Multi-constellation Augmentation Service System (MASS)

Primary Results of Wide Area Real-Time Differential GPS Prototype System in China

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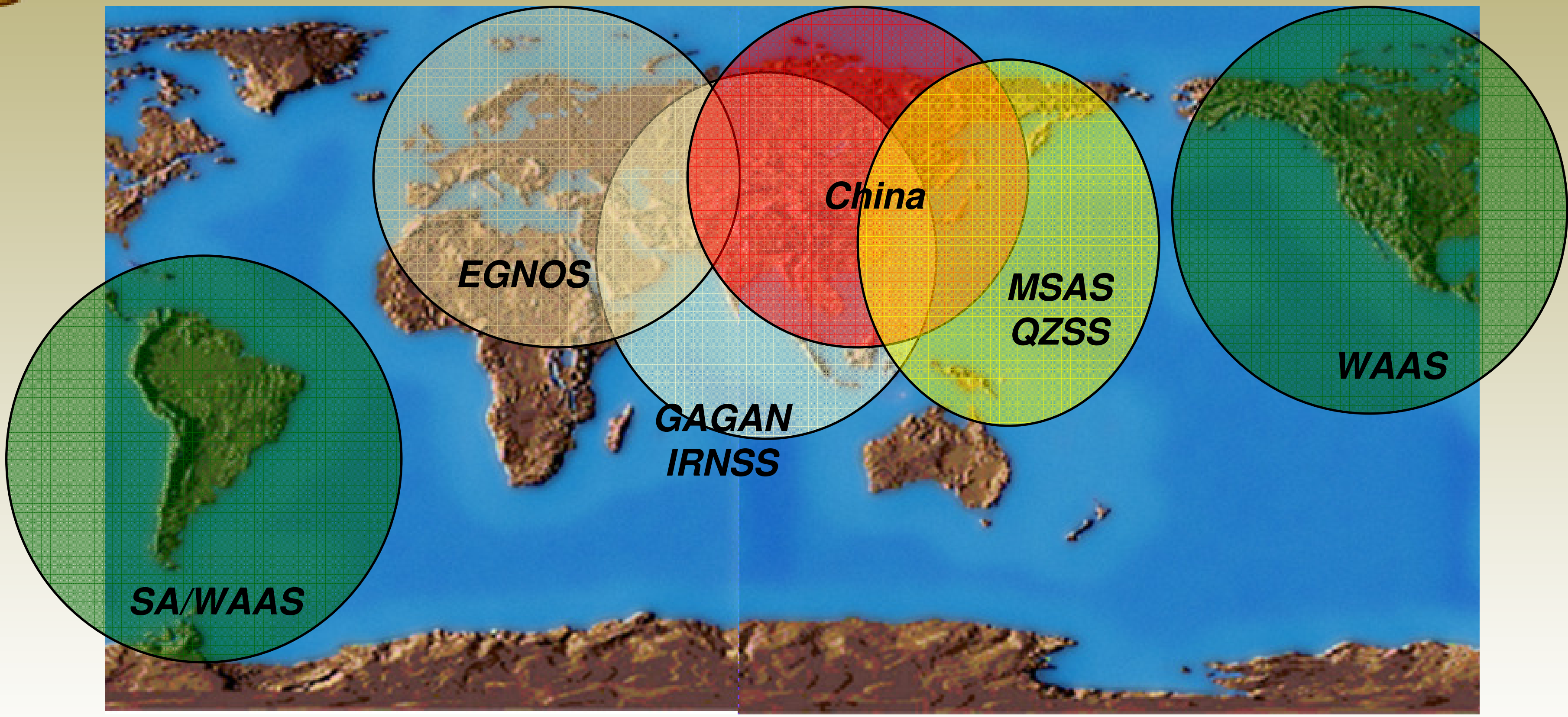
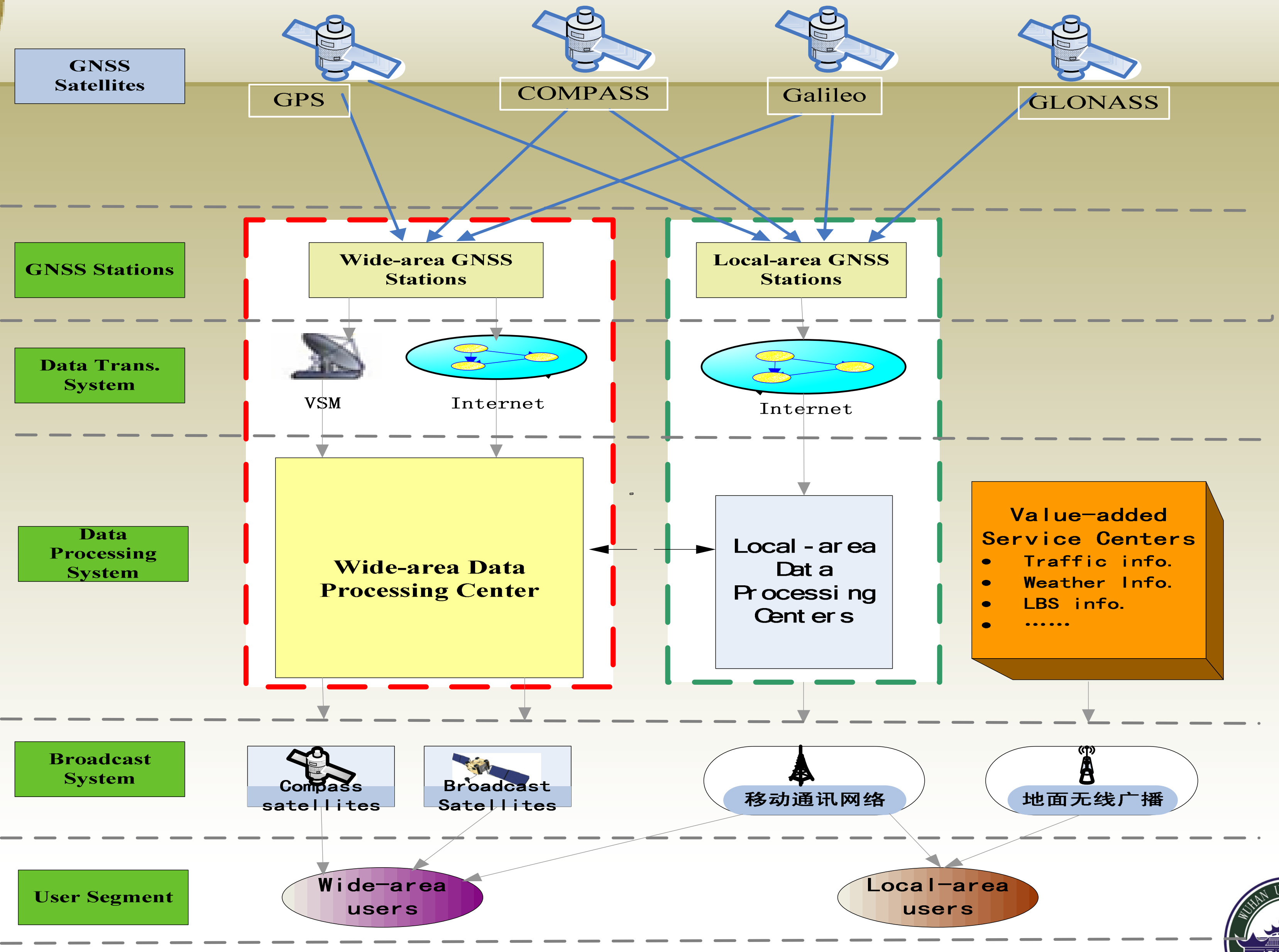
Contents

World-wide GNSS Augmentation System



Multi-constellation Augmentation Service System(MASS)



Positioning and Navigation Performance

Wide Area:

- **Duel frequency : < 0.3m (After initialized, RT, K)**
- **Single frequency: < 1 m (RT, K)**
- **Value-added service**

Local Area:

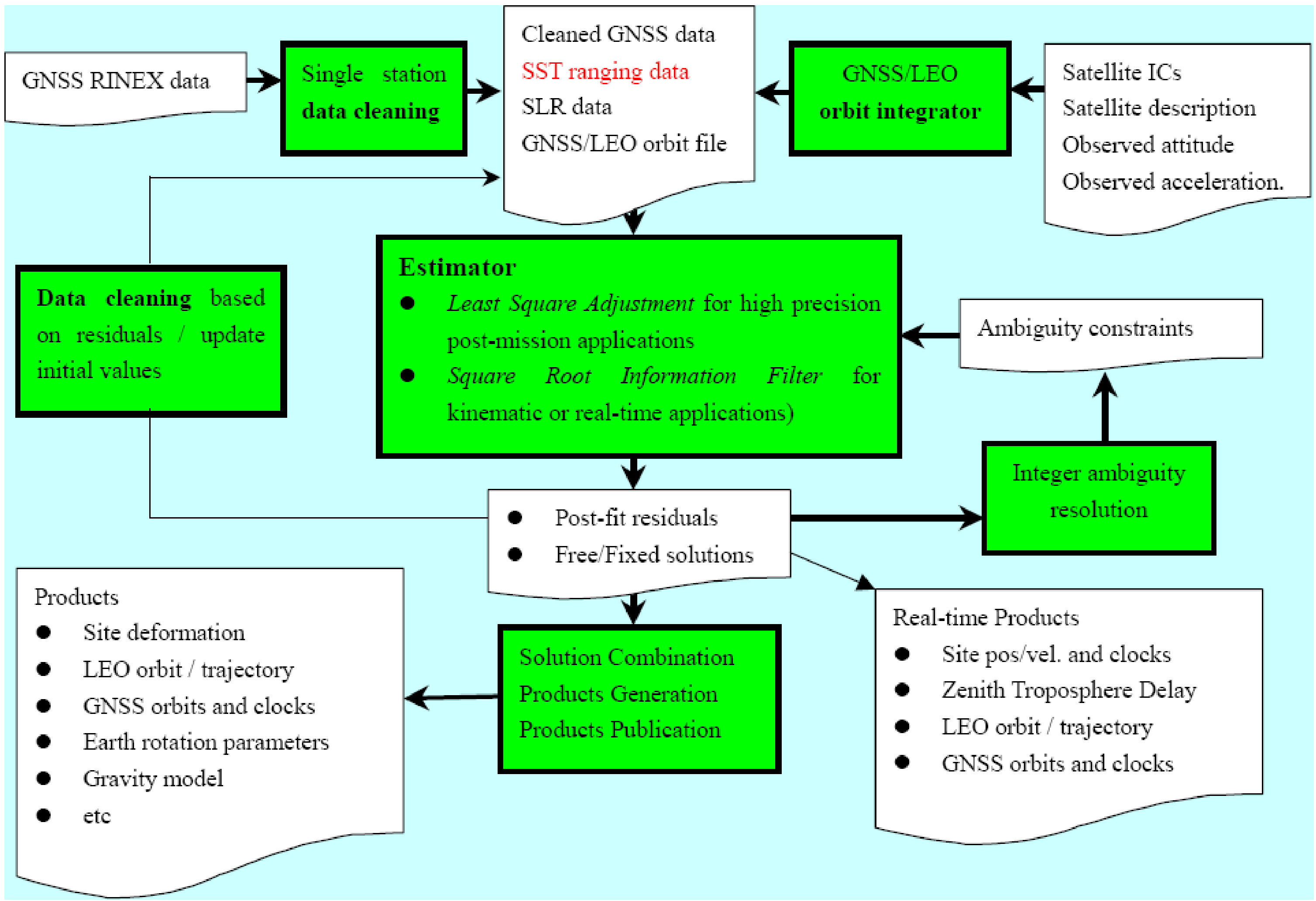
- **Duel frequency : < 0.03m (After initialized , RT, K)**
- **Single frequency : < 0.3m (RT, K)**
- **Value-added service**

PANDA Software

*PANDA : P*ositioning *A*nd *N*avigation *D*ata *A*nalyst

- **To derive possible information from GNSS/SLR/VLBI data in real-time and post-mission**
- **Developed at Wuhan University since 2001**
- **Current Applications**
  - **POD of GNSS (COMPASS, GPS, Galileo)**
  - **POD of LEOs (CHAMP, GRACE, COSMIC , …)**
  - **Huge GNSS Network Processing**
  - **Global Ionosphere Maps (GIM)**
  - **Satellite Gravity Recovery**
  - **Combine Solution for Reference Frame Maintaining**
  - **PPP**
  - …..

PANDA Software

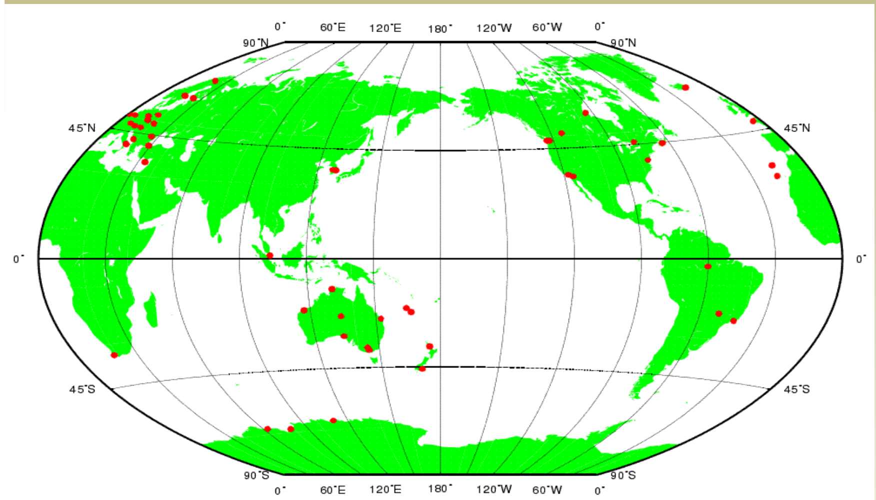


New Development: Real-Time

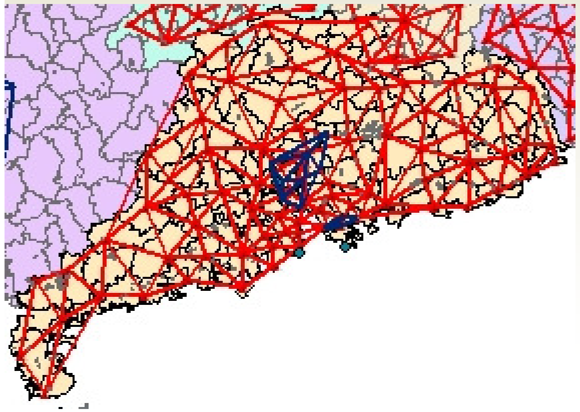
- PPP Based Positioning Service System
  - Real-time GPS orbits
  - Real-time GPS Satellite Clock Offsets
  - Precise Point Positioning

Real Time GNSS Platform in Wuhan University

68 real-time GNSS Data world-wide

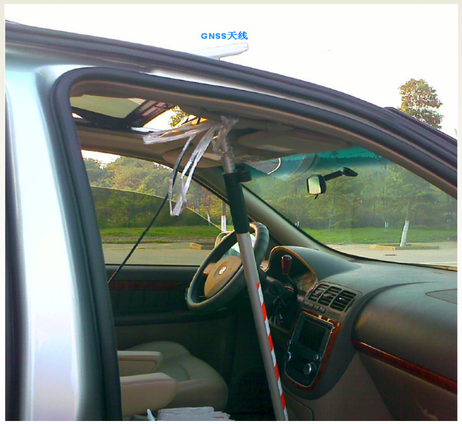


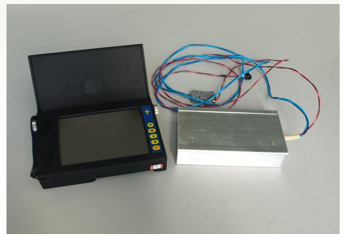
Analysis Center (IBM BladeCenter)



Real Time Data Source in Guangdong Province

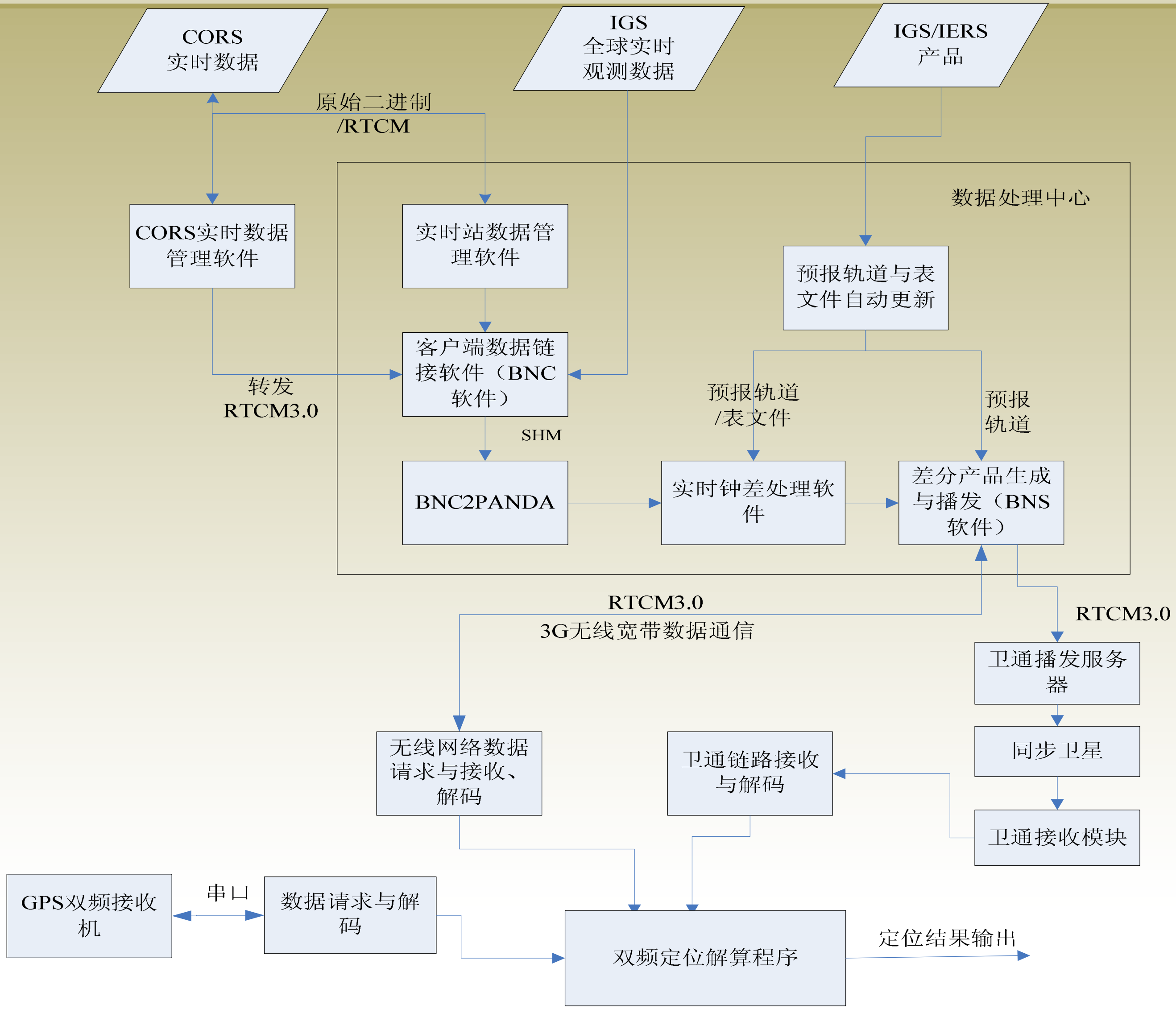
Satellite Communication equipment



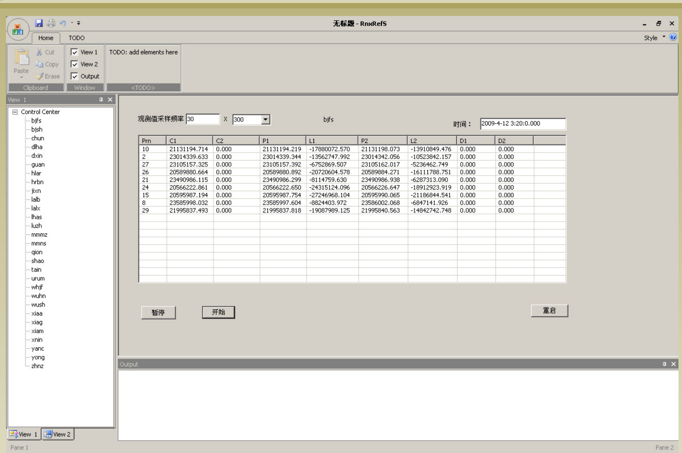


Demo terminal and vehicle

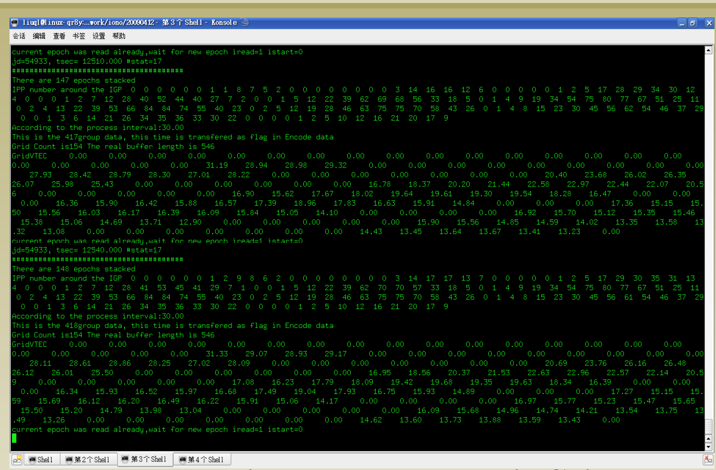
Flow Chart of RT GNSS Processing



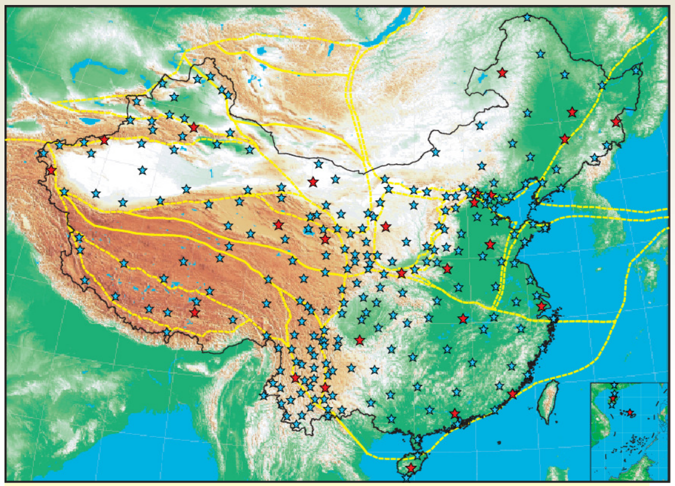
Post-Simulation System with old GNSS Network Data



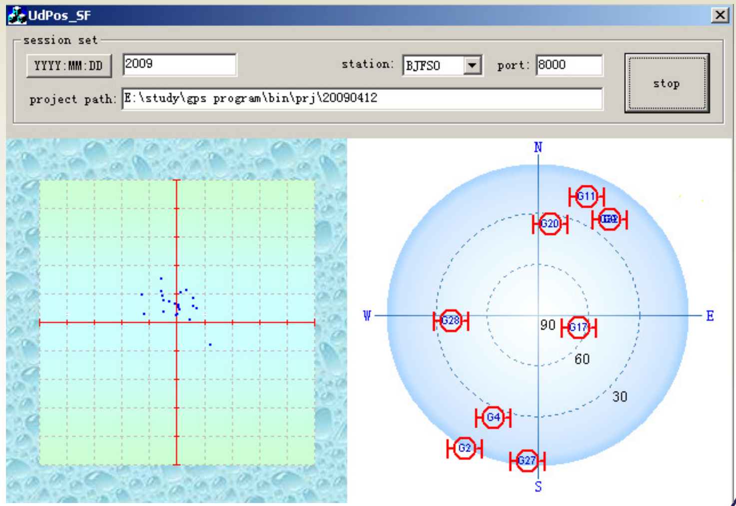
RINEX Data distribution Software



Regional RT Ionospheric Grids



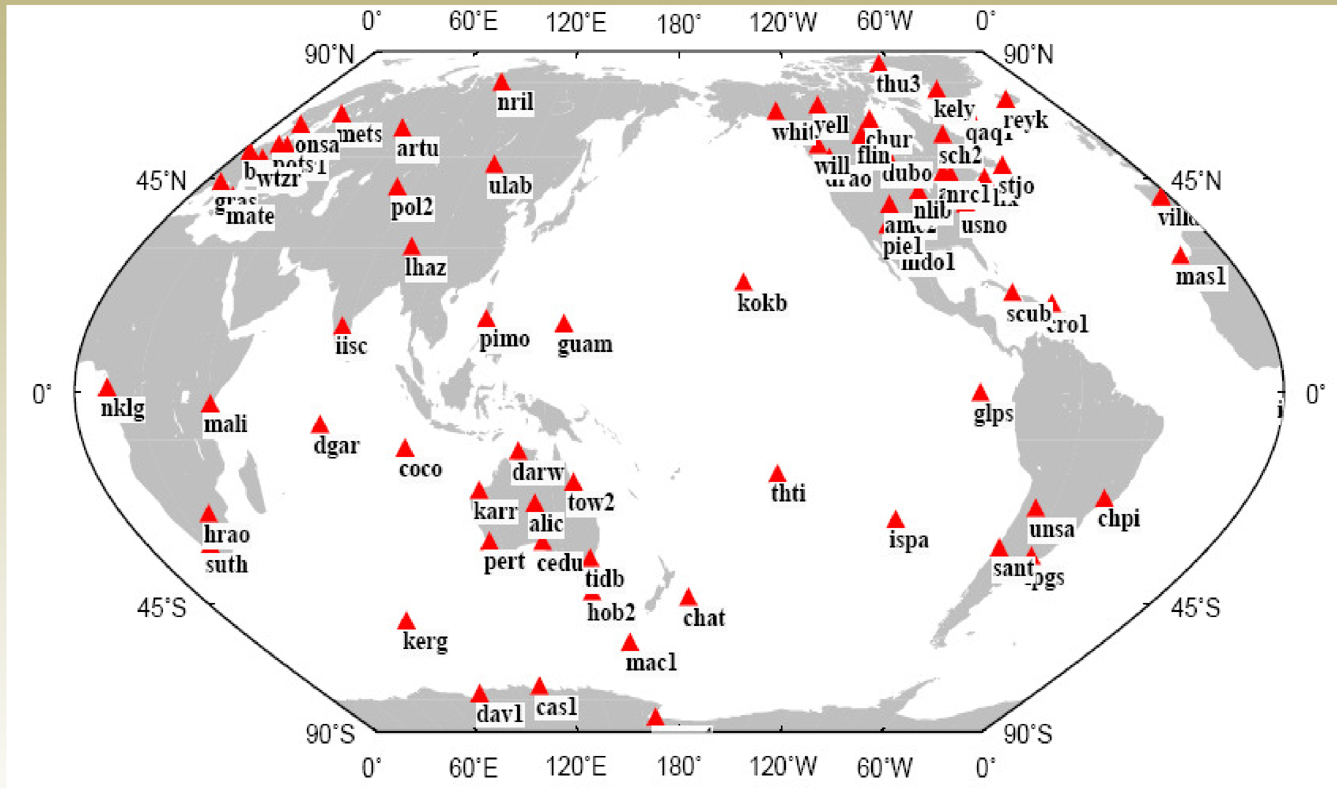
CMONOC 26 GNSS Stations



Single-frequency demo software

Preliminary Results

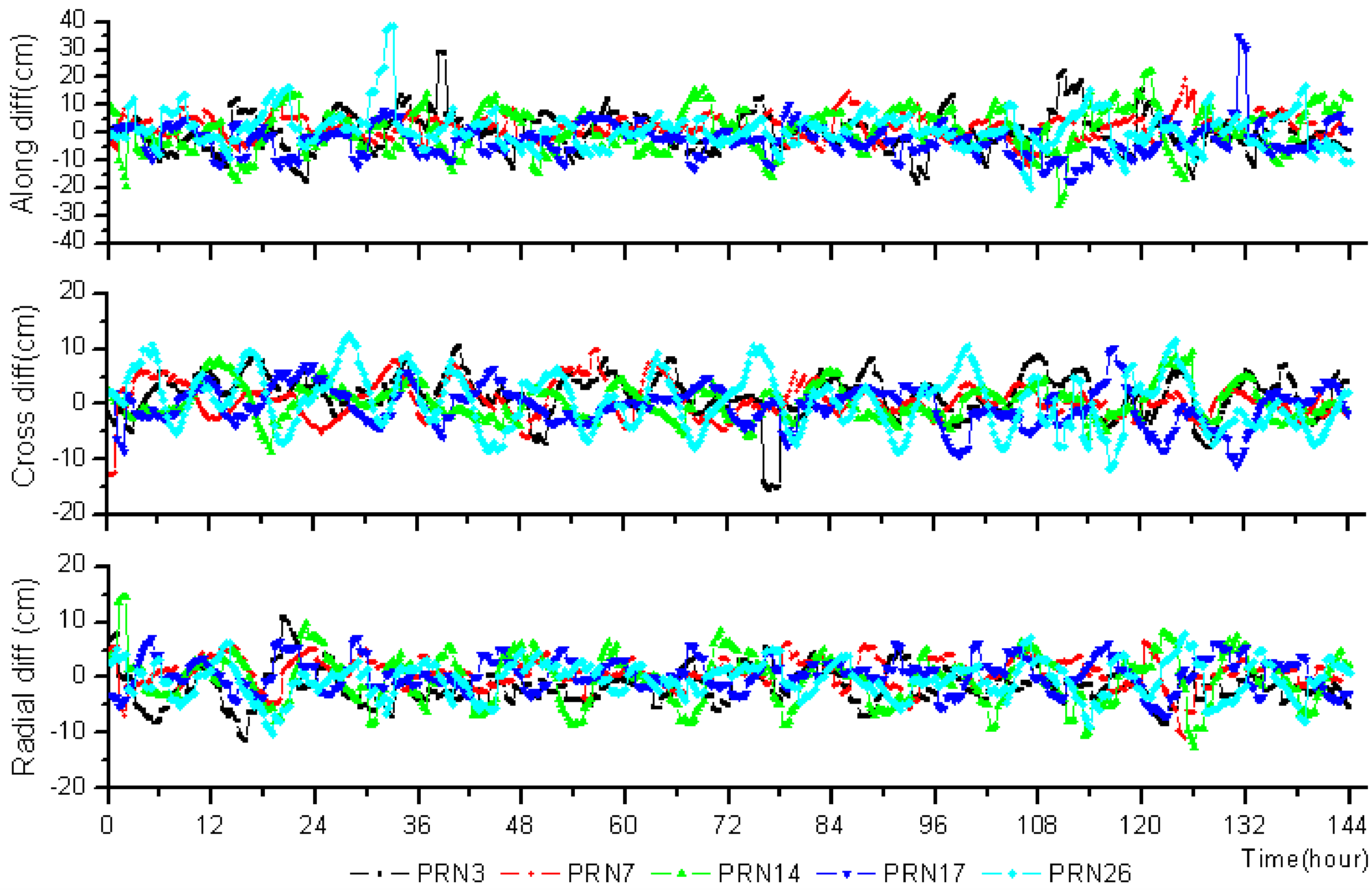
Test Network



The distribution of the 70 IGS stations for Real time satellite orbit determination (70stations)

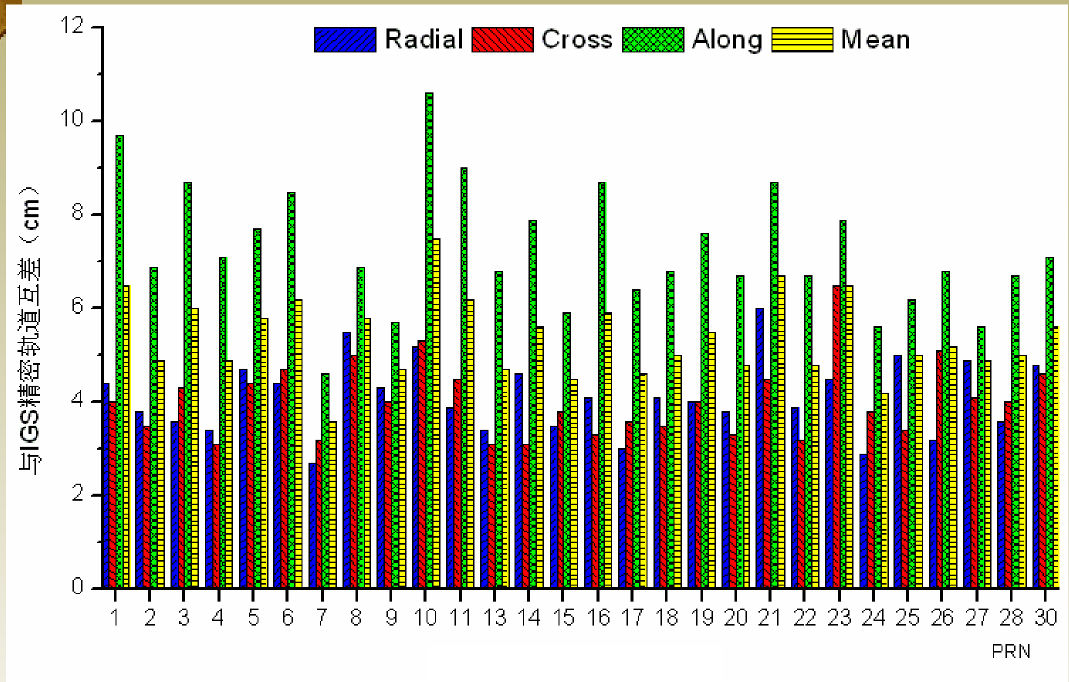
Rinex data are inputted as stream through simulated real-time model

Result of RT-POD (Hourly predicted) vs IGS Finals



Difference between calculated real-time orbits and IGS final products

RT POD Based on IGS RT Data



POD Precision (cm) :

4.11

4.03

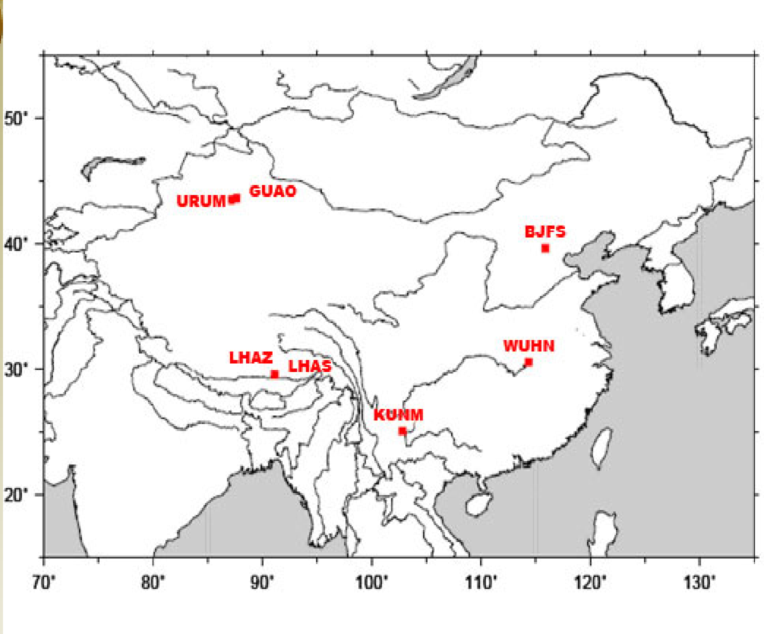
7.27

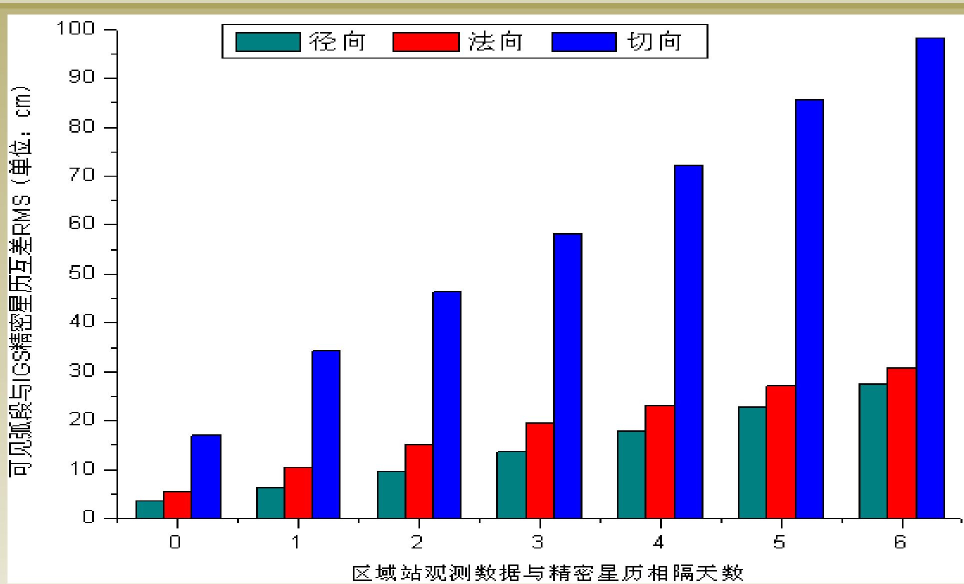
5.40

Method:
Normal Equation Combining with short-arc sliding window observations for RT POD

	Max（cm）	Min（cm）	average（cm）
Radial	6.0	2.7	4.1
Cross	6.5	3.1	4.0
Along	10.6	4.6	7.3
Mean	7.5	3.6	5.4

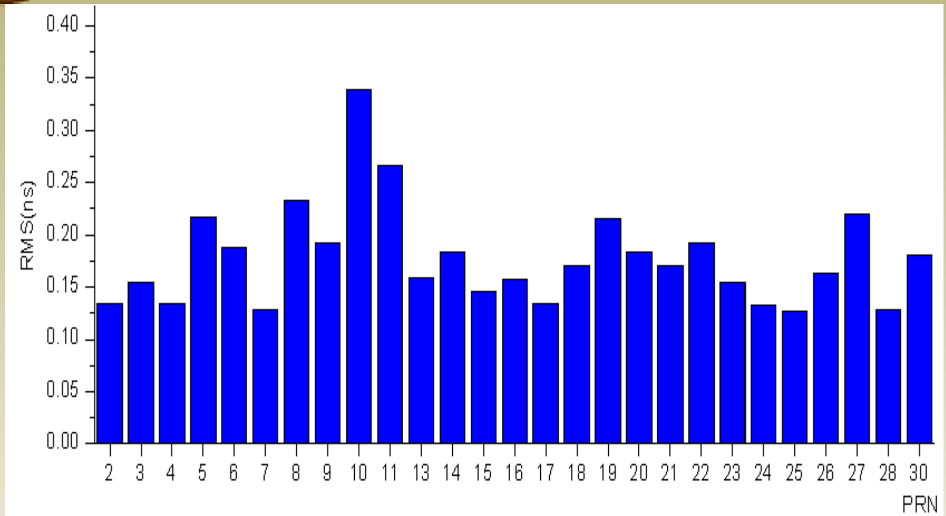
RT POD Augmentation Based on Regional GNSS Data





Scheme	Visible Arc RMS/cm			Total Arc RMS/cm		
	Predicted orbit	Regional Augment.	Improvement (%)	Predicted orbit	Regional Augment.	Improvement (%)
1	12.7	10.9	13.8	13.2	11.7	10.8
2	46.0	21.6	52.9	46.5	23.4	49.6
3	106.0	29.7	72.0	106.5	32.8	69.2
4	196.0	37.5	80.9	196.4	41.9	78.6
5	317.9	46.3	85.4	318.4	52.3	83.6
6	475.1	54.9	88.4	475.4	62.6	86.8

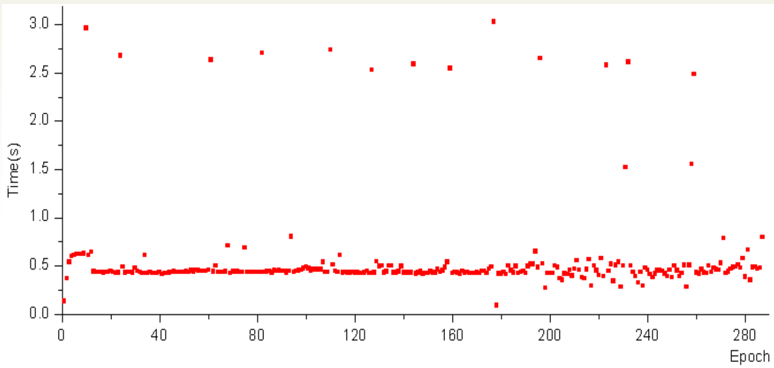
Result of RT-CLK vs IGS Finals



DOY	max(ns)	min(ns)	mean(ns)
198	0.30	0.04	0.13
199	0.36	0.10	0.22
200	0.38	0.07	0.16
201	0.31	0.07	0.18
202	0.30	0.12	0.19
203	0.41	0.07	0.21
mean			0.18

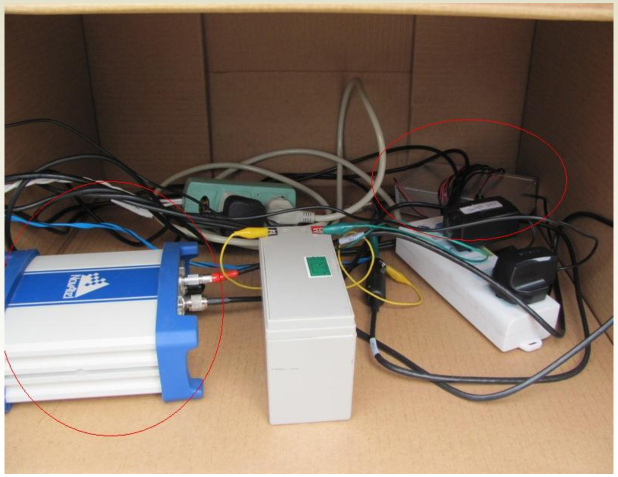
RMS values of the difference between the calculated Sat-Clock and IGS final products over the period day 198-203 of year 2006

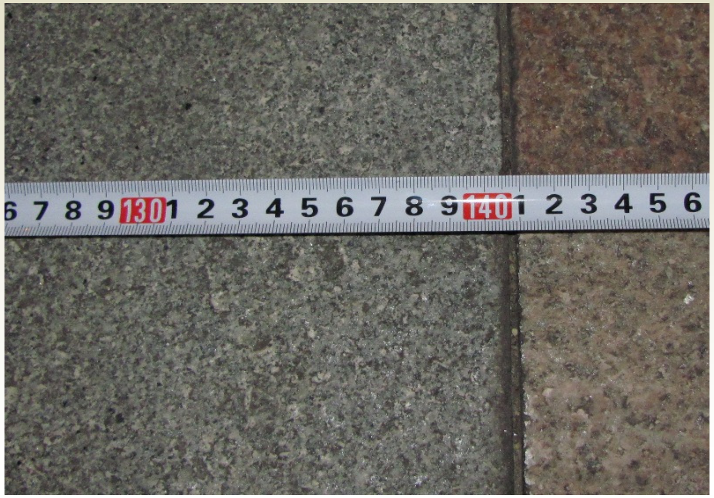
Statistics of the RMS values
Mean RMS = 0.18 nanosecond



CPUT per epoch on IBM T60 notebook
Mean cup time =0.6s

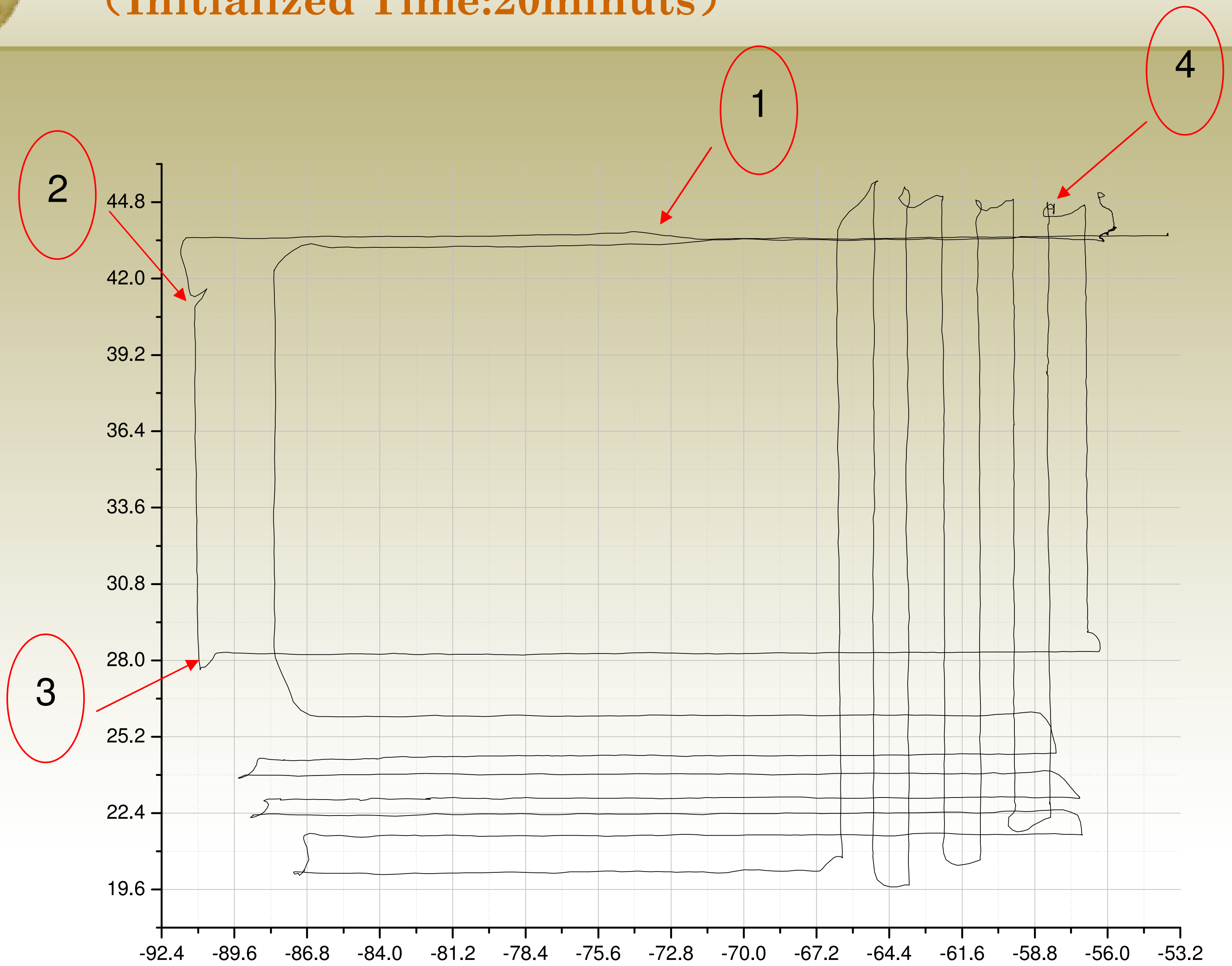
Handhold Kinematic Test



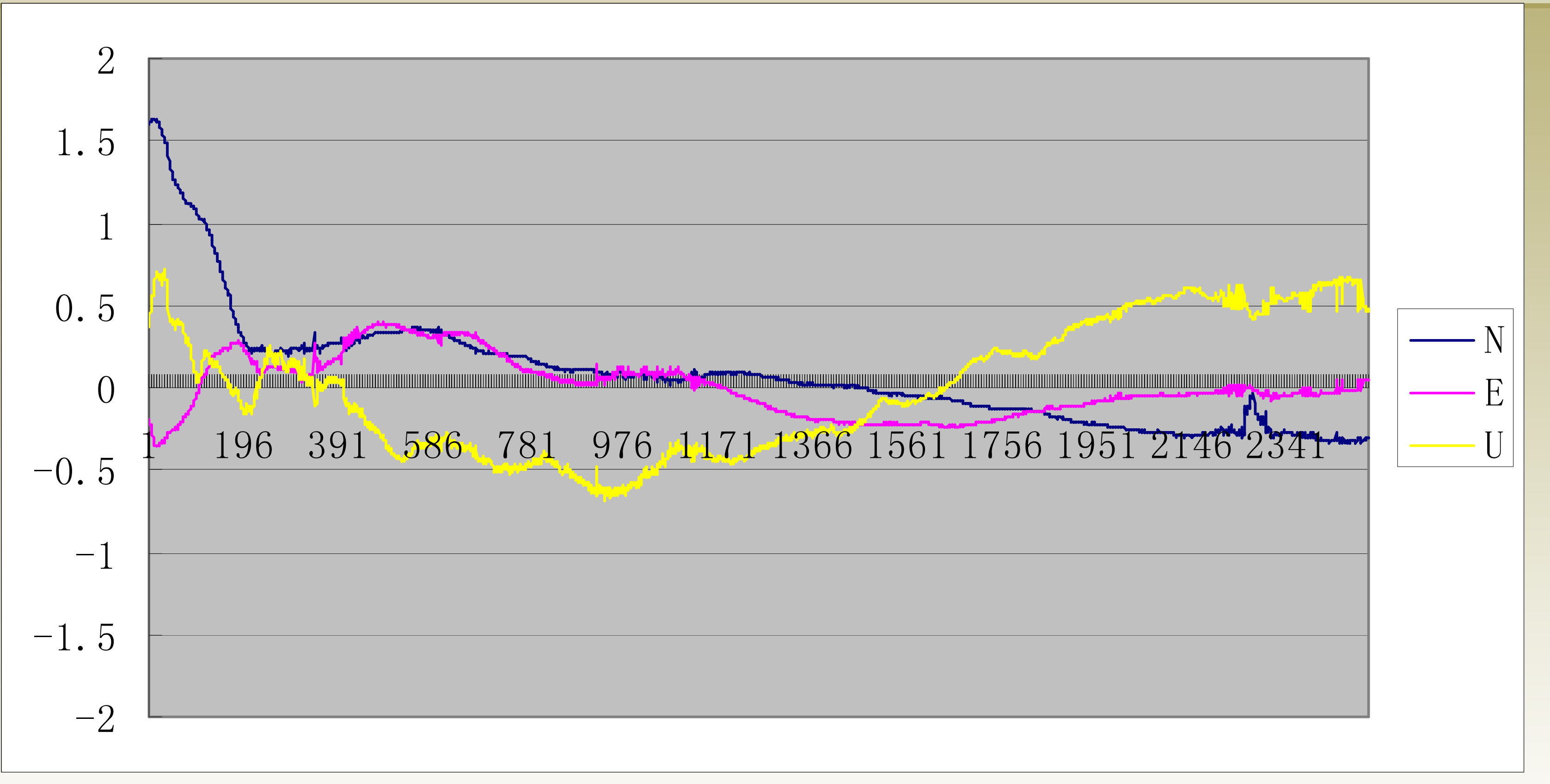


Results of Handhold Test

(Initialized Time:20minuts)

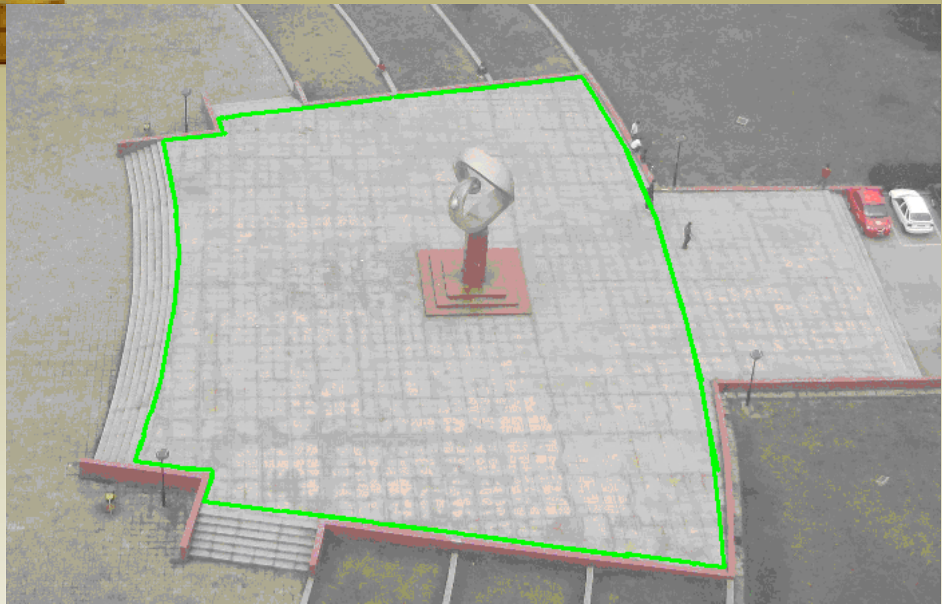


Kinematic PPP Results vs. Post DD

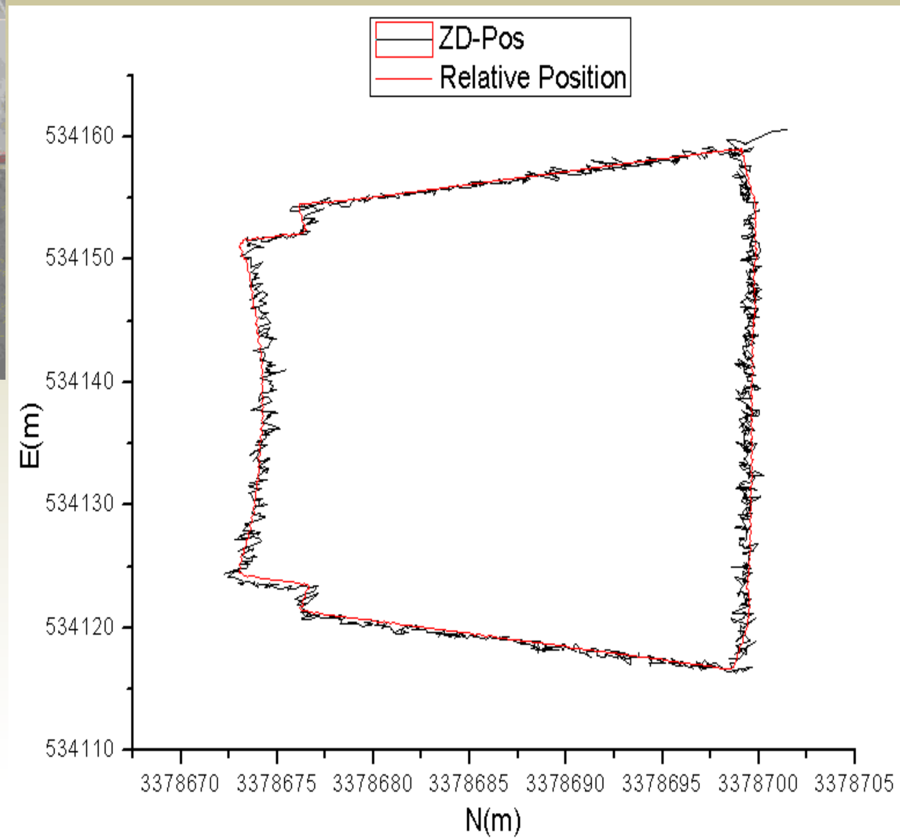


	N	E	U
RMS(m)	0.206181	0.170222	0.403532

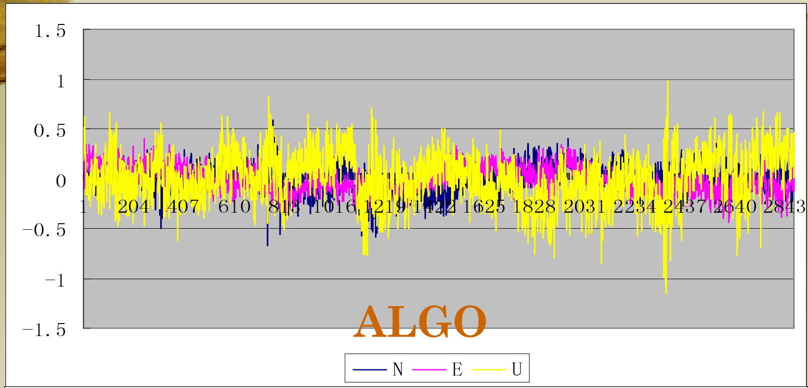
Single-Frequency GPS Receiver Kinematic Test

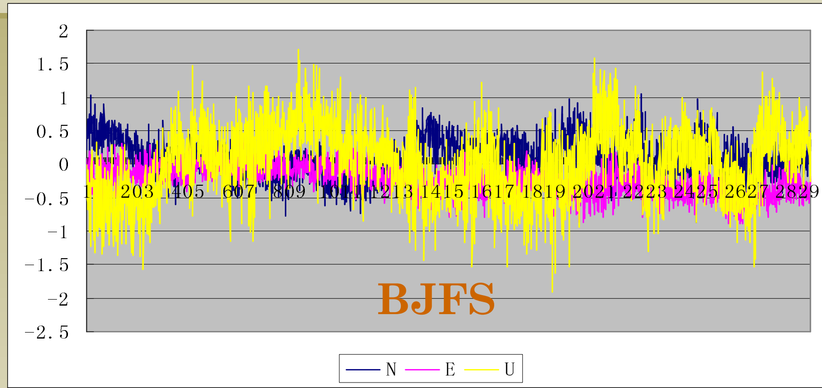


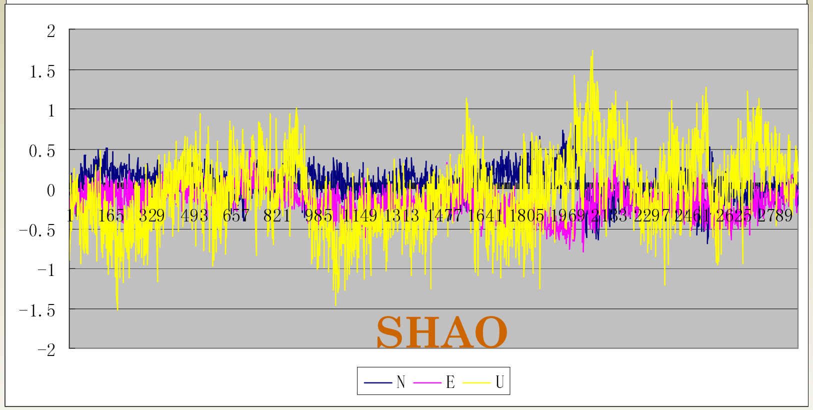
动态测试地点实拍图

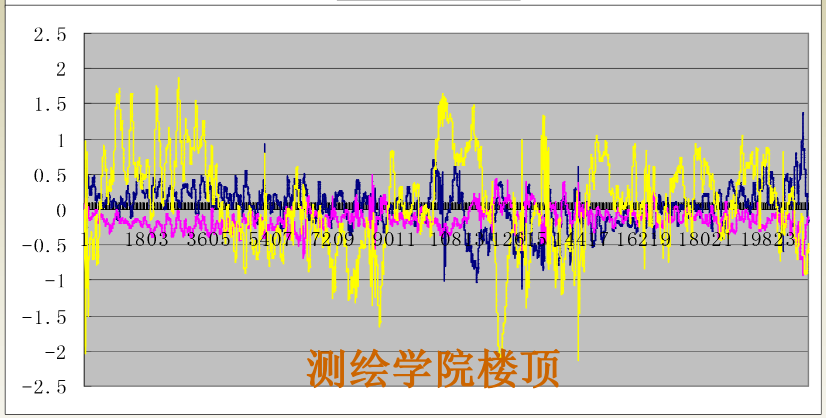


Single Frequency PPP with RT Products



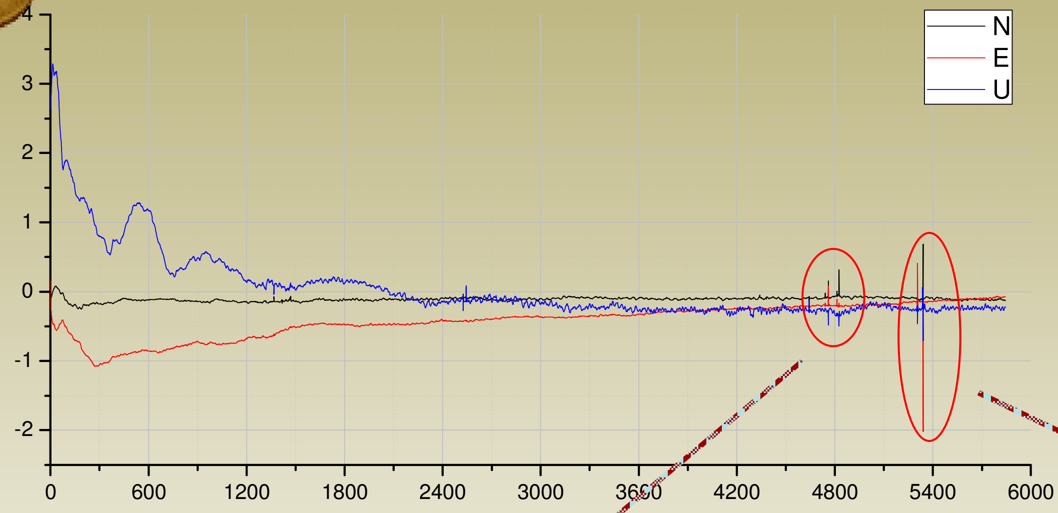






	N（m）	E(m)	U(m)
ALGO	0.14162	0.128424	0.248683
BJFS	0.275009	0.224492	0.528504
SHAO	0.192542	0.182978	0.475936
WHU	0.285737	0.143631	0.656127

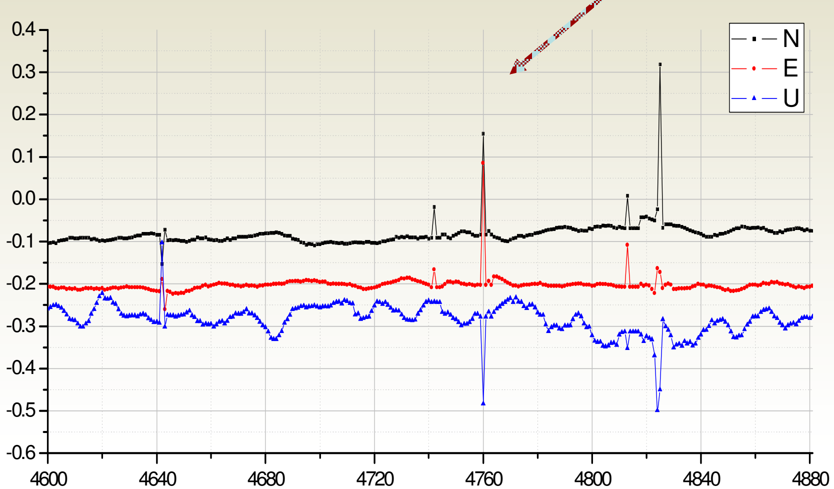
Blocking Test for PPP quick recovery

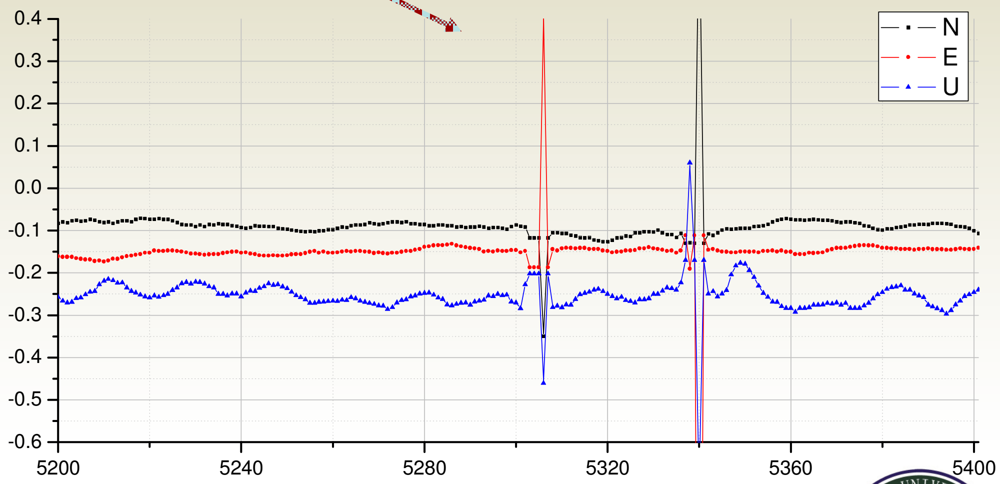


N: 1.52cm

E: 11.6cm

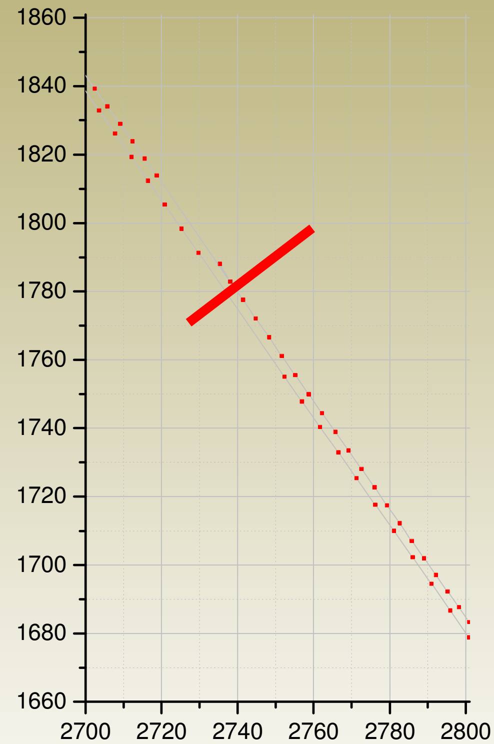
U: 10.3cm

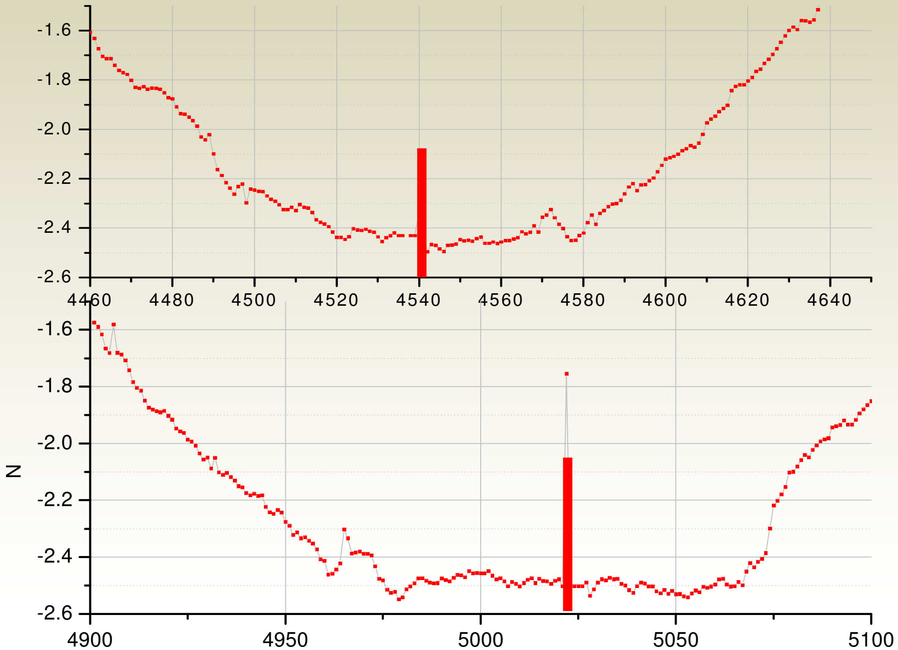




Block Test for PPP quick recovery in Kinematic mode

Advertisement board

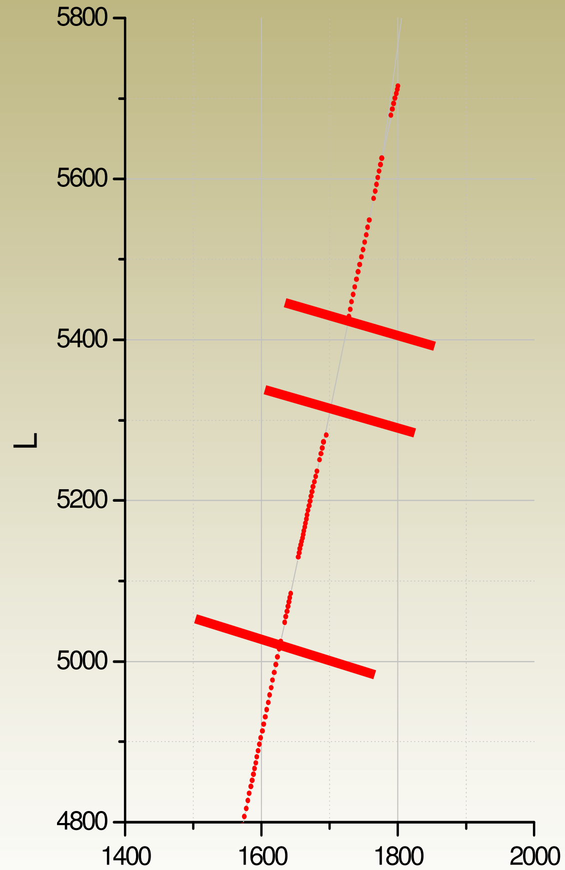




Time Series of Height

Block Test for PPP quick recovery in Kinematic mode

Walking Bridge



GNSS Integrity

What is GNSS Integrity?

1. Tell users how good your GNSS service is?
   -----Performance Evaluation: accuracy, availability, coverage
2. Find Faults and provide alarming to users.
   -----Fault Detection, check to what extent the fault affects the performance.

Why GNSS Integrity is so important?

1. Consumer customers

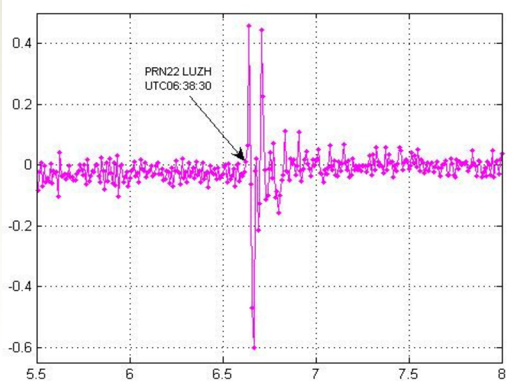
man is independent, GNSS device is just an aiding tool for his life to make convenience. So personal PND has lower request in GNSS integrity. But we still improve through RAIM,…, so that the performance of the products become better and better…..

2. Safety related intelligent system

In those intelligent control systems, i.e. airplane, intelligent driving , their performance mostly depends on the computer's analysis, not human's strong brain.

How to realize GNSS Integrity?

1. (inherent) Trace each step in product producing and evaluate it
   SBAS: orbit, sv clock, ionospheric delay, algorithm developed for it, i.e. RAIM
2. (outside checking) redundant monitoring and Alarming
   SBAS: build tracking and checking system to validate the performance.



Thank You For Your Attention !

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