GNSS Integrity Technology Development Methodology

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Overview & Outline

- **Integrity Technology Architecture Analysis**
- **Integrity Technology Development Propose**
- **Integrity Monitoring during the Construction of GNSS**

Integrity Technology Architecture Analysis

- **Integrity: From the Performance Stability Requirement of Dynamic User for Navigation**

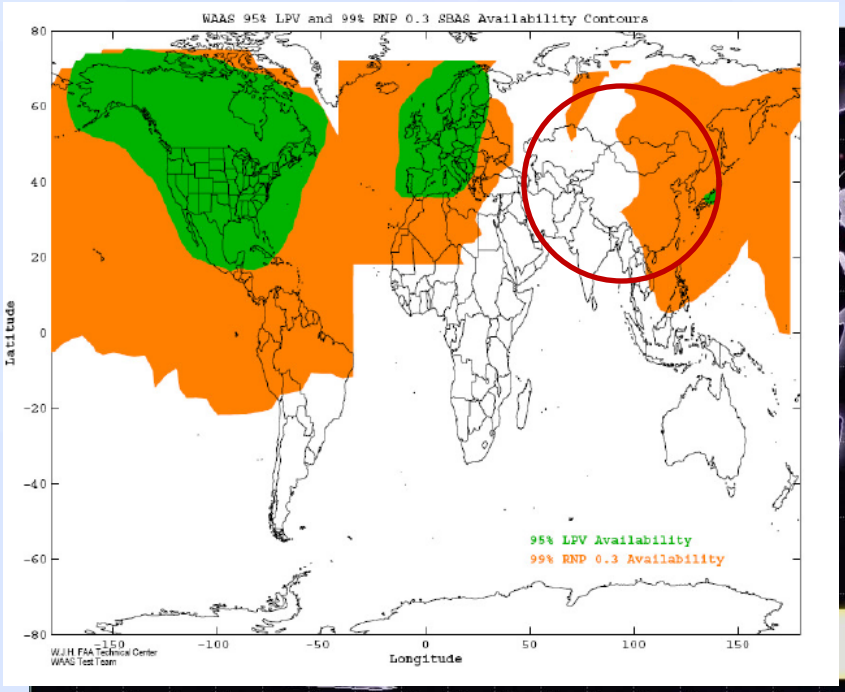
- SOL Service: Civil Aviation, Railway.....
- Reliability Service: ITS, Fishing, Disaster Alarm.....

Integrity Technology Architecture Analysis

- **GNSS Development Status**
  - With the improvement of clock and ephemeris propagation accuracy, SPS users will enjoy navigation service with accuracy better than 10m;
  - Integrity is under consideration during both the GPS modernization and Galileo design:
    - GPS: URA and UDRA are introduced to ensure navigation accuracy
    - Galileo：SoL service is designed for high integrity requirement users

Integrity Technology Architecture Analysis

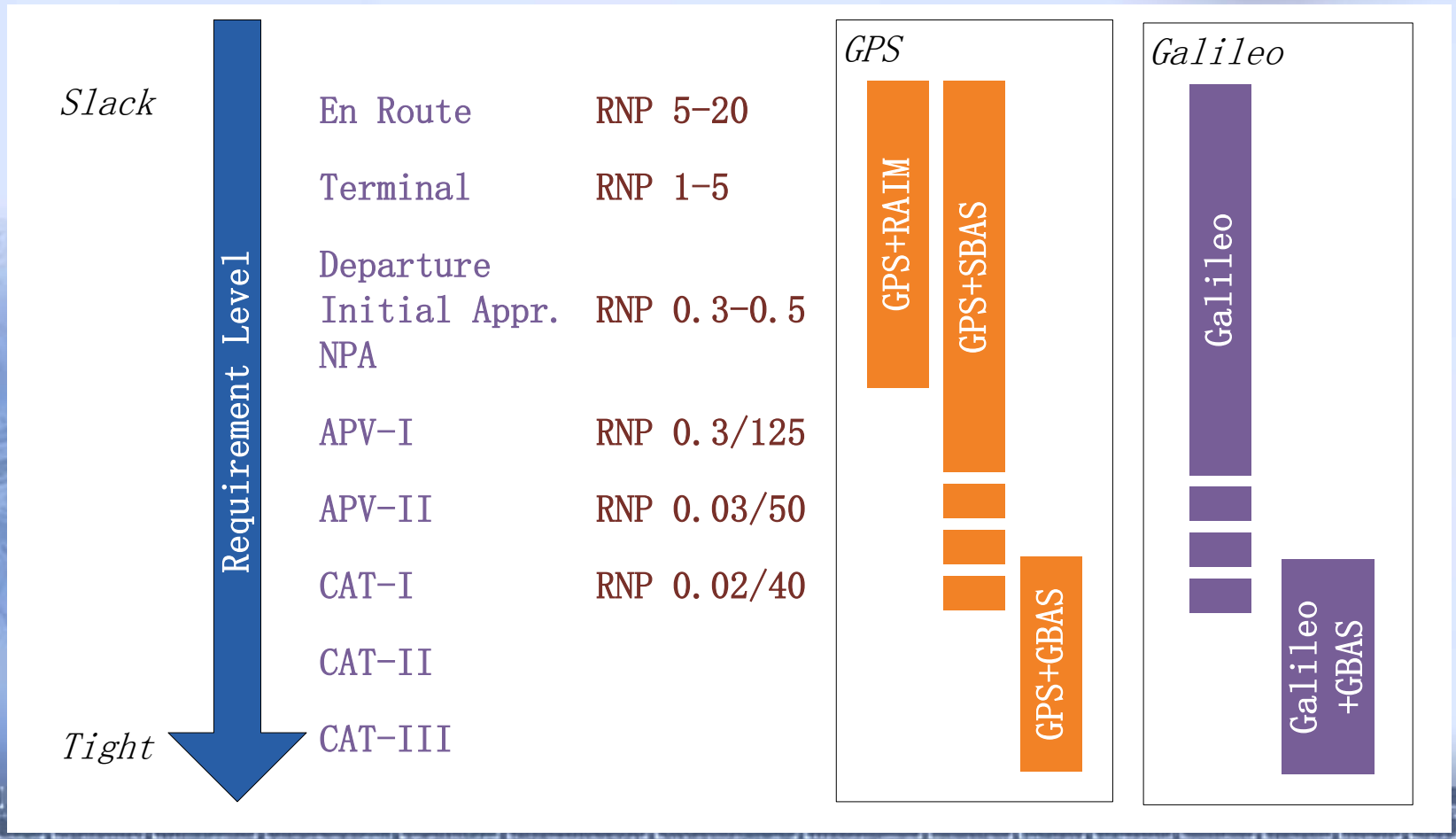
- **SBAS Development**
  - SBAS is designed to provide integrity augmentation service for aviation users
  - WAAS improvement
  - EGNOS and QZSS building



By Leo Eldredge

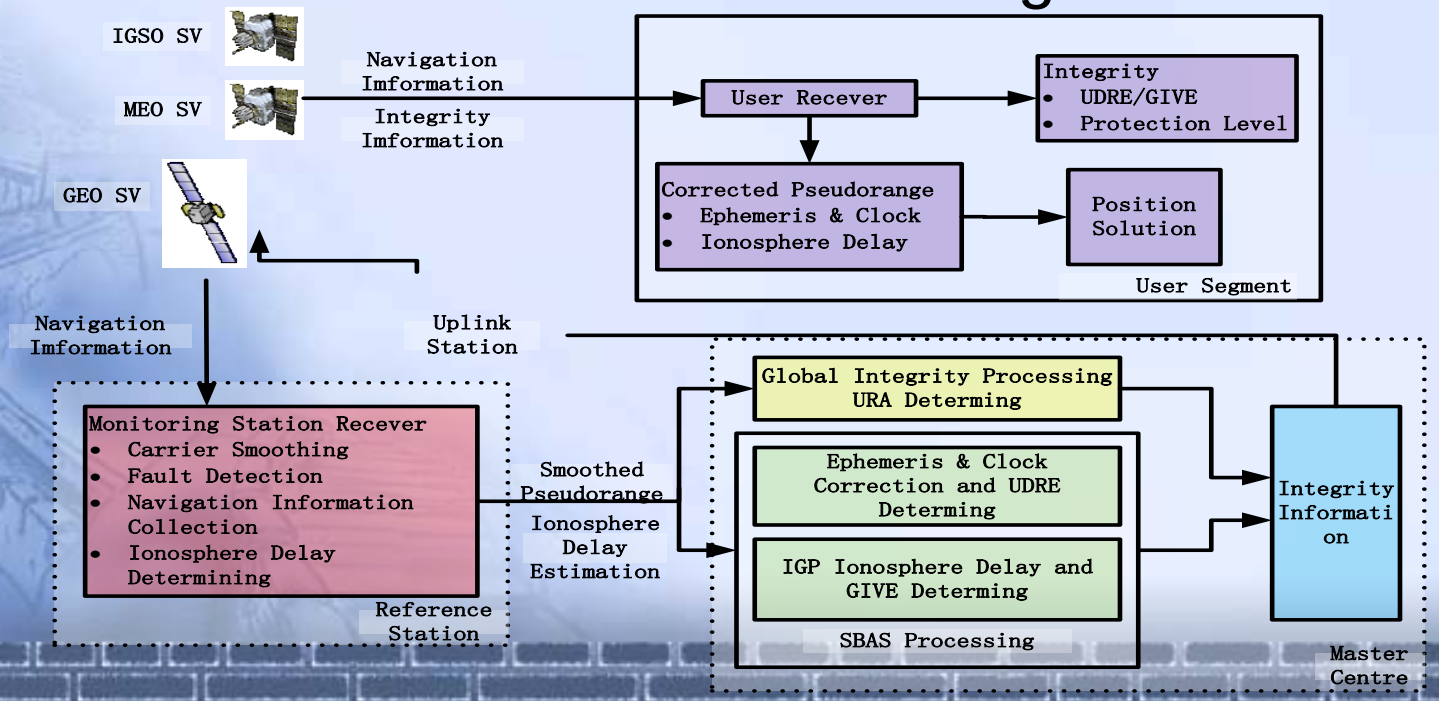
Integrity Technology Architecture Analysis

- **Current GNSS Integrity Architecture**



Integrity Technology Architecture Analysis

- **The Similarity between System Integrity Service and SBAS Service**
  - Space segment error monitoring ability;
  - Reference stations net distributing in wide area.



Integrity Technology Architecture Analysis

- **Integrity Service Development Consideration**
  - Integration Design between System Integrity Service and SBAS Service;
  - Multi-GNSS Compatible and Seamless transition ability;
  - Supporting multiple user requirement

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Integrity Technology Development Propose

- **Basic Principle for System Design**
  - Reference to relative civil aviation standard (RTCA DO-229D, FAA-E-2892b, ICAO Annex 10, *etc*.), compatible with current equipment;
  - Augmentation Service Capability of Multi- GNSS System.

Integrity Technology Development Propose

- **Future Integrity Service Performance Suggestion**
  - GNSS System Integrity Service (SPS users)
    - Broadcast ephemeris & clock accuracy evaluation
    - Capability of global broadcasting
    - Integrity performance – NPA level
  - SBAS Integrity Service (aviation users)
    - Ephemeris, clock and ionosphere correction and confidence information
    - Capability of Wide Area Augmentation
    - Integrity performance-CAT I level

Integrity Technology Development Propose

- **Global Integrity Service Consideration**
  - Capability of global service;
  - Assess user requirement, confirm reasonable service performance;
  - The interoperation with GPS, GALILEO, *etc.*;
  - Reference station optimizing distribution for global integrity service;
  - Feasibility of inter satellite links.

Integrity Technology Development Propose

- **SBAS Service Consideration**
  - Capability of wide area augmentation;
  - Capability of multi-GNSS compatible augmentation service;
  - Seamless transition with current system (WAAS, EGNOS, *etc.*);
  - Taking full advantage of GEO, IGSO and LEO satellite communication recourse;
  - Taking full advantage of ground communication recourse such as VHF, Internet, *etc.*

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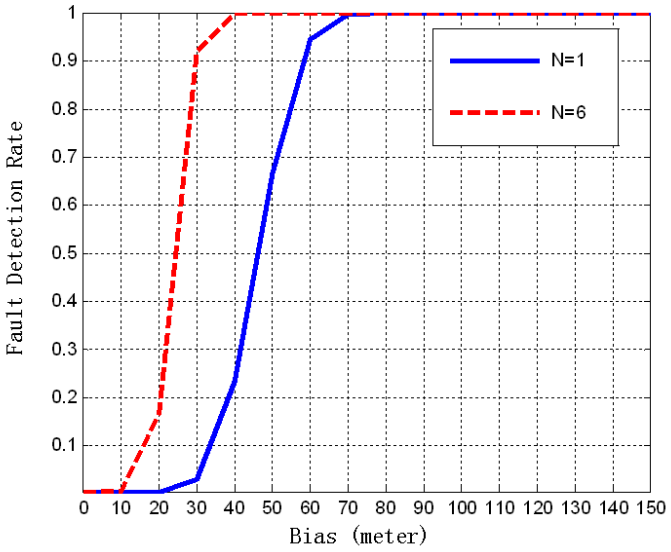
Integrity Monitoring during the Construction of GNSS

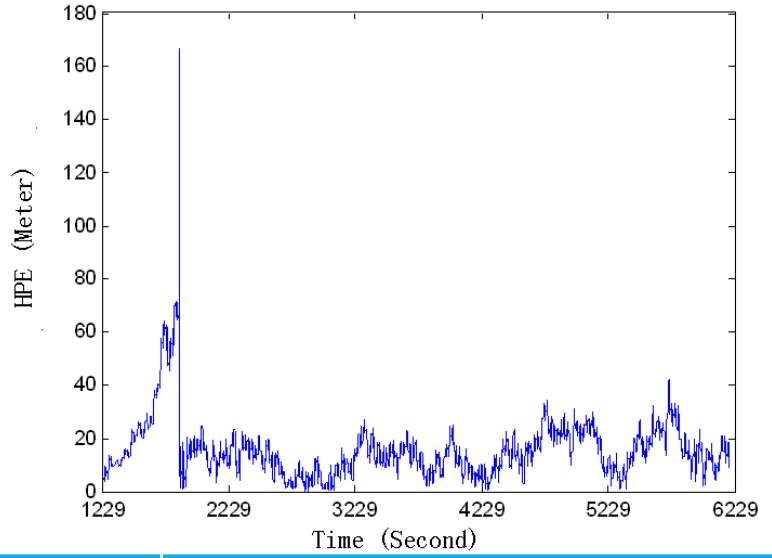
- **GNSS Development Stage:**
  - Test Stage, Basic Construct Stage, Enhance Stage, Architecture Construct Stage
- **BeiDou:** Basic Construct Stage
- **Galileo:** Test Stage
- **Similar Problem During GNSS Construction:**

Solution:
Integrate with other navigation method, ensure user integrity by RAIM

Integrity Monitoring during the Construction of GNSS

- **Integrate with INS**

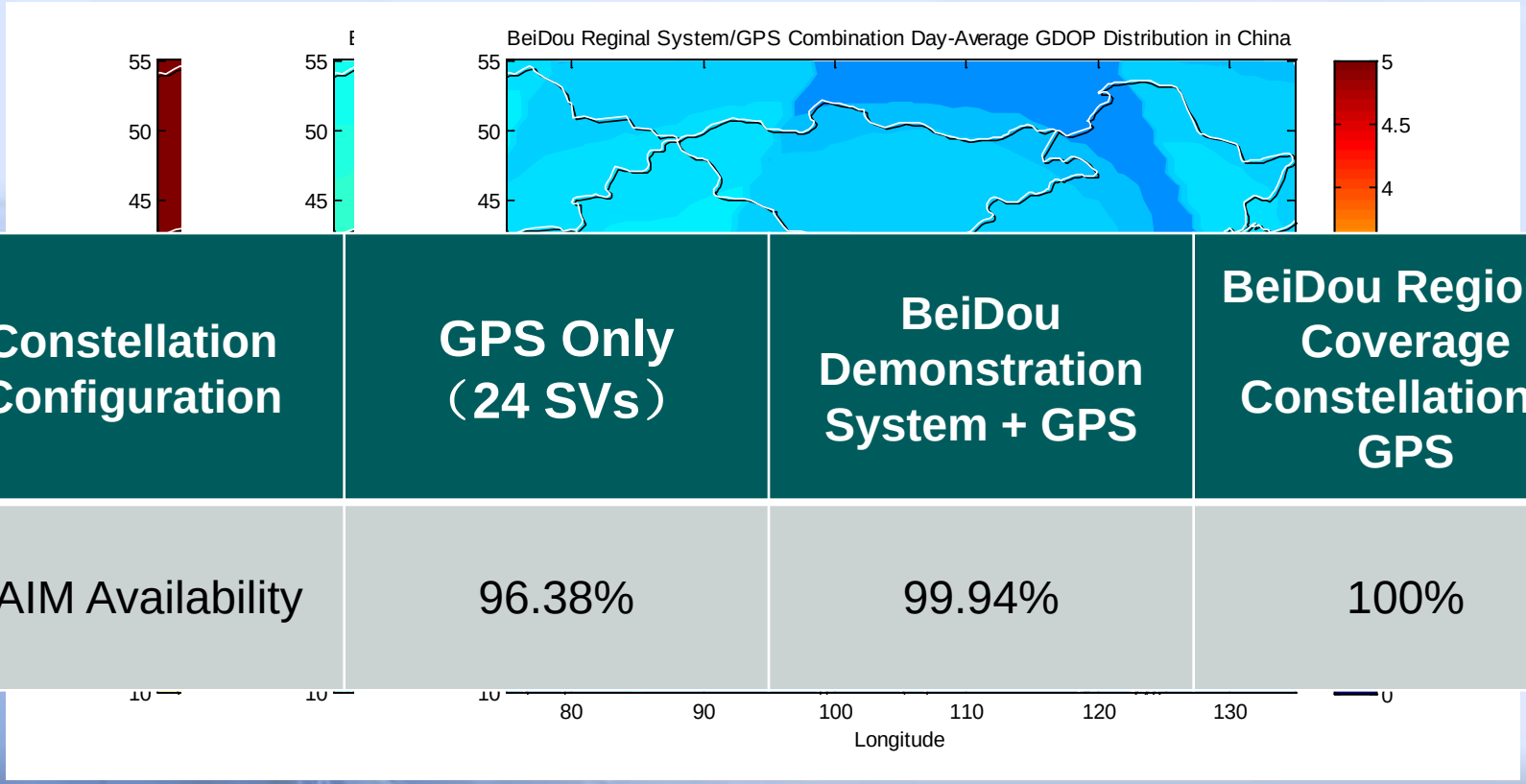




Operation	GPS	BeiDou Demonstration System	
		Major Error	Minor Error
En-Route	√	√	×
Terminal	√	√	×
NPA	√	√	×

Integrity Monitoring during the Construction of GNSS

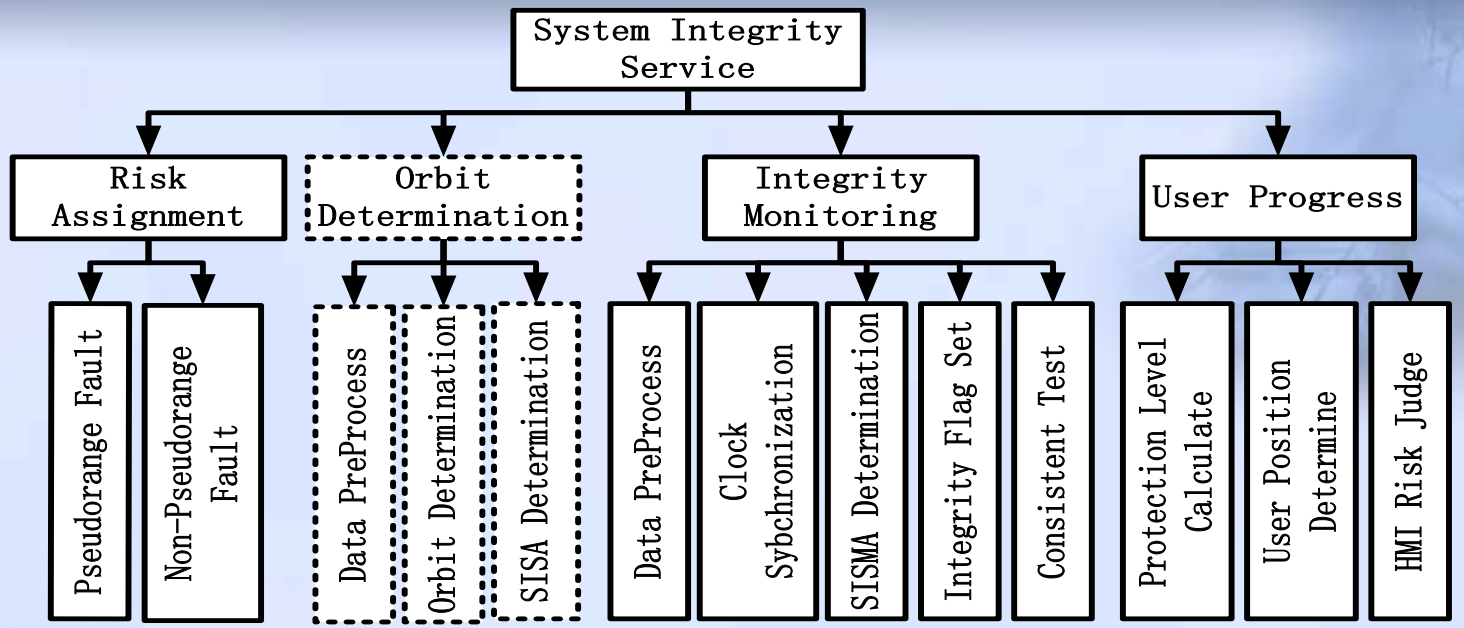
- **Integrate with accomplished GNSS**

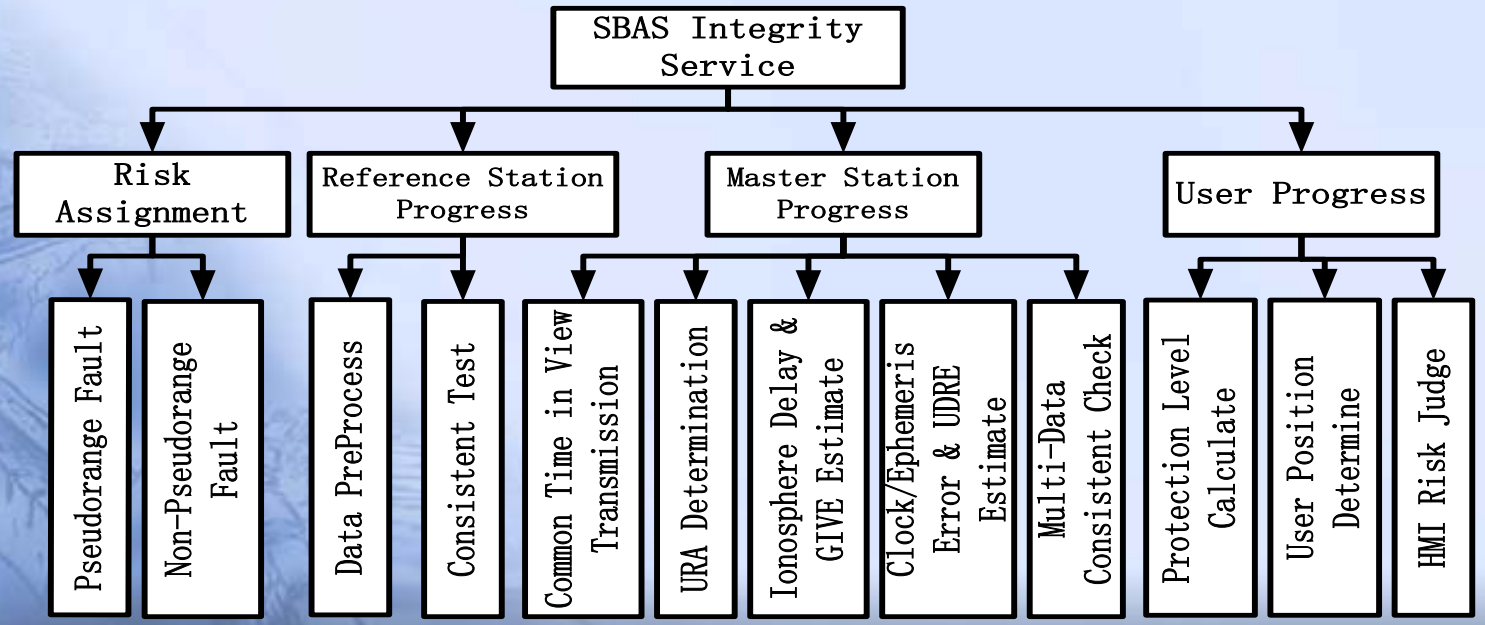


Constellation Configuration	GPS Only（24 SVs）	BeiDou Demonstration System + GPS	BeiDou Regional Coverage Constellation + GPS
RAIM Availability	96.38%	99.94%	100%

THANK YOU ！

BACKUP


System Integrity Service
Risk Assignment
Orbit Determination
Integrity Monitoring
User Progress
Pseudorange Fault
Non-Pseudorange Fault
Data PreProcess
Orbit Determination
SISA Determination
Data PreProcess
Clock Sybchronization
SISMA Determination
Integrity Flag Set
Consistent Test
Protection Level Calculate
User Position Determine
HMI Risk Judge


SBAS Integrity Service
Risk Assignment
Reference Station Progress
Master Station Progress
User Progress
Pseudorange Fault
Non-Pseudorange Fault
Data PreProcess
Consistent Test
Common Time in View Transmission
URA Determination
Ionosphere Delay & GIVE Estimate
Clock/Ephemeris Error & UDRE Estimate
Multi-Data Consistent Check
Protection Level Calculate
User Position Determine
HMI Risk Judge