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Update of BeiDou System and its Applications

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April 21,2013 Baska, Croatia

Outline

- Understanding GNSS
- Update of BeiDou System
- BeiDou Applications

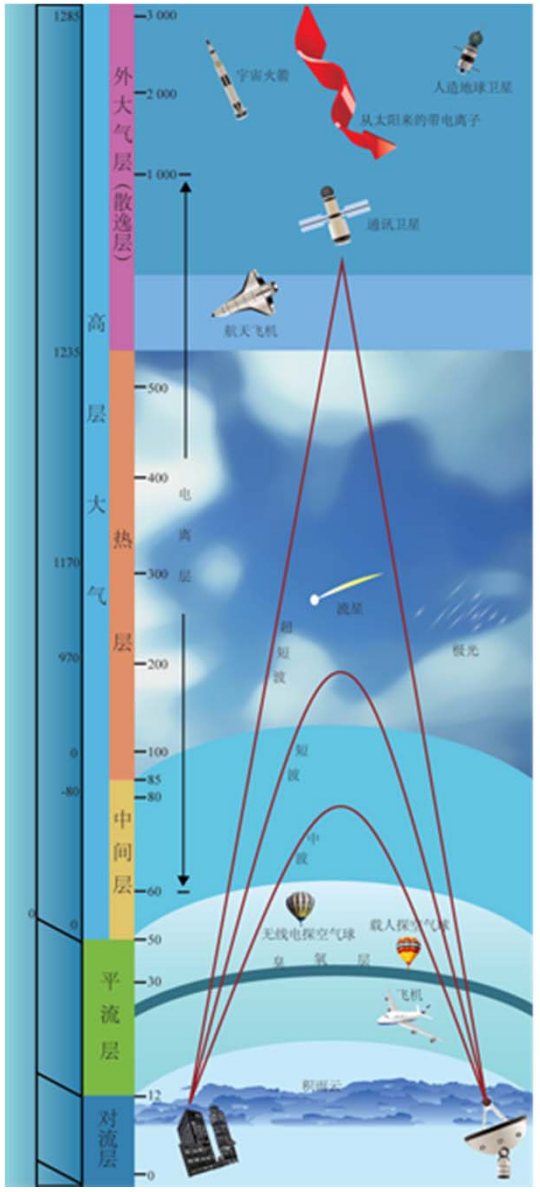
Understanding GNSS

Satellite is an object which has been placed into orbit by human endeavor.

The first Man-Made Satellite was launched by Russia in 1958.

Understanding GNSS

- Navigation Satellite
- Remote Sensing Satellite
- Earth Observation Satellite
- Meteorological Satellite
- Communication Satellite
- Direct-broadcast Satellite
- ……



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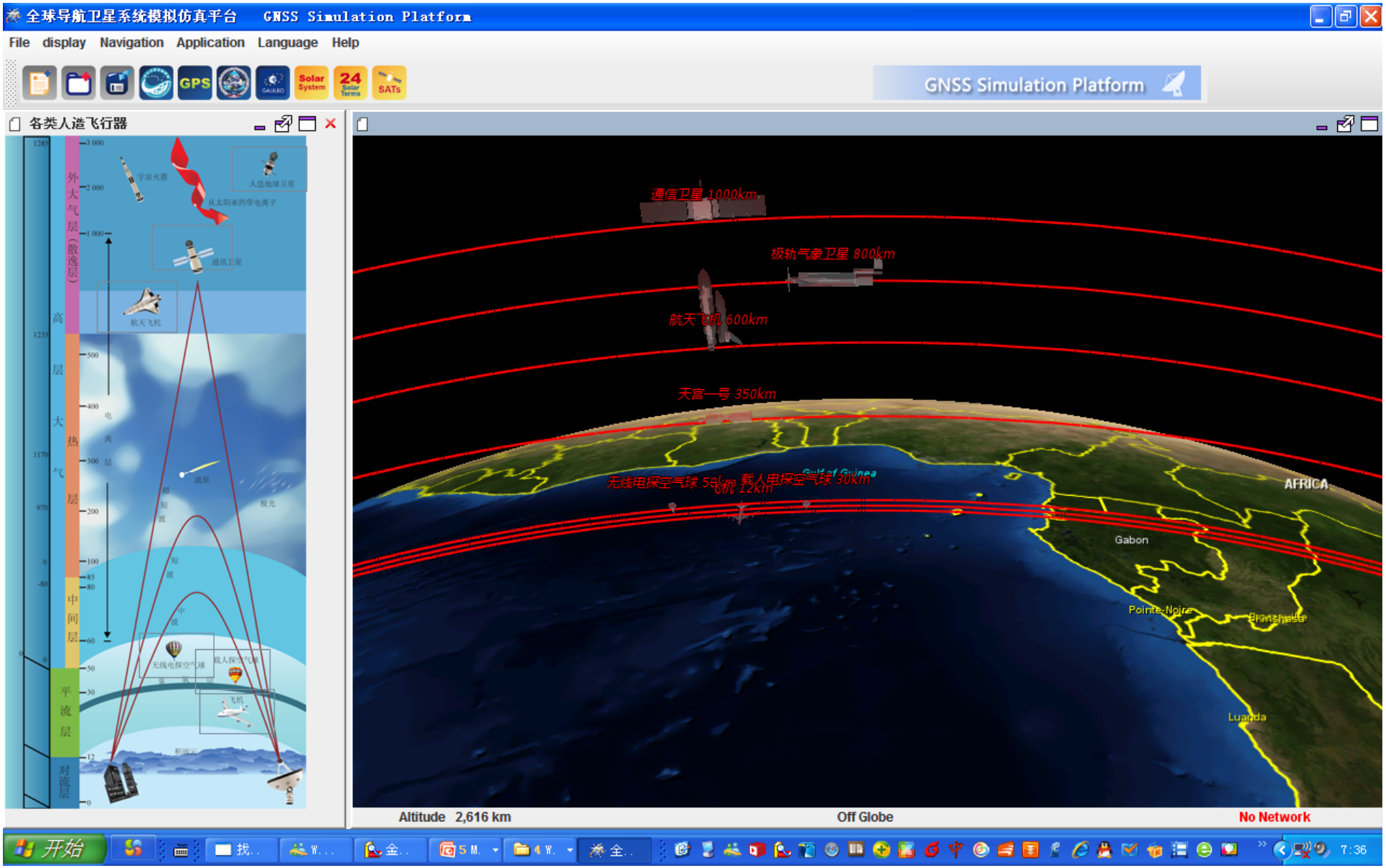

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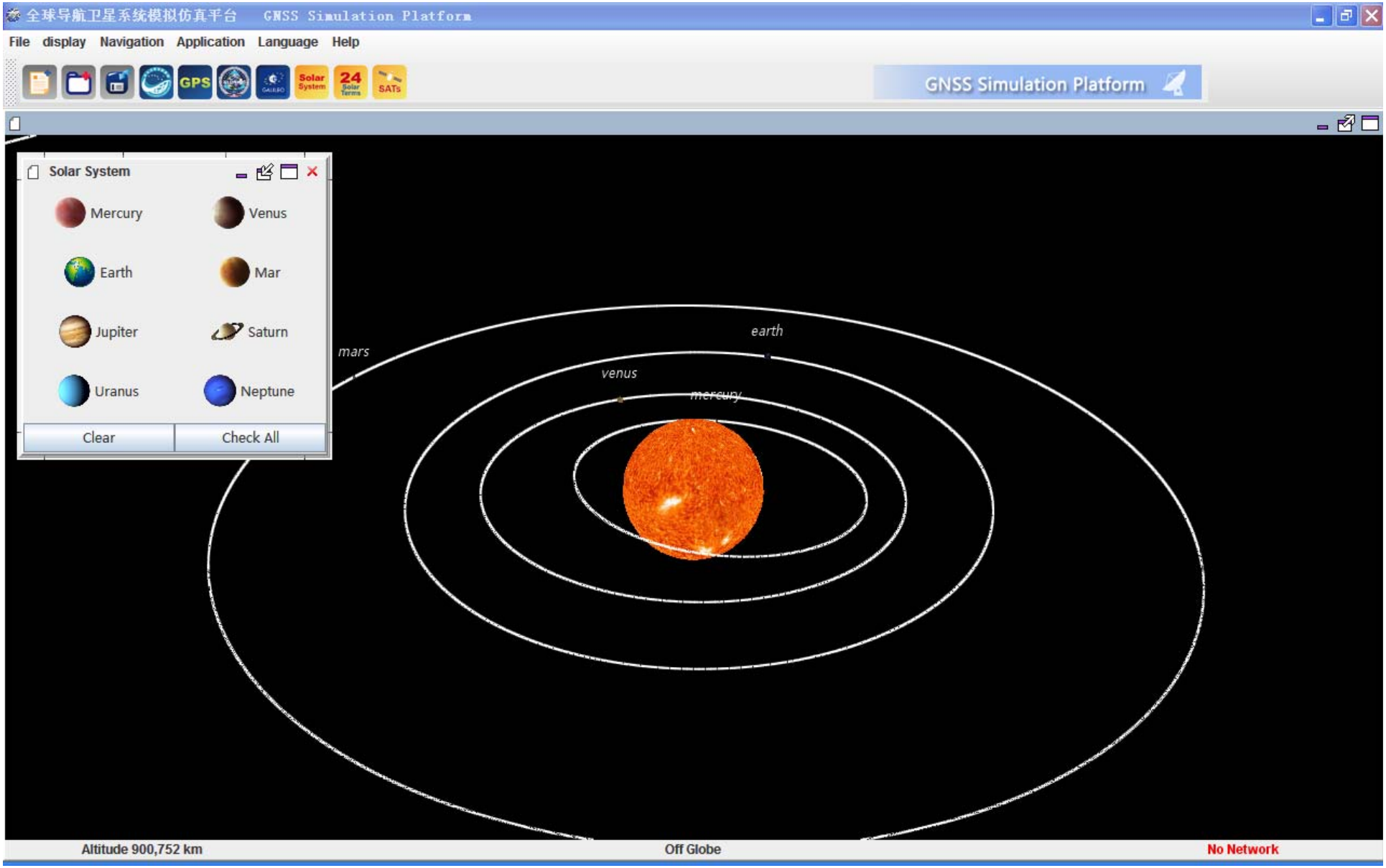

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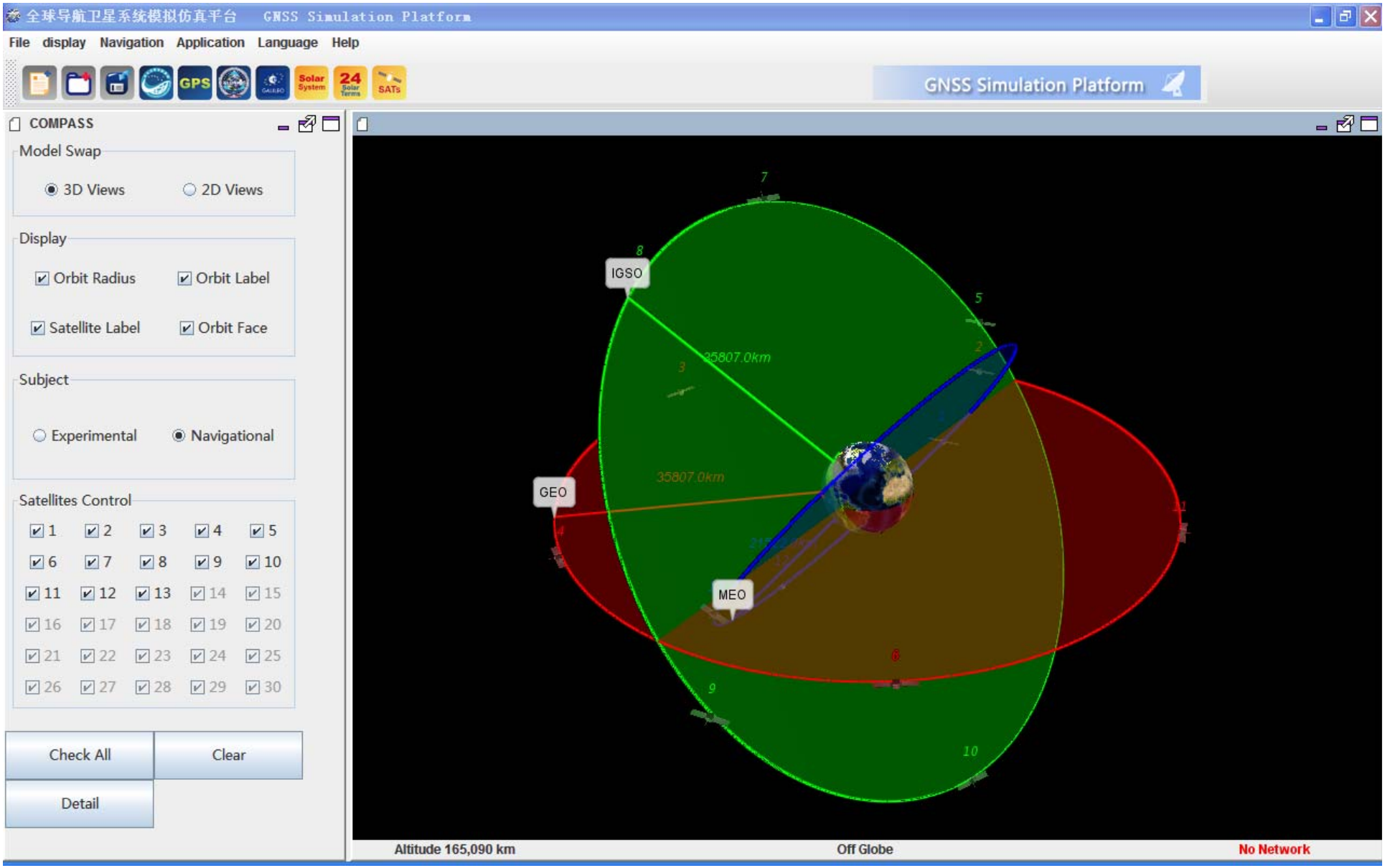

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Understanding GNSS

Providers

- GPS
- GLONASS
- Galileo
- BeiDou
- QZSS
- IRNSS

Update of Beidou Sytem

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Part Ⅰ Development Plan

Part Ⅱ System Progress

Part Ⅲ conclusions

CONTENTS

Part Ⅰ Development Plan

Part Ⅱ System Progress

Part Ⅲ conclusions

1. Development Objective

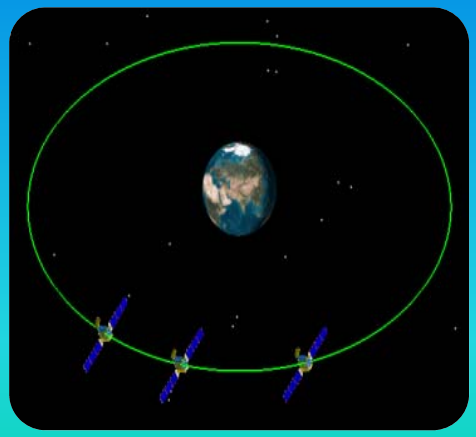
- **Stable, reliable and high quality service**
- **Serve the world, benefit the mankind**

Objective:

- **Meet the requirements of national security and social economic development.**
- **Accelerate informationization drive as well as economy development mode transformation.**
- **Realize social and economic benefits.**
- **Make contribution to international GNSS community.**

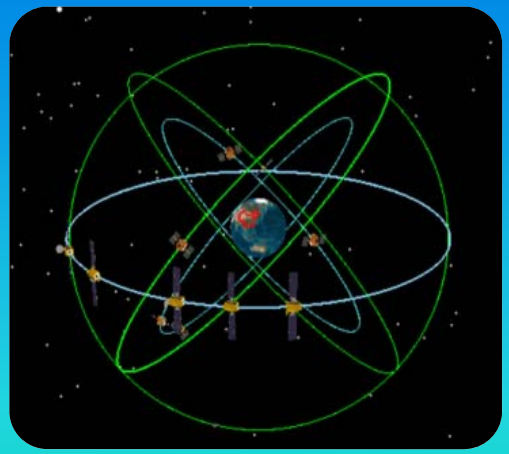
2. Development Plan

1st Step



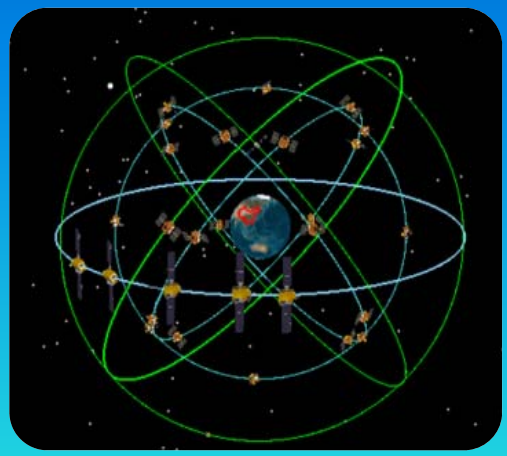
BeiDou Demonstration System

2nd Step



BeiDou Navigation Satellite System

3rd Step



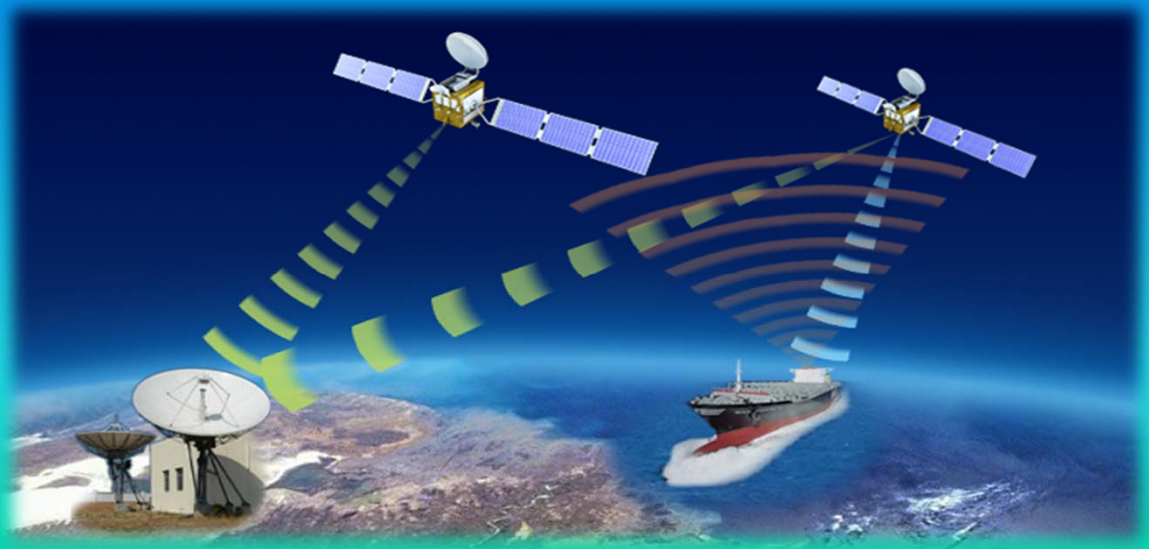
BeiDou Navigation Satellite System

1994 1996 1998 2000 2002 2004 2006 2008 2010 2012 2014 2016 2018 2020

2. Development Plan

1st step | 2nd step | 3rd step

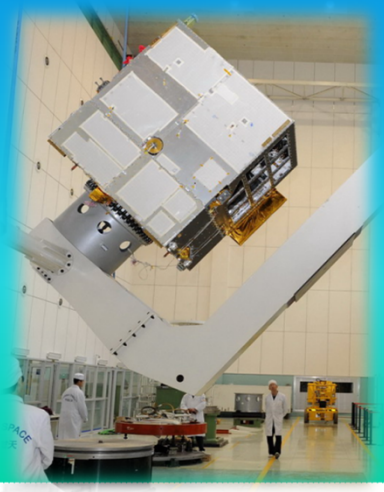
First initiated in 1994, BeiDou demonstration system was able to provide regional active services in 2000.

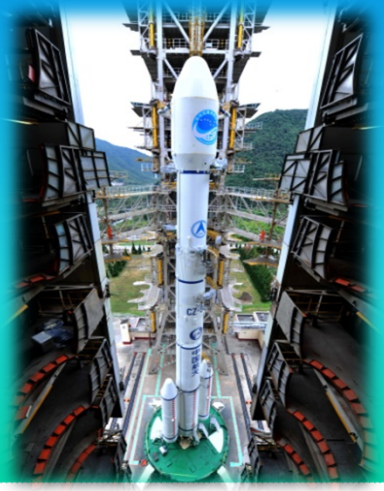


2. Development Plan

1st step | 2nd step | 3rd step

BeiDou system construction was initiated in 2004 and will provide regional passive services by 2013.



2. Development Plan

1st step | 2nd step | 3rd step

BeiDou system will be developed continuously to provide global passive services by 2020.

3. Basic Policy

- **Provide continuous space-based PVT services for global users free of charge, continue maintenance and complement in order to enhance service performance.**
- **Formulate application industry plan and standard to push forward development of GNSS industry and promote BeiDou worldwide use.**
- **Strengthen international cooperation, including advocating for international GNSS Monitoring and Assessment, achieving compatibility and interoperability between BeiDou and other GNSS, ensuring BeiDou diversified applications.**

4. System Description

System Structure

Space segment

- 5 GEO Satellites
- 30 Non-GEO Satellites

Ground Control Segment

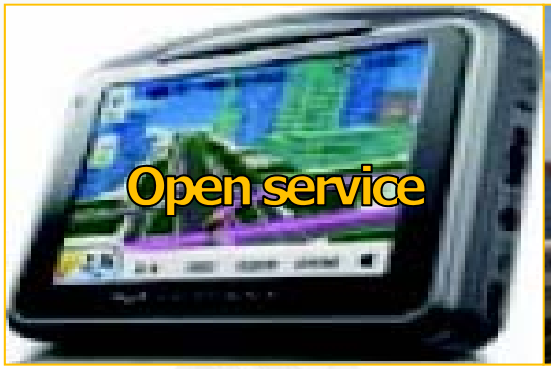
- Master Control Station (MCS)
- Uplink Stations (US)
- Monitoring Stations (MS)

User Segment

- BeiDou user terminals
- Terminals compatible with other GNSS

4. System Description

Service and Performance



Positioning accuracy
≤ 10 meters

Timing accuracy
≤ 20 ns

Velocity accuracy
≤ 0.2 m/s

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Part Ⅰ Development Plan

Part Ⅱ System Progress

Part Ⅲ Conclusions

1. System Construction

1) Satellite launch record

Launch Time	Satellite Number
2007	1
2009	1
2010	5
2011	3
2012	6

2012. 2. 25 › 2012. 4. 10 › 2012. 9. 19 › 2012. 10. 25

GEO

2 MEO

2 MEO

GEO

1. System Construction

2) Constellation status

- 14 BeiDou operational satellites in orbit.
- Constellation of 5GEOs,5IGSOs and 4MEOs.

Stage	BeiDou Navigation Satellites System															
Num	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16
Type	MEO	GEO	GEO	GEO	IGSO	GEO	IGSO	IGSO	IGSO	IGSO	GEO	MEO	MEO	MEO	MEO	GEO
Date	2007.4.14	2009.4.15	2010.1.17	2010.6.2	2010.8.1	2010.11.1	2010.12.18	2011.4.10	2011.7.27	2011.12.2	2012.2.25	2012.4.30	2012.4.30	2012.9.19	2012.9.19	2012.10.25
Status																

Operational Flight test In maintenance

1. System Construction

3) Ground control segment

- Construction of Master Control Station, Uplink Stations and Monitoring Stations have been accomplished.
- Employ BeiDou Time (BDT) and CGCS2000 Coordinate.

MCS

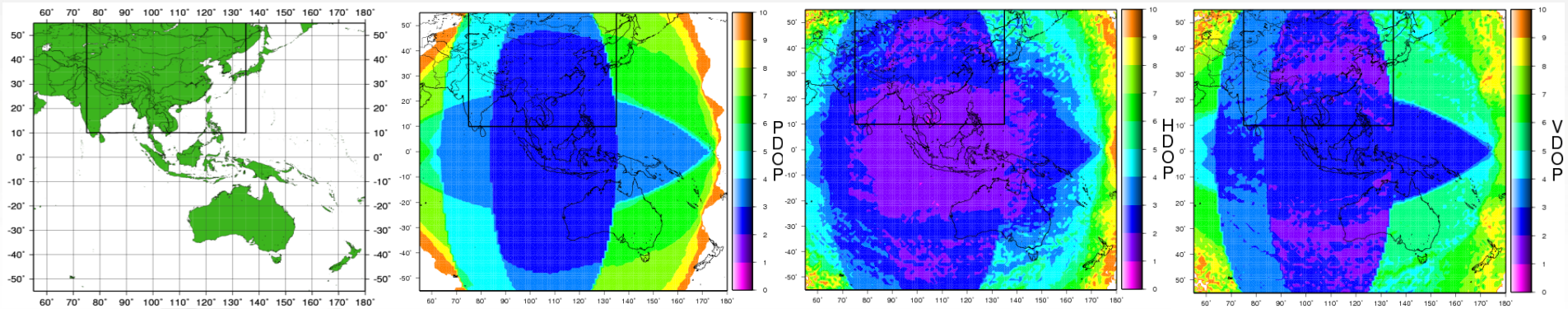
US

MS

1. System Construction

4) Coverage

Service area: 55 °S ~55 °N, 55 °E ~180 °E.

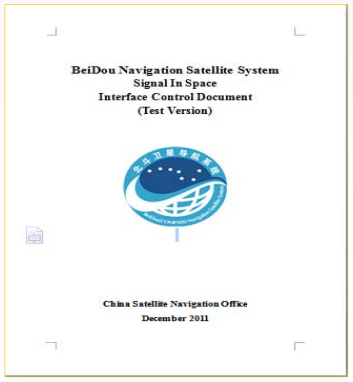


Service area PDOP HDOP VDOP

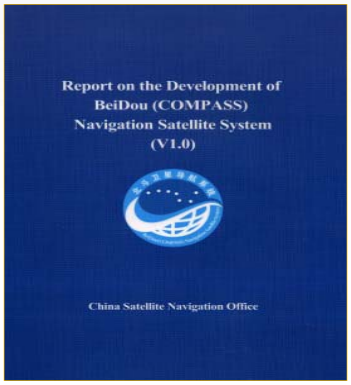
1. System Construction

5) Initial Operational Capability

- **Provide Full Operational Service for China and its surrounding areas since December 27, 2012**
- **Publish BDS Interface Control Document (ICD) for signal-in-space**


BeiDou Navigation Satellite System
Signal In Space
Interface Control Document
(Test Version)

China Satellite Navigation Office
December 2011


Report on the Development of
BeiDou (COMPASS)
Navigation Satellite System
(V1.0)

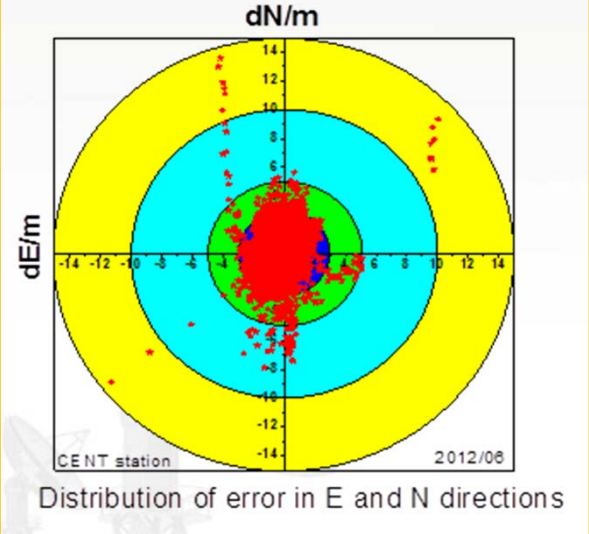
China Satellite Navigation Office

1. System Construction

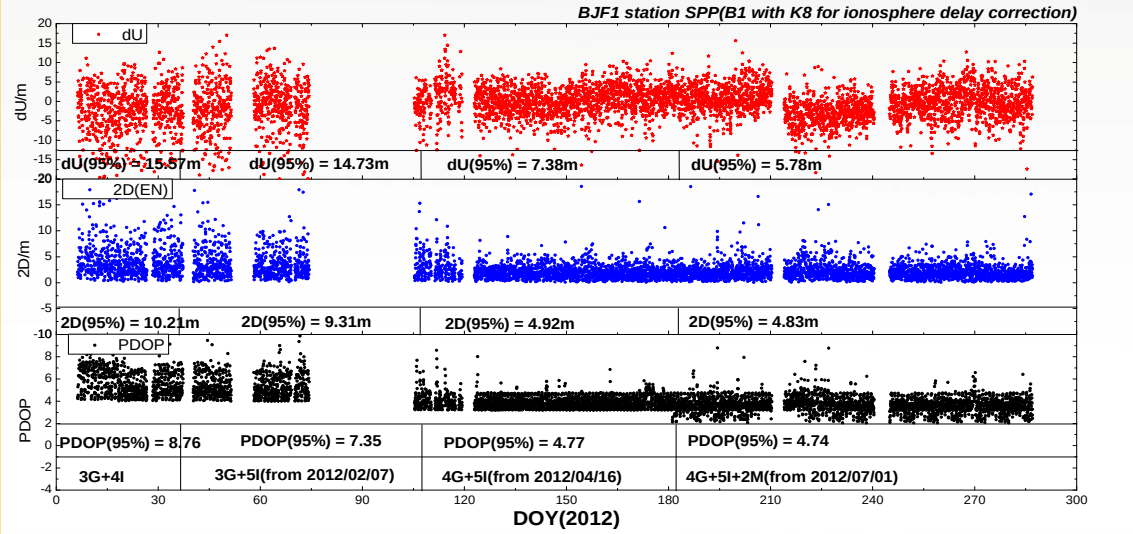
6) Practical Operational Capability

Positioning and velocity accuracy

- **Horizontal ≤ 10m (95%) .**
- **Vertical ≤ 15m (95%) .**
- **Velocity ≤ 0.2m/s.**



Distribution of error in E and N directions

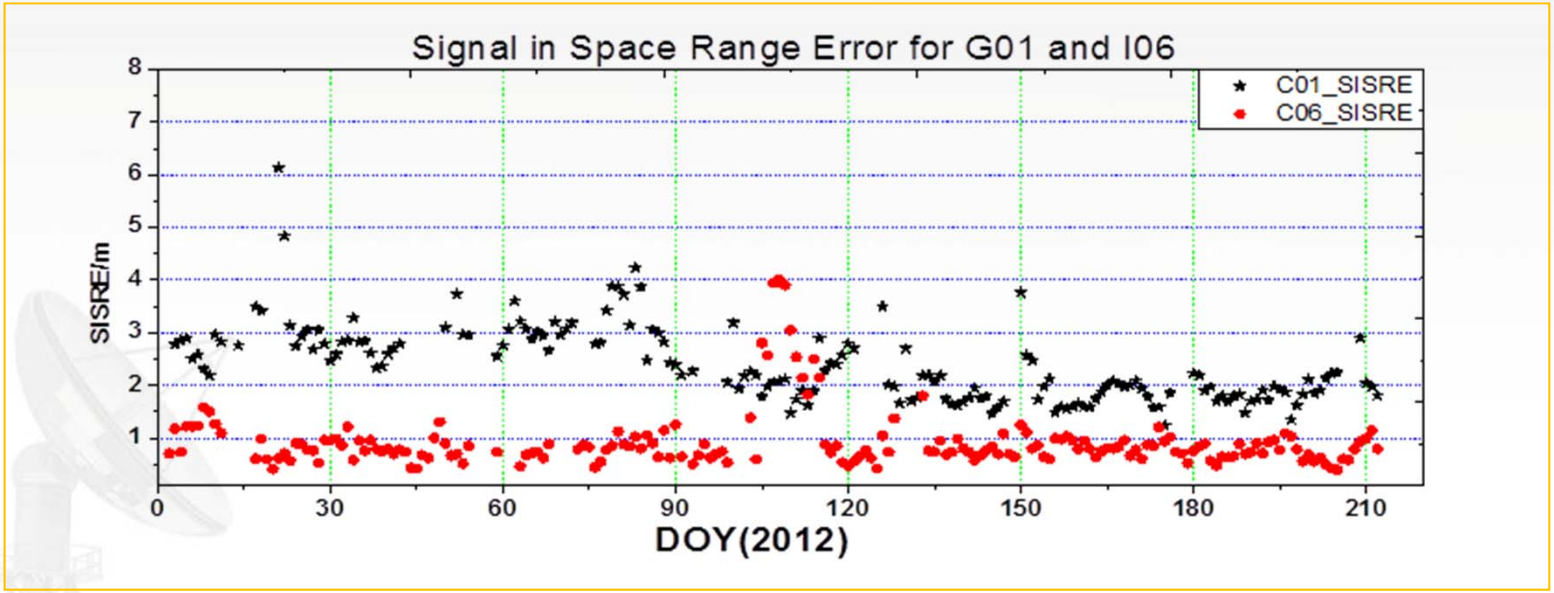


1. System Construction

6) Practical Operational Capability

Broadcast ephemeris precision

- **URE ≤ 1.5m.**
- **Clock bias ≤ 5ns.**

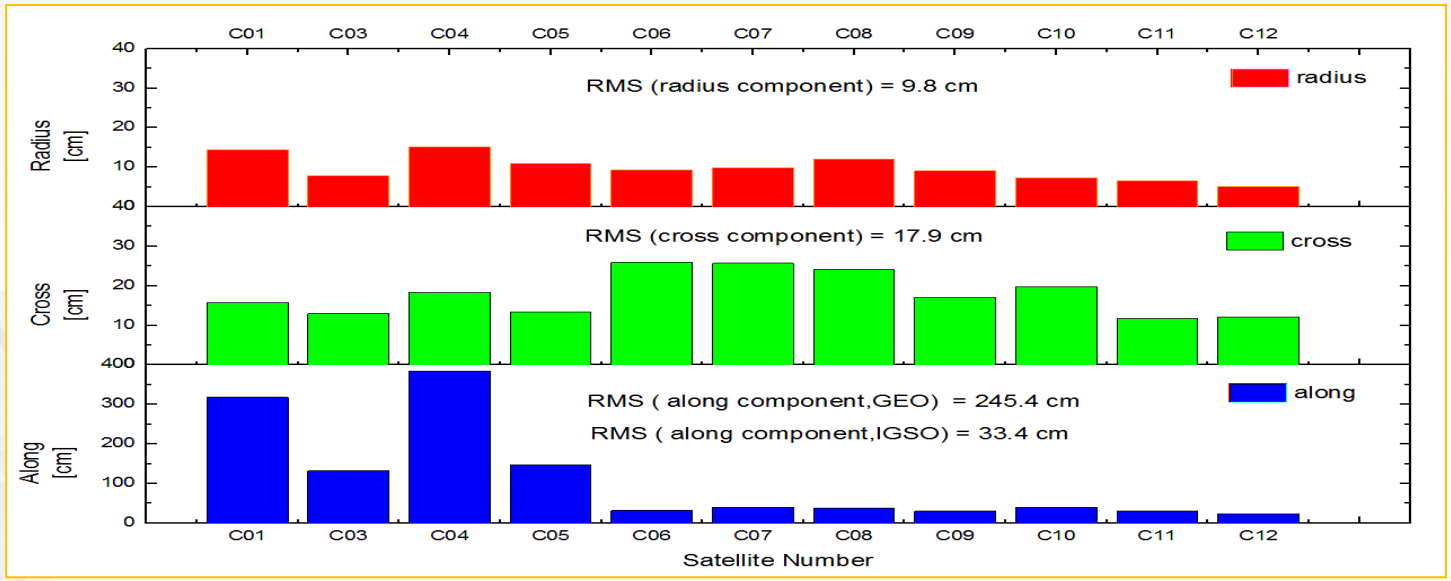


1. System Construction

6) Practical Operational Capability

Orbit determination and time synchronization

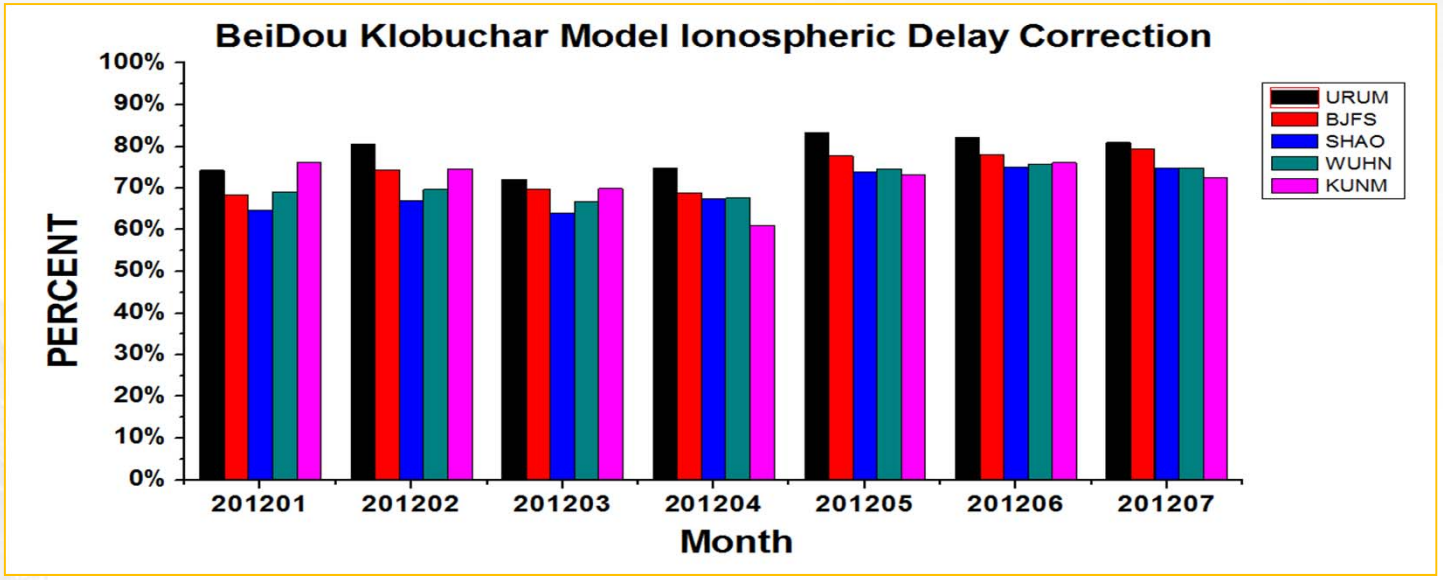
- Orbit determination < 10 m.
- Time synchronization < 2ns.



6) Practical Operational Capability

Ionospheric Model

- **Ionospheric correction of Klobuchar 8 model is about 80%.**

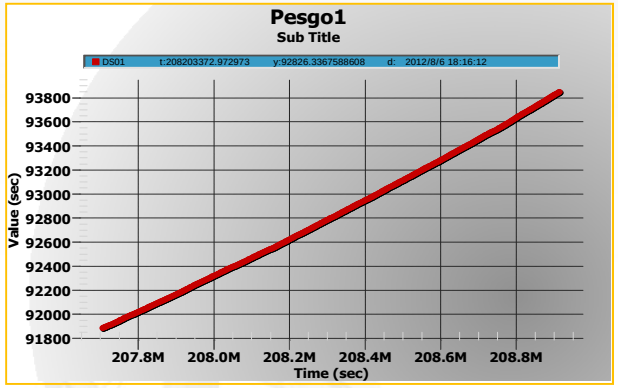


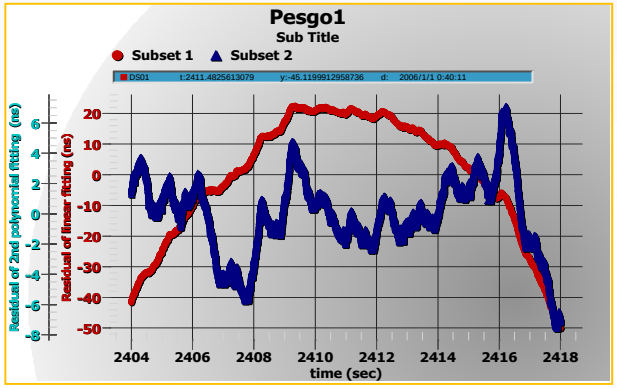
1. System Construction

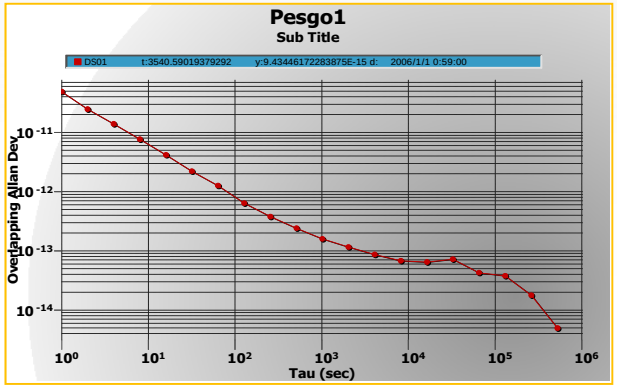
6) Practical Operational Capability

Satellite clock performance

- frequency accuracy of the master clock is 1.62E-12 .
- drift is 3.05E-14.
- ten thousand seconds stability is 6.59E-14.







2. System Application

Since IOC provision, the continuous constellation deployment, gradual improvement of service performance has

- **promoted R&D of BeiDou chips and terminals.**
- **Implemented application demonstration in various industries and regions.**
- **Popularized mass market.**

2. System Application

1) Fundamental Products

Chips, antennas, OEM have been launched to market.

Chips

OEM

Antenna

2. System Application

2) Industry Popularization

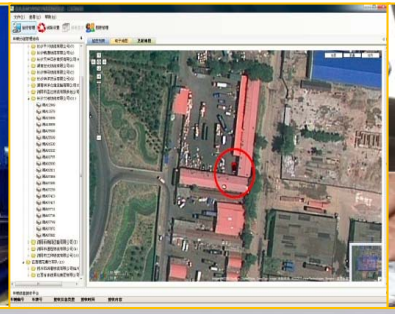
Transportation

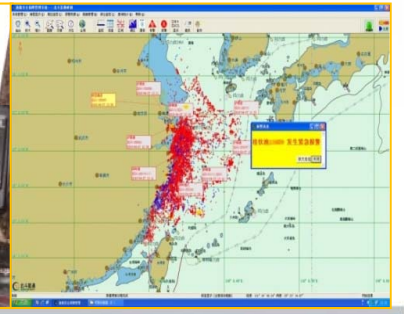
- Road transportation management.

Marine Fishery

- Vessel position monitoring.
- Emergency rescue and region alarm.
- Port entry and depart management.







2. System Application

2) Industry Popularization

Rescue

- rescue dispatching.
- emergency communication.
- rapid report.

Meteorology

- Meteorological sounding.
- Meteorological monitoring.
- Meteorological information gathering and release.

2. System Application

3) Popular Application

BeiDou chips embedded mobile phones and vehicle terminals have been in practically used.

3. International Activity

- Undertake more international responsibilities through ICG related activities.
- Cooperate with major GNSS, and popularize applications with neighbor countries.
- Promote international technical exchange.
- Promote BeiDou to merge into international standards.

3. International Activity

1) International Exchange

- World-oriented CSNC
- Academic exchange activities
- Education and training

International GNSS exchange and training center

GNSS frontier technology summer school

3. International Activity

1) International Exchange

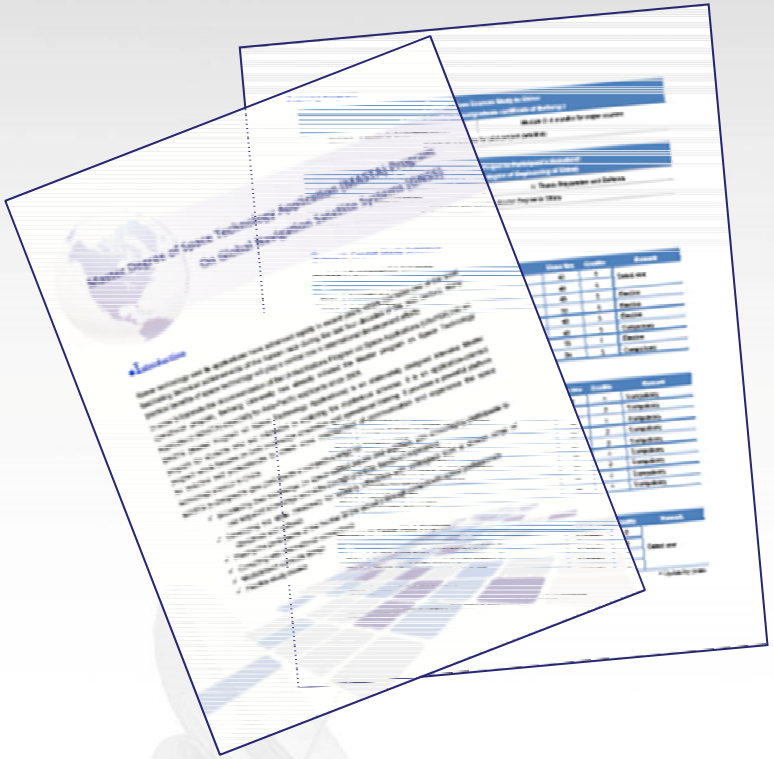
The 4th CSNC

- Will be held on May 15-17, 2013 in Wuhan, China
- An open platform for academic exchanges
- Theme: BeiDou Application---- Opportunities and Challenges
- www.beidou.org.cn

3. International Activity

1) International Exchange

Education and training on GNSS in 2013



MASTA Program on GNSS 2013

2nd BeiDou/GNSS Summer school 2013

3. International Activity

2) Coordination

Multilateral

- Deeply participate in activities of ICG as one of core system providers.
- Host the 7th meeting of ICG.
- Speed up iGMAS construction, strengthen cooperation with IGS, related organizations and other GNSS.

8th meeting of ICG Providers' forum

55th meeting of COPUOUS

iGMAS tracking stations

3. International Activity

2) Coordination

Bilateral Coordination

- Comply with radio regulations of ITU.
- carry out more than 10 rounds of bilateral and multilateral coordination to jointly share frequency and orbit resources.

2011 orbit safety consultation meeting for140E

Technical Working Group meeting on C&I between China and Europe

Frequency coordination of China and US

12th Satellite Network coordination meeting between China and Japan

3. International Activity

2) Coordination

Bilateral Coordination

- **Meetings between China and Russia Satellite Navigation Cooperation to promote satellite navigation monitoring, interoperability and application.**
- **Satellite navigation cooperation meetings between China and Pakistan to jointly promote BeiDou/GNSS**

China-Russia Aerospace cooperation working group meeting

2nd China-Pakistan Satellite Navigation Cooperation Meeting

3. International Activity

3) BADEC

(1) Overview

- BADEC is short for BeiDou+ Application Demonstration & Experience Campaign (BeiDou+ stands for multi-GNSS including BeiDou).
- To advocate international users, to learn about and apply BeiDou/GNSS, survey and collect requirements from international users, explore new applications together, so as to provide better GNSS services to the mankind and realize mutual development of all GNSS.

3. International Activity

BADEC CONTENT

Exhibition & Propagation	Demonstration & Experience	Discussion & Exchange	Education & Training
Exhibition	Application Demo	Forum	Degree Education
Products Expo	User experience	Symposium	Short-term Training
Website	Pilot Project	Technical Seminar	Workshop
Video	Joint Research	Face-to-face Exchange	Summer School
.....	.....	.....	.....
Popularize and display the development and application achievement of BeiDou/GNSS, by applying traditional and new media forms	Focused on typical application requirement of users, jointly conduct pilot projects and encourage the development of new innovative application	Enhance exchange and communication among system providers, products providers and users, to promote the sustainable development of GNSS	GNSS Application Technologies Training based on ICG regional education and training centers, or relevant education resources

3. International Activity

3) BADEC

(3) Current and follow-up activities

- BeiDou Tour: To conduct itinerant BADEC activities majorly in the Asia-Pacific region, make detailed scheme and arrangement based on specific status and requirements of different countries.
- International projects: To jointly launch application pilot project and focus on the fields with wide application requirements, such as disaster monitoring, emergency management, transportation, marine fishery, personal LBS, etc

3. International Activity

4) iGMAS

(1) Overview

Several GNSS monitoring activities are underway. e.g.

- **preliminary experience of iGMAS,**
- **the long-term successful operation of IGS,**
- **the achievements in GNSS signal monitoring made by Stanford University, DLR, Information Analysis Center of Roscosmos, MGA and others.**

Objective & tasks:

To promote the sharing of the global monitoring resource and provide better GNSS service for users.

to support related activities and develop proposals to optimize existing and planned capabilities, and identify additional necessary activities

To discuss the related standards, the sharing mode of resource

To develop the monitoring and assessment products

To provide assessment service effectively

3. International Activity

4) iGMAS

GNSS Monitoring and Assessment Item

- Constellation Status
  - Satellite Operational Status
  - Orbit Parameters
  - DOP
- Navigation signals
  - User Received Signal Level
  - Power Spectrum
  - Ranging Code Waveform in the Time Domain
  - Modulation Error
  - Correlation Characteristics
- Navigation Message
  - Signal-In-Space User Ranging Error（SISURE）
  - Signal-In-Space Continuity
  - Signal-In-Space Availability
  -
- Service Performance
  - Position, Velocity and Timing (PVT) Accuracy
  - Service Continuity
  - Service Availability
  - Service Integrity

3. International Activity

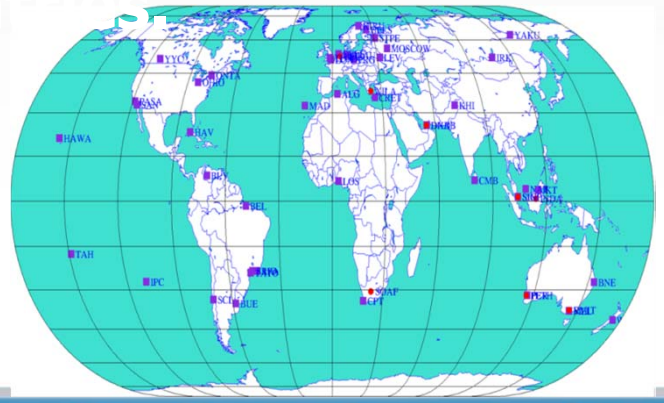
4) iGMAS

(2) iGMAS Progress

Tracking Station

- Signal monitoring station, ten domestic tracking stations established.
- Cooperation intentions reached for 43 stations with 37 organizations in 23 countries.

The specific plan of establishing stations with Russia, Pakistan and other countries is consulting.



3. International Activity

4) iGMAS

(2) iGMAS Progress

Data Center

- Two data centers are under construction at Wuhan University and National Time Service Center.

Operation Control Center

3. International Activity

4) iGMAS

(3) Current and Follow-up activities

- ✓ ICG Subgroup activities on International GNSS Monitoring and Assessment
- ✓ Need more countries and organizations to take part in, e.g. building stations jointly, sharing data and products with each other etc. Call for Participation! www.beidou.gov.cn
- ✓ Monitoring and Assessment Item is being under discussion.
- ✓ To support various campaign e.g. IGS M-GEX, by sharing stations, raw data and geodetic receivers with other system capabilities.

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Part Ⅰ Development Plan

Part Ⅱ System Progress

Part Ⅲ Conclusions

Conclusions

BDS Construction

- The second deployment step has been accomplished.
- BDS has possessed full operational capability for most Asia-Pacific area since the end of 2012.

BDS Application

- ICD has been released to support industry development .
- BDS chips is matured day by day.
- Application is promoted in large scale.

Conclusions

International Activity

- International exchange, coordination and cooperation.
- BADEC, promote multi-GNSS applications.
- International monitoring and assessment, ensure reliable GNSS services for global users.

BeiDou Applications

GNSS is now everywhere and it can serve for everyone.

No one can address all GNSS applications, especially when users create new ones almost every day.

1) Vessel Monitoring and Management
2) Government Vehicles Management
3) Meteorological and Instrument Development

1) BeiDou Application in Vessel Monitoring and Management

Content

Background

- Situation of Vessel Monitoring at Home and Abroad
- Advantages of BeiDou in Vessel Monitoring

BeiDou and Vessel Monitoring

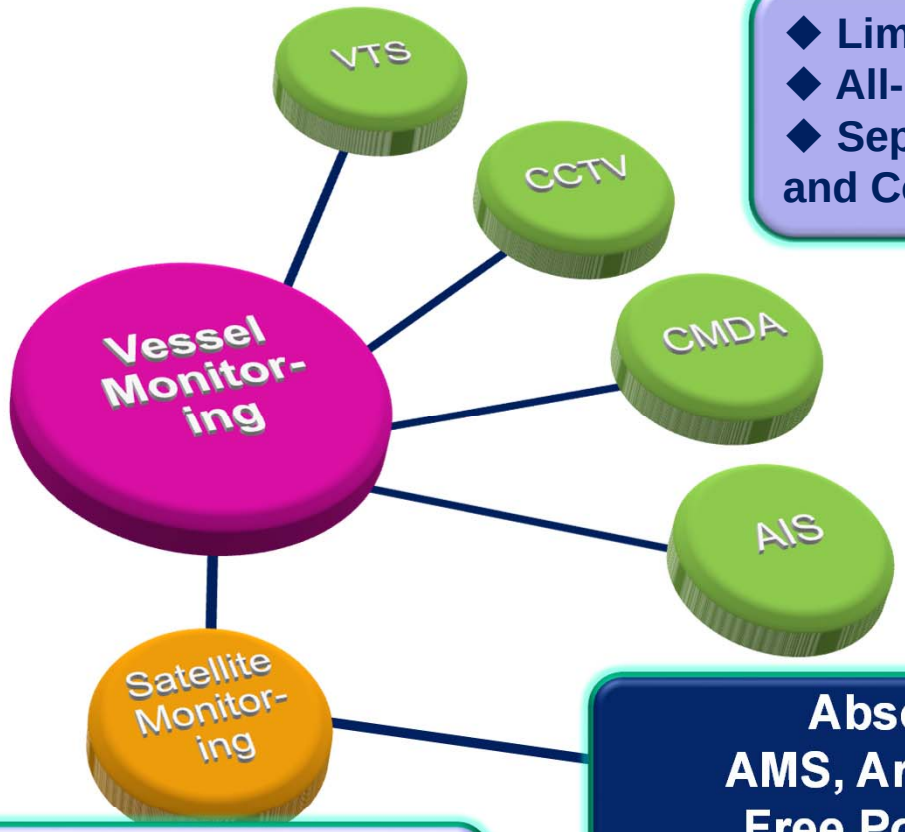
- Application Mode of BeiDou in Vessel Monitoring
- Services Frame Provided by BeiDou VMS
- Services Provided by BeiDou VMS

Conclusion

- BeiDou is Notably Applicable to Vessel Monitoring

Background

Situation of Vessel Monitoring at Home and Abroad



◆ Limited Coverage Area
◆ All-day Service Impossible
◆ Separation between Positioning and Communication

Absolute Software,
AMS, Argos CLS, AST Ltd,
Free Port-Eye from a sky

◆ Separation between Positioning and Communication
◆ Expensive

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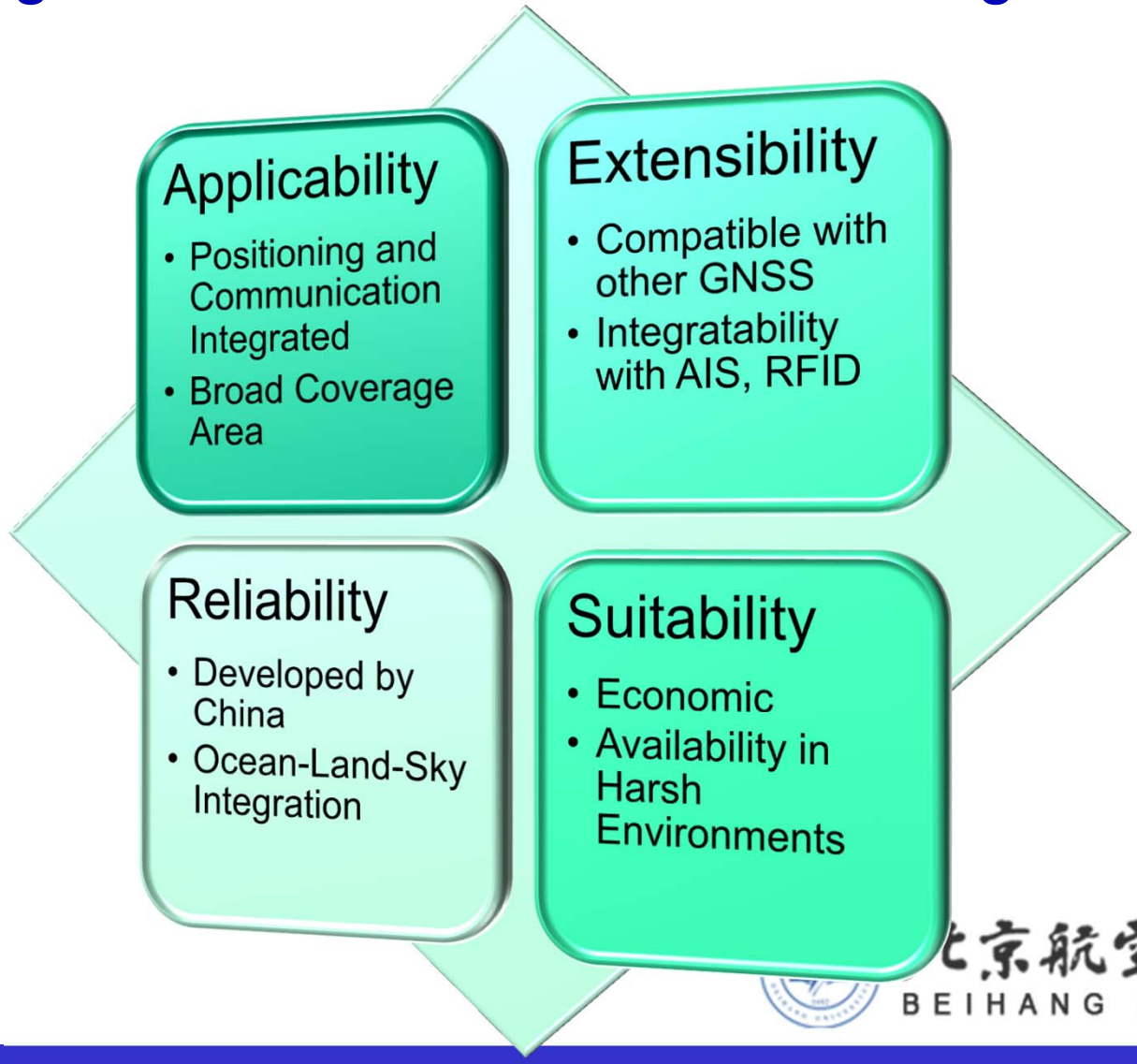
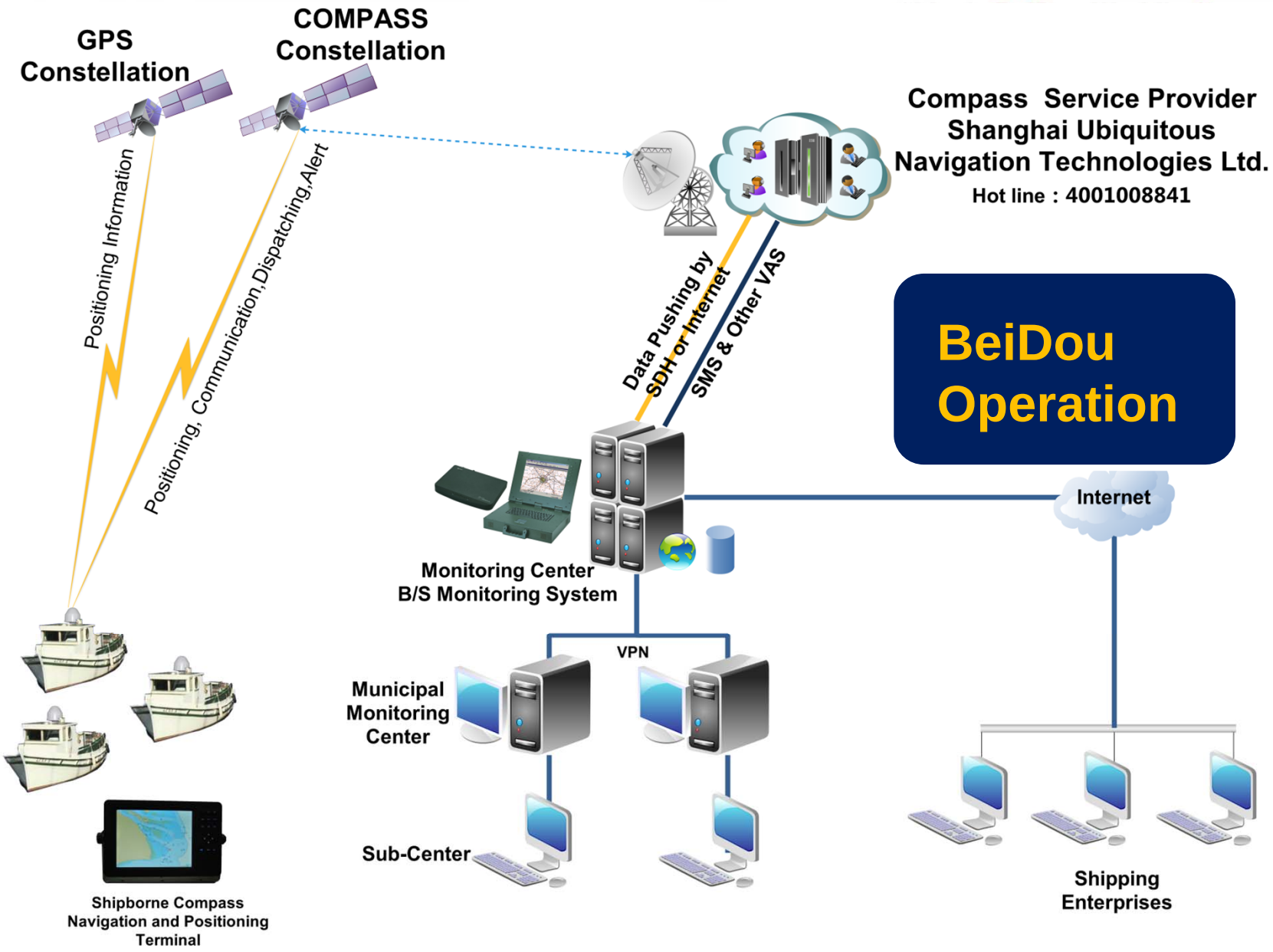
Background

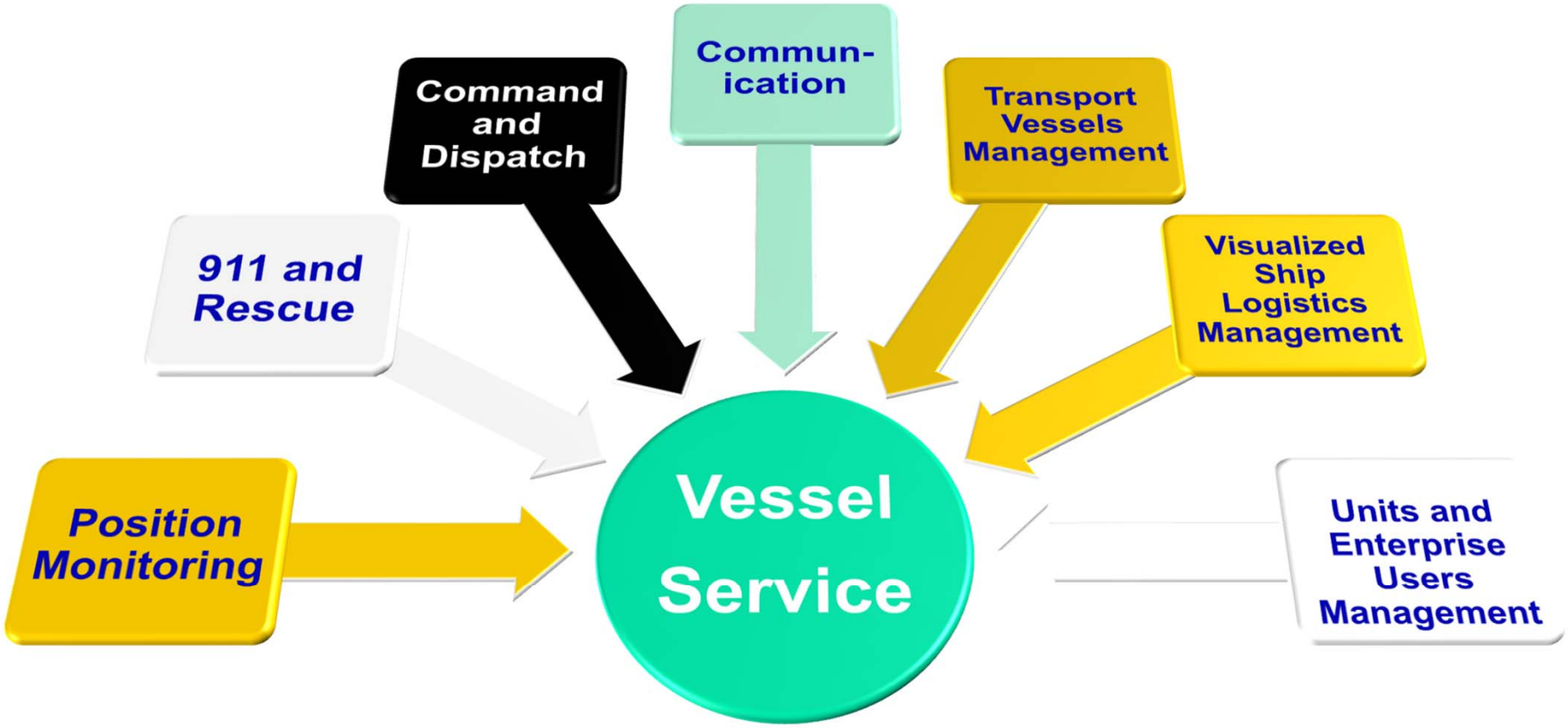
Advantages of BeiDou in Vessel Monitoring



Application Mode of BeiDou in Vessel Monitoring



Services Frame Provided by BeiDou VMS



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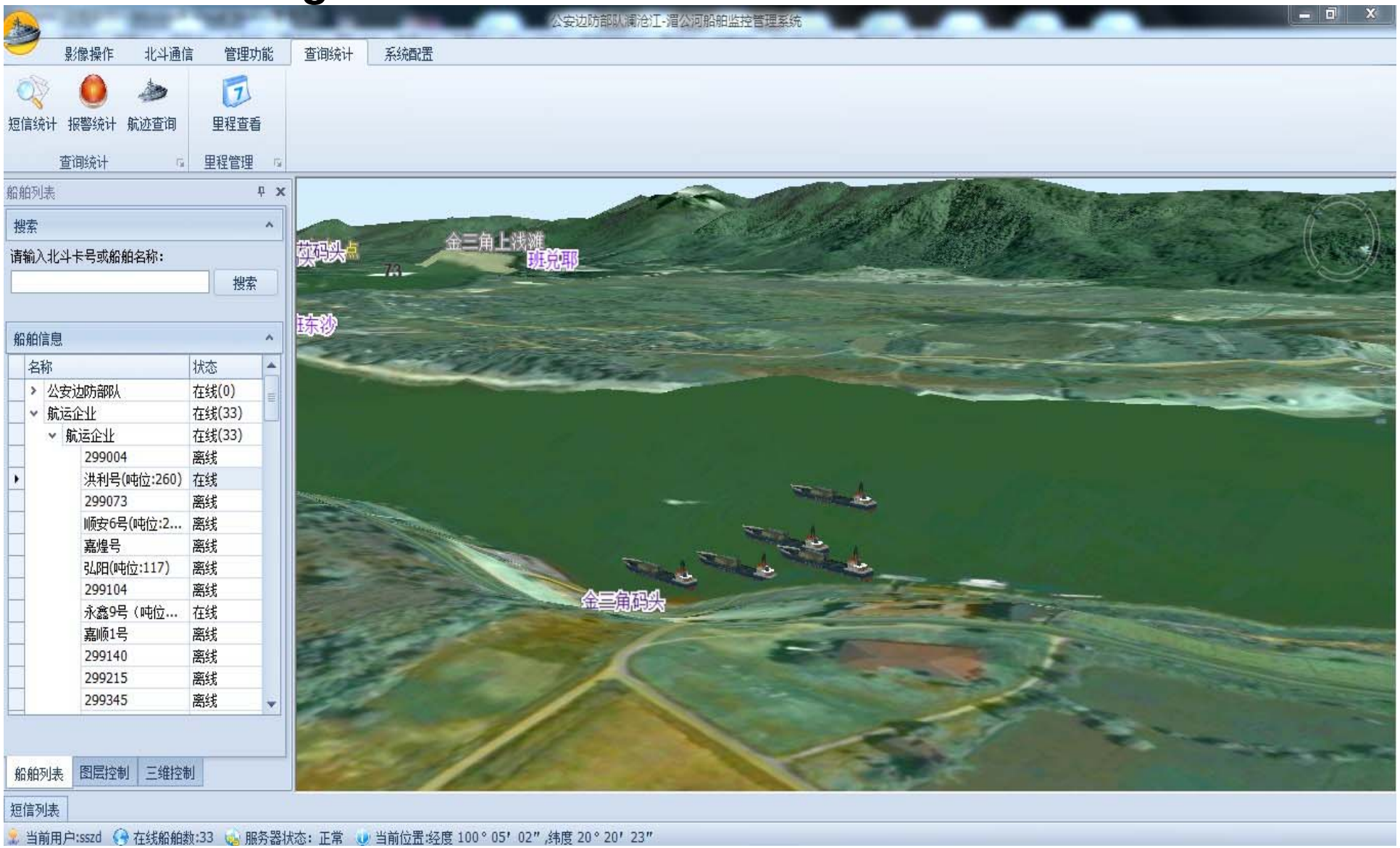
Services Provided by BeiDou VMS

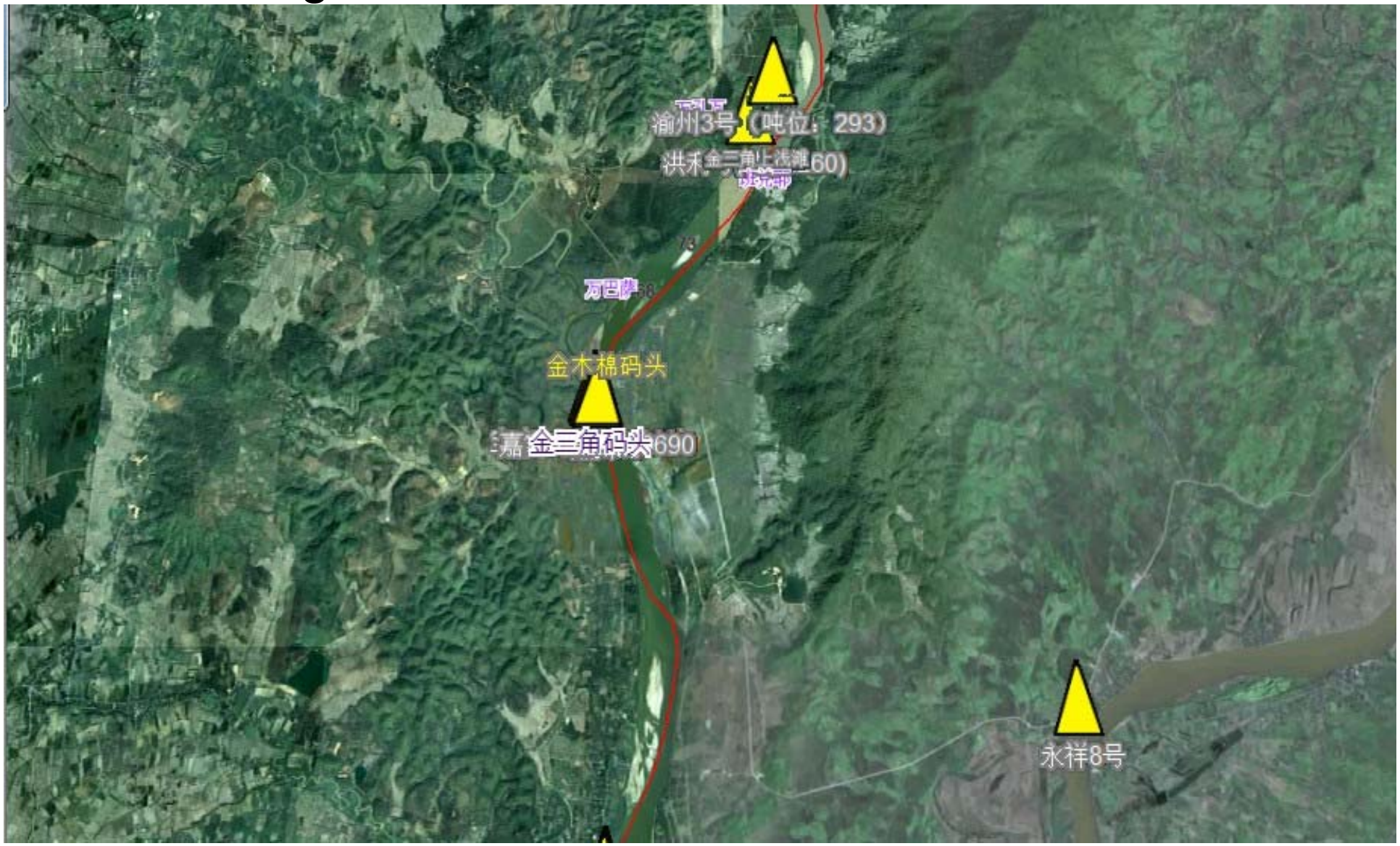
China's BeiDou World's Compass

Inland shipping (Lancang Jiang (Mekong River)): RS + 3D Image + BeiDou



Services Provided by BeiDou VMS

Inland shipping (Lancang Jiang (Mekong River)): RS + 3D Image + BeiDou



Services Provided by BeiDou VMS

Inland shipping (Lancang Jiang (Mekong River))：
RS + 3D Image + BeiDou

Project Effect

- BeiDou Advantage：Positioning and Communication Integrated in the Remote Inland River Area
- Integration Characteristics：BeiDou+RS+3D very suitable for the Environmental monitoring
- Notable Benefits：BeiDou protects ship crew's life and property safety
- International Corporation: BeiDou promotes the international Exchanges and Cooperation

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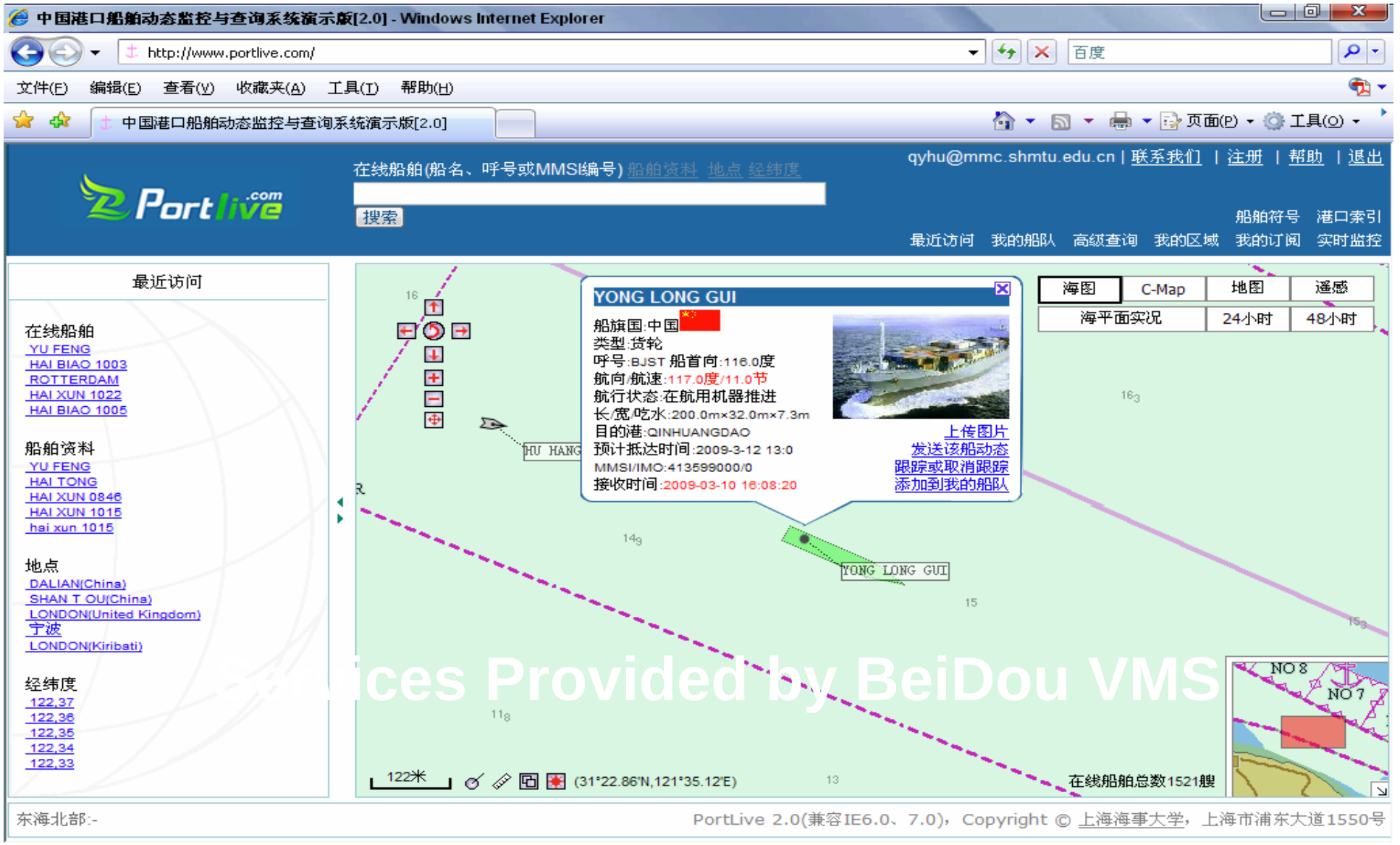
Intelligent Ship Logistics :
BeiDou Position Service + Short Messages + Sensors Integration

China's BeiDou World's Compass



Services Provided by BeiDou VMS

Services Provided by BeiDou VMS

Intelligent Ship Logistics :
BeiDou Position Service + Short Messages + Sensors Integration

Distinguish-ing Features

- BeiDou achieves the dynamic management of cargo and makes the logistics system more efficient.
- BeiDou Early Warning improves the safety of the ocean cargo transportation.
- BeiDou LBS Service offers cargo real-time monitoring (temperature, humidity, etc.) for special logistics.
- BeiDou Logistics can be integrated into Internet of Things.

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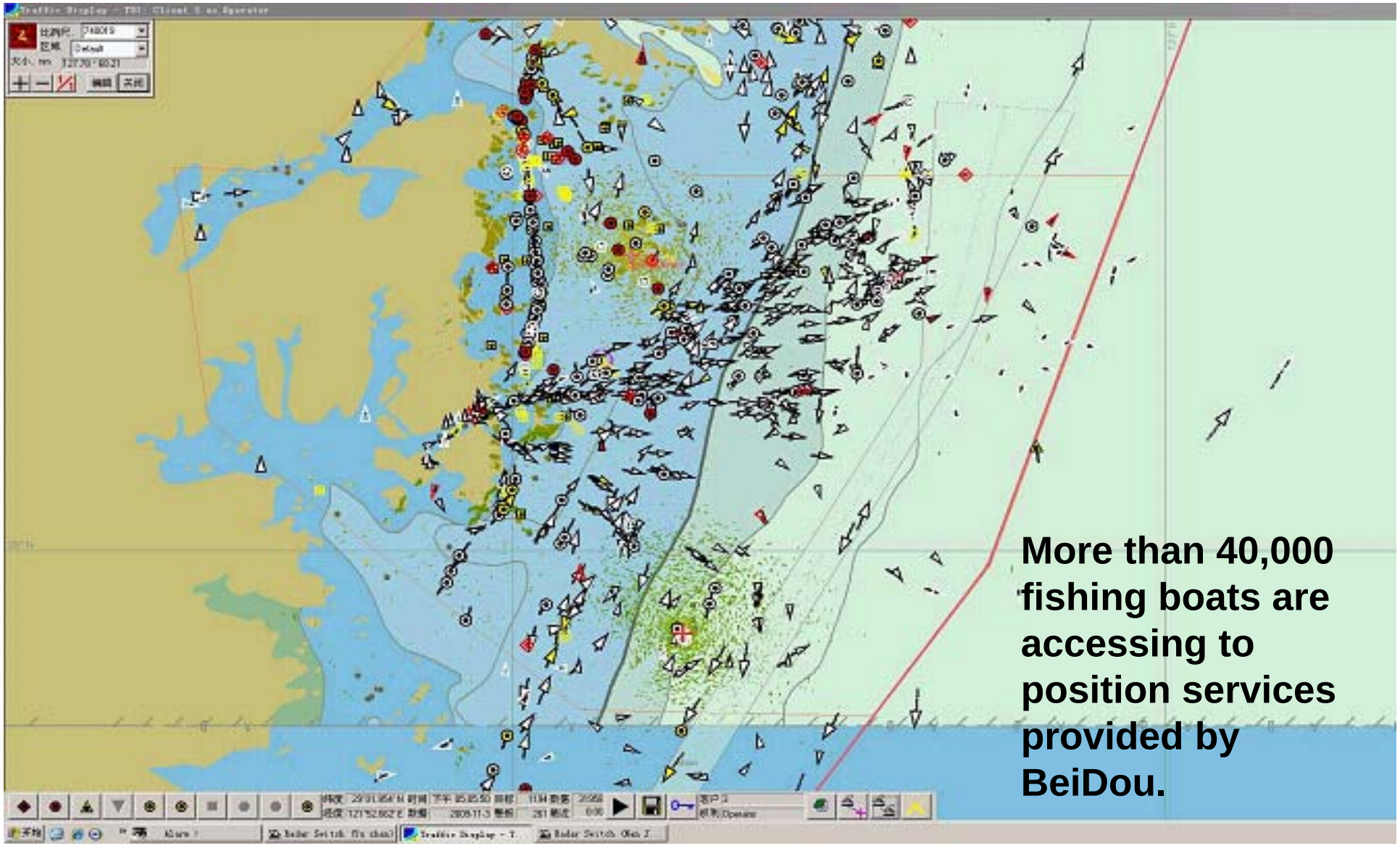
Services Provided by BeiDou VMS

The Application of BeiDou in the Marine Fisheries ——Position Service

China's BeiDou World's Compass



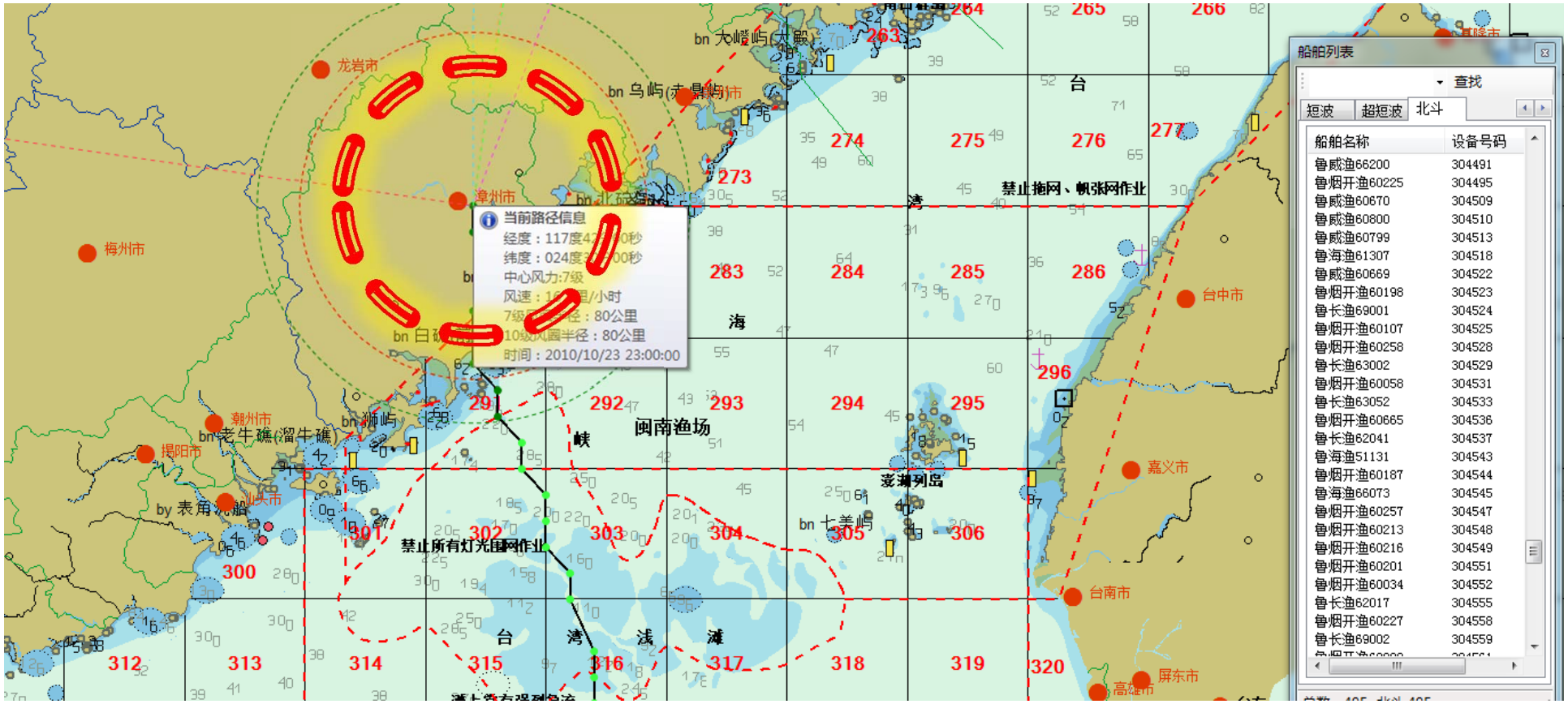
More than 40,000 fishing boats are accessing to position services provided by BeiDou.

Services Provided by BeiDou VMS

The Application of BeiDou in the Marine Fisheries ——Communicate Service

China's BeiDou World's Compass

The Application of BeiDou in the Marine Fisheries
——Typhoon Warning Service



Services Provided by BeiDou VMS

The Application of BeiDou in the Marine Fisheries
——Search and Rescue Services

China's BeiDou World's Compass

Services Provided by BeiDou VMS

Applications on the other Vessels

MV Xue Long

- Scientific Ship Monitoring
- Scientific Data Acquisition

Sailboat

- Competition Sailing Monitoring Service
- Personal Navigation Service

Yacht

- Vocation Navigation Service
- Emergency 911 Communication Service

Conclusion

BeiDou is Notably Applicable to Vessel

- Positioning a
- Various Wate
  Offshore, Oc
- Various Boat

- Autonomous Navigation
- Monitoring
- SMS Communication
- Monitoring Management
- Intelligent Logistics
- Emergency Rescue
- Scientific Investigation

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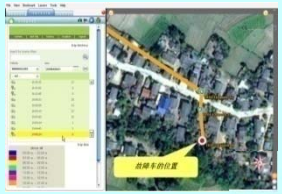
2) BeiDou Application in Government Vehicles Management

- Government Vehicles Management has become more and more important for the government to improve public service ability.
- The former management lacks effective supervision, and in urgent needs of information methods.

BeiDou

GPS

GNSS



GIS

RFID

Management System

Vehicle Terminal | Administrator of the unit | leader | Management group of the city public service vehicles | System maintenance person

The policy of the usage of public service vehicles

The Presentation Layer

Terminal Communication | Tracing Query | Alarm System | Quantitative management | Payment Management | Statistics Report

The Application Support Layer
(Uniform identity authentication, authority, data management, Protocol analysis, system management)

Base Layer
(network, hardware platform, database, system management)

The system of alarm protection

- Vehicle Monitoring
- Real Time Vehicle Tracing
- Emergency Alarm
- Information Release

Vehicle monitoring, commanding and dispatching

Government vehicle

Logistics

School Bus

Passenger Bus

Wireless Communication 、 Network

Internet

Public Wireless Network(2G/3G)

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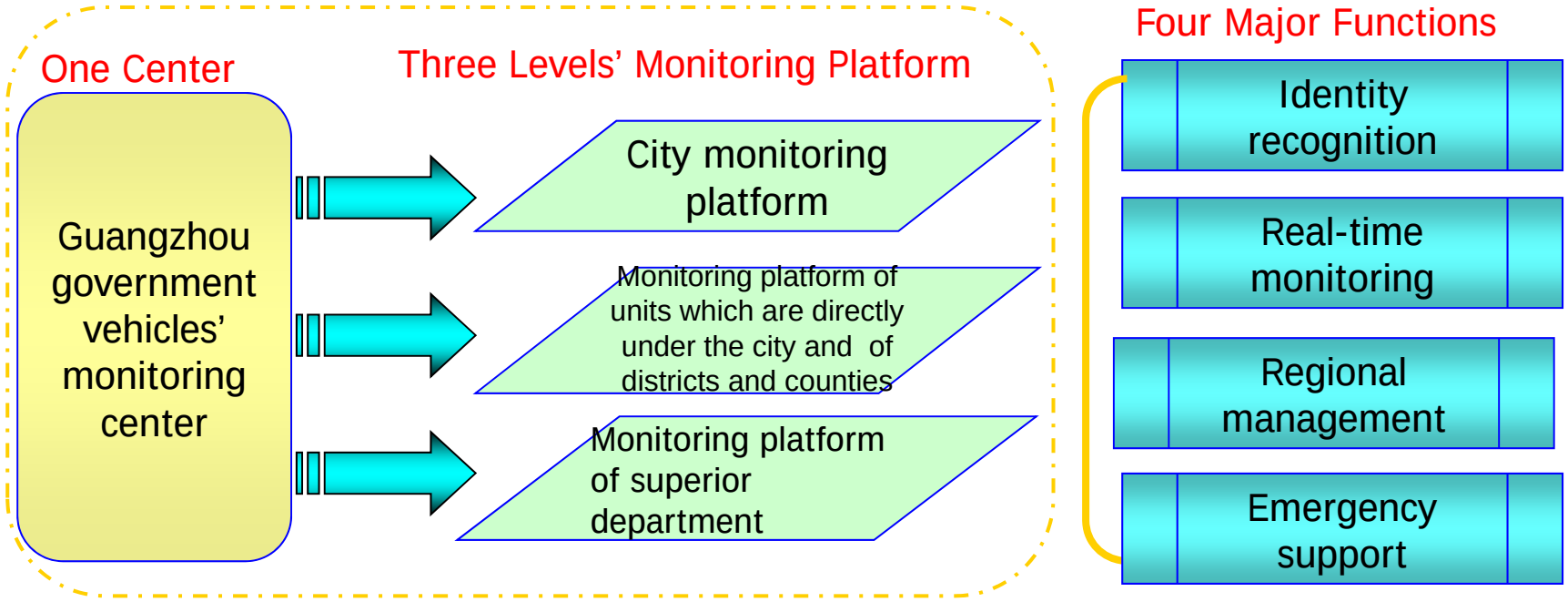
The management information system of Guangzhou government vehicles

- Base on combined BeiDou/GPS navigation
- Monitoring the vehicle's route、parking places，avoiding uneconomic running， clamping down illegal government vehicle usage



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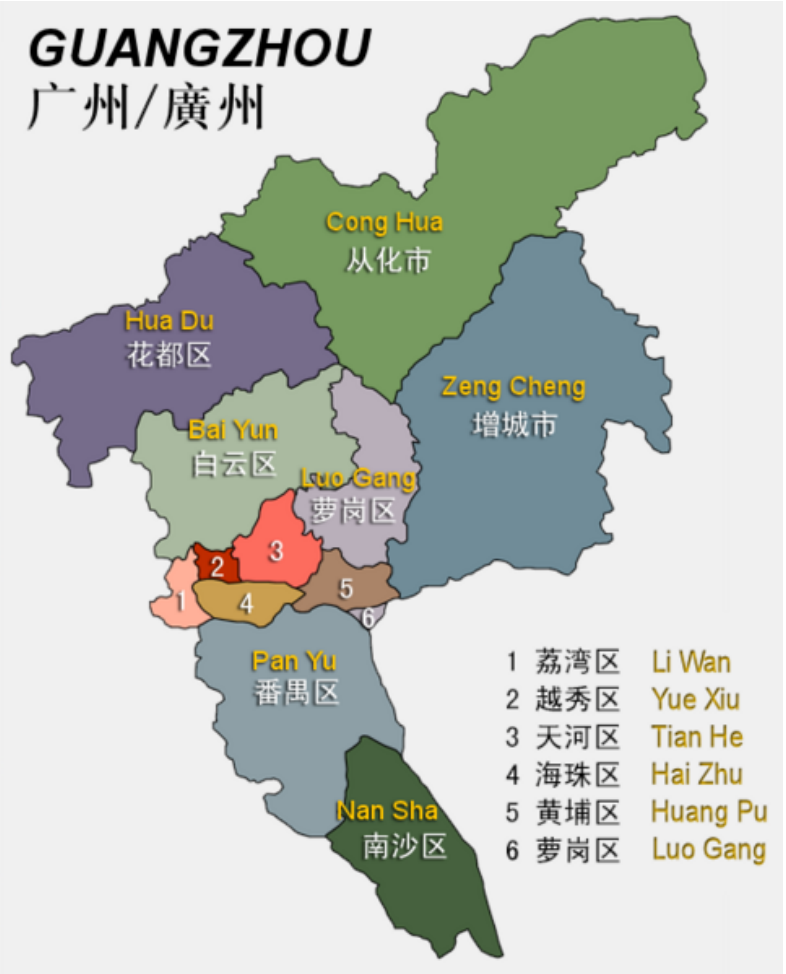
The management information system of Guangzhou government vehicles

Monitor Objective	**Guangzhou government vehicles**
Driving Area	**Ten districts, two cities, and a few other regions**
GNSS Application Mode	**Positioning** **Velocity Measurement**
Positioning Mode (could be set)	**BeiDou+GPS** **BeiDou** **GPS**



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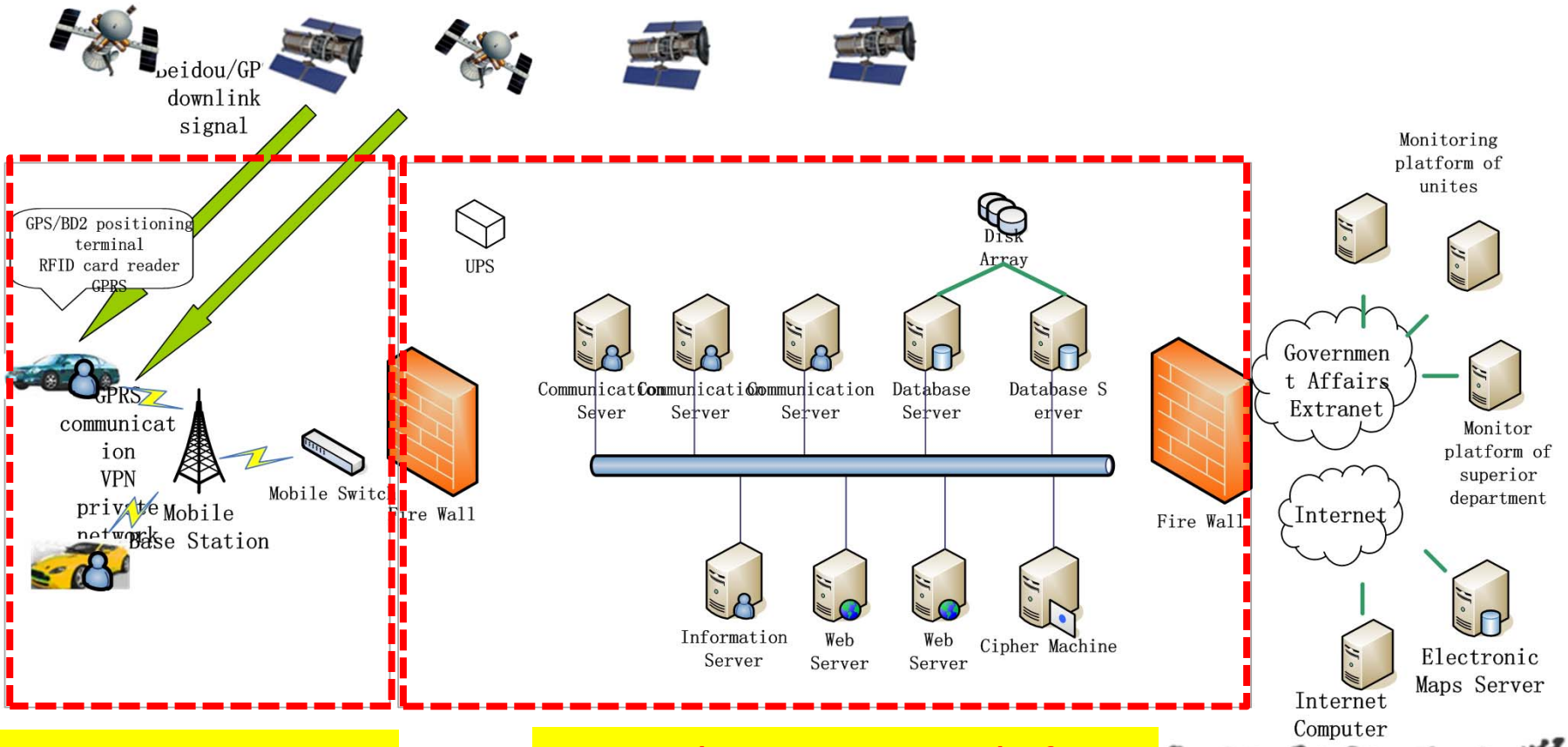
System Architecture



Vehicle Terminal

Central Management Platform

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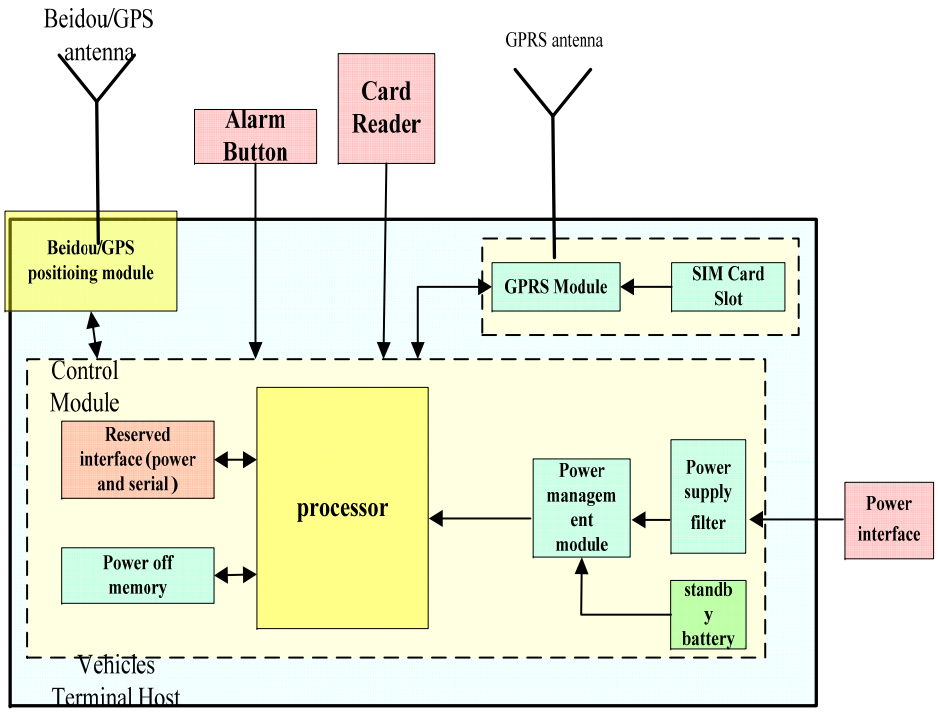
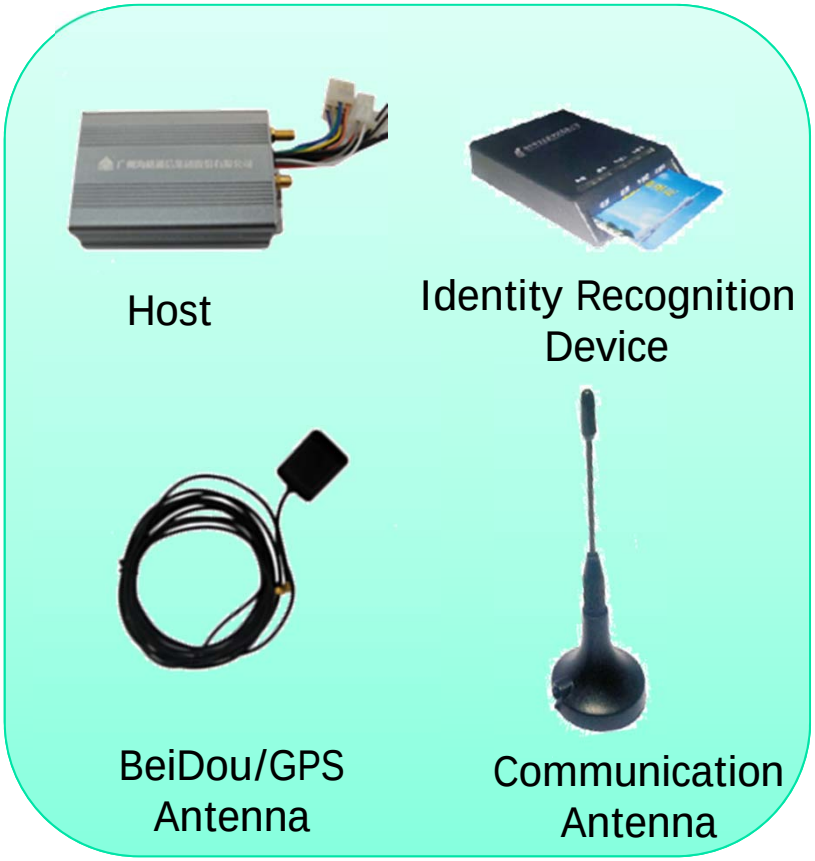
Vehicle Terminal

- BeiDou/GPS compatible receiver
- Identity recognition device





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Key features and specifications

1. Vehicle status and road tracking control
2. Mileage statistics
3. Acousto-optic reminder
4. Remote upgrade
5. Remote setting
6. Communication backup
7. Road tracking compensation
8. Emergency alarm and abnormal alarm
9. Low voltage protection and alarm
10. Low power mode
11. Emergency shutdown

Accuracy Index	
Measurement Accuracy	0.1 m/s
Combined Positioning Accuracy	Level：10m， Altitude：10m
Positioning velocity update rate	1times/s
Time index	
Cold Start	37s
Warm Start	1s
Loss of lock catch	1s
Signal system and working mode	
Input Signal	B1:1561.098MHz，C Code； L1: 1575.42MHz，C/A Code
BeiDou positioning	Support
GPS positioing	Support
Dual positioing	Support

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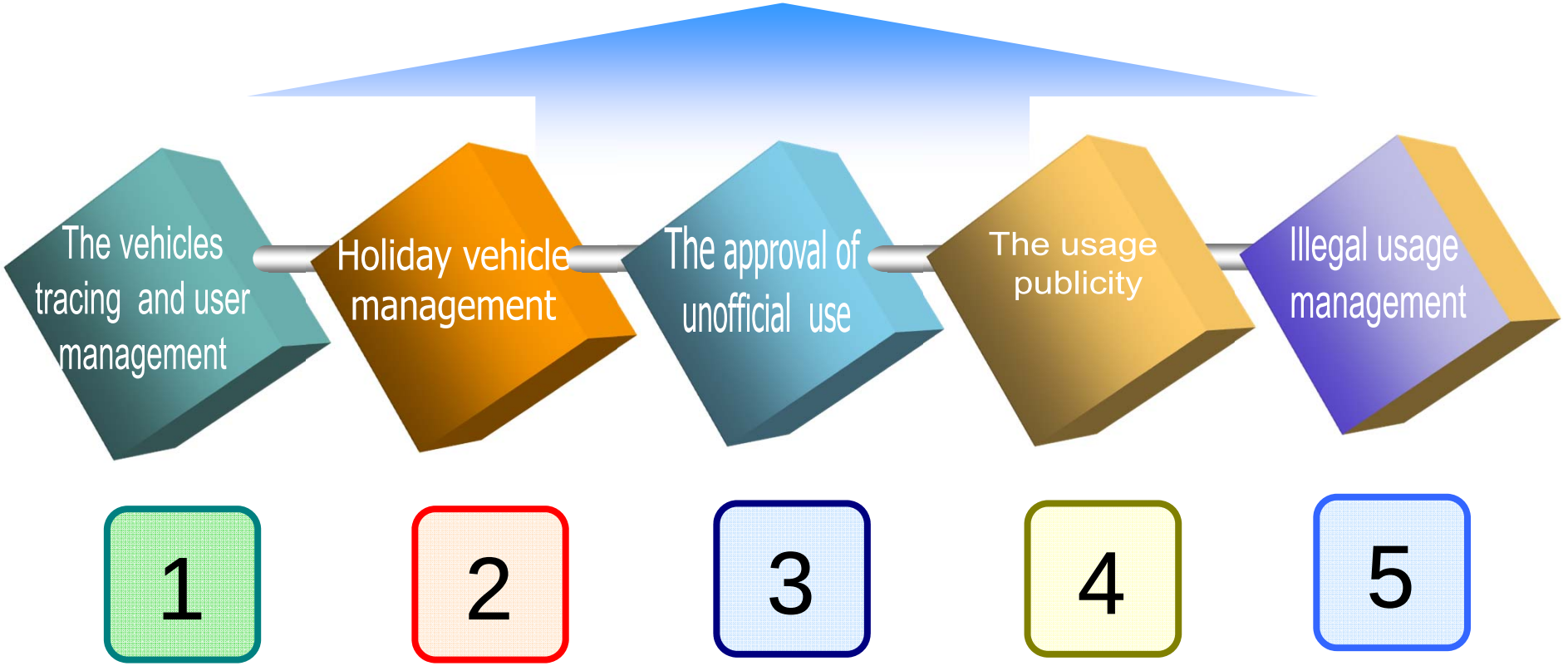
The Five Implementation of the management of government vehicles



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User Management

Identity Recognition

Reminder of forgetting to Plug in the Card

Text Message

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Vehicle Tracing Management

Real-time vehicle tracking
History query

Electronic fence
cross-border alarm

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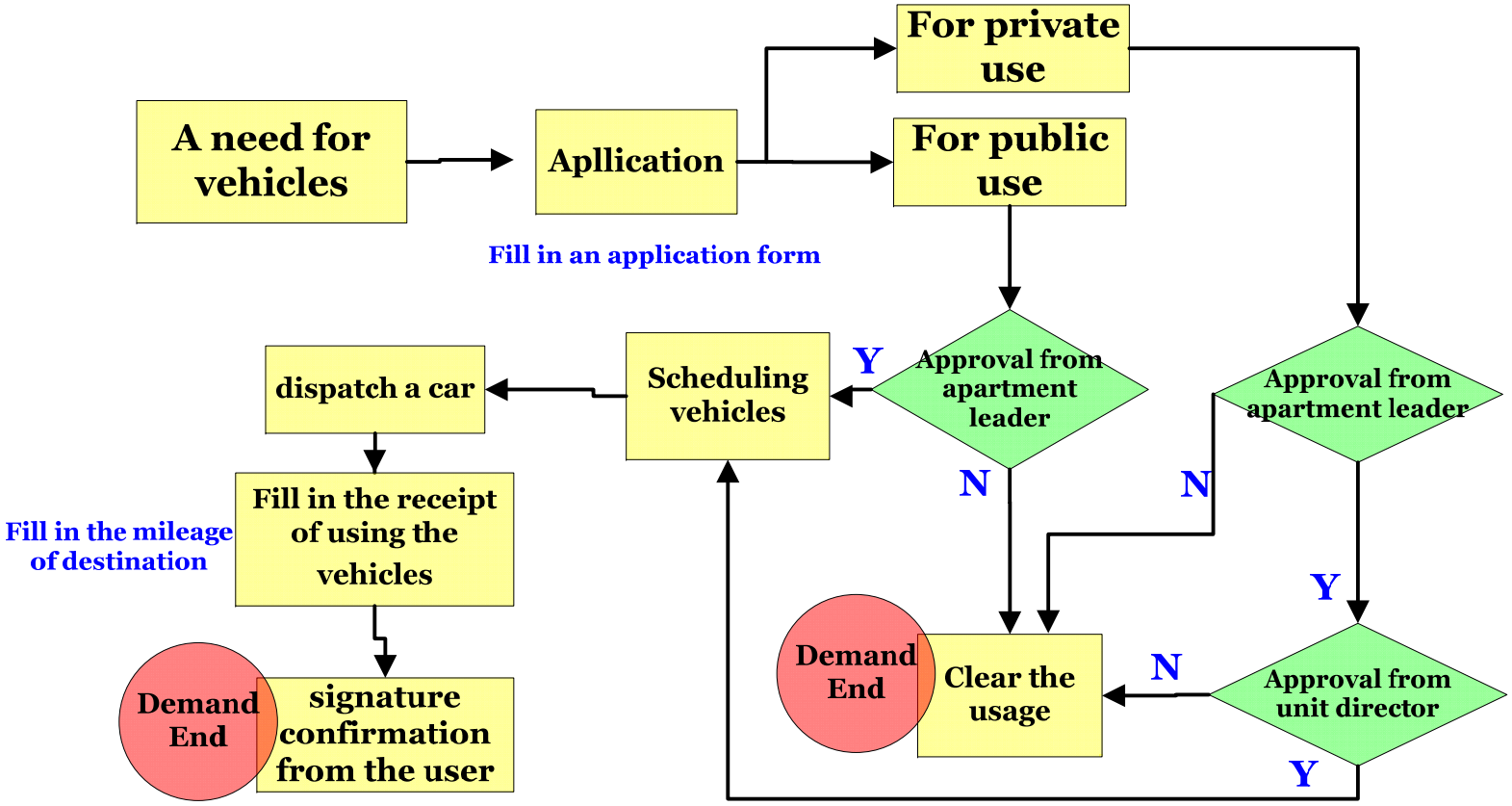
Vehicle Application Process



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Statistics Analysis

- vehicles' status
- abnormal usage
- payment
- mileage
- .....

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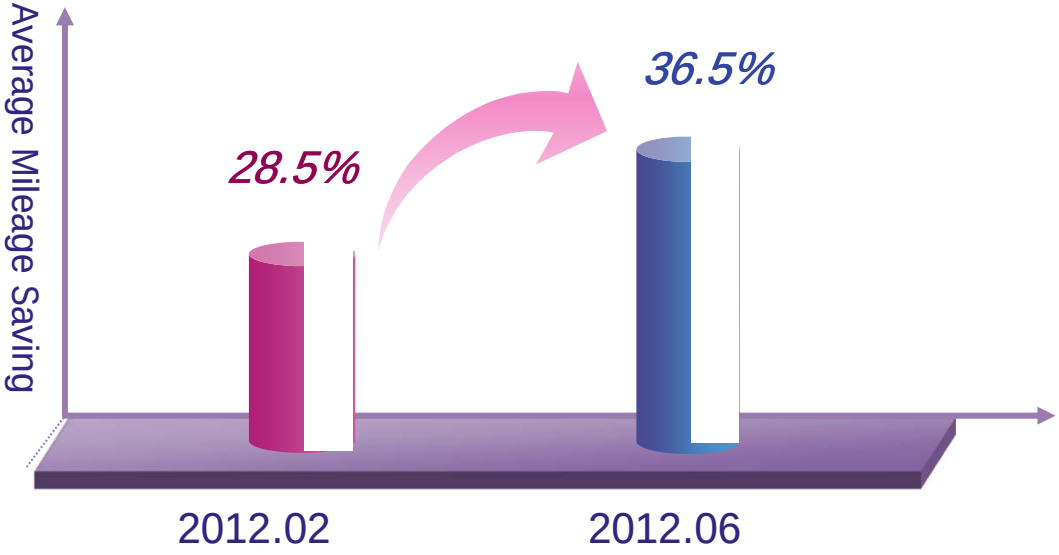
The Achievement of the Project

- 8440 government vehicles have been fitted with BeiDou/GPS monitoring device
- The system has been running for one year, showed reliable performance and got satisfied feedback
- Not only did vehicle management improve, cases of personal usage markedly decreased
- Reduced the cost, Improved the efficiency



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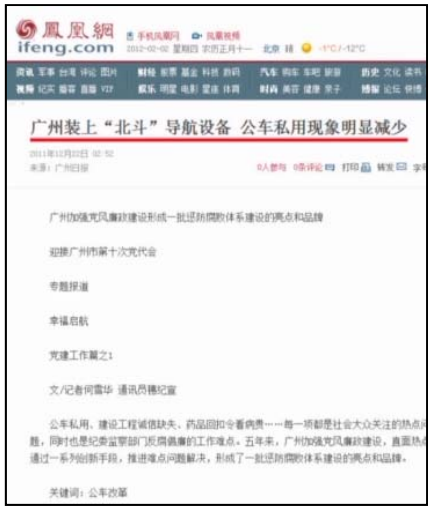
Project's Social Impact

- Achieved volume applications of BeiDou in the field of civilian vehicles monitory
- Got praise from China Satellite Navigation Office, government, and industry experts
- Got media attention, and follow-ups



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GNSS Application Effect

Reference: Evaluation Report of Guangzhou government vehicles project users, 2012.9

Static test

Location：
Guangzhou Science City,
Roof of the 6th floor

Test Environment：Broad Vision with no obstructions

Test Group	Test date and the weather	Positioning Module/Positioning Mode	HDOP	Number of visible satellite	Positioning accuracy availability (10m，95%)
Group A	Aug.4: cloudy 11:04:11～13:19:30 Data set N=10845	T-Module BeiDou	2.181	7.04	90.8%
Group B	Aug.4:cloudy 10:28:07～13:26:05 Data set N=10715	U-Module BeiDou+GPS	0.784	15.99	100%
Group C	Aug.7: Clear 13:32:50～16:35:40 Data Set N=10971	U-Module BeiDou	1.14	9	>99.99%
Group D	Aug.7日:Clear 13:33:12～16:35:48 Data Set N=10958	H-Module BeiDou	1.39	8.04	100%
Group E	Aug.8:Clear 16:46:58～ 18:29:49 Data Set N=6172	U-Module BeiDou	1.43	7.29	97.7%
Group F	Aug.8:Clear 16:46:43～18:29:58 Data Set N=6182	H-Module BeiDou	1.77	6.6	100%
Group I	Aug.9:Clear 8:30:16～20:31:34 Data Set N=42662	H-Module BeiDou+GPS	0.74	15.41	100%
Group J	Aug.9:Clear 8:30:16～20:31:34 Data Set N=40141	T-Module BeiDou	2.42	7.45	94.7%

GNSS Application Effect

Dynamic Test

Aug.29,2012 , Guangzhou Science City, open area

BeiDou Positioning Mode

Dual Positioning Mode

Reference: Evaluation Report of Guangzhou government vehicles project users, 2012.9

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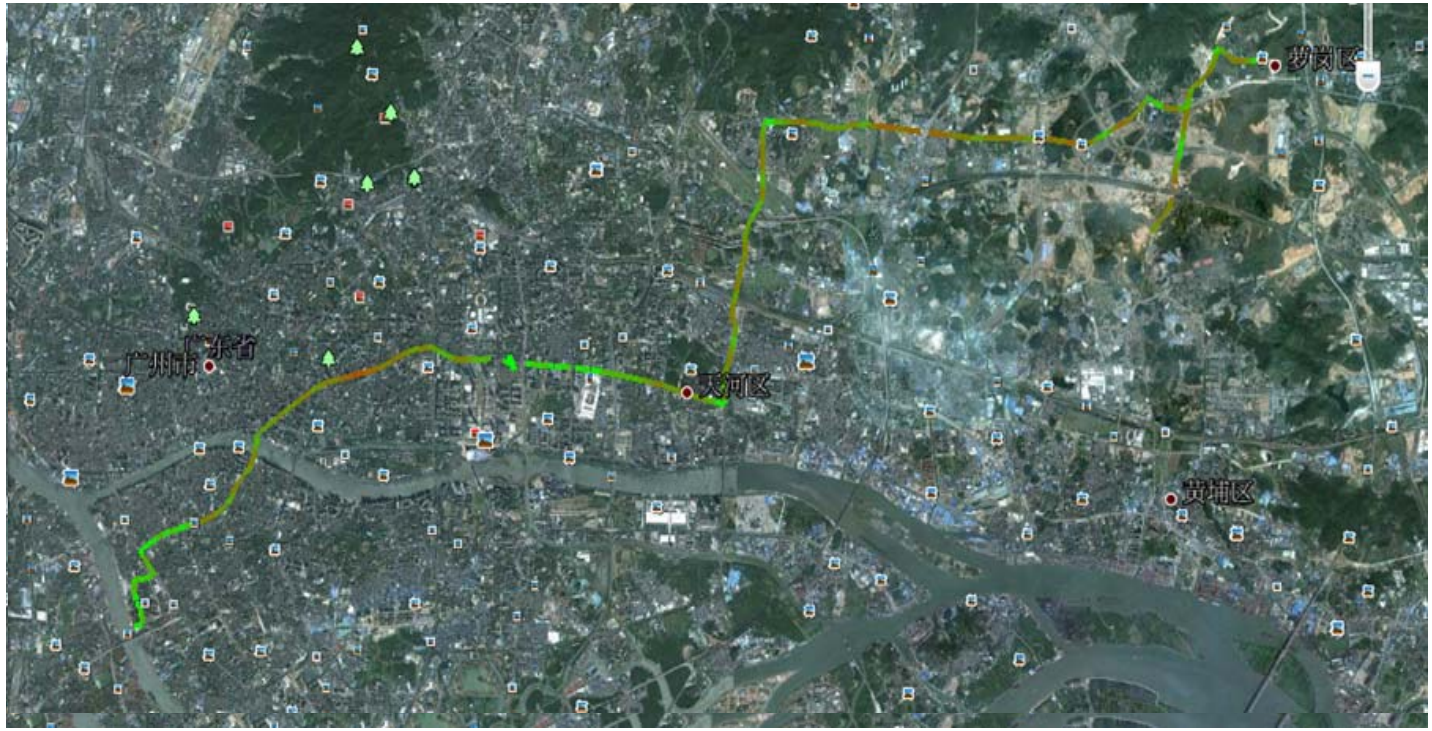
GNSS Application Effect

In Guangzhou Area, the application of GPS is fine, BeiDou is usable, BeiDou+GPS has better effect



Aug.29, 2012, Urban area test, Dual Positioing Mode
Aug.29, 2012, Urban area test, BeiDou Positioing Mode

Note : Red line means failed be positioned, belonging to the linear prediction linear.

Reference: Evaluation Report of Guangzhou government vehicles project users, 2012.9

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GNSS Application Effect

User experience index survey

Date： Aug.2012

Location： Guangzhou

Target： 120 vechicles

Choose one unit from each of the ten districts and two cities, totally 12 units, and 10 cars from each unit

Pattern： Dynamic Test

Index： Positioning Tracing Accuracy
Positioning Tracing Coherence
Positioning Results Stability

User Experience Index Questionnaire of Guangzhou Government Vehicle project

	Sum	Average	Degrees of Satisfaction
Positioning Tracing Accuracy	973	88. 5	Satisfied
Positioning Tracing Coherence	960	87.3	Satisfied
Positioning Result Stability	1017	92.5	Very Satisfied
Total Score	2950	268.2	Satisfied

Reference: Evaluation Report of Guangzhou government vehicles project users, 2012.9

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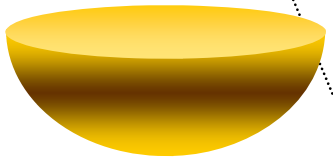

- Guangzhou government vehicle project verified the availability of the BeiDou system
- The multi-system can effectively improve the availability of satellite navigation positioning
- The mature application of BeiDou in Guangzhou government vehicle system played a good demonstration effect in the industry
- Strengthen international technical exchanges, technical cooperation and project cooperation, and jointly promote the GNSS industry booming

3) BeiDou Application in Meteorological and Instrument Development

Contents

- Introduction to the GNSS/MET for BeiDou
- The development of the BeiDou radio-sonde system
- The development of the GNOS for BeiDou occultation on FY-3

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Introduction to the GNSS/MET for BeiDou

In 2011, China meteorological administration implemented an application – the demonstration project of the atmosphere and marine sounding based the BeiDou navigation system and its meteorological application.

It aims to enhance the 3D observation for the local severe weather over the focused area, to increase the ability of data gathering for the weather forecast, and to better the service of the weather warning over the remote and undeveloped region.

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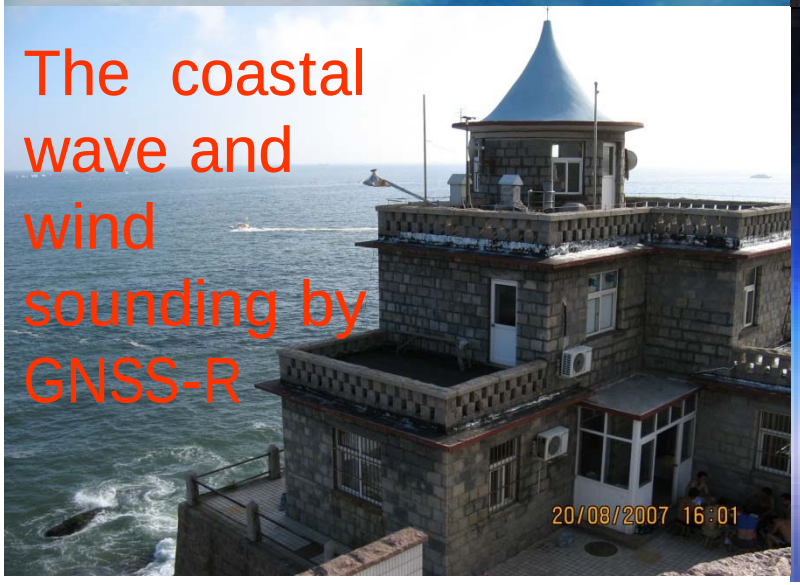
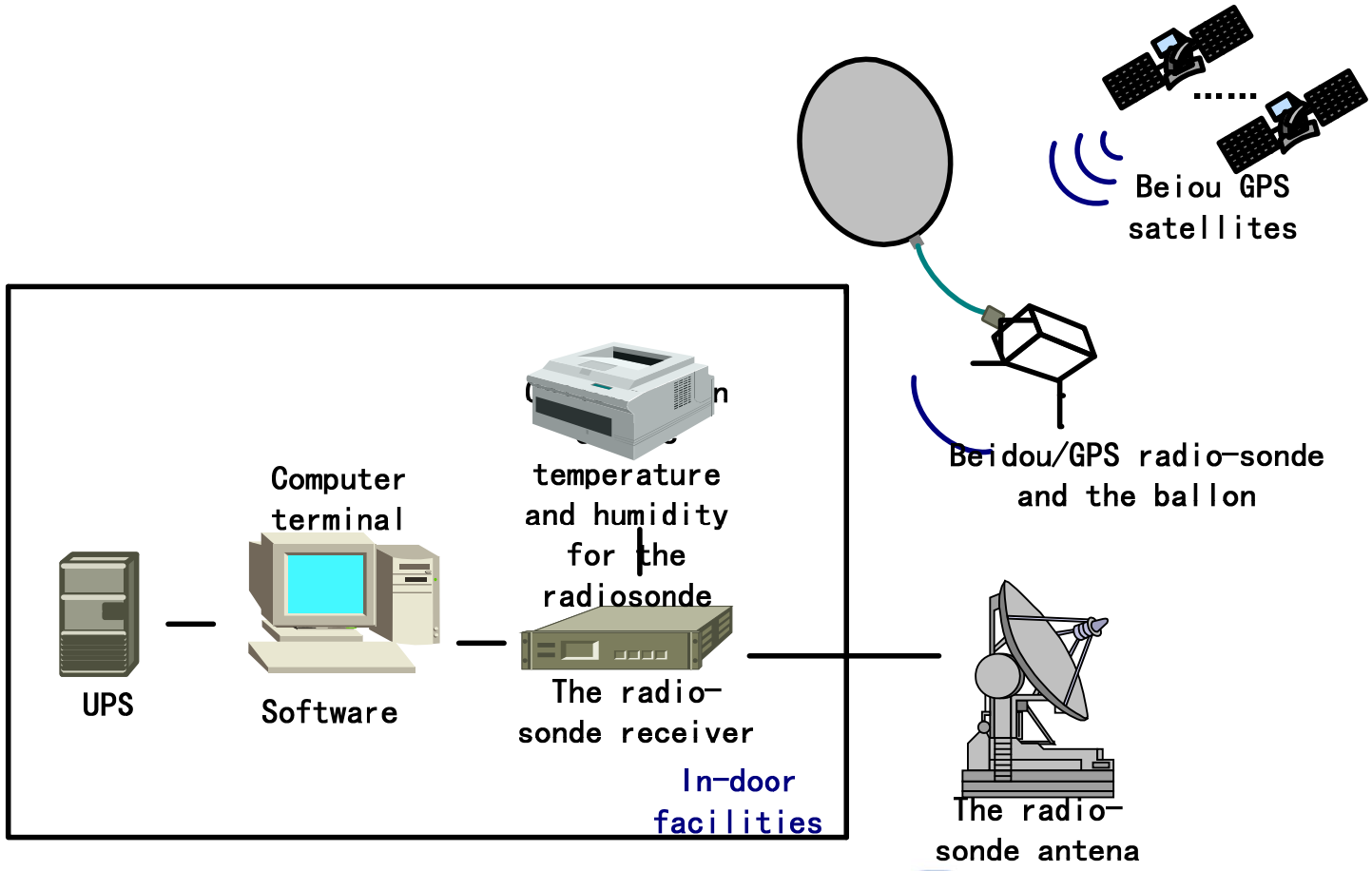
Introduction to the GNSS/MET for BeiDou



Development of the BeiDou radio-sonde system

- Construction of the BeiDou radio-sonde system



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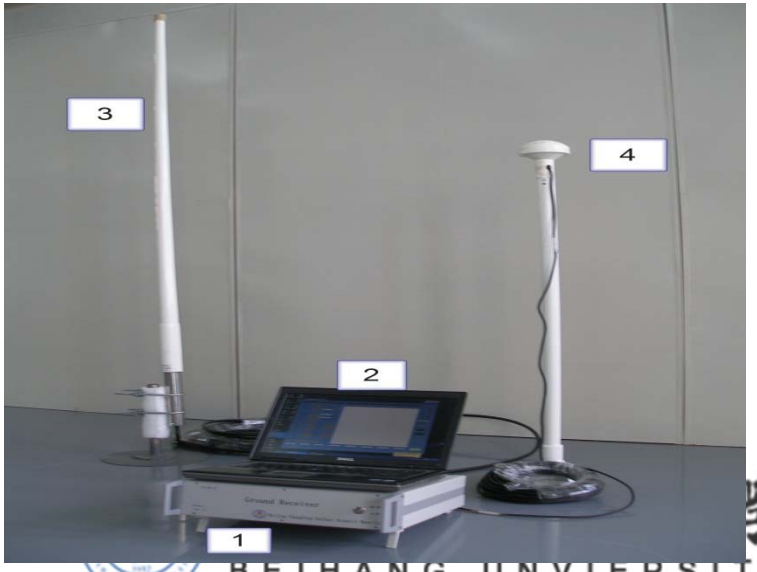
Development of the BeiDou radio-sonde system

- Radio-sonde
- Surface receiving system
  - 1、receiver
  - 2、computer and processing software
  - 3、radio-sonde antenna
  - 4、reference differential receiver and antenna



Development of the BeiDou radio-sonde system

- The BeiDou wind sounding module is the CC50 BeiDou/GPS receiver by Beijing oriental navstar science Co. Ltd.
- The BeiDou antenna is a ceramic active microstrip antenna.

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Development of the BeiDou radio-sonde system

- The system experiments was conducted in 2010 and 2011.
- In 2010, the BeiDou radio-sonde was compared with the international GPS radio-sonde.
- In 2011, the BeiDou radio-sonde was used for the evaluation of the operation test for BeiDou.

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Development of the BeiDou radio-sonde system

- Exp 1—static test
  - The static performance of positioning and velocity measurement

Model	CEP50 (m)	horizontal STD (m)	Elevational STD (m)	Velocity STD(m/s)	Average PDOP
GPS	2.10	2.67	5.49	0.02	1.8
BeiDou	4.91	6.06	13.12	0.02	2.6
GPS+ BeiDou	2.18	2.8	6.33	0.02	1.2

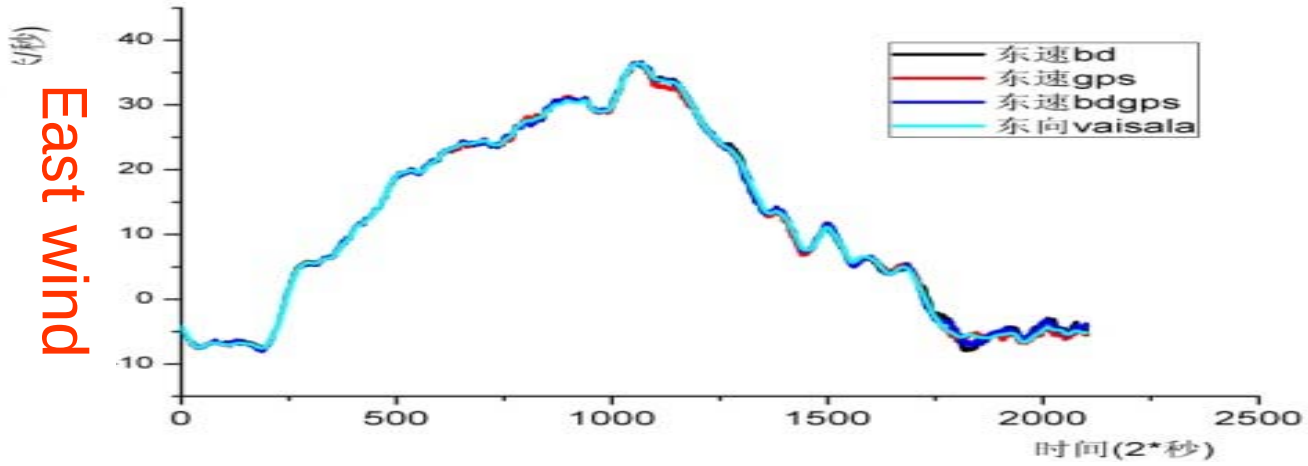
Test time：2012-09-12、2012-09-18、2012-09-20

Development of the BeiDou radio-sonde system

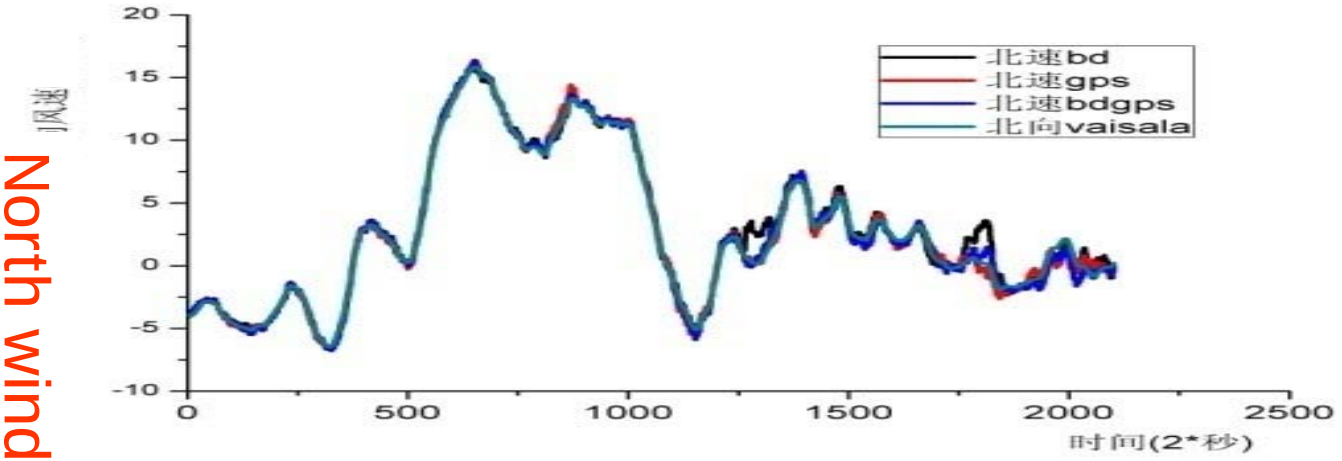
- Exp 2—Field experiment
  - Compare the performance of positioning and velocity measurement with the BeiDou radio-sonde and the reference GPS radio-sonde tied to the same balloon.
  - the BeiDou radio-sonde uses 3 models for positioning and velocity measurement:
    - BeiDou Satellites only
    - GPS satellites only
    - GPS and BeiDou Satellites
  - The reference GPS radio-sonde is Vaisala GPS R92 。

Development of the BeiDou radio-sonde system

East wind



North wind



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Development of the BeiDou radio-sonde system

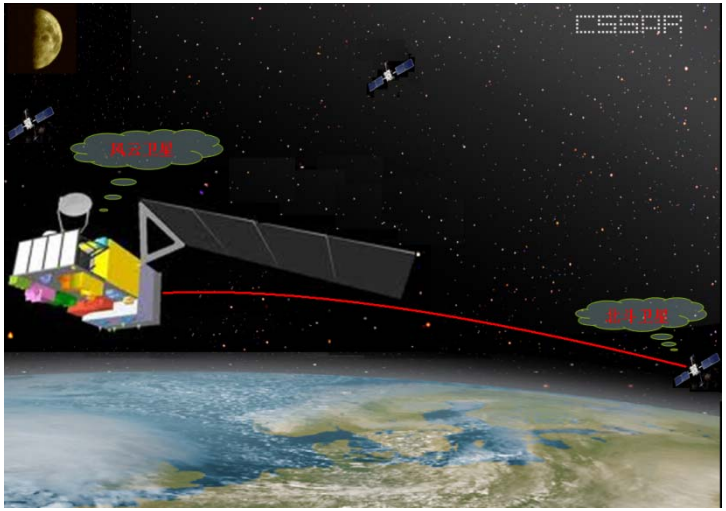
Statistical result

Precision	Wind Speed (m/s)	Wind Direction (degree)
BeiDou only	0.60	4.8
GPS only	0.54	4.0
Bending with GPS and BeiDou	0.50	4.0

The precision demand of current wind sounding is 1 m/s in speed and 5 degrees in direction. It suggest that the module can meet the operational demand of upper air wind sounding with 3 models to measure the wind.

Development of the BeiDou radio-sonde system

- The high precision GNSS receiver is needed for the application of the remote sensing of IPW and TEC. Lauched on the satellite, such receiver even adapted to the circumstance of very high speed.
- The GNOS(GNSS Occultation Sounder) will be first launched on China FY-3 /02 （ lauched in 2013).
- The Occultation application demands high technique of receiver manufacturing and processing of high precision of positioning and remote sensing.



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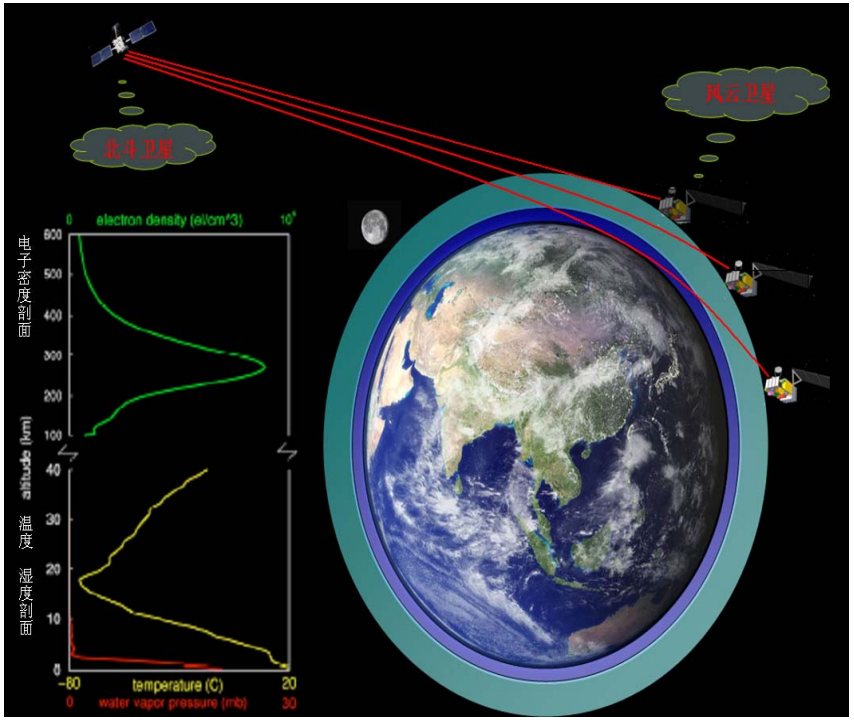
Development of the BeiDou radio-sonde system

The GNOS receives the earth limb occultaion BD/GPS signal, refracted passing through the atmosphere, retrieving the atmospheric profile of temperature, humidity, and ionospheric profile of TEC, by very high measurement of the path bending and the phase amplitude change.



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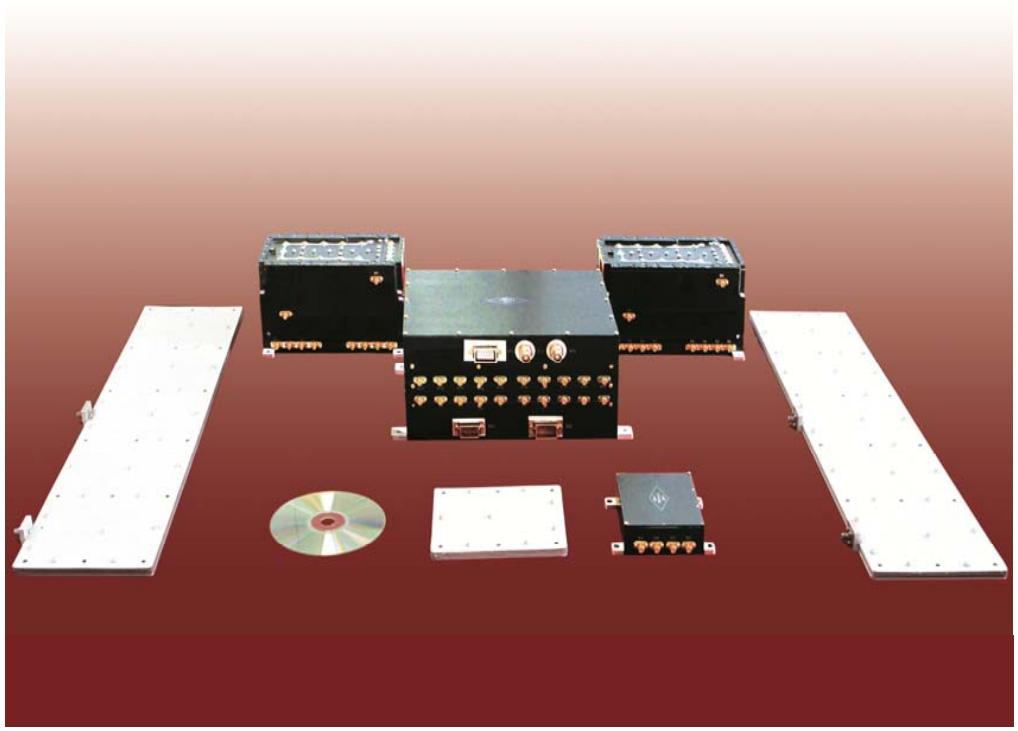
Development of the BeiDou radio-sonde system

- GNOS receiving both the GPS and the BeiDou signal with 8 positioning charnels and 8 occultation charnels.
- It is consisted of 3 RTF units, a DSP unit and 3 antenna for the forward /backward occultation and the zenith postioning.
- It adopts the open loop tracking technique in the occultation receiving.



GNOS manufactured by
The space technique and application research center of CSA

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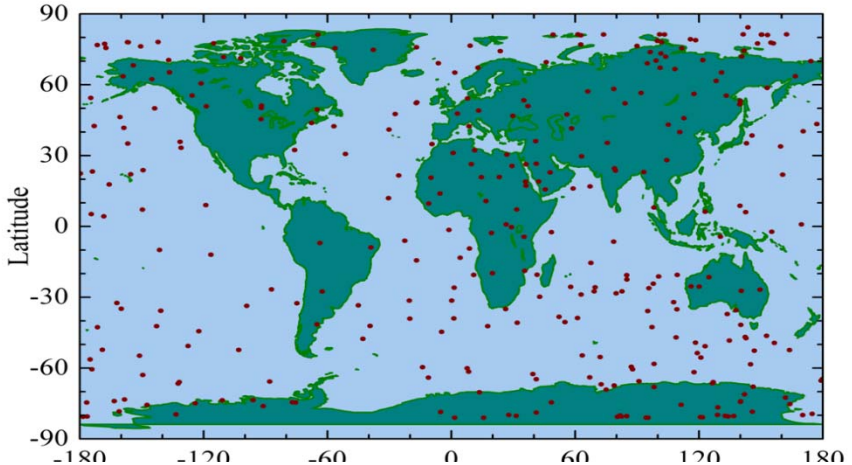
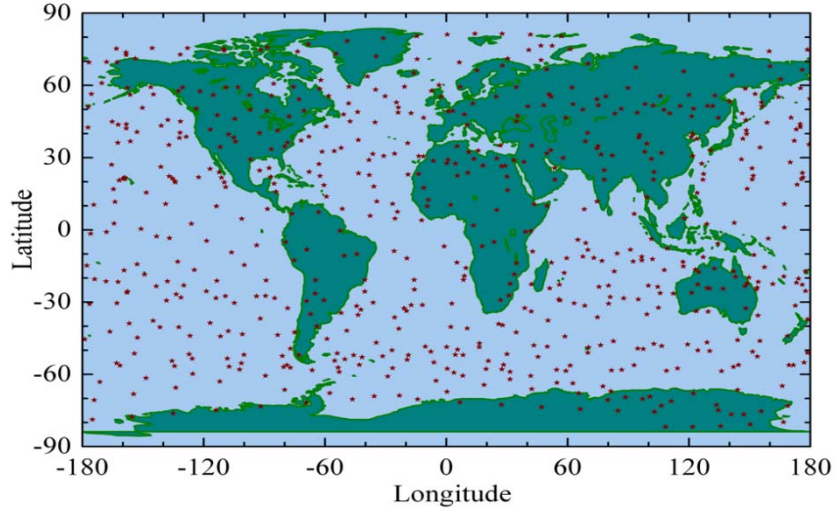
Development of the BeiDou radio-sonde system

- With GPS，about 500 occultation events can be detected.
- With BeiDou orbit of 5GEO/3IGSO/4MEO and 4GEO/3IGSO/2MEO, 320 and 640 events can be detected respectively. (Simulated right)





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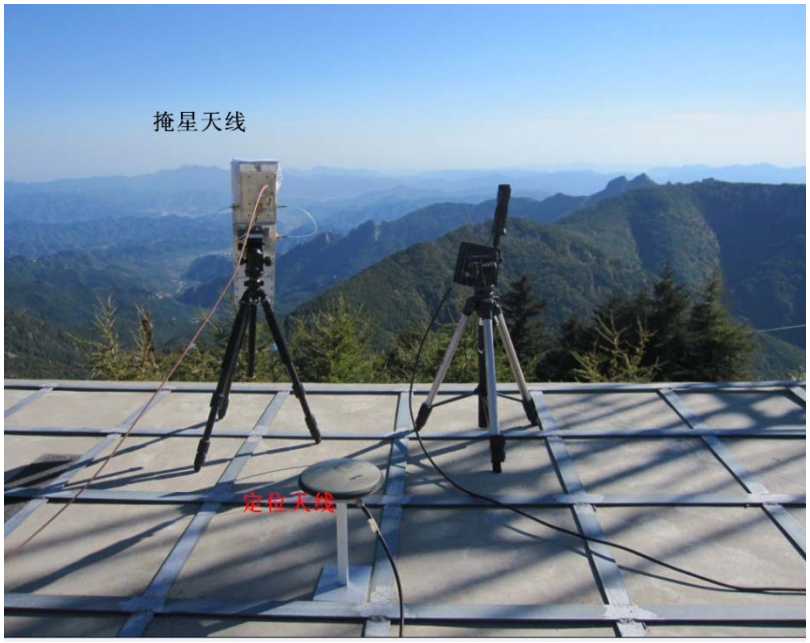
Development of the BeiDou radio-sonde system

In 2012，CMA and CSSA jointly conducted the first surface test—the mountain based BeiDou occultation experiment.

The test began on 2012-9-18 and ended on 2012-9-28.

The GNOS was set up on the mountain top of the Mount Wuling （117.478°E，44.598°N，2083.28m）with its antenna facing the southeast and covering azimuth of 180 and elevation angle of -35 to +35.



Surface test—the mountain based BeiDou occultation experiment

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Development of the BeiDou radio-sonde system

Total 55 BeiDou occultation events were received, with 14 of MEO11 and 12 , and 41 of IGSO.

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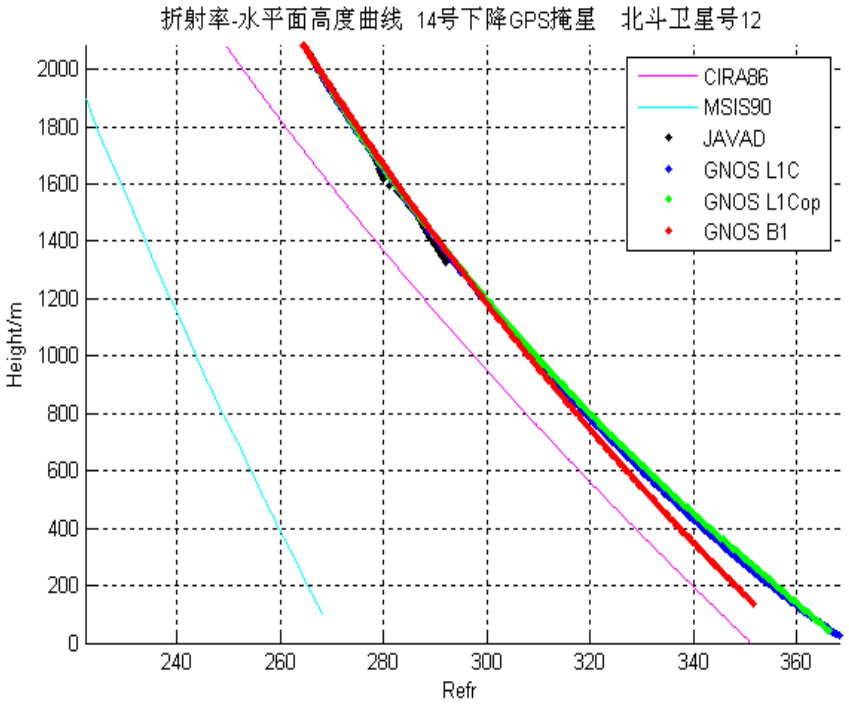
Development of the BeiDou radio-sonde system

Comparison of the retrieval from BeiDou (PRN 12) and GPS (PRN14) at 6:00 in 2012-9-23. The result shows less than 3% of reflectivity exist between the GPS and the BeiDou.



PS： black for JAVAD/L1C retrieval

Blue for GNOS with close loop retrieval

Green for GNOSwith L1C open loop retrieval

Red for GNOS BeiDou retrieval

Purple for CIRA86 computation

Light blue for MSIS90 computation

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Conclusions

- The successful development of the BeiDou radio-sonde system is a trademark for the demonstration and construction of china's next upper air sounding system.
- The GNOS occultation application will enhance the technique of high precision receiver manufacturing and positioning and remote sensing, and deepen and widen the BeiDou scientific application.

Summary

- Understanding GNSS
- Update of BeiDou System
- BeiDou Applications

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Thanks for Your Attention!

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