Testbed of AIS R-mode in China (AAPS Project)

QING Hu

eMail:hq0518@dlmu.edu.cn

OVERVIEW

1. Introduction
2. Elements of AIS R-Mode Testbed
3. Testbed Infrastructure
4. Experiments
5. Conclusions

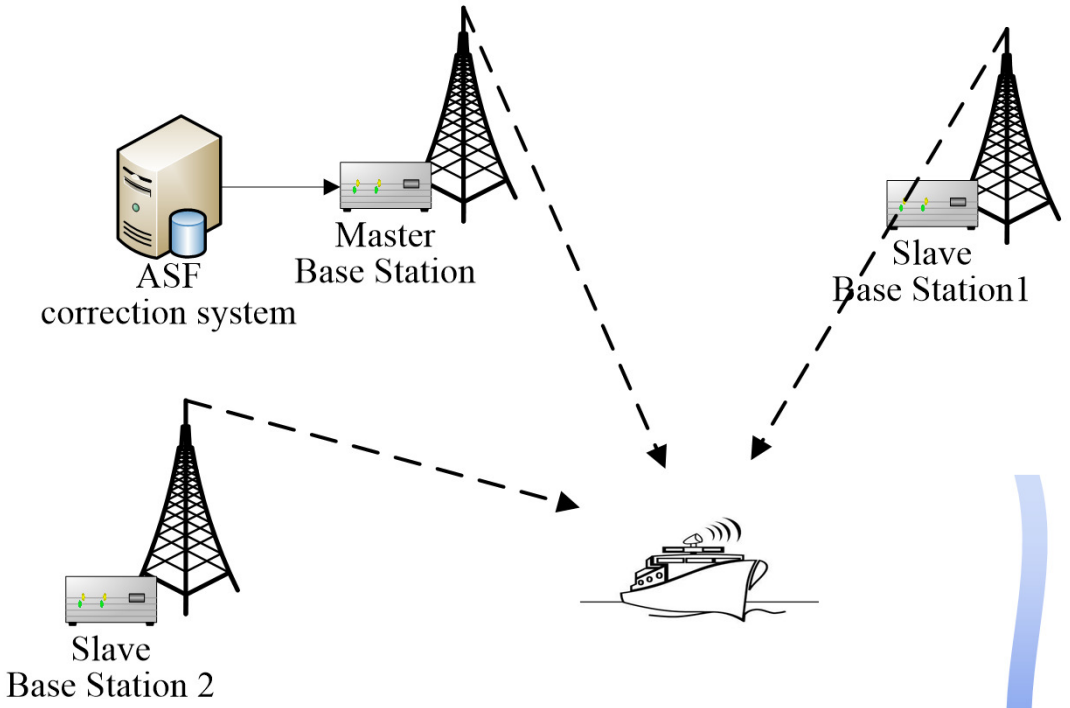
1. INTRODUCTION

- In order to overcome the vulnerability of the GNSS and provide robust PNT information for safety and security at sea, development and trials of ranging-mode using MF and AIS signals to enhance marine navigation is encouraged.
- Testbed of AIS R-mode in China was developed with a 3-years (2012-2015) project called the AIS Autonomous Positioning System (AAPS).

- Funding support: Key Technologies R&D Program (Ministry of Science and Technology of China)
- Partnership: China MSA, DMU, NGCN, DNA, NMNS, NAOC, etc.

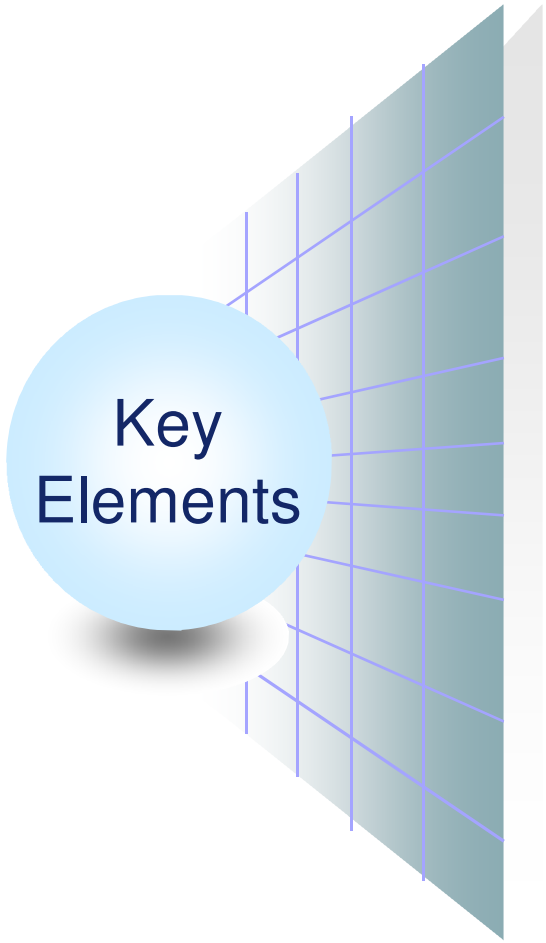
2. ELEMENTS OF AIS R-MODE TESTBED

- AIS R-Mode Testbed is comprised of a master AIS base station (BS), some slave base stations, several shipborn AIS equipment and an additional secondary factor (ASF) correction system.
  - BSs send signal one by one with time synchronization.
  - TOA/TDOA is used to estimate the vessel position by measuring the VHF AIS signal from the BSs.



  - The ASF correction system is set up to improve the positioning accuracy.

2. ELEMENTS OF AIS R-MODE TESTBED



I Range Measurement Method

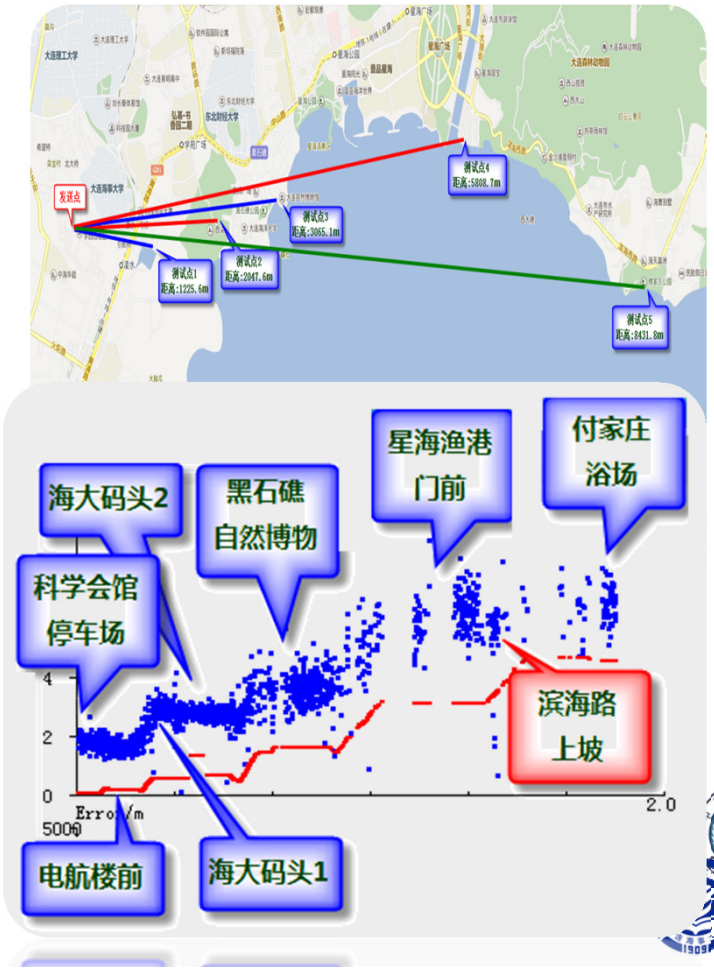
II Analysis of Geometric Dilution of Precision

III Time Synchronization Problem

IV ASF Correction

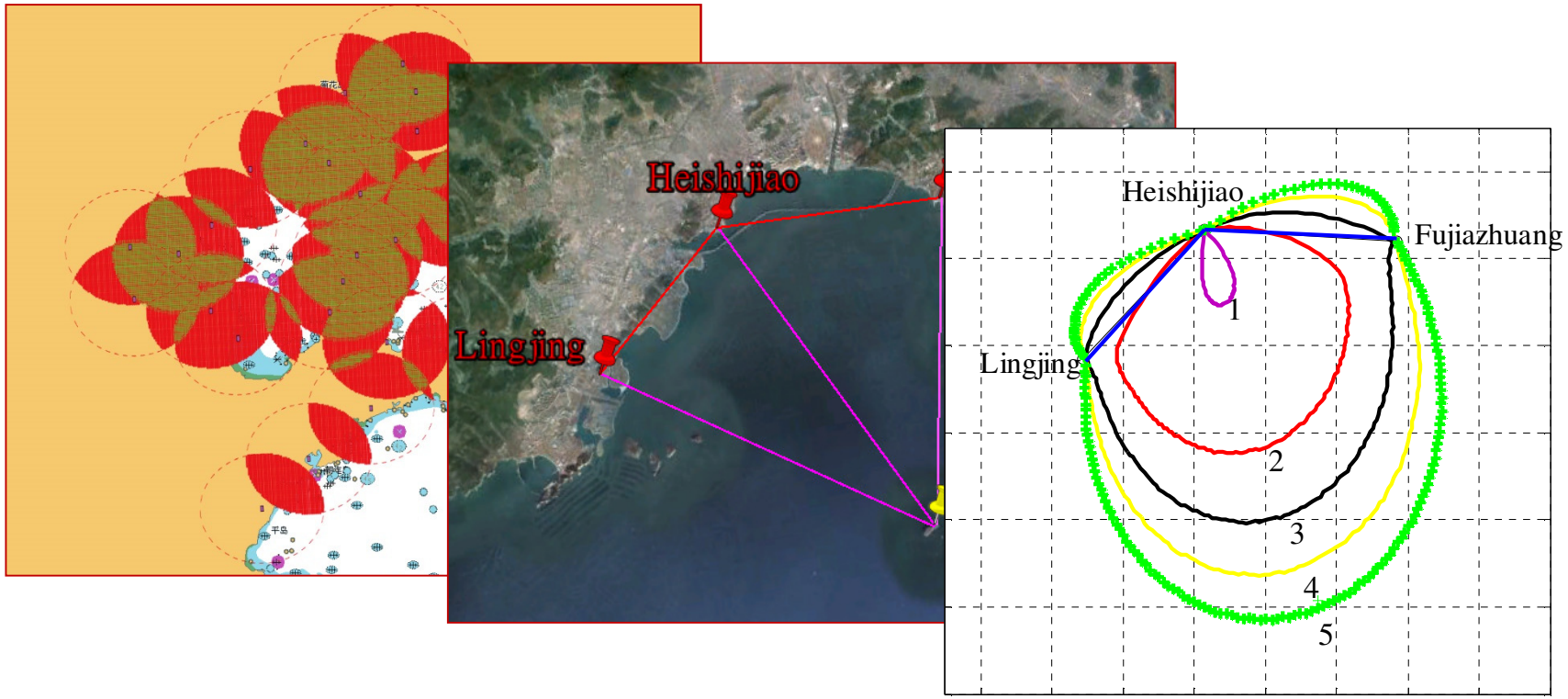
I. Range Measurement Technique

- The noncoherent demodulation is widely used in traditional shipborn AIS equipment for communication. There is not strict requirement for the decision time of each bit.
- **GMSK demodulation based on carrier phase tracking technique,** which is used to estimate carrier frequency and carrier phase. It can provide precision time of each bit transitions with assistance of the carrier tracking in one slot.



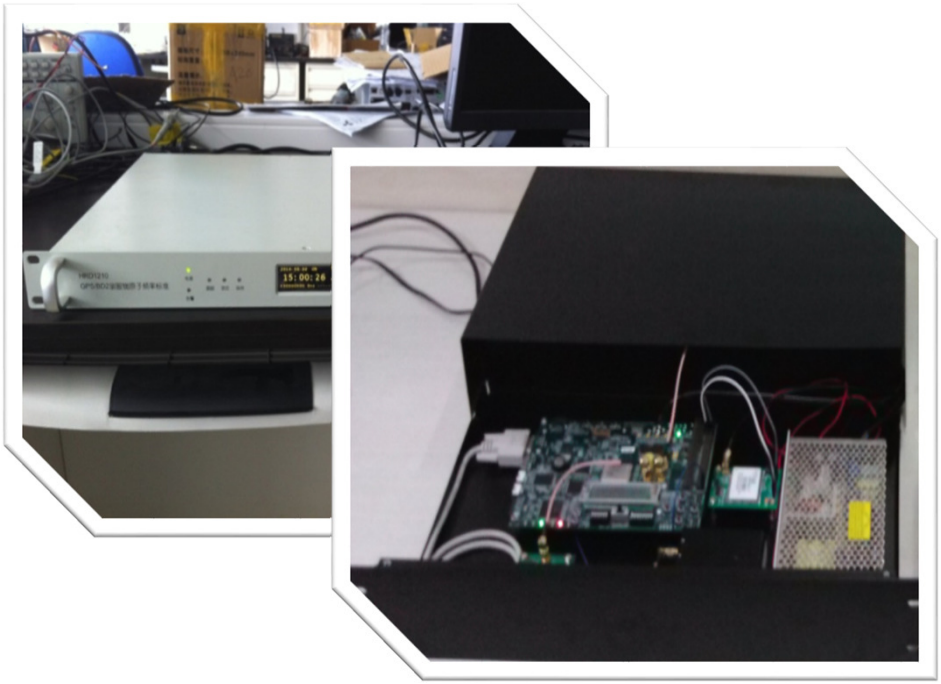
II. Geometric Dilution of Precision

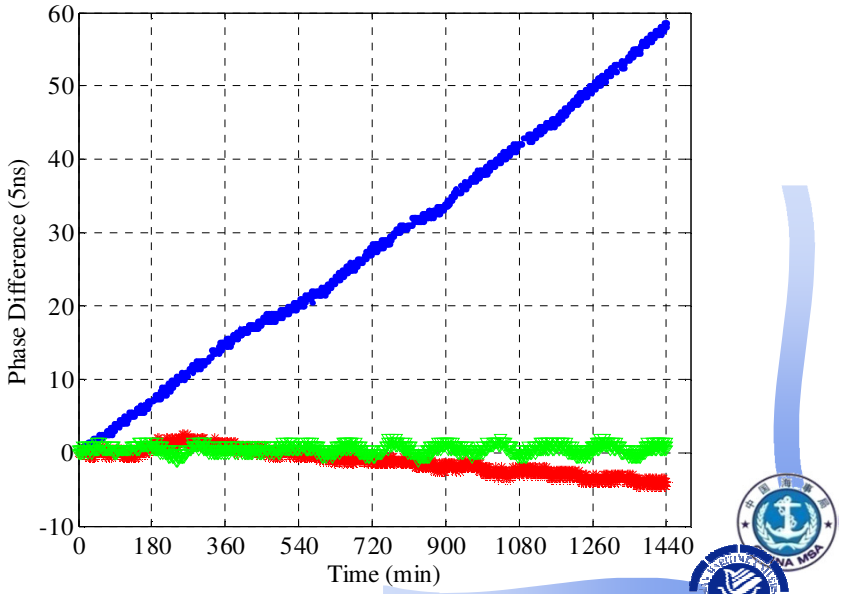
- Accuracy is a crucial parameter for evaluating a positioning system.
- The accuracy depends on the measurement accuracy and the geometry of the BSs, which is described by the GDOP.



III. Time Synchronization

- Time synchronization among all the BSs in the testbed.
- In AIS, BS has a time source synchronization to UTC better than 50μs. It cannot meet the accuracy requirement for the position system obviously.
- All AIS base stations in AAPS are synchronized with the **GNSS disciplined rubidium clock**.





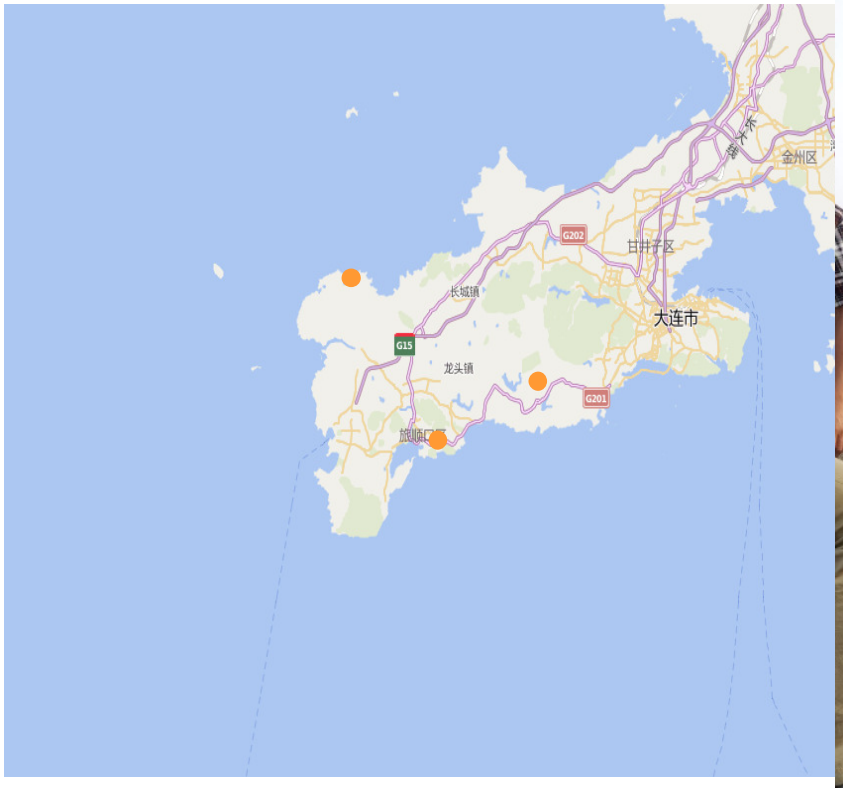
IV. ASF Correction

- Due to VHF signals propagation path environment with different conductivity, topography and weather, there are some significant factors effect positioning accuracy.
- 

3. TESTBED INFRASTRUCTURE

❖ High Accuracy Reference System

For obtaining a high accuracy reference position to verify the performance of AAPS project, **a GNSS CORS** system is designed and established in the Dalian coastal area. This CORS system is used to assess AAPS shipborn equipment.



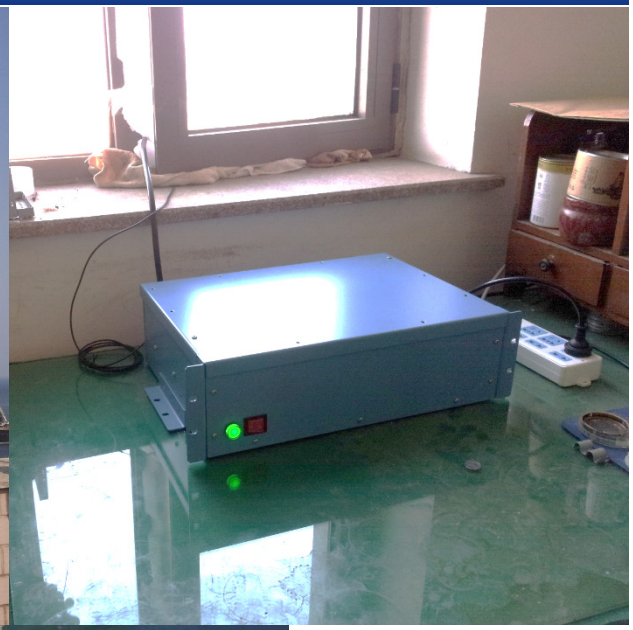
3. TESTBED INFRASTRUCTURE

❖ On-board and Shore Equipment

On-board and shore equipment for AAPS have been developed and implemented.

3. TESTBED INFRASTRUCTURE

- Layout of Testbed Bas



4. EXPERIMENTS

- To verify to the function of the above elements of the Testbed, experiments can be divided into three phases.

Phase 1

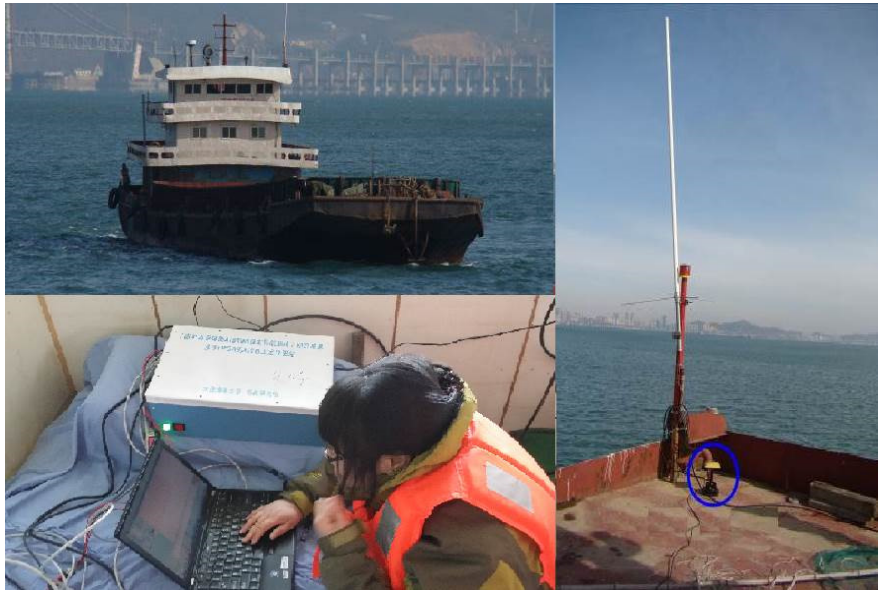
Lab

- The first phase

4. EXPERIMENTS

❖ The Third Phase

- Dozens of experiments are performed using an engineering ship -- Changsheng526 during 5 months.
- The estimated position of the vessel is compared with the high precision position provided with above CORS system.



- The anchoring and dynamic positioning experiments of testbed are performed in an area where GDOP is less than 1.5.

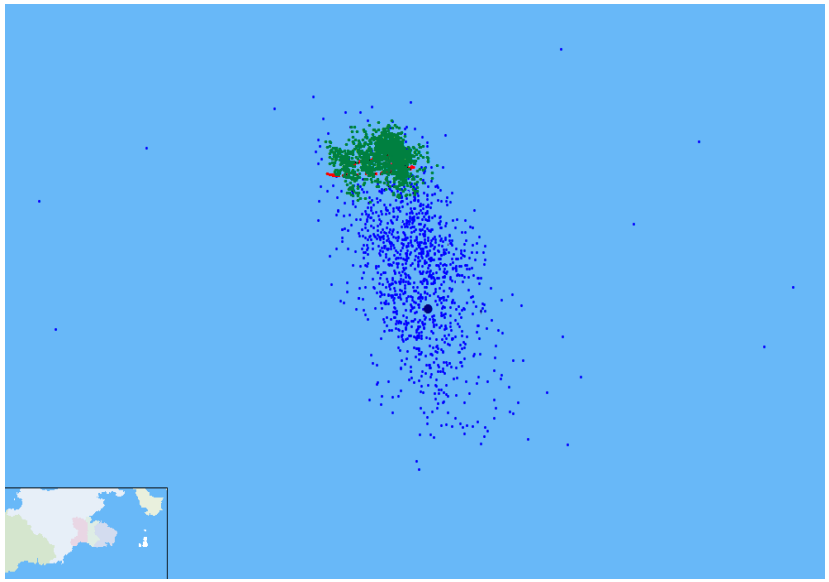
4. EXPERIMENTS

- Scenario

4. EXPERIMENTS

❖ Anchoring Positioning Experiment

Positioning results of the shipborne AIS receiver for AAPS are collected for 86 min.



The vessel was in anchoring. There was a transverse drift when it was at anchor due to the influence of the wind and current.

4. EXPERIMENTS

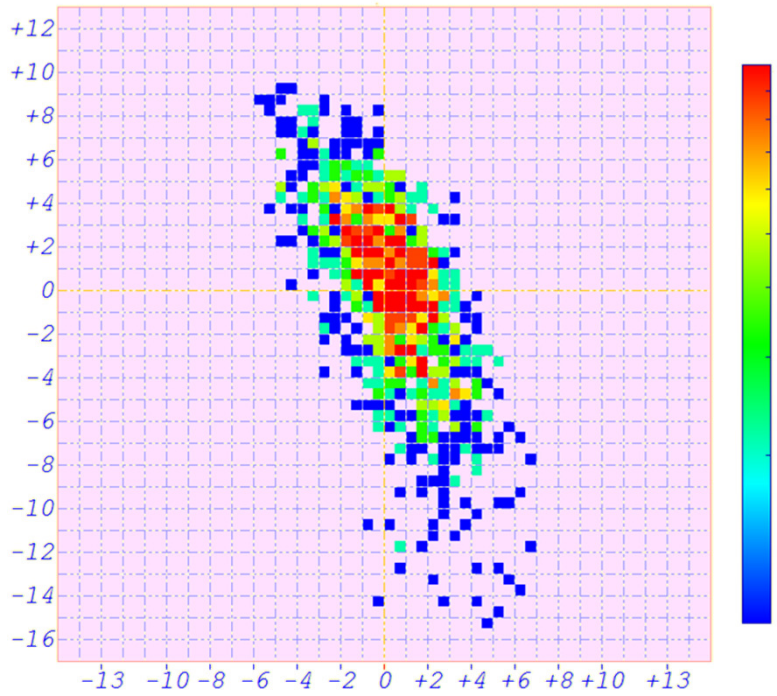
❖ Anchoring Positioning Experiment

The positioning error after ASF correction:

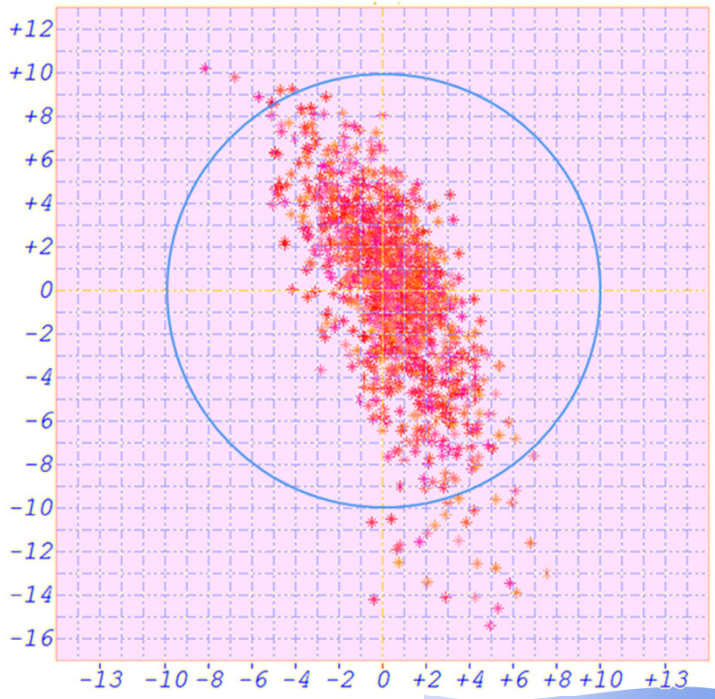
Latitude errors: mean –0.667m & RMS 4.039m

Longitude errors: mean +0.424m & RMS 2.084m

Position accuracy: 9.090m (2σ)



Thermography Diagram

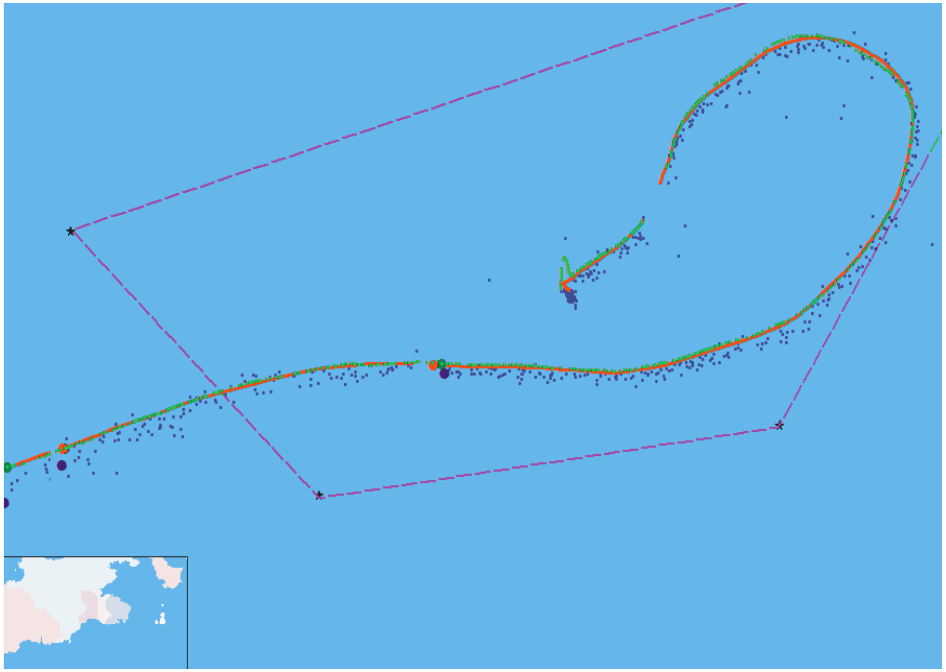


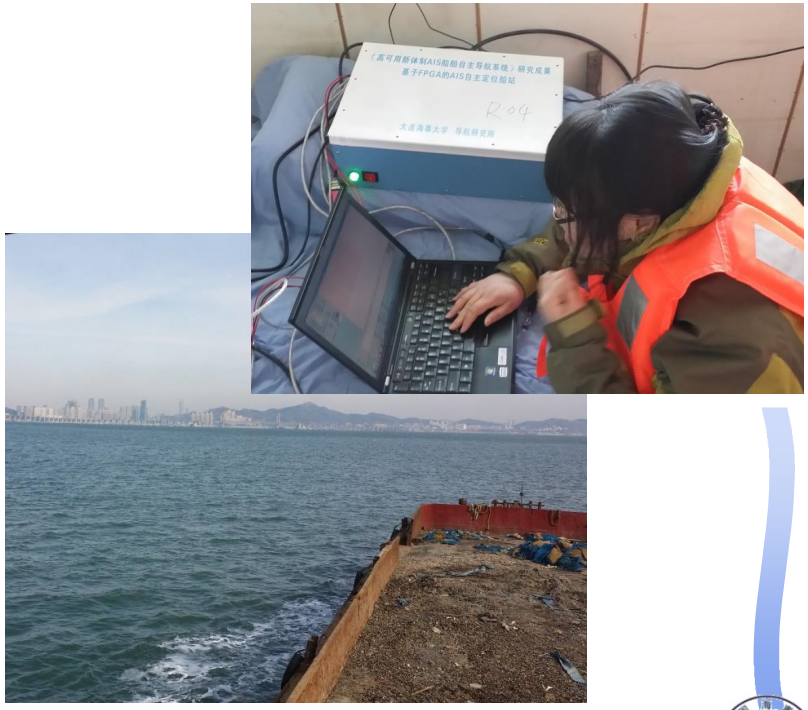
Scatter Diagram

4. EXPERIMENTS

❖ Dynamic Positioning Experiment

The dynamic position experiment for the verification system of AAPS was performed in the area where GDOP is less than 1.5.





4. EXPERIMENTS

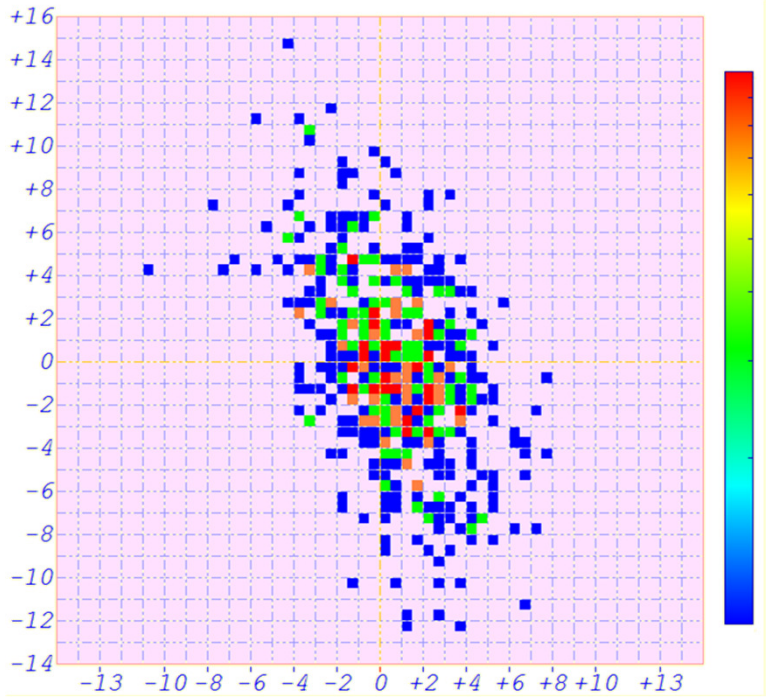
❖ Dynamic Positioning Experiment

The positioning error after ASF correction:

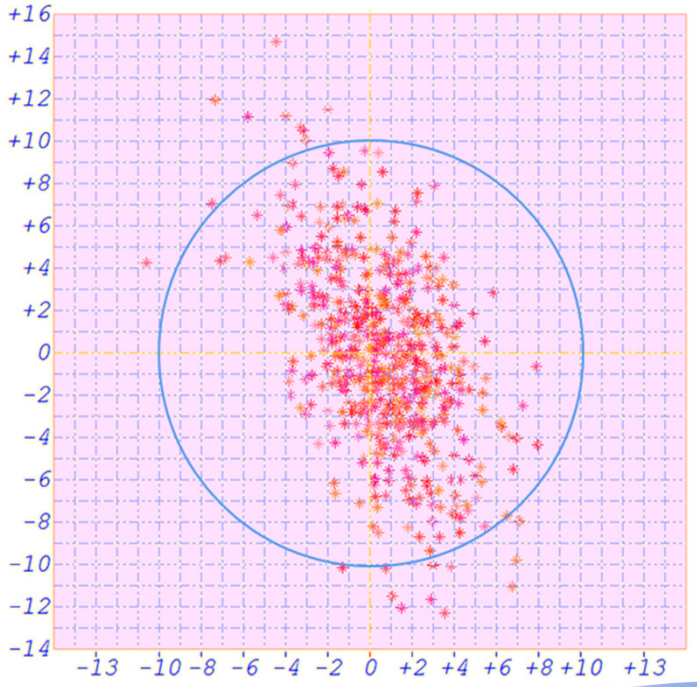
Latitude errors: mean –1.189m & RMS 4.224m

Longitude errors: mean +0.682m & RMS 2.534m

Position accuracy: 9.851m (2σ)



Thermography Diagram



Scatter Diagram

5. CONCLUSIONS

- AIS R-mode is feasible verified by the testbed of AAPS in the Xinghai Bay of Dalian.
- According to the anchoring and dynamic positioning experiment results, the positioning precision of AAPS is about 100 m (2σ) in an area where GDOP is less than 1.5, and it can decrease to 10 m (2σ) using the ASF correction.

- Future Work
  - Time synchronization among multi-base station should be further researched;
  - Positioning methods when referenced AIS base stations is less than three;
  - ASF data modeling;
  - Stability and reliability of AAPS on AIS R-mode;


中国海事局
CHINA MSA
DALIAN MARITIME UNIVERSITY
大连海事大学
1909
学汇百川 德济四海
THANK YOU !