International Civil Aviation Organization

FIFTH MEETING OF SPECTRUM REVIEW WORKING GROUP (SRWG/5)

Video Teleconference, 15 – 17 March 2021

Agenda Item 7: State and regional updates

ANALYSIS OF GPS SIGNALS INTERFERENCE BASED ON QAR DATA

(Presented by China)

SUMMARY

This paper introduces a new initiative in detecting and positioning the source of GPS Radio Frequency Interferences. The use of QAR data analysis has achieved positive results.

1. INTRODUCTION

1.1 Background

GPS is one of the main and important GNSS for the civil aviation at present. GPS signals loss may result in wrong reports of aircraft position, and as such the flight crew may lose the situational awareness. This may lead to breakthrough of the command altitude of the aircraft or lead to flight conflict, may also lead to false alarming such as GPWS terrain, pull up, etc. or delay the emergency response of the crew for the true warnings. Therefore, it causes potential safety hazards in the aviation operation.

In order to detect and identify the sources of GPS radio frequency interferences effectively, Civil Aviation Administration of China (CAAC) used the quick access recorder (QAR) data collected by the Flight Operational Quality Assurance (FOQA) station to carry out special monitoring and data analysis.

1.2 Introduction of CAAC FOQA station

China is the only country in the world that implement the comprehensive monitoring and analysis of all the Chinese fleet, flights and typical safety occurrences for the commercial air transport. In January 2018, CAAC FOQA station was official put online. It is a large-scale and centralized QAR data analysis and application system, and currently monitors over 3,800 commercial aircraft. It processes and analyzes more than 16,000 flights and more than 150GB QAR data every day. It has functions such as QAR raw data decoding, data extraction, correlation analysis, risk assessment, etc. The data analysis service of this system has significantly improved the flight operational quality and safety supervision capability of CAAC.

2. QAR DATA ANALYSIS ON GPS SIGNALS INTERFERENCE

According to the relevant technical parameters of the GPS system recorded in the QAR of each aircraft type, CAAC verified and confirmed that the special monitoring of GPS signal interference could be done on the Boeing B737NG, B757, Airbus A320 series and A330.

2.1 Monitoring Parameters

Boeing 737NG as an example,

Based on the decoding document of Boeing 737NG model (DIGITAL FLIGHT DATA ACQUISITION UNIT 737-600 / -700 / -700C / -800 / -900 DATA FRAME INTERFACE CONTROL AND REQUIREMENTS DOCUMENT), the details of parameter definitions are shown as below,

FMC-08			Digital Discretes Port D14							737-7										
PORT	LBL	SDI 9-10	PARAMETER ASSIGNMENT	FMT	I-MSB	I-LSB	O-MSB	O-LSB	WORD	SUBF	SUPF	ONE LOGIC	ZERO LOGIC	PWR	RRE	GE1	GE2	NOTES	FAA	REV
D14	277	XX	FMC SELECTED PRIMARY NAV SOURCE	COD	18	11	12	5	**284**	0	0	CODED	CODED					15C/5E	60	

NOTE 15C FMC Selected Nav Source

(737-B, -3C, -7)

FMC-08; Label 277_XX

The recorded FMC navigation sensor selection is determined per the following tables:

Table 15C-1 FMC Navigation Source

Bit	Signal	One State	Zero State
22	Spare	N/A	N/A
21	Spare	N/A	N/A
20	Spare	N/A	N/A
19	Spare	N/A	N/A
18	DME	CODED	CODED
17	DME	CODED	CODED
16	IRS	Single	Dual
15	GPS	Yes	No
14	MLS	Yes	No
13	LOC	Yes	No
12	Spare	N/A	N/A
11	VOR	Yes	No

When the FMC Nav Source data is derived from GPS it states “Yes” （GPS =“Yes”）,otherwise it states “No” （GPS =“No” ）.
Example of navigation source data changes:

21/01/2020 Time	FLIGHT_PHASE	GPS_INVALID_CNT	FMC_NAV_GPS	ALT_STDC (feet)	IASC (knot)
00:15:58	CLIMB	0	YES	11211	230.3
00:15:59	CLIMB	0	YES	11227	230.0
00:16:00	CLIMB	0	YES	11243	230.0
00:16:01	CLIMB	0	YES	11259	229.8
00:16:02	CLIMB	0	YES	11277	229.8
00:16:03	CLIMB	0	YES	11295	229.8
00:16:04	CLIMB	0	YES	11313	230.0
00:16:05	CLIMB	0	YES	11331	229.8
00:16:06	CLIMB	0	YES	11351	229.5
00:16:07	CLIMB	0	YES	11368	229.3
00:16:08	CLIMB	0	YES	11384	228.8
00:16:09	CLIMB	0	YES	11402	228.5
00:16:10	CLIMB	0	YES	11417	228.0
00:16:11	CLIMB	0	YES	11431	228.0
00:16:12	CLIMB	0	YES	11447	227.8
00:16:13	CLIMB	0	YES	11461	227.5
00:16:14	CLIMB	0	YES	11475	227.0
00:16:15	CLIMB	0	YES	11489	226.3
00:16:16	CLIMB	1	NO	11503	225.8
00:16:17	CLIMB	1	NO	11514	225.5
00:16:18	CLIMB	1	NO	11525	225.8
00:16:19	CLIMB	1	NO	11533	226.0
00:16:20	CLIMB	1	NO	11539	226.3
00:16:21	CLIMB	1	NO	11542	226.8
00:16:22	CLIMB	1	NO	11544	227.3
00:16:23	CLIMB	1	NO	11545	227.5
00:16:24	CLIMB	1	NO	11546	228.0
00:16:25	CLIMB	1	NO	11544	228.5
00:16:26	CLIMB	1	NO	11543	229.0
00:16:27	CLIMB	1	NO	11541	229.3
00:16:28	CLIMB	1	NO	11540	229.3
00:16:29	CLIMB	1	NO	11538	229.5
00:16:30	CLIMB	1	NO	11537	229.5
00:16:31	CLIMB	1	NO	11537	229.8
00:16:32	CLIMB	1	NO	11537	230.0
00:16:33	CLIMB	1	NO	11537	230.0

2.2 Logic and Criteria

An interference incident is indicated whenever the GPS signal is not used for 3 seconds.

When an incident is detected, the program extracts parameters at appear/end of the incident for data analysis. Parameters including altitude, speed, flight phase, latitude and longitude etc.

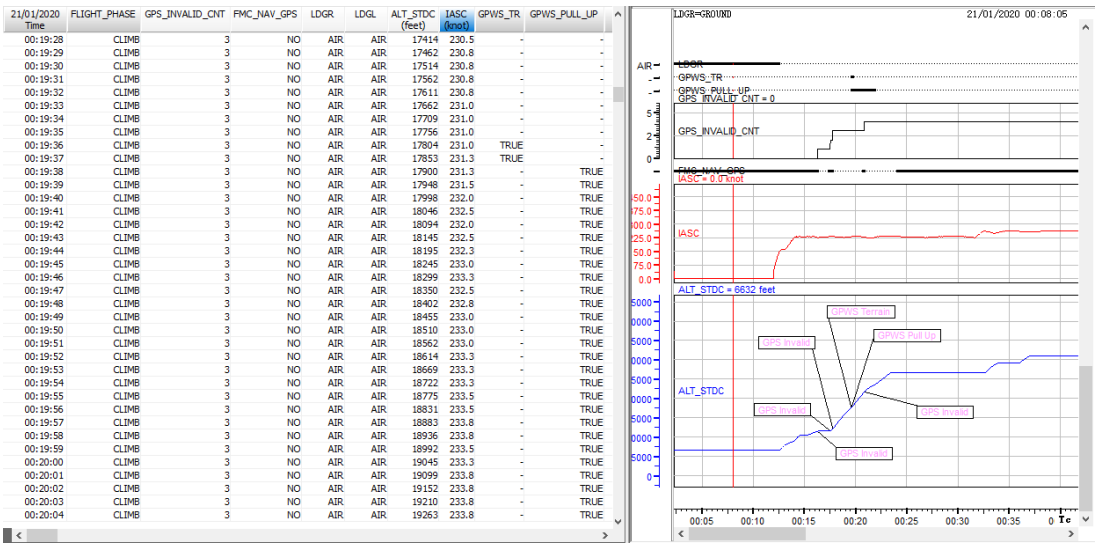
2.3 Data comparison

The results of interference incident are also contrastively analyzed with the information of Aviation Safety Information System of CAAC. For instance, on January 21, 2020, scheduled flight B737-700 from Kunming to Xi'an, during the climb phase, the CDU delivered a warning message of "L/R GPS INVALID" while the FMC amber indicator steady. When the altitude was close to 6000 meters, the “TERR” display on the ND changed from green to red, and EGPWS warning "TERRAIN, TERRAIN, PULL UP" was triggered.

The analysis of the flight segment, incident and related parameters are shown in below.

1	S.I.	Flight Type	Flight No	From	Take-Off Runway	To	Landing Runway	Departure Date	Take off Date	Airborne Duration	Recorder Type	Param. Quality	Recording Ratio	First Frame	Frame Nr
1		Commercial		ZPPP	21	ZLXY	05R	21/01/2020 00:02:32	21/01/2020 00:12:29	01:48:47	QAR/DAR	100.%	99.94%	1	1884

6	Root Version No	Flight Phase	Event No	Event Date	Severity Class	Event Description	Event Type	Limit	Maximum Value	Duration	Average Gap	Time To Peak	Flight No	From	Take-Off Runway	To	Landing Runway
1	407	CLIMB	8973	21/01/2020 00:16:16	7	GPS Invalid	Operation	1.	1.	65	0.	0		ZPPP	21	ZLXY	05R
2	407	CLIMB	8973	21/01/2020 00:17:31	7	GPS Invalid	Operation	1.	2.	5	0.	0		ZPPP	21	ZLXY	05R
3	407	CLIMB	8973	21/01/2020 00:17:46	7	GPS Invalid	Operation	1.	3.	180	0.	0		ZPPP	21	ZLXY	05R
4	407	CLIMB	6012	21/01/2020 00:19:35	5	GPWS Terrain	Operation	0.	0.	2	0.	0		ZPPP	21	ZLXY	05R
5	407	CLIMB	6013	21/01/2020 00:19:37	5	GPWS Pull Up	Operation	0.	0.	131	0.	0		ZPPP	21	ZLXY	05R
6	407	CLIMB	8973	21/01/2020 00:20:51	7	GPS Invalid	Operation	1.	4.	195	0.	0		ZPPP	21	ZLXY	05R



21/01/2020 Time	FLIGHT_PHASE	GPS_INVALID_CNT	FMC_NAV_GPS	LDGR	LDGL	ALT_STDC (feet)	IASC (knot)	GPWS_TR	GPWS_PULL_UP
00:19:28	CLIMB	3	NO	AIR	AIR	17414	230.5	-	-
00:19:29	CLIMB	3	NO	AIR	AIR	17462	230.8	-	-
00:19:30	CLIMB	3	NO	AIR	AIR	17514	230.8	-	-
00:19:31	CLIMB	3	NO	AIR	AIR	17562	230.8	-	-
00:19:32	CLIMB	3	NO	AIR	AIR	17611	230.8	-	-
00:19:33	CLIMB	3	NO	AIR	AIR	17662	231.0	-	-
00:19:34	CLIMB	3	NO	AIR	AIR	17709	231.0	-	-
00:19:35	CLIMB	3	NO	AIR	AIR	17756	231.0	-	-
00:19:36	CLIMB	3	NO	AIR	AIR	17804	231.0	TRUE	-
00:19:37	CLIMB	3	NO	AIR	AIR	17853	231.3	TRUE	-
00:19:38	CLIMB	3	NO	AIR	AIR	17900	231.3	-	TRUE
00:19:39	CLIMB	3	NO	AIR	AIR	17948	231.5	-	TRUE
00:19:40	CLIMB	3	NO	AIR	AIR	17998	232.0	-	TRUE
00:19:41	CLIMB	3	NO	AIR	AIR	18046	232.5	-	TRUE
00:19:42	CLIMB	3	NO	AIR	AIR	18094	232.0	-	TRUE
00:19:43	CLIMB	3	NO	AIR	AIR	18145	232.5	-	TRUE
00:19:44	CLIMB	3	NO	AIR	AIR	18195	232.3	-	TRUE
00:19:45	CLIMB	3	NO	AIR	AIR	18245	233.0	-	TRUE
00:19:46	CLIMB	3	NO	AIR	AIR	18299	233.3	-	TRUE
00:19:47	CLIMB	3	NO	AIR	AIR	18350	232.5	-	TRUE
00:19:48	CLIMB	3	NO	AIR	AIR	18402	232.8	-	TRUE
00:19:49	CLIMB	3	NO	AIR	AIR	18455	233.0	-	TRUE
00:19:50	CLIMB	3	NO	AIR	AIR	18510	233.0	-	TRUE
00:19:51	CLIMB	3	NO	AIR	AIR	18562	233.0	-	TRUE
00:19:52	CLIMB	3	NO	AIR	AIR	18614	233.3	-	TRUE
00:19:53	CLIMB	3	NO	AIR	AIR	18669	233.3	-	TRUE
00:19:54	CLIMB	3	NO	AIR	AIR	18722	233.3	-	TRUE
00:19:55	CLIMB	3	NO	AIR	AIR	18775	233.5	-	TRUE
00:19:56	CLIMB	3	NO	AIR	AIR	18831	233.5	-	TRUE
00:19:57	CLIMB	3	NO	AIR	AIR	18883	233.8	-	TRUE
00:19:58	CLIMB	3	NO	AIR	AIR	18936	233.8	-	TRUE
00:19:59	CLIMB	3	NO	AIR	AIR	18992	233.5	-	TRUE
00:20:00	CLIMB	3	NO	AIR	AIR	19045	233.3	-	TRUE
00:20:01	CLIMB	3	NO	AIR	AIR	19099	233.8	-	TRUE
00:20:02	CLIMB	3	NO	AIR	AIR	19152	233.8	-	TRUE
00:20:03	CLIMB	3	NO	AIR	AIR	19210	233.8	-	TRUE
00:20:04	CLIMB	3	NO	AIR	AIR	19263	233.8	-	TRUE

The duration of two incident from different system recorded are basically matching, which further verifies the rationality and accuracy of the monitoring logic.

2.4 Results

CAAC processed and analyzed parameters at appear/end time of GPS signals unused, such as altitude, speed, flight phase, latitude and longitude and other parameters of multiple flights. Those parameters have been further applied to GPS signal interference source positioning and daily interference incident monitoring in many airports.

This is a new QAR data analysis application, and has achieved positive results. In 2020, dozens of GPS interference sources such as GPS signal jammer installed in parking lots or personal vehicles had been identified and located with the support of QAR data analysis.

3. ACTION BY THE MEETING

3.1 The meeting is invited to:

a) note the information contained in this paper; and

b) discuss any relevant matter as appropriate

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