The technology of GNSS interference detection and localization in city and aviation

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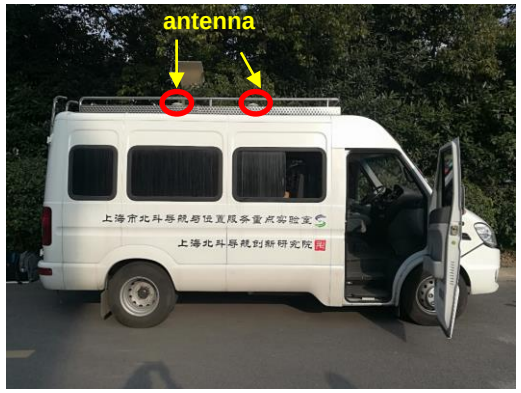
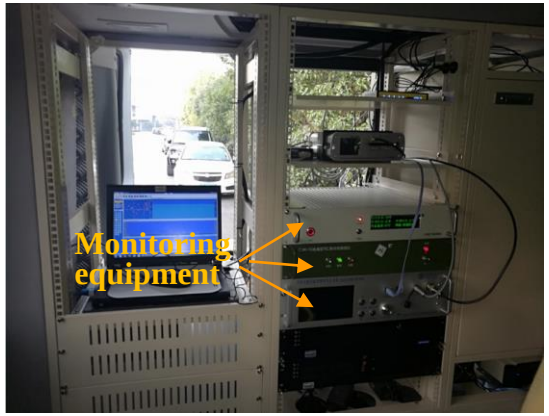
CONTENT

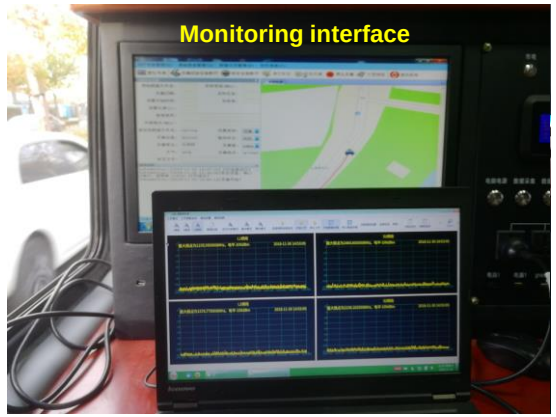
/1 Project Introduction in China

- Project: Technology and demonstration system of GNSS interference detection and localization in city and infrastructure.
- Duration: 2018.5-2021.4。
- Project content:
  - Measurement of GNSS electromagnetic environment in cities and infrastructures.
  - GNSS interference monitoring network design for city and infrastructure.
  - GNSS interference detection and localization technology in city and infrastructure.
  - Threat assessment of GNSS interference.
  - Develop a demonstration system of GNSS interference monitoring.

I. Measurement of GNSS electromagnetic environment in city and airport.

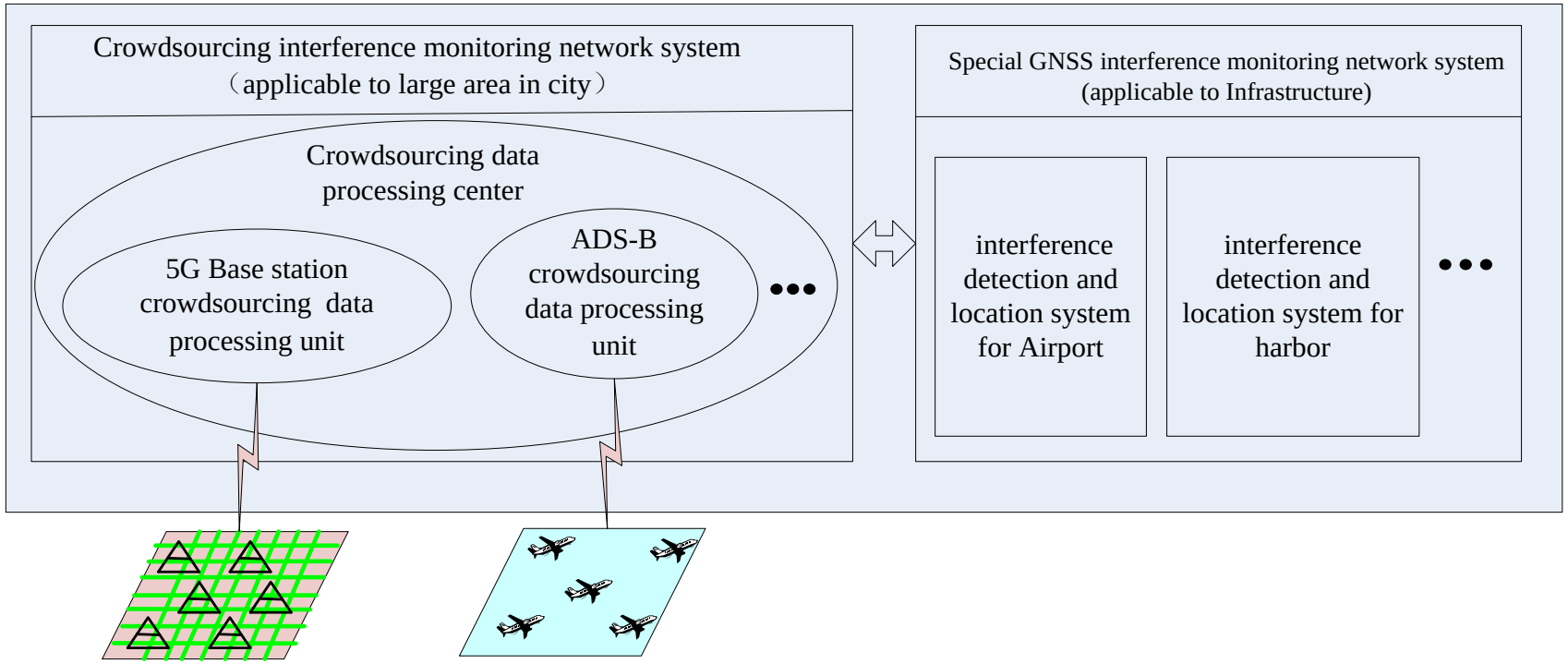






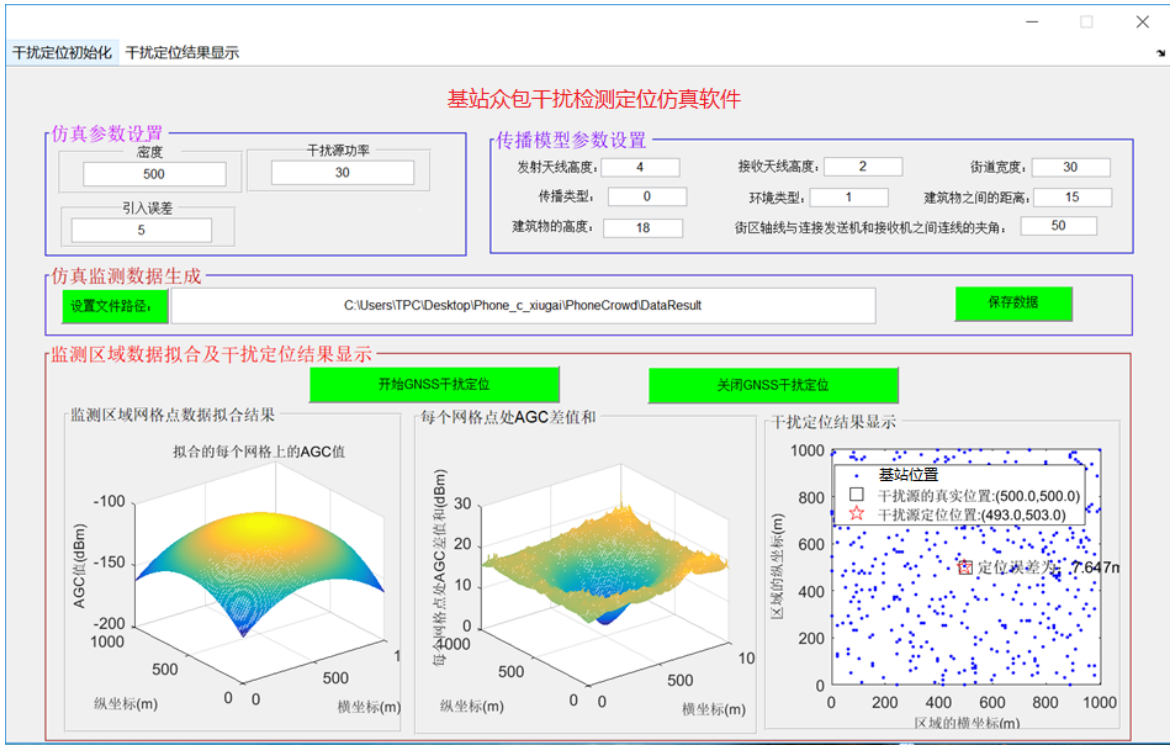
We did measurement in many cities and airports. We found that the electromagnetic environment is complex, which even cause the GNSS receivers lose lock

II. Monitoring network design for city and infrastructure

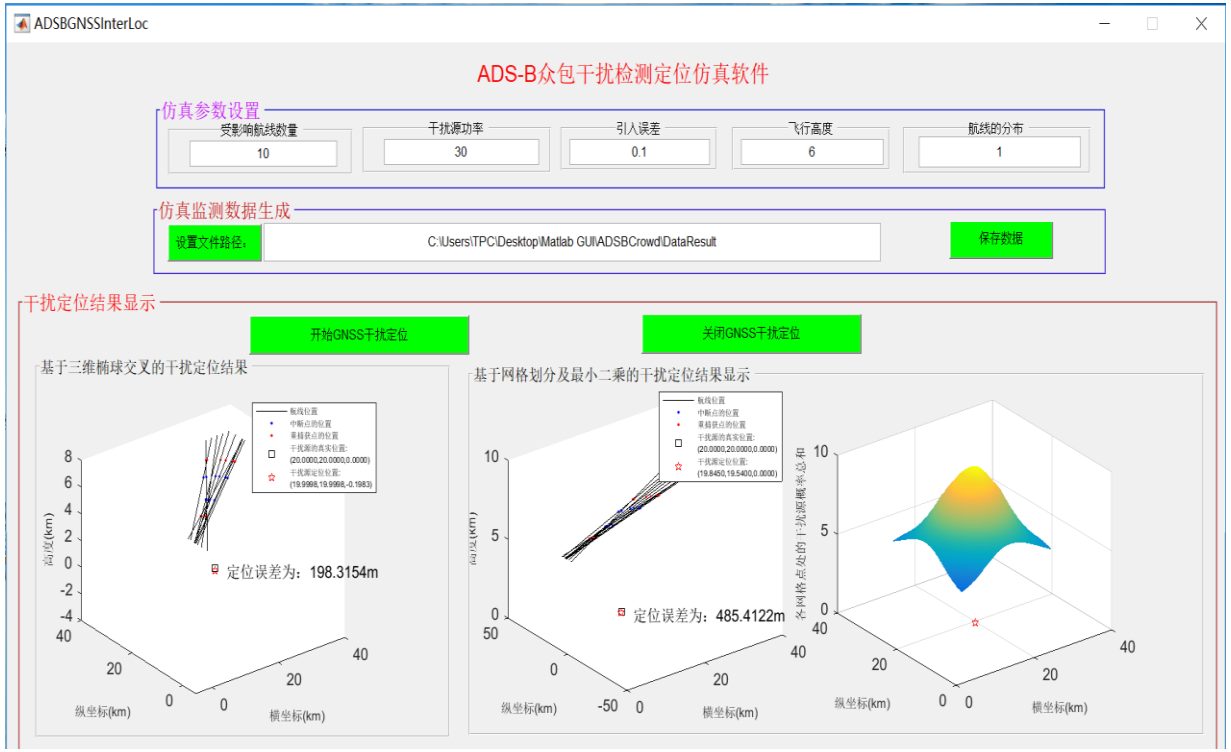


It includes design of interference monitoring network for GNSS application system and infrastructure based on crowdsourcing and design of special GNSS interference monitoring system for infrastructure.

Simulation on GNSS interference detection and localization technology based on 5G base station and ADS-B.



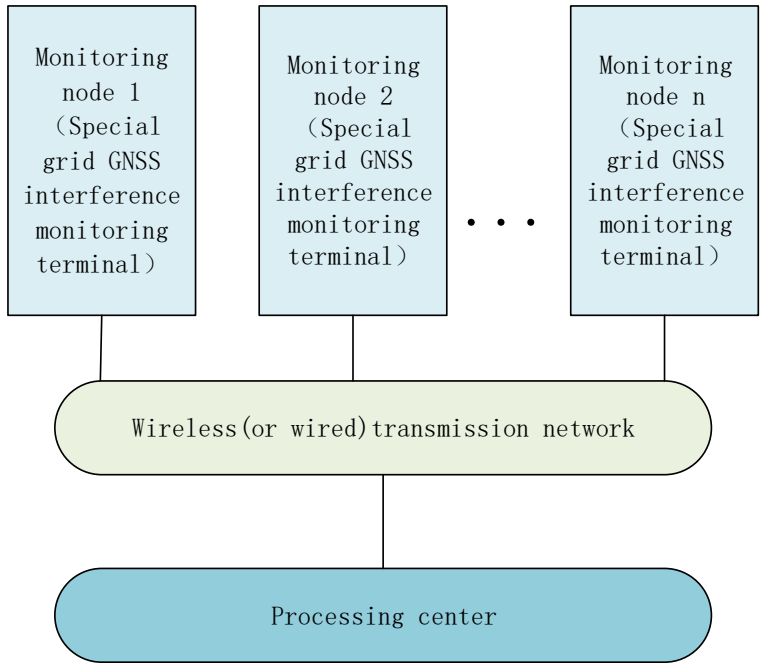
simulation of interference detection and localization technology based on 5G base station.



simulation of interference detection and localization technology based on ADS-B.

III. GNSS interference detection and localization technology in city and infrastructure

1)Special grid GNSS interference monitoring technology and equipment.



Antenna

Receiver

Through fusion method, the information collected by the grid nodes is processed comprehensively. When GNSS timing is available, TDOA method is used for interference localization. When GNSS timing is not available, the positioning based on the power and propagation characteristics of interference signals is used.

The performance index of the gridding interference monitoring network.

✓ **Success rate test of GNSS interference detection**

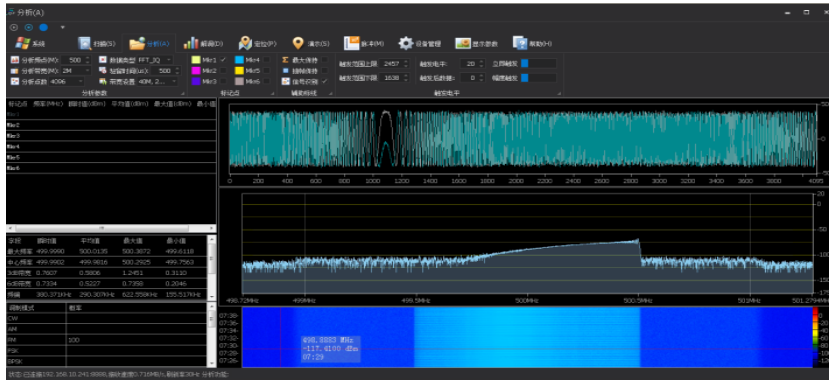
Serial number	Index	Test times	Success times	Success rate
1	Success rate test of GNSS interference detection	100	98	98%

✓ Accuracy and success rate of GNSS interference localization

Serial number	Index	Test duration	Test times	Success times	Localization accuracy	Success rate
1	Positioning accuracy of wideband interference	30min	180	180	28.58m	/
2	Positioning accuracy of pulse interference	30min	180	180	24.06m	/
3	Success rate	1h	360	360	/	100%

Interference source erection

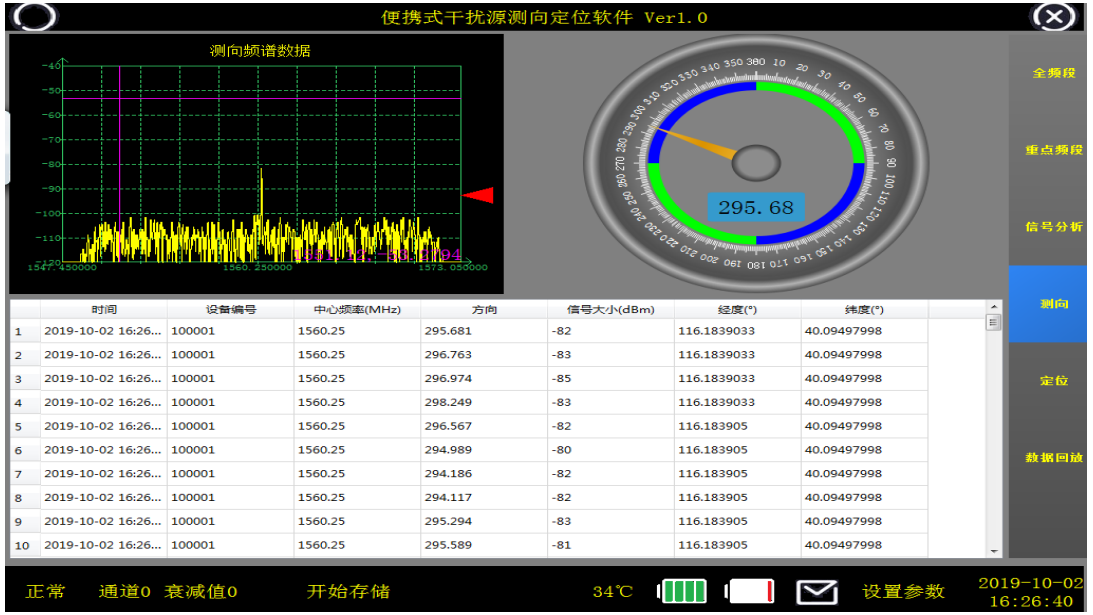
Installation of grid monitoring terminal



Broadband interference detection

2) GNSS interference source localization technology based on UAV

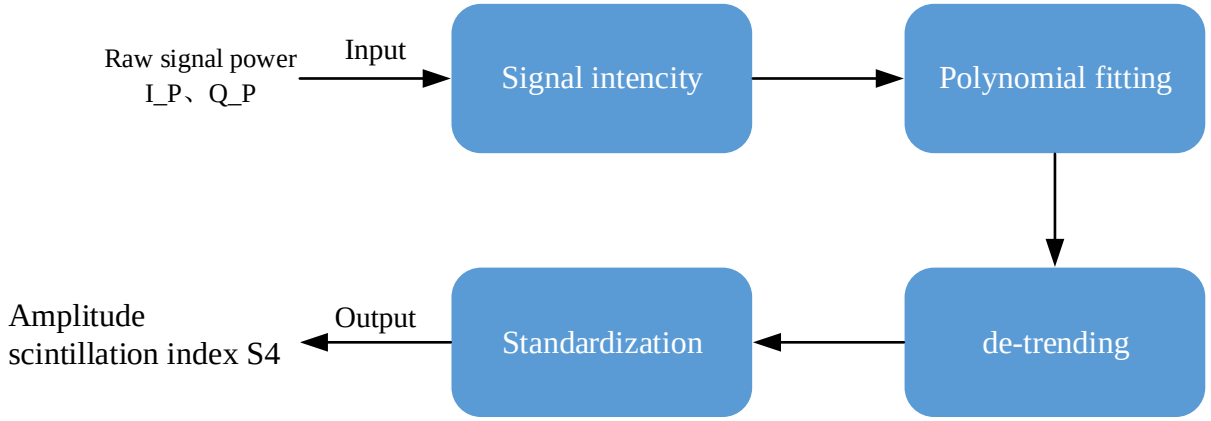
The position of the interference source is determined by the intensity and direction of interference signal.



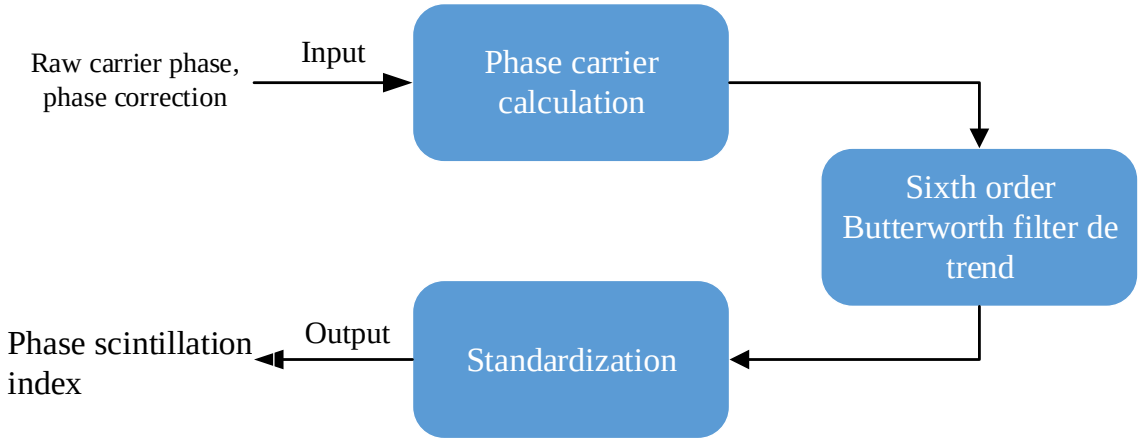
The performance index of the GNSS interference localization based on UAV.

Index	Result
Bandwidth measurement error	1.52%
Pulse interference monitoring accuracy	0.64us
Frequency accuracy	0.44 f×10^{-7}Hz
Voltage leve measurement error	1.6dB
dynamic range	80dB
interference source type of detection and localization	Narrowband, wideband, pulse
Interference signal identification	90% of AM、 FM、ISB、 USB、 CW、 ASK、 BPSK、QPSK、 FSK、 QAM
Localization accuracy	0.07R
Localization success rate	95%
Direction finding accuracy of interference source	1.6°

3) Research on recognition of ionospheric scintillation



Extraction of Amplitude scintillation index

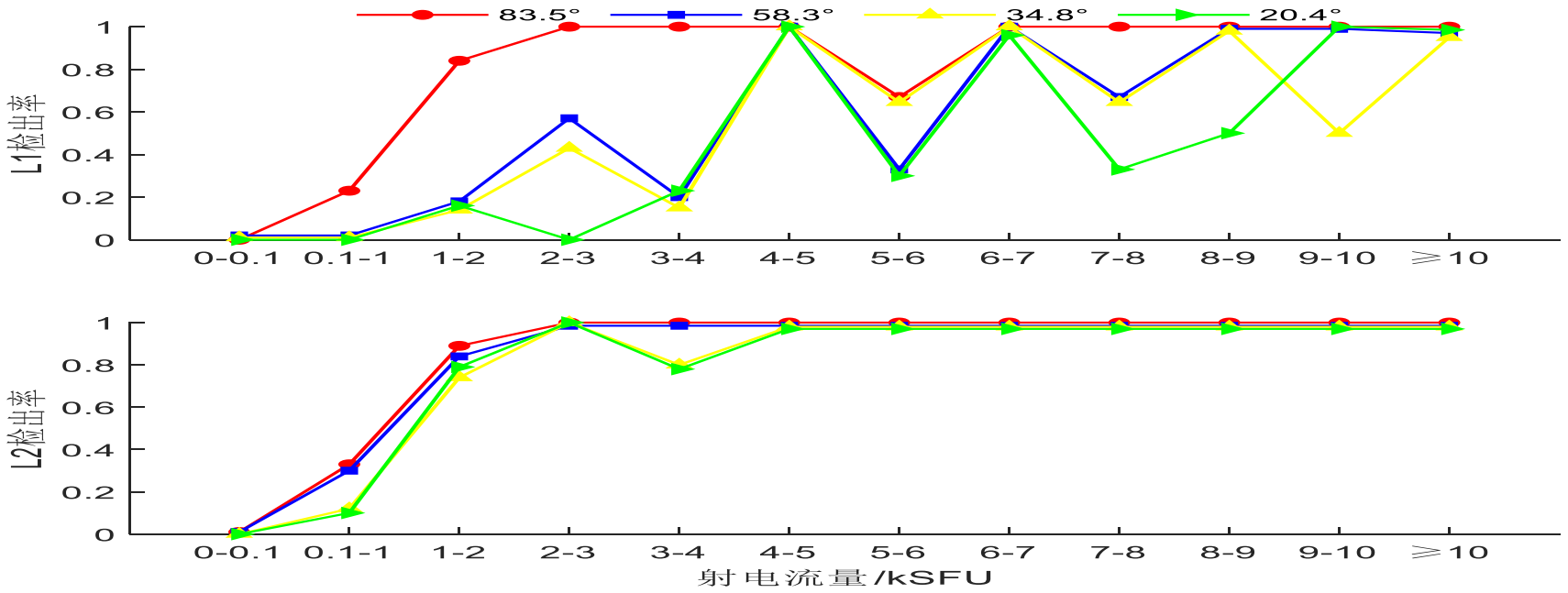


Extraction of Phase scintillation index

4) **Research on recognition of Solar radio**

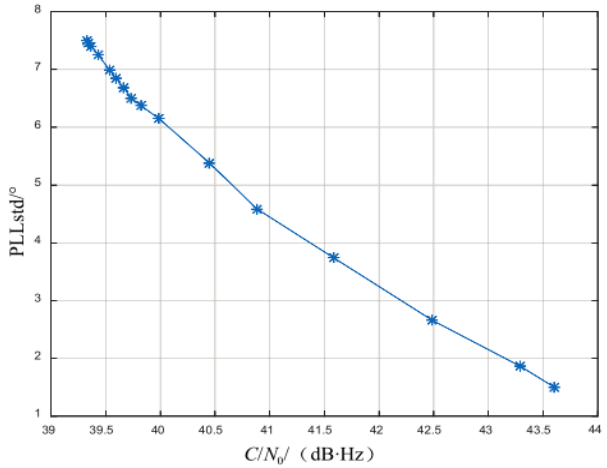
The detection model is developed

- ✓ **The relationship between solar radio and the number of receiving satellites is studied;**
- ✓ **The relationship between solar radio and incident angle is studied;**
- ✓ **The joint monitoring data analysis of multiple stations was carried out;**
- ✓ **The detection rate corresponding to radio flow is studied.**



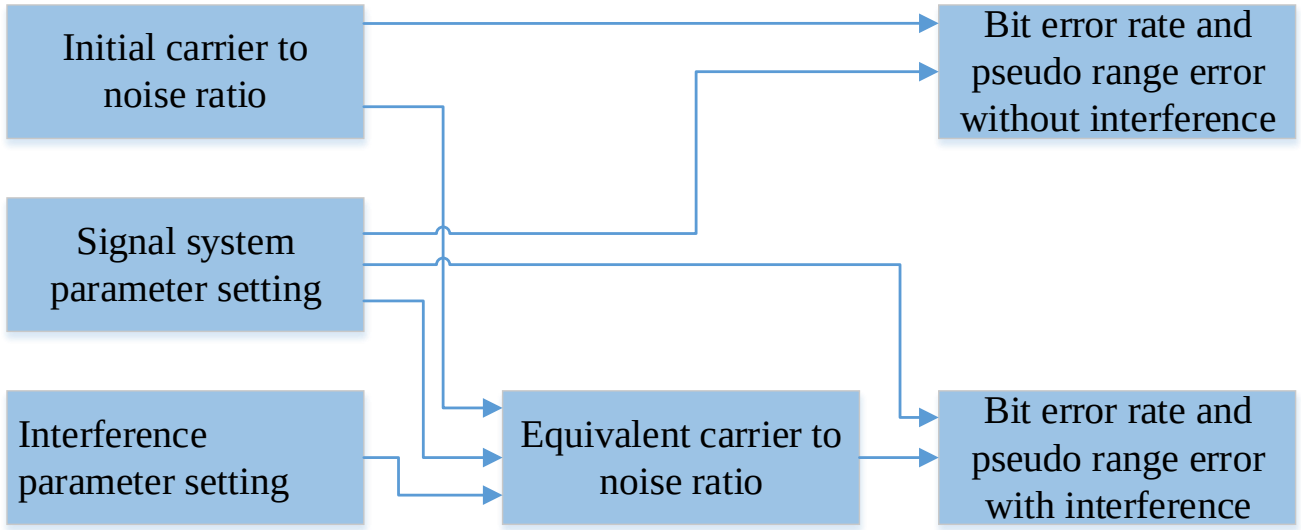
IV. Threat assessment of GNSS interference

Evaluation of pulse interference to general GNSS receiver



The relationship between the C/N0 and the standard deviation of the receiver tracking PLL

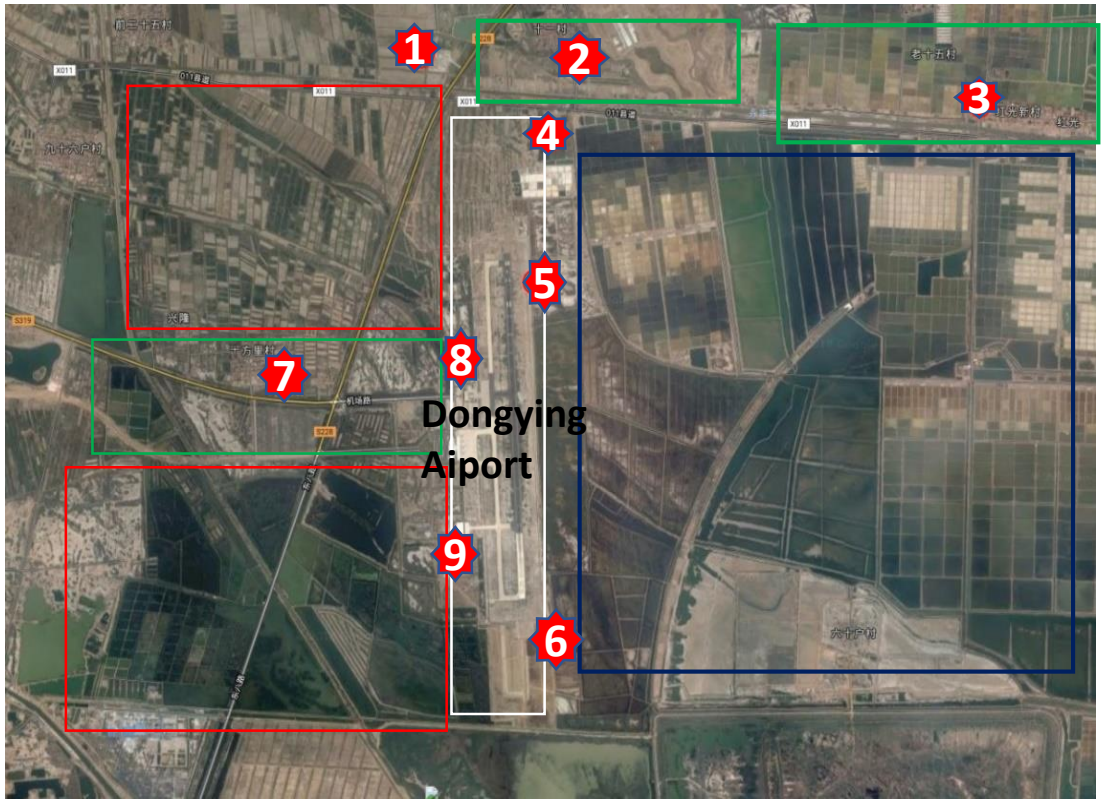
Bit error and ranging performance evaluation of receiver with interference



Analysis algorithm flow

Ⅴ. Develop a demonstration system of GNSS interference monitoring

The demonstration system will be built in Dongying airport.



The area in the red frame is wetland, the blue frame is crab breeding pond, the green frame is part of the village. Select 8 grid interference monitoring points.

Flight test diagram

02

An interference case in Guangzhou Baiyun airport

I、An interference case in Guangzhou Baiyun airport

民航GPS受干扰！中南空管电波卫士出动！

民航中南地区空中交通管理局 7月24日

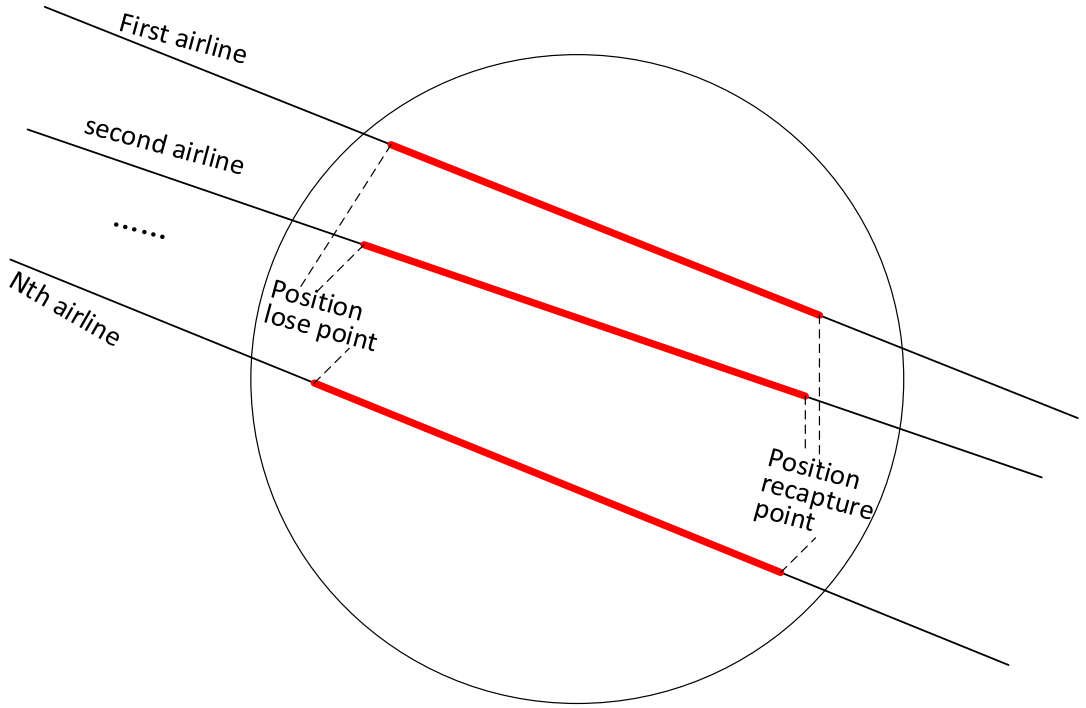
中南空管局强协同、高效率

协助排查广州白云机场GPS干扰问题

The crew frequently reported the global positioning system (GPS) signal failure in the five side approach area of Guangzhou Baiyun Airport during in July, 2019 .

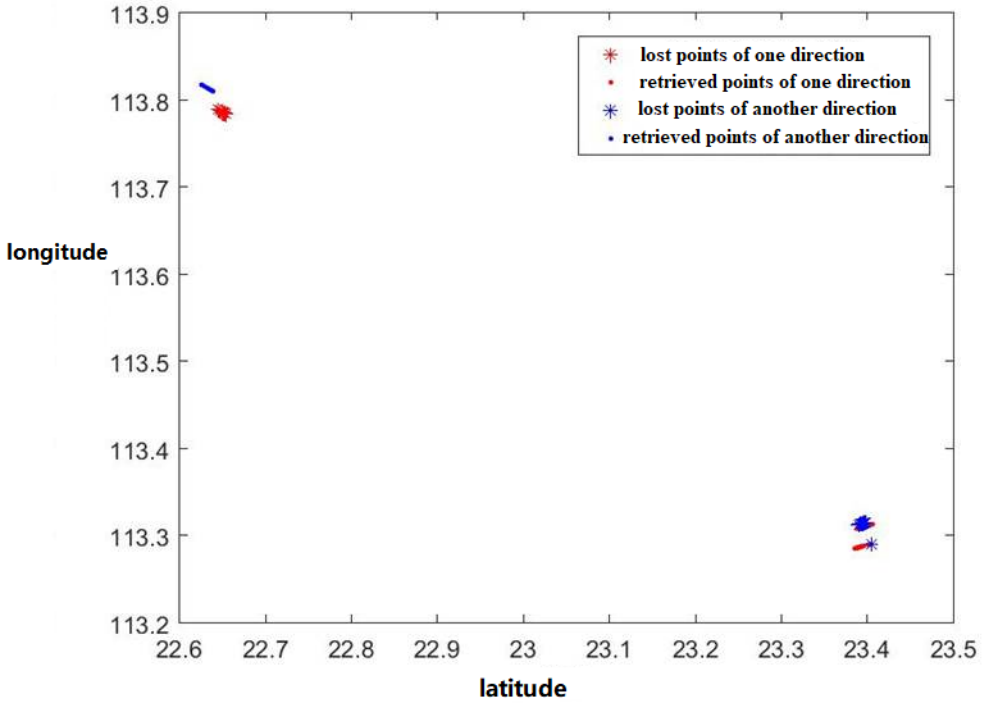
II、ADS-B data analysis during interference

■interference detection method based on ADS-B

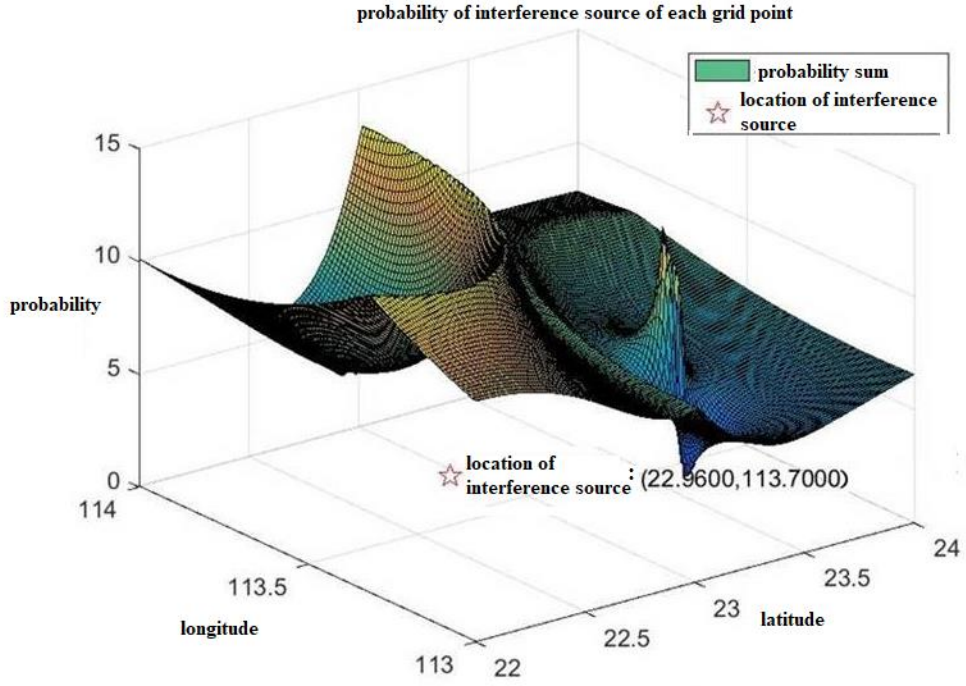


■ADS-B data analysis results during GPS interference in Baiyun Airport

The ADS-B data from July 8 to July 9 during the interference period is collected and analyzed. There are 19 flights whose ADS-B signal fails to work. The information of these 19 flights is used to roughly position the interference source.



Extraction of lost points and retrieved points of position information



Rough positioning results of interference source based on ADS-B information

III、Interference source confirmation

According to the results of rough positioning, the interference source was confirmed by a UAV and vehicle equipment.

Finally, it is confirmed that the interference source is the 4G device on the communication tower, which transmits interference signals due to error.

03

Conclusion

- The following relevant research has been done in a project:

  ① Design the interference monitoring network system for city and infrastructure;

  ② Research on the technology of GNSS interference detection, location, identification and threat analysis.

  ③The deployment point of GNSS interference test monitoring is preliminarily designed.

- The result of the project is applied to the GPS interference detection and localization analysis of Baiyun Airport in Guangzhou.
- It is necessary to establish the GNSS interference detection and location system in the airport.