monitoring tasks.

In this paper, the RFI monitoring system and usually direction finding (DF) method utilized by the Flight Inspection Center of CAAC is introduced in more details. Additionally, the activities and results on the radio interference monitoring are reviewed. In order to improve the accuracy of orientation and position of interference sources, the CFIC has made some endeavor to testify the orientation error and the corresponding compensation, which shows very good results.

INTRODUCTION

Radio interference signals affect the command and communication of air traffic control personnel to the aircraft. Terrestrial radio navigation equipment serves as the "eye" of the aircraft flying in the air, providing azimuth and height information for the aircraft. Its signals are very sensitive to radio interference, making navigation signals unstable and even guiding aircraft falsely.

In order to solve the problem of radio interference in civil aviation, the national radio management department invested a lot of manpower and resources to build the ground radio interference monitoring capability, which includes ground stations, land mobile radio interference monitoring vehicle and monitoring equipment handset and etc. However, it is difficult to locate the interference source on the ground due to the shadowing and multipath effects of the radio signals propagating along the surface of the earth, which costs very much time and money but with very poor outcome.

Compared to the ground radio interference monitoring method, airborne method has the dominant advantages, e.g. less effects of shadowing and reflection, existence of line of sight monitoring link which facilitates the searching and locating the interferer even in the case of fast locating the spiteful interferer. To deal with the radio interference induced damage to the civil flight safety, increase the monitoring efficiency and break through the monitoring limits, the CFIC has built up the resources on the airborne radio interference monitoring to provide the corresponding administration with efficient and accurate information and evidence on the illegal radio interferer, which rapidly locates the interferer by utilizing the characteristics of radio interference.

MONITORING SYSTEM

Based on its technical advantages, the CFIC has constructed the radio interference monitoring platform by installation of the additional monitoring equipment as shown in table 1 to the current existing airborne flight inspection system.

Table 1 Additionally installed equipment for radio interference monitoring

Equipment	Function
Spectrum Analyzer	Observe and record the information on the interference frequency and spectrum, and speculate the carrier interference
Direction Finder	Monitor the radial direction of the interferer
Positioning System	Provide the real-time longitude and latitude of the airplane
Voice Recorder	Record the interfering voice, identify the interference from the radio station and provide the evidence for the administration
VHF Transceiver	Communicate with the ground station to rapidly locate the harmful interference
Sound Control Board	Call control and sound selection e.g. sound of spectrum, locating, VHF
Computer	Data processing and analysis
Antenna	Radio signal reception and transmission

MONITORING METHOD

Same as other inspection agency who is in charge of radio monitoring around the world, （Direction Finder, DF） is utilized to determine the location of interference source. However, the traditional method only can find the relative position of the interferer to the airplane in the air, which means only the direction is found without any other accurate location information. To increase the interference source location accuracy, the Flight Inspection Center of CAAC has improved the system software of the flight calibration system by the adoption of Multi-line of Bearing (M-LOB) intersection algorithm which reduces the location estimation error and the rapid position variation of the aircraft is also considered. Figure 1 shows the illustration of M-LOB algorithm.

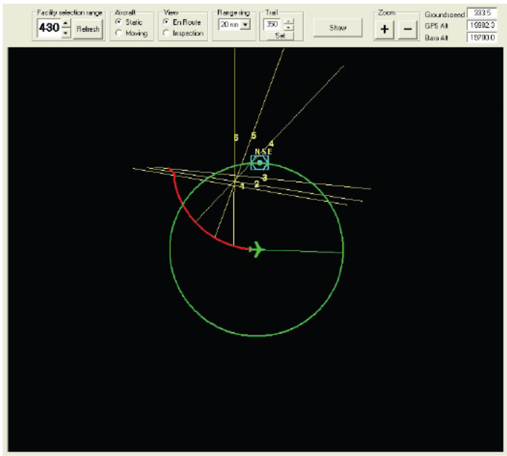

Figure 1 Illustration of Multi-line of Bearing

MONITORING PRACTICE

The Flight Inspection Center of CAAC has carried out may special and urgent radio monitoring and maintenance tasks such as the tasks for the 2008 Olympics, 2010 Shanghai Expo, Guangzhou Asian Games, and etc. During the operation, the Flight Inspection Center of CAAC has suppressed dozens of interference sources and built up the radio emergency guarantee mechanism, which has purified the electro-magnetic environment of the civil aviation and guaranteed the flight safety.

In September of 2012, the Flight Inspection Center of CAAC is responsible of the radio interference monitoring for some important meetings in China. During the operation, the monitoring team has finished 50 hours monitoring flight which covered 7 Chinese civil aviation area, found 77 interference source and suppressed 28 hidden interference dangers to the civil aviation safety. Figure 2 shows the spectrum of the interference source during some task.

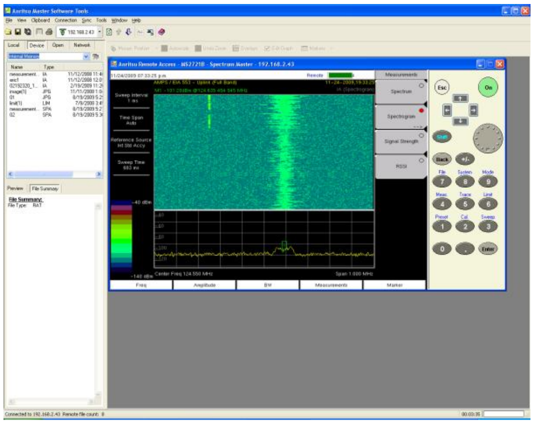

Figure2 Spectrum of interference source

TEST AND COMPENSATION

To testify the accuracy of the monitoring, the CFIC has performed the direction locating accuracy experiment at Xilinhot airport. In the experiment, the radio transmitter with carrier frequency 123.5 MHz and AM modulation is used as the ground interference source. The location of the interference source is N:43-55.227 and E：115-58.068 with magnetic variation of W6.8°. The monitoring airplane has testified the 1 & 2 quadrants and 3 & 4 quadrants according to profile 1 & 2.

Profile 1 ： Perform level flight along with the downwind leg of runway no. 22, the distance between the flight trajectory and the runway is 5 nautical miles with height of 2400 m. The starting point is 13 nautical miles to the end of the runway 22 and the end point is 13 nautical miles to the threshold of runway 22. The position of the airplane relative to the interference source is recorded periodically, where A represents the relative direction to the interference source (obtained through the direction calculation based on the presumed VOR database), B represents the indicated interference source by DF, and C represents the aircraft heading. The calculated and true coordinates of the interference source are compared 1 & 2 quadrants based on the recorded data A, B, and C. The experiment results are summarized in Table 2 and the flight illustration is shown in Figure 3.

Table 2. Summarized experiment results in 1 & 2 quadrants for profile 1.

A	Measured B	C	Calculated B（A-180-C）	Difference
238	28	35	23	-5
243	33	35	28	-5
256	35	35	41	6
260	45	35	45	0
270	64	35	55	-9
280	83	35	65	-18
300	91	35	85	-6
310	113	35	95	-18
325	128	35	110	-18

340	118	35	125	7
350	136	35	135	-1
360	146	35	145	-1
5	148	35	150	2
10	158	35	155	-3
Interferer Coordinates		43-55.134	115-57.338	992m

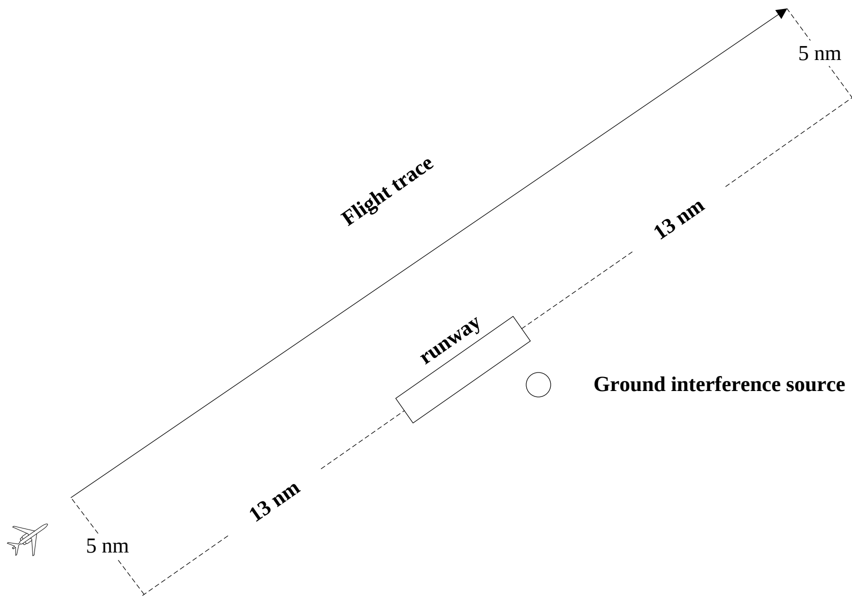

Figure3 Flight illustration for profile 1

Profile 2 ： Perform level flight along with the left downwind leg of runway no. 04, the distance between the flight trajectory and the runway is 5 nautical miles with height of 2400 m. The starting point is 13 nautical miles to the end of the runway 04 and the end point is 13 nautical miles to the threshold of runway 04. The position of the airplane relative to the interference source is recorded periodically, where A represents the relative direction to the interference source (obtained through the direction calculation based on the presumed VOR database), B represents the indicated interference source by DF, and C represents the aircraft heading. The calculated and true coordinates of the interference source are compared 3 & 4 quadrants based on the recorded data A, B, and C. The experiment results are summarized in Table 3 and the flight illustration is shown in Figure 4.

Table 3. Summarized experiment results in 3 & 4 quadrants for profile 2.

A	Measured B	C	Calculated B（A+180-C）	Difference
17	327	215	342	15
10	334	215	335	1
5	328	215	330	2

358	323	215	323	0
350	313	215	315	2
340	280	215	305	25
330	274	215	295	21
320	270	215	285	15
305	262	215	270	8
285	258	215	250	-8
265	229	215	230	1
246	207	215	211	4
242	191	215	207	16
Interferer Coordinates		43-55.094	115-58.171	283m

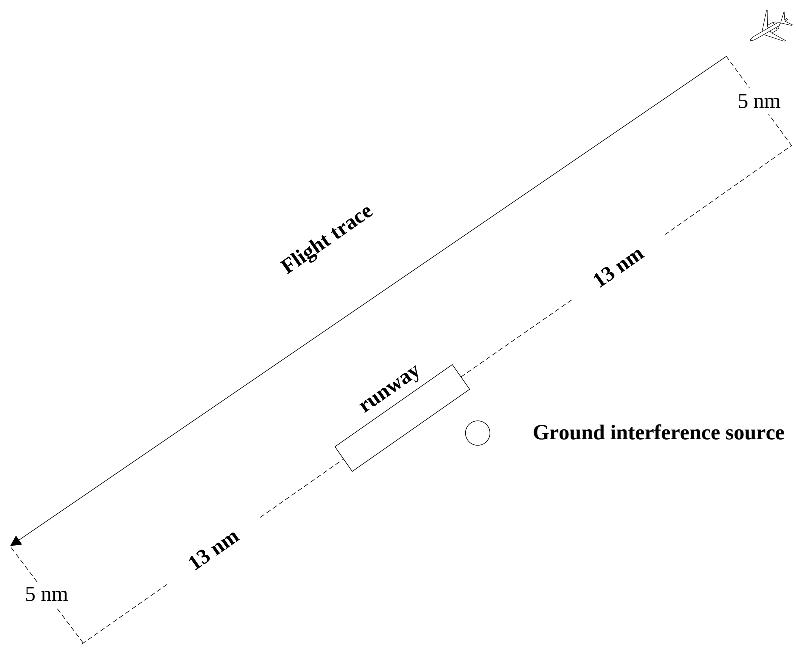

Figure4 Flight illustration for profile 2

According to the experiment results, we optimized the direction accuracy of the RFI function in the calibration system which compensated the error in multiple directions based on the table in figure 5.

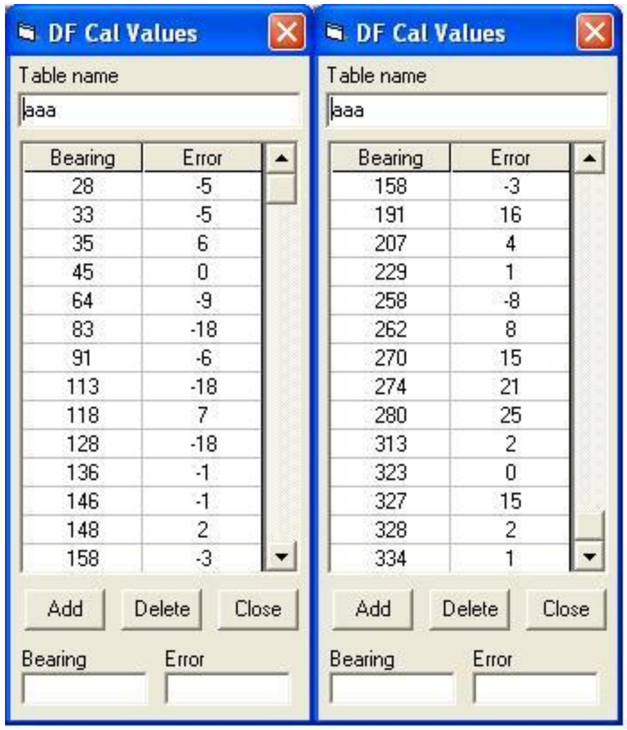

Figure 5 Error compensation table of the onboard system.

FURTHER WORK

In recent years, the CFIC has summarized some experience to deal with this kind of radio frequency interference (RFI) monitoring and location task for the VHF band, but the similar work in the UHF band is still kept blank, which requires our further exploration on the methodology and experiments.

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