



ICAO

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Navigation and Surveillance Sub-group (CNS SG/25) of
APANPIRG**

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Agenda Item 5: Navigation

5.4 Other navigation related issues

**RESEARCH ON OPERATIONAL QUALITY ANALYSIS OF INSTRUMENT LANDING
SYSTEM BASED ON AIRBORNE DAR DATA**

(Presented by China)

SUMMARY

This paper introduced a new method for analyzing the operational quality of instrument landing system based on flight airborne DAR data.

1. INTRODUCTION

1.1 The Instrument Landing System (ILS) is a support device for precision approach and landing, ensuring safe landing in low visibility and inclement weather conditions. In order to ensure safety, the ILS needs to be checked every six months, and there is a lack of spatial signal quality monitoring technology between flight inspections. If the spatial signal quality of the ILS is analyzed based on the on-board data of the daily running flight, the spatial signal quality verification means of the ILS can be supplemented, and the safety hazards existing in the flight operation can be found, and the safety pressure can be reduced. Therefore, it is of great significance to carry out the analysis of the operational quality of the ILS based on the airborne data.

1.2 There are many types of airborne data, such as FDR (Flight Data Recorder), QAR (Quick Access Recorder) and DAR (Digital ACMS Recorder). FDR is black box data, not easy to obtain. The data acquisition frequency and accuracy in QAR cannot be customized, and the signal accuracy and frequency of the ILS are insufficient. The data acquisition frequency and accuracy in DAR can be customized to improve the accuracy and frequency of the ILS signal, so that the ILS signal acquisition frequency reaches 8 times per second.

1.3 Currently, China Southern Airlines has totally 220 Airbus 320 series aircraft and 45 Airbus 330 series aircraft equipped with high-precision airborne DAR data output capacity, which provides about 600 high-precision airborne data per day covering 230 sets of ILS in China.

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1.4 Based on the data mentioned above, an ILS operation quality monitoring platform has been built, which can monitor key parameters of LOC and GP in real time and discover hidden hazard in daily flights.

2. DISCUSSION**2.1 Improved positioning accuracy**

2.1.1 Obtaining the accurate track position of the flight is the difficult and key point of this project. This project, making uses of extracted airborne recorded data such as high-precision, high-frequency GPS, inertial navigation data, radio altitude and aircraft attitude, can provide the horizontal accuracy about 3 meters; The accuracy of the radio altimeter on the runway is better than 1 meter. Using the key algorithm of radio altitude difference and inertial navigation to calculate, within 2 kilometers from the entrance of runway and 90% probability, the altitude error of the aircraft can be corrected and restrained within 1 meter. The accuracy and frequency of LOC and GP DDM are close to the flight inspection. The radio altitude matching terrain algorithm is used to correct the delay between the GPS and the receiver signal. The delay is normally distributed between 0 and 3 seconds. The median is 1.5 seconds. The consistency of the airborne data analysis results and the correlation with the flight verification results is strong, which demonstrates that the positioning accuracy can meet the requirements of airborne data analysis.

2.2. Consistency of data analysis

2.2.1 Select 30 runways, which have a total of 14295 data items, group by the runway firstly and then group by date. Having 5 data items in each group, there is a total of 2859 groups of mean values. According to the statistical principles, 95% of the group averages are selected for each runway to calculate the standard deviation and range. Consistency can be demonstrated by standard deviation and range.

2.2.2 The average standard deviation of the GP Angle, GP half-width and TCH are 0.012 degrees, 0.08 degrees and 0.2 meters, accounting for 5%, 13% and 7% of the alarm threshold. The average standard deviation of structure zone 1, zone 2 and zone 3 is 0.6, 2.7, 2.4 μ A, accounting for 2%, 9% and 8% of the alarm threshold.

GP	GP Angle	Half-width	TCH	Structure Zone1	Structure Zone2	Structure Zone3
Average standard deviation of 30 runways	0.012	0.008	0.20	0.6	2.7	2.4
Proportion of standard deviation to alarm threshold	5%	13%	7%	2%	9%	8%
Average range of 30 runways/2	0.019	0.012	0.32	0.8	4.2	3.6
Average range/2/average standard deviation	1.6	1.6	1.6	1.3	1.5	1.5

2.2.3 The average standard deviation of the LOC Alignment angle and LOC half-width is 0.1 degrees, which accounts for no more than 6% of the alarm threshold; the average standard deviation of structure zone 1, zone 2 and zone 3 is 1 μ A, which accounts for no more than 7% of the alarm threshold.

LOC	Alignment Angle	Half-width	Structure Zone1	Structure Zone2	Structure Zone3
Average standard deviation of 30 runways	0.009	0.013	0.7	1.1	0.8
Proportion of standard deviation to alarm threshold	6%	5%	2%	7%	5%
Average range of 30 runways/2	0.019	0.028	1.4	2.2	1.6
Average range/2/average standard deviation	2.1	2.1	2.1	2.0	1.9

2.3 Correlation with flight inspection

2.3.1 Select 30 runways, which have a total of 14295 data items, group by the runway firstly and then group by date. Having 5 data items in each group, there is a total of 2859 groups of mean values. According to statistical principles, we define the analysis result of airborne data for each runway by arithmetic average of 95% of the group averages for that runway. Considering the average of the final value of the last flight inspection No. 1 and 2 transmitters and the initial value of the next flight inspection No. 1 and 2 transmitters as the reference value of flight inspection, we can perform the flight inspection correlation analysis by comparing the analysis results of the airborne data with the reference values of the flight inspection.

2.3.2 Due to the influence of various factors such as aircraft taxiing, take-off, and interference during the operation of the aircraft, the average deviation of LOC parameters, such as LOC Alignment angle, LOC half-width, with flight inspection is 0.03 degrees, accounting for 20% and 12% of the alarm threshold. The average deviation of the structure of zone 1, zone 2 and zone 3 is 1µA, 2µA and 1µA, accounting for 3%, 13% and 7% of the alarm threshold.

LOC	Alignment Angle	Half-width	Structure Zone1	Structure Zone2	Structure Zone3
Average deviation with flight inspection	0.03	0.03	1	2	1
Percentage of deviation in alarm threshold	20%	12%	3%	13%	7%

2.3.3 In the GP parameters, the average deviation of GP Angle, GP half-width and flight inspection is 0.01 degrees, accounting for 4% and 16% of the alarm threshold; the average deviation of the structure of zone 1, zone 2, and zone 3 is 2µA, 4µA and 4µA, accounting for 7%, 13%, and 13% of the alarm threshold.

GP	GP Angle	Half-width	TCH	Structure Zone1	Structure Zone2	Structure Zone3
Average deviation with flight inspection	0.01	0.01	0.4	2	4	4
Percentage of deviation in alarm threshold	4%	16%	13%	7%	13%	13%

2.4 Facility difference inspection analysis

2.4.1 Through the analysis of 30 runways data, the system can clearly reflect the difference of LOC and GP.

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2.4.2 More than 50 flight tests were carried out at Guangzhou International Airport and Nanyang Airport. Adjusting parameters such as LOC Alignment angle, LOC width, GP angle, GP width, the changes of analysis results were consistent with the changes in facility status. It indicates that when facility parameters reached to the warning threshold, this system can send out warning in time.

2.4.3 Witnessed by ILS experts from all over the country, it was verified at Nanyang Airport that when the change of transmitter parameters or antenna site caused the air parameters exceeded the flight inspection qualification threshold, the change of project-related parameters were consistent with expectations, and can send out warning.

LOC	LOC Width	Alignment Angle	GP Angle	GP Half-Width	GP Structure
Simulation value of facility change	0.4	0.1	0.2	0.09	Place a bus in area A
Airborne data change data	0.38	0.1	0.19	0.08	50

2.4.4 In the LOC facility, the system can distinguish the differences of facility well. Take Zhangjiajie Airport and Nanyang Airport as an example, the LOC half width is about 2 degrees, which is quite different from other facility, and the distinction is obvious, which is in line with the actual situation of the facility. The airport runway is short, so that the LOC half-width of the facility is larger.

LOC	Alignment Angle	Half-Width	Structure Zone1	Structure Zone2	Structure Zone3
Maximum direction	Xi'an 23L	Zhangjiajie 08	Zhangjiajie 26	Xi'an 05R	Shenyang 24
Maximum value	0.06	2.14	4.6	6.7	4.5
Minimum value	-0.05	1.43	1.8	2.3	1.3
Minimum direction	Shenyang 24	Changsha 36R	Changsha 36R	Shanghai 36R	Haikou 27

2.4.5 In the GP facility, the system can distinguish the facility differences well. Zhangjiajie Airport has the largest GP angle in all runways, the system analysis result is 3.19 degrees, and the design GP angle is 3.2 degrees; GP angle of Shenyang 24 is 3.08 degrees, which is basically the same as 3.06 degrees in the flight inspection. Among the 30 runways, Changsha 36R GP has the largest structure zone3, which is consistent with flight inspection result.

GP	GP Angle	TCH	Half-Width	Structure Zone1	Structure Zone2	Structure Zone3
Maximum direction	Zhangjiajie 08	Daxing 19R	Zhangjiajie 08	Shenyang 06	Changsha 36R	Changsha 36R
Maximum value	3.19	17.3	0.38	5.0	19.5	16.6
Minimum value	2.96	15.6	0.32	3.1	10.8	7.6
Minimum direction	Shenzhen 16	Sanya 26	Shenzhen 34	Hongqiao 36R	Nanyang 23	Shanghai 36R

2.5. Found ILS operational problems and suggestions

2.5.1 The ILS signal quality monitoring system has been built, which can monitor values of flight inspection related parameters such as GP angle, half-width, TCH and structure and send out warning. When a number of consecutive flights exceed the flight inspection threshold, the system can automatic warning. Individual average warnings on 30 runways in the past six months are all generated when relevant facilities are not in use.

2.5.2 The system will alarm when the structure of LOC or GP is unqualified caused by the jitter or excessive width of a single ILS signal. The system gives a total of 890 single-flight warnings, of which 60% were caused of LOC and 40% were caused of GP, of which 90% generated on mixed takeoff and landing runways and 10% generated on the take-off and landing separation runway. Ground flights will cause significant short-term interference to the quality of the LOC signal. It is recommended that the CAT I ILS airports should provide relevant information notifications to remind pilots to pay attention to the short-term ILS signal jitter. CAT II and III ILS airports must strictly implement ground aircraft control measures.

3. ACTION BY THE MEETING

3.1 The meeting is invited to:

- a) note the information contained in this paper.
- b) discuss any relevant matters as appropriate.
