GNSS interference detection for aviation in China

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1. Status of GNSS interference detection in civil aviation in China

2. GNSS interference detection system for airport
Application of GNSS in aviation

- Satellite navigation in civil aviation (mainly used in navigation and timing): important.
- GNSS can meet accuracy requirements of aviation.

NextGen Navigation Services
- Operational capability based on GPS
- Consistent with ICAO Global Vision
- Fully operational by 2030

Accuracy requirements of aviation

<table>
<thead>
<tr>
<th></th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Horizontal (95%)</td>
</tr>
<tr>
<td>Airway (ocean)</td>
<td>3.7km</td>
</tr>
<tr>
<td>Airway (land)</td>
<td>3.7km</td>
</tr>
<tr>
<td>Terminal</td>
<td>0.74km</td>
</tr>
<tr>
<td>NPA</td>
<td>220m</td>
</tr>
<tr>
<td>APV I</td>
<td>16m</td>
</tr>
<tr>
<td>APV II</td>
<td>16m</td>
</tr>
<tr>
<td>CAT I</td>
<td>16m</td>
</tr>
<tr>
<td>Aviation timing</td>
<td>Us level</td>
</tr>
</tbody>
</table>

(from FAA)
GNSS interference affects safety of aviation

- GNSS signal is weak (-160dBW on the ground), and vulnerable to interference.
- Safety of aviation will be seriously affected when GNSS was interfered.
**Typical GNSS interference cases in airports**

- Many GNSS interference cases in airport have been reported.

<table>
<thead>
<tr>
<th>Time</th>
<th>Location</th>
<th>Description</th>
<th>RFI source</th>
<th>RFI source belongs to</th>
</tr>
</thead>
<tbody>
<tr>
<td>1997</td>
<td>Lucano airport, Switzerland</td>
<td>GPS L1, L2 were interfered at civil/military airport</td>
<td>Permanent transmitter</td>
<td>Italian military</td>
</tr>
<tr>
<td>2002</td>
<td>Frankfurt airport, Germany</td>
<td>Received signal at L1 band was interfered around the airport with coverage of 150km</td>
<td>unclear</td>
<td>Unclear</td>
</tr>
<tr>
<td>2009~2011</td>
<td>Newark, USA</td>
<td>GBAS system anomaly often</td>
<td>GPS private jammer</td>
<td>personal</td>
</tr>
</tbody>
</table>
**Example 1: GPS interference in Foshan airport**

- In Sep. 2009, During the flight inspection, GPS receiver was found to be interfered.
- Result: positioning unavailable.
- RFI source: Yagi directional antenna on top of a building of community policeman team (with direction to the airfield runway).

Spectrum of interference signal
In Nov. 8th, 2015, during the flight inspection of the west runway of Chengdu Shuangliu airport.

The flight inspection crew reported that there was GPS signal interference near the runway, causing the onboard flight inspection system failure.

RFI Source: illegal transmitter installed in a automobile repair plant.
Example 3: GPS interference in Shijiazhuang airport

- During 14-19 Oct. 2015, in Shijiazhuang airport. GPS navigation signal was not available, the flight inspection cannot be finished.
- Result: cannot positioning in the northwest runway, may cause potential safety risk during aircraft take-off and landing phase.
- RFI source: illegal used transmitter in a village, can shield 2G, 3G, 4G and GPS signals.

Transmitter
At present, still no special-purpose device and system for GNSS interference detection in aviation. General spectrum detection device from Radio management administration is used.

The general spectrum detection device is not enough for GNSS interference detection in aviation.

- Can not detect weak GNSS interference signal
- Can not detect spoofing.

special-purpose device and system is necessary.
1、Status of GNSS interference detection in civil aviation in China

2、GNSS interference detection system for airport
In view of the serious GNSS interference problem in civil aviation, special-purpose device and system have been developed in China.

- Development of device for GNSS interference detection
- Development of demonstration system for GNSS interference detection
- ....
A project on demonstration system of GNSS interference detection in Dongying Shengli airport has been initiated.
Scheme of GNSS interference detection system for airport

Data process & analysis center in airport

RFI detection system based on ADS-B

Fixed RFI detection system (direction-finding, grid monitoring)

Movable RFI detection system (vehicle, airborne)

National Radio Administration

Information sharing

Interference elimination

RFI Report from pilot
Function of data process & analysis center

- Collection of RFI information (from pilot report and RFI monitoring info)
- Data process and analysis (including interference identification)
- Information storage
- Threat evaluation
- Warning and information sharing
Interference identification

First, receiver problem, constellation anomaly and space weather should be excluded

Step 1.
Check whether it is the problem of receiver

easy

Step 2.
Identification of GNSS constellation anomaly
- Signal power
- Signal correlation peak
- Navigation message
- Quality of measurement

Step 3.
Identification of space weather and RFI
- Spatial and temporal distribution of interference
- Amplitude and its statistical characteristics of signal
- Amplitude spectrum of signal

Difficult & important

Workflow of GNSS interference identification
Then, RFI can be identified in detail.

**Type of interference:**
- continuous wave interference,
- frequency modulated interference,
- white nose interference,
- deceptive interference etc.

**Parameters for interference evaluation:**
- effective carrier noise ratio,
- acquiring performance,
- tracking performance,
- timing performance etc.

**Results:**
- decrease of carrier and noise ratio of visible satellites,
- wrong acquiring of receiver,
- decrease of number of acquired satellite,
- increase of searching and acquiring time,
- distortion of code correlator and carrier phase tracker,
- result from discriminator tracking loop,
- decrease of timing performance.
Continuous RFI detection with fixed system or ADS-B

RFI detected?

Y → RFI source localization

With vehicle system

RFI source localized?

N → RFI reported from pilot?

Y → RFI source localization

With airborne system

End
ADS-B in aircraft or vehicle can broadcast its own No. location and velocity, and receive info from ADS-B in other aircraft or vehicle.

Approximate position of interference source can be derived from interrupted latitude, longitude, height and time info of ADS-B.
1) Ground RFI DF(direction finding) system

DF system can be used to detect interference and find direction of RFI source.

2) Ground RFI grid detection system

Grid system can be used to detect interference and localize RFI source by TDOA method.

- Detect weak GNSS interference signal
- Detect spoofing.
Cross localization can be used with vehicle-system to accurately localize RFI source.
When interference cannot be detected with ground system, airborne-system will be used for detection.

Step 1: Use airborne-system to measure the direction of interference at different points and approximately localize RFI source by cross localization;
Step 2: Use ground movable instruments to accurately localize RFI source.

Airborne platform can be airplane or UAV etc.
Title: Recommendation on GNSS interference detection in civil aviation

Background/Brief Description of the Issue:
Interference has became serious threat to GNSS application in aviation.

Discussion/analysis
In order to keep GNSS safer operation of civil aviation, ICG should investigate GNSS interference detection status of each member states in detail, and provide scheme for GNSS interference detection system together with ICAO.

Recommendation
It is recommended that ICG should
- invite member states to report on present status and efforts of GNSS interference detection in civil aviation. Based on this further info sharing action can then be considered.
- consider inviting ICAO participants/experts to discuss scheme for GNSS interference detection system.
Proposed ICG-13 WG-S Action

• WG-S will invite member states and experts to the ICG-13 meeting to report on present status and efforts of GNSS interference detection in civil aviation, including the utilization of ADS-B

• Based on this further information sharing, subsequent action can be considered

(from WG S intersessional meeting)
Thank you!
Thank you!
Thank you!
Thank you!
Thank you!