TOKNAV

Deformation Monitoring Solution System

- **Professional Original Equipment Manufacturer**
- **Original Design Manufacturer**

No.9 Caipin Road, Building B, Room 902-3, Huangpu District
510000
Guangzhou China

CONTENTS

Website：www.toknav.cn   Email: info@toknav.cn

1. Company Introduction

TOKNAV is a global brand of Guangzhou TokSurvey Information Technology Co., Ltd., which was founded in 2019 by a group of top professional engineers in the industry. We focused on the research, development and sales of industrial precision measuring equipment and GNSS precision measuring equipment.

Headquartered in Guangzhou, TOKNAV also has overseas offices in the United States. TOKNAV products are trusted by customers for their accuracy reliability, and portability.

Our products include RTK serial, data collector, antenna, GIS, data collector software and GNSS application solutions. It is widely used in the fields of surveying and mapping, precision agriculture, unmanned vehicles, automatic control of construction machinery, and deformation monitoring.

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Certifications

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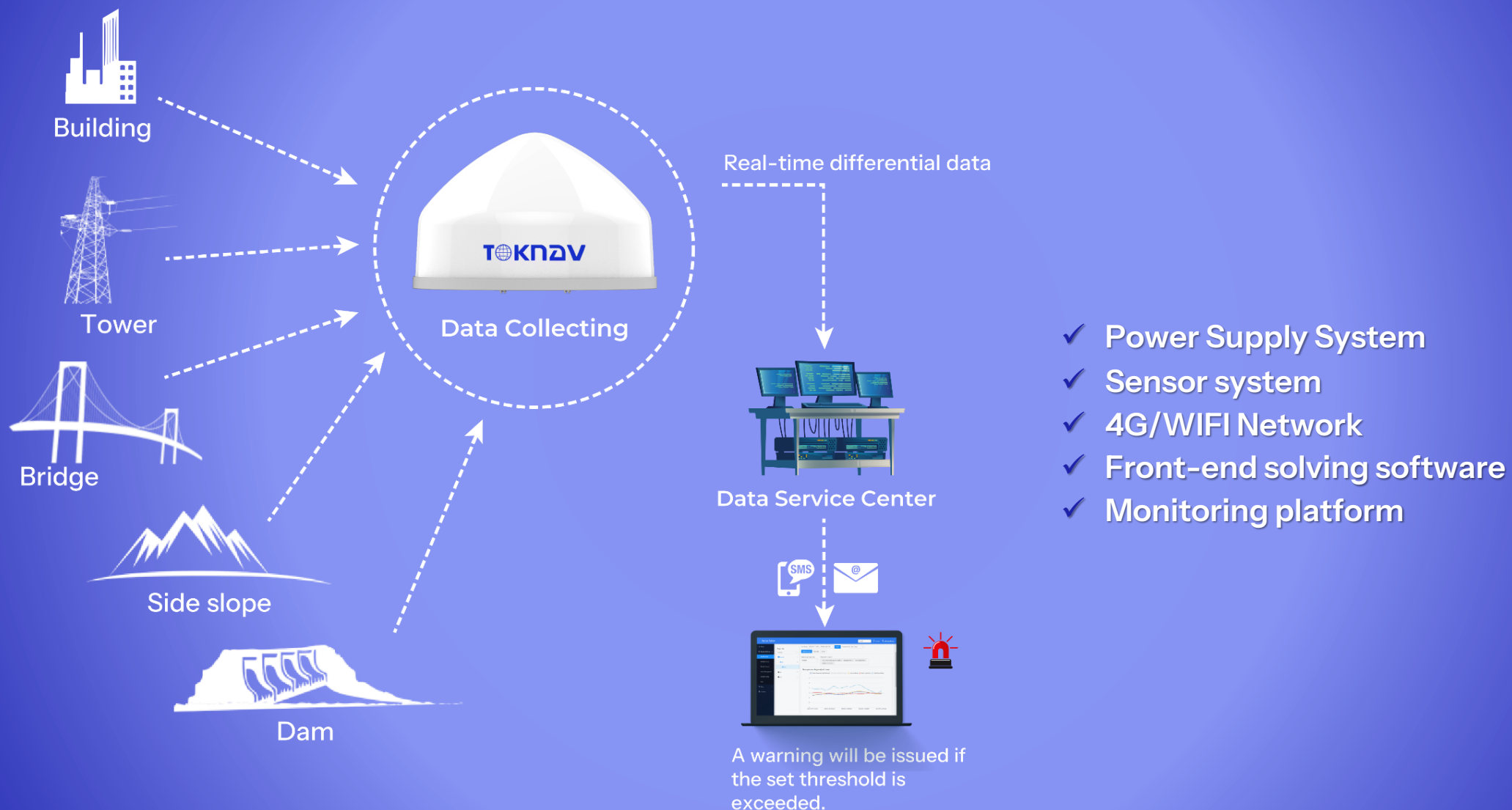# TOKNAV

2 System Introduction

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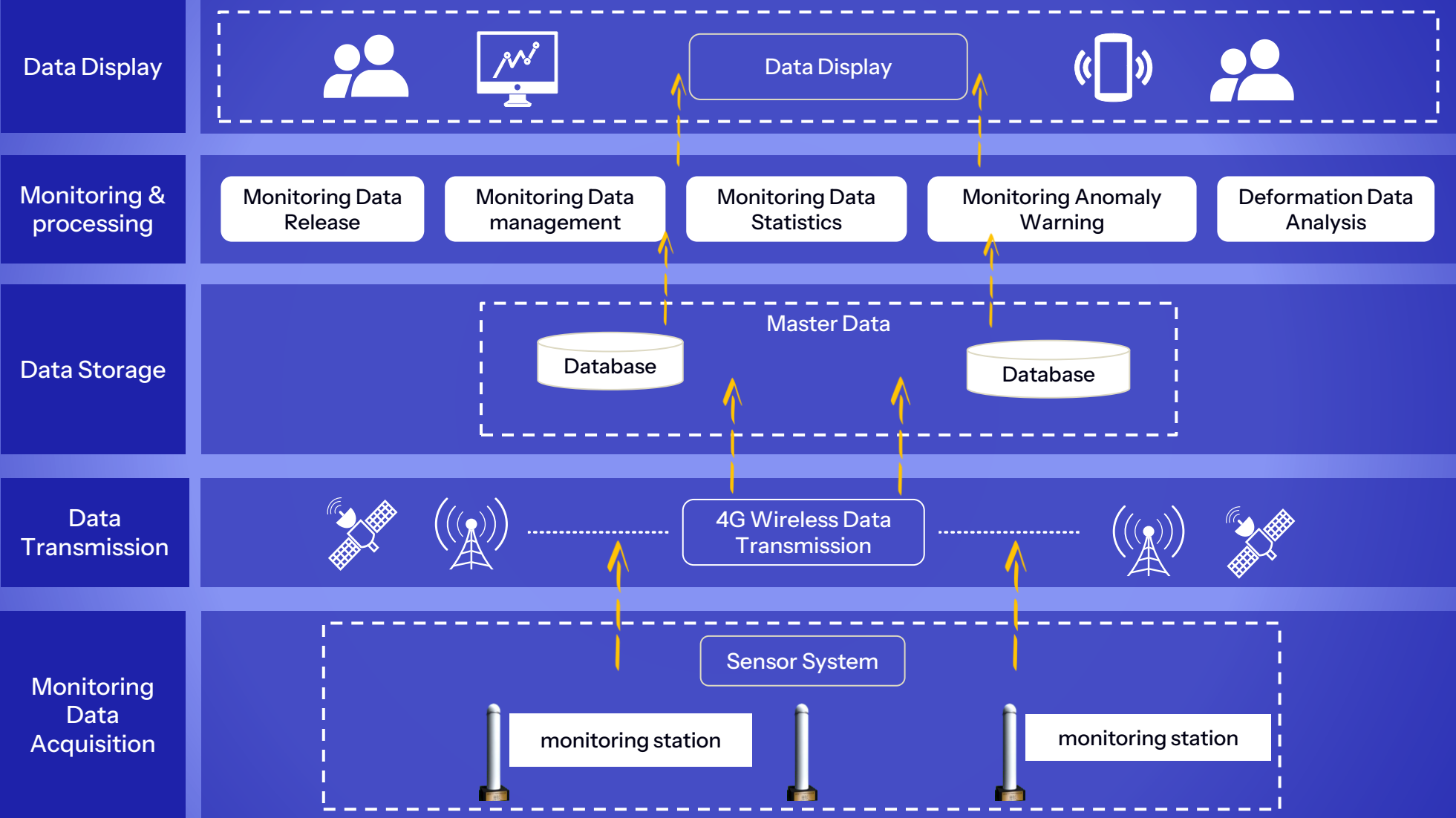
2.1 System Description

The Deformation Monitoring System sets up base stations and monitoring stations in the monitoring area. It operates through a WIFI self-organizing network or 4G network, and is equipped with a solar power supply system. It is deployed with zero wiring to achieve applications such as <u>automatic collection, transmission, analysis, alarm</u>, and early warning of geological disasters

2.2 System Architecture

Building

Tower

Bridge

Side slope

Dam

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Data Collecting

Real-time differential data

Data Service Center

SMS

A warning will be issued if the set threshold is exceeded.

✓ **Power Supply System**
✓ **Sensor system**
✓ **4G/WIFI Network**
✓ **Front-end solving software**
✓ **Monitoring platform**

2.2 System Architecture

Data Display	👥 📊 Data Display 📱 👥
Monitoring & processing	Monitoring Data Release · Monitoring Data management · Monitoring Data Statistics · Monitoring Anomaly Warning · Deformation Data Analysis
Data Storage	Master Data — Database · Database
Data Transmission	🛰️ 📡 ······ 4G Wireless Data Transmission ······ 📡 🛰️
Monitoring Data Acquisition	Sensor System · monitoring station · monitoring station

3 Hardware & Software

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3.1 U6 Universal Monitoring All-in-One Machine

U6 is a Toknav self-developed and designed, customized GNSS receiver for deformation monitoring and early warning system, with single BeiDou, high accuracy, low power consumption, high cost-effective, integrated, easy to install, etc., the whole power consumption <1.8W, equipped with a small solar energy system, which can meet the demand for long time monitoring.

136mm

Φ 213mm

Suitable for reservoir dams, highway slopes, mine tailing dams and other deformation monitoring applications.

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3.1 U6 Universal Monitoring All-in-One Machine

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Fully certified:

- ✓ Dust and waterproof test
- ✓ Cold and thermal shock test
- ✓ Temperature cycling test
- ✓ Sweep sine vibration test
- ✓ MTBF value not less than 85000 hours
- ✓ Electrostatic discharge test
- ✓ Electrical immunity test
- ✓ Type approval certificate for measuring instruments
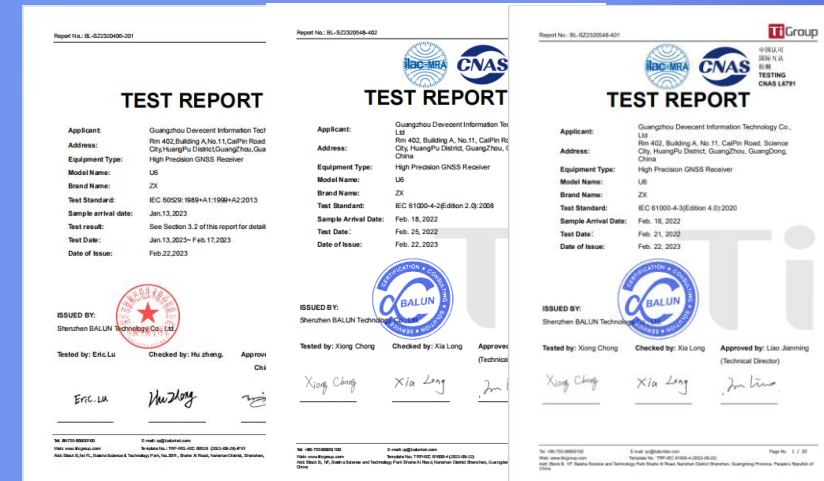
3.1.1 U6 Parameters

GNSS	GPS	L1(c/a)/L2p(w)/L5	
	GLONASS	G1/G2	
	BDS	b1i/b2i/b3i/b1c/b2a	
	GALILEO	E1/E5b/E5a	
	QZSS	L1/L2/L5	
	Single point positioning (RMS)	Plane: 1.5m	Elevation: 2.5m
	RTK(RMS)	Plane: 8mm+1ppm	Elevation: 15mm+1ppm
	Static solution	Plane: 2.5mm+1ppm	Elevation: 5.0mm+1ppm
	Front-end static solution	Plane: 5.0mm+1ppm	Elevation: 10.0mm+1ppm

3.1.1 U6 Parameters

MOBILE NETWORK	LTE FDD	B1/B3/B5/B8
	LTE TDD	b38/b39/b40/b41
	TD-SCDMA	B34/B39
	CDMA	BC0
	WCDMA	B1/B8
	GSM	900/1800MHz
LORA RADIO	Frequency	410.125~493.125MHz
	Transmit Power	30dBm
	Communication Distance	10km (under open conditions)
WIFI	Support 802.11 b/g/n	
BLUETOOTH	V2.1+EDR/V4.0 dual mode	
INTERNAL STORAGE	Onboard 32GB, recurring storage	
SIM	External Nano SIM	

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3.1.1 U6 Parameters

ACCELERATION/ INCLINATION	Acceleration Measurement Range	±6g
	Acceleration Measurement Accuracy	±1mg
	Inclination Measurement Range	±90°
	Inclination Measurement Accuracy	±1°
	Sampling interval	0s～24h
	Upload interval	0s～72h
ENVIRONMENTAL CHARACTERISTICS	Operating Temperature	-40℃～+85℃
	Shock Resistance	IEC60068-2-6
	Three-proof grade	IP68
ELECTRICAL CHARACTERISTICS	Power supply	9～36V DC
	Power Consumption	1.8W
	Data Port	12 ports (RS232+RS485+Power) SMA*1(Lora Radio)

3.1.2 U6 Characteristic

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Linux System

Linux + Cortex-A7 intelligent system platform, bringing users efficient computing and unlimited expansion of product functions.

Cloud Service

The U6 can regularly report the location of the device, network status, signal strength, satellite status and other host status, and support the cloud platform to restart, set up, upgrade and other operations on the remote device.

Combined Antenna
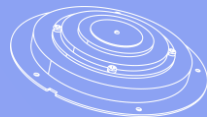
New 4-in-1 combination antenna, GNSS, WiFi, Bluetooth, 4G in one, smaller size, better signal.

High-precision & Low-power GNSS Module

The U6 integrates high-precision and low-power positioning module, full-system, full-frequency point, and multi-star solving.

4G Full Network Communication

Based on the Linux platform 4G all-network solution, fully support 2/3/4G network, better compatibility, stronger signal, more stable connection.

High-precision Sensor

Built-in high-precision three-axis accelerometer and barometer in the host, combined with the newly designed fusion algorithm engine, effectively eliminating false alarms and supporting medium and long-term warning.

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The GNSS high-precision monitoring platform early warning system is a monitoring system platform integrating multiple technologies such as data solution, data analysis, data processing, remote control, and data early warning, with GNSS precise positioning technology as its core. Through wireless communication technology, it integrates various monitoring sensors (GNSS receivers, rain gauges, settlement meters, water level meters, displacement meters, inclinometers, etc.) to achieve automatic on-site information collection, data storage management, disaster prediction and prevention functions.

The monitoring system is widely used in the monitoring of geological hazards such as landslides with potential safety hazards, dam deformation monitoring, surface subsidence monitoring in mining areas, tailings pond deformation monitoring, bridge deformation monitoring, and deformation monitoring of high-rise buildings, which can effectively prevent and avoid disaster events, and ensure the safety of important facilities and people's property.

3.2 Core software
— Monitoring Calculation Management Platform

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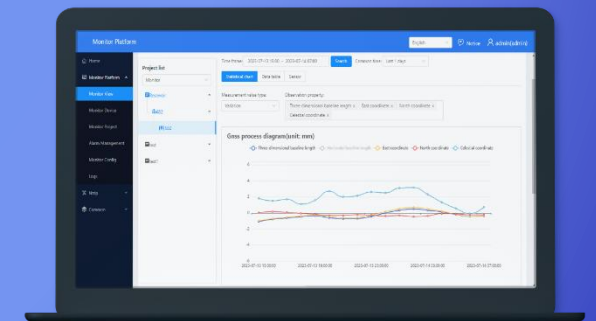
Post-processing and Calculation Engine

Performs baseline adjustment and least squares adjustment processing by receiving raw real-time data streams from monitoring stations and reference stations, with configurable adjustment intervals
◆ Monitoring accuracy: H: 2.5 mm + 0.5 ppm; V: 5 mm + 0.5 ppm
◆ Monitoring Frequency: Near real-time, 1h/2h/4h/8h/24h
◆Application Scenarios: Stable network environment for base stations and monitoring stations
◆ Data Format: RTCM3.2

RTK Engine

When deformation occurs or is detected in its early stages, the RTK engine is activated to provide real-time monitoring data with centimeter-level accuracy.
◆ Monitoring accuracy: Consistent with traditional RTK positioning
◆ Monitoring frequency: Real-time, second-level
◆Application scenarios: High-frequency monitoring requirements

Distributed Processing Engine (Edge Computing)

The distributed processing auxiliary engine primarily provides base station data relay and reception of processing results for the receiver front-end processing.
◆ Monitoring accuracy: H: 2.5 mm + 0.5 ppm; V: 5 mm + 0.5 ppm
◆ Monitoring Frequency: Near real-time, 1h/2h/4h/8h/24h
◆Application Scenarios: Front-end local area networking with millimeter-level accuracy requirements

Full-featured remote management engine

Full-featured command set for remote management
Simplified integration functionality: Customers' own display platforms only need to read the coordinate data from the solution results to calculate deformation values, without requiring integration development with the device
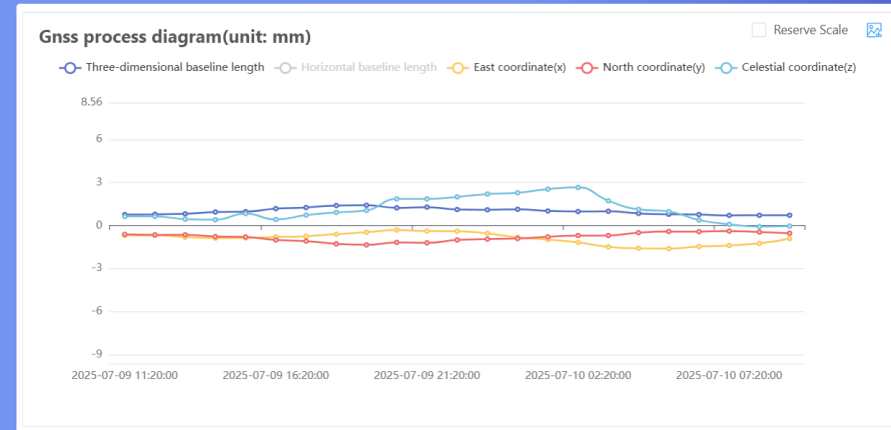
3.2 Core software
— Monitoring Calculation Management Platform
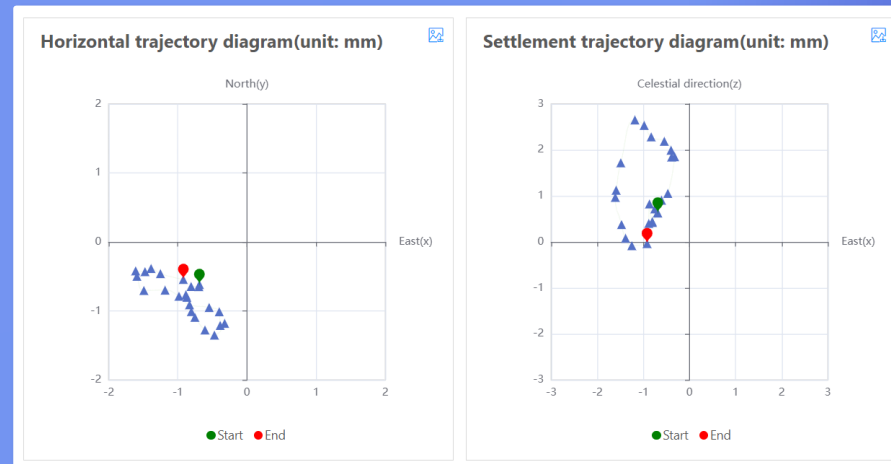
-Solution results

You can view the results of each point on the created project:

- ✓ GNSS Process Diagram
- ✓ Settlement Trajectory Diagram
- ✓ Horizontal Trajectory Diagram

Pic 3-1 GNSS Process Diagram

Pic 3-2 Settlement Trajectory Diagram
and Horizontal Trajectory Diagram

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3.2 Core software
— Monitoring Calculation Management Platform

-Sensor Data

The platform can provide four types of sensor data:

- ✔ **Voltage**
- ✔ **Acceleration**
- ✔ **Air pressure**
- ✔ **Temperature**

and plot their changes over time.
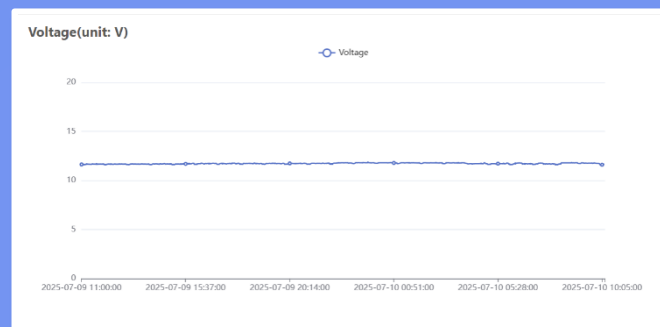
Pic 3-3 Voltage
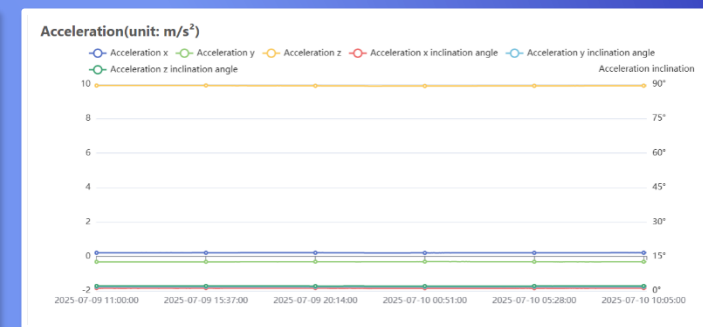
Pic 3-4 Acceleration
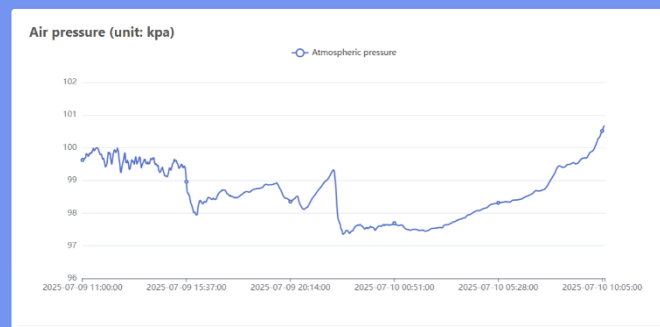
Pic 3-5 Air pressure

Pic 3-6 Temperature

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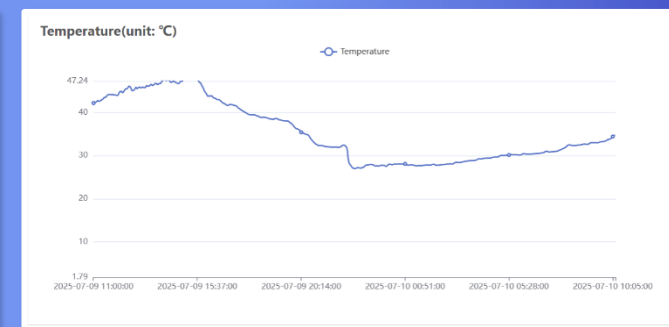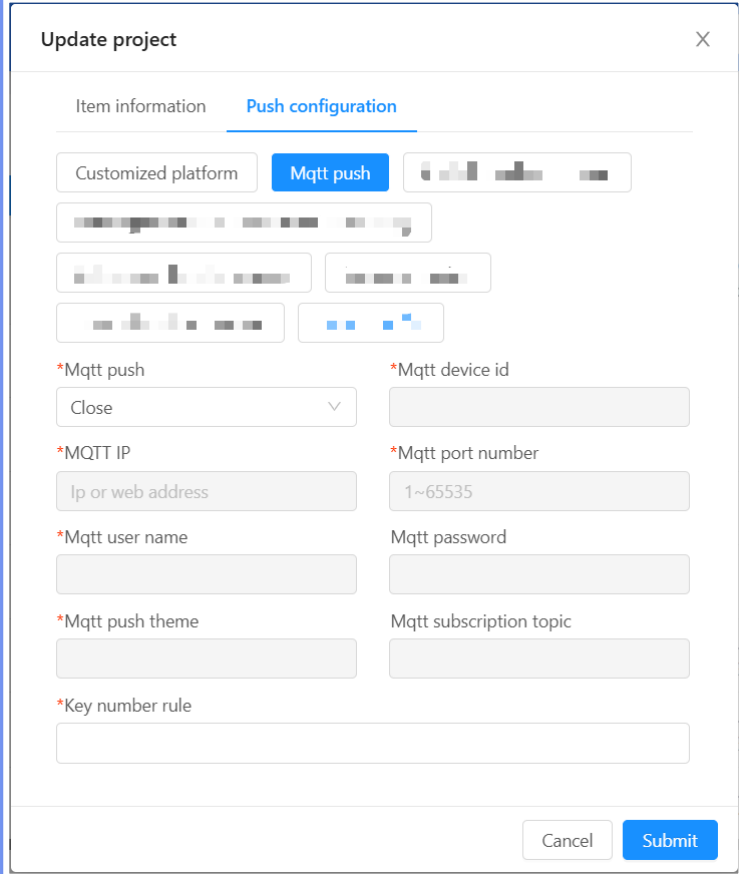
3.2 Core software
— Monitoring Calculation Management Platform

-Data Push

The monitoring cloud platform uses HTTP protocol to push information, and can be customized to push information:

Project name, Base station number, Mobile station number, Solving time, Solving data start time, solving data end time, Solving time interval, ECEF coordinates, coordinates of the mobile station with respect to the northeast day of the base station, and the amount of coordinate change...
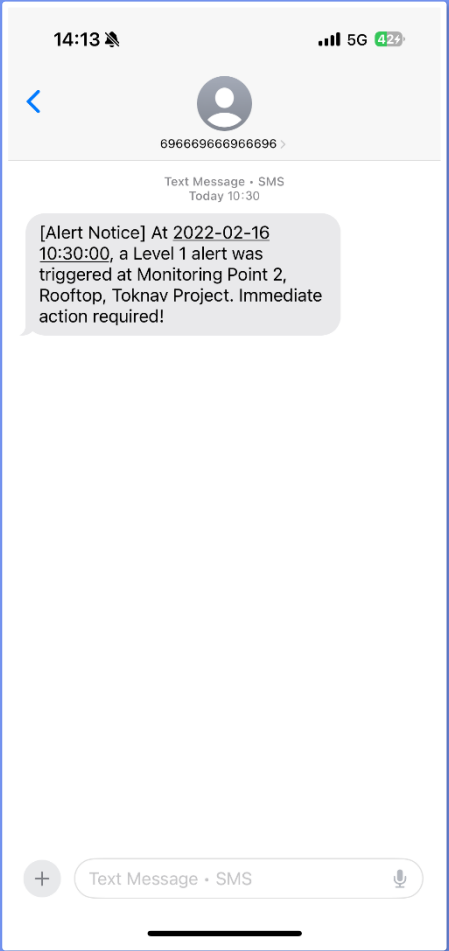
Pic 3-7 Project Configuration
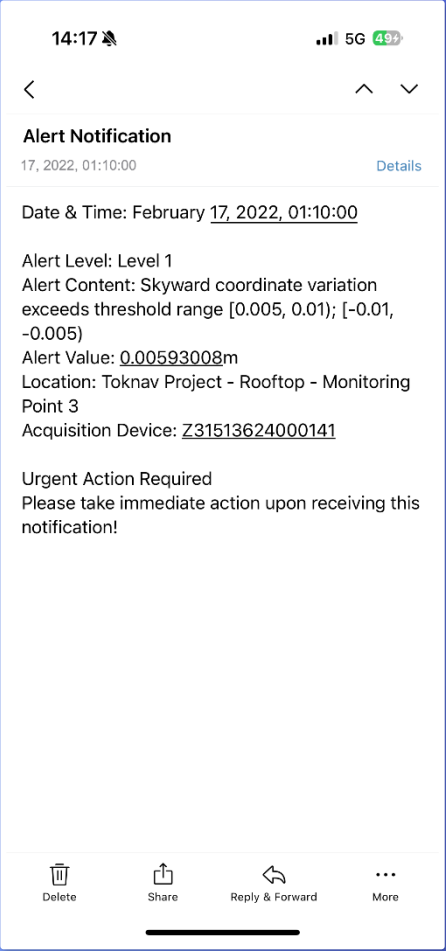
3.2 Core software
— Monitoring Calculation Management Platform

-Early Warning Push Setting

Supports notification methods:

Email and SMS

Pic 3-8 SMS

Pic 3-9 Email

4 System Advantage

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4. System Comprehensive Advantage

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Millimeter-level accuracy

The platform solves the data with stability, high precision and small error.

High real-time

Real-time data collection, with deformation monitoring results output every 4 hours. The system can be switched to a fast mode, outputting monitoring results every 0.5 hours.

Rich forms of alarm

The early warning release method is flexible, and the early warning is sent and received by email, SMS, etc.

Long-range control & management

Support remote devices on the platform to restart, set, upgrade and other operations.

High-performance antenna

Features an internally integrated, self-developed, high-performance antenna with choke shorting columns and vertical choke plates, effectively suppressing multipath signals and improve the measurement accuracy of the antenna.

All weather operation

In severe weather such as thunder and rainstorm, it can run stably and has strong lightning protection and anti-interference performance.

4.1 Core Technology Advantages

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Data Acquisition

Utilizes high-precision GNSS satellite positioning technology to obtain high-precision three-dimensional coordinates of monitoring points on the deformed body online in real time. Through quantitative analysis of the coordinate change data, real-time monitoring of the surface displacement of the monitoring object is realized, with an accuracy of up to millimeters.

Deployment Platform

Through automatic deployment, isolated physical resources such as computing, storage, network, etc. can be quickly virtualized into a pool of infrastructure resources, and provide interfaces for resource access and management, realizing the overall deployment automation from hardware to operating system, middleware, and applications
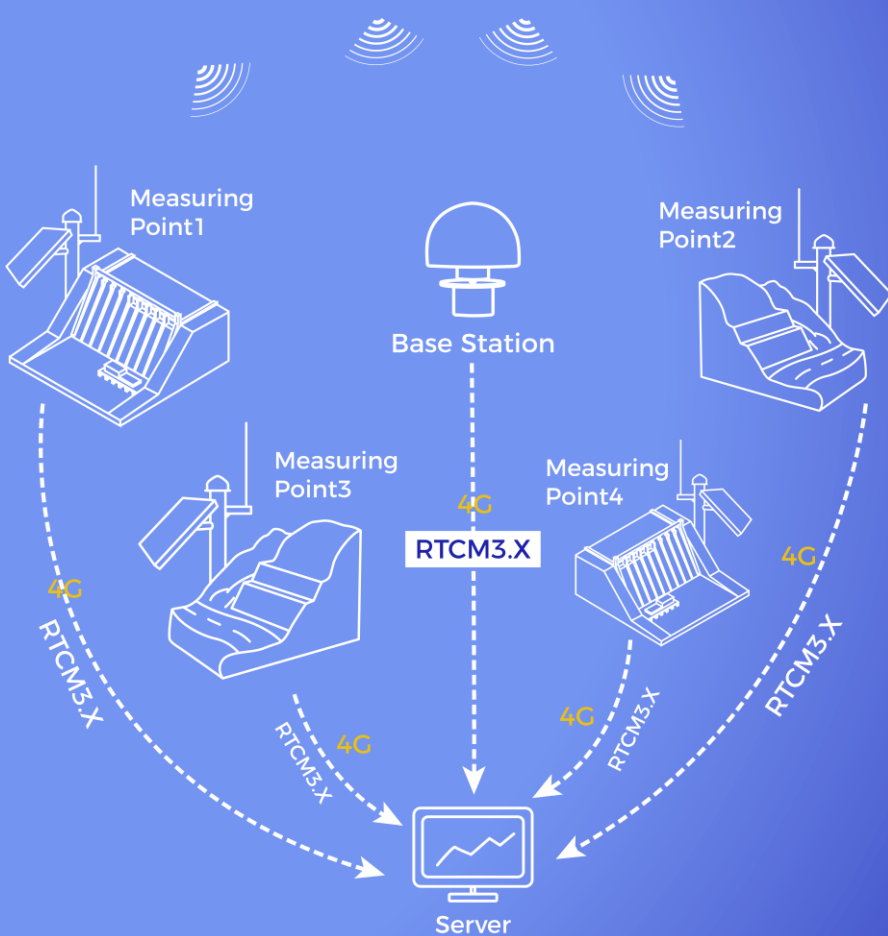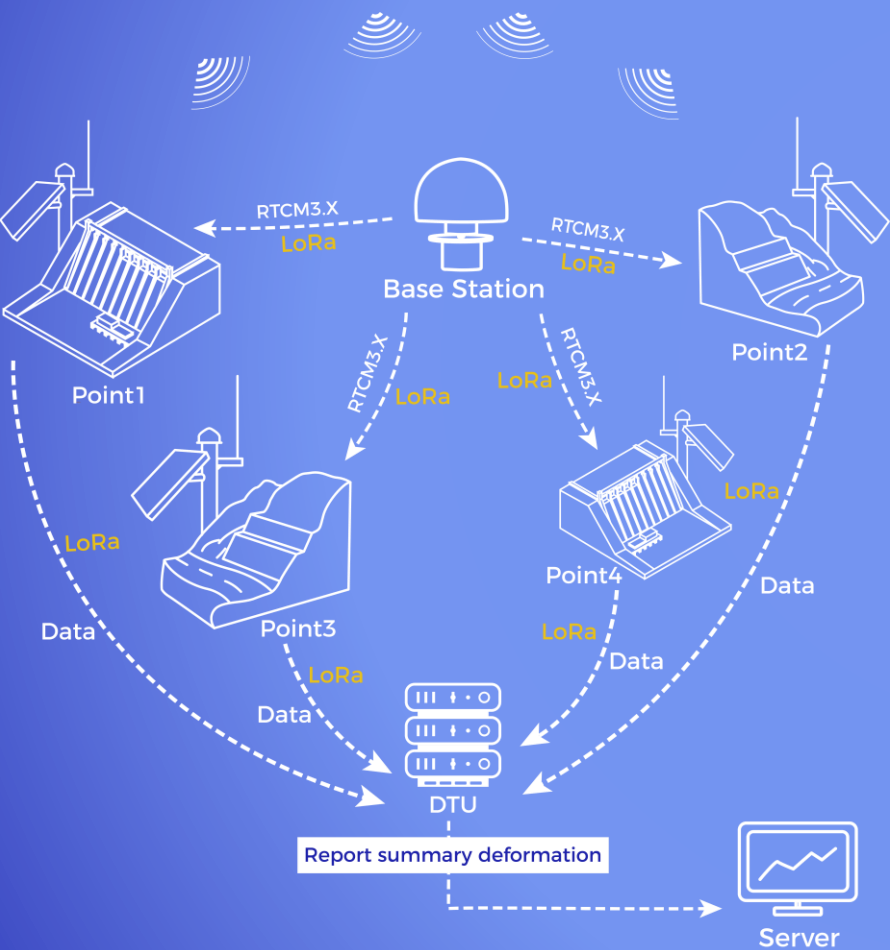
Monitoring Platform

The monitoring and control of various types of information of the cloud system is realized through the operation collection component, data configuration component, service monitoring component for monitoring node information, and user-friendly console component.

4.2 Solution Schematic Diagram

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- Front-end calculation solution
- Back-end calculation solution

Base Station

RTCM3.X
LoRa

RTCM3.X
LoRa

Point2

RTCM3.X
LoRa

RTCM3.X
LoRa

Point1

LoRa

Data

Point3

LoRa

Data

LoRa

Point4

LoRa

Data

Data

DTU

Report summary deformation

Server

Measuring Point1

Measuring Point2

Base Station

Measuring Point3

4G

RTCM3.X

Measuring Point4

4G

RTCM3.X

RTCM3.X

4G

RTCM3.X

4G

RTCM3.X

RTCM3.X

4G

Server

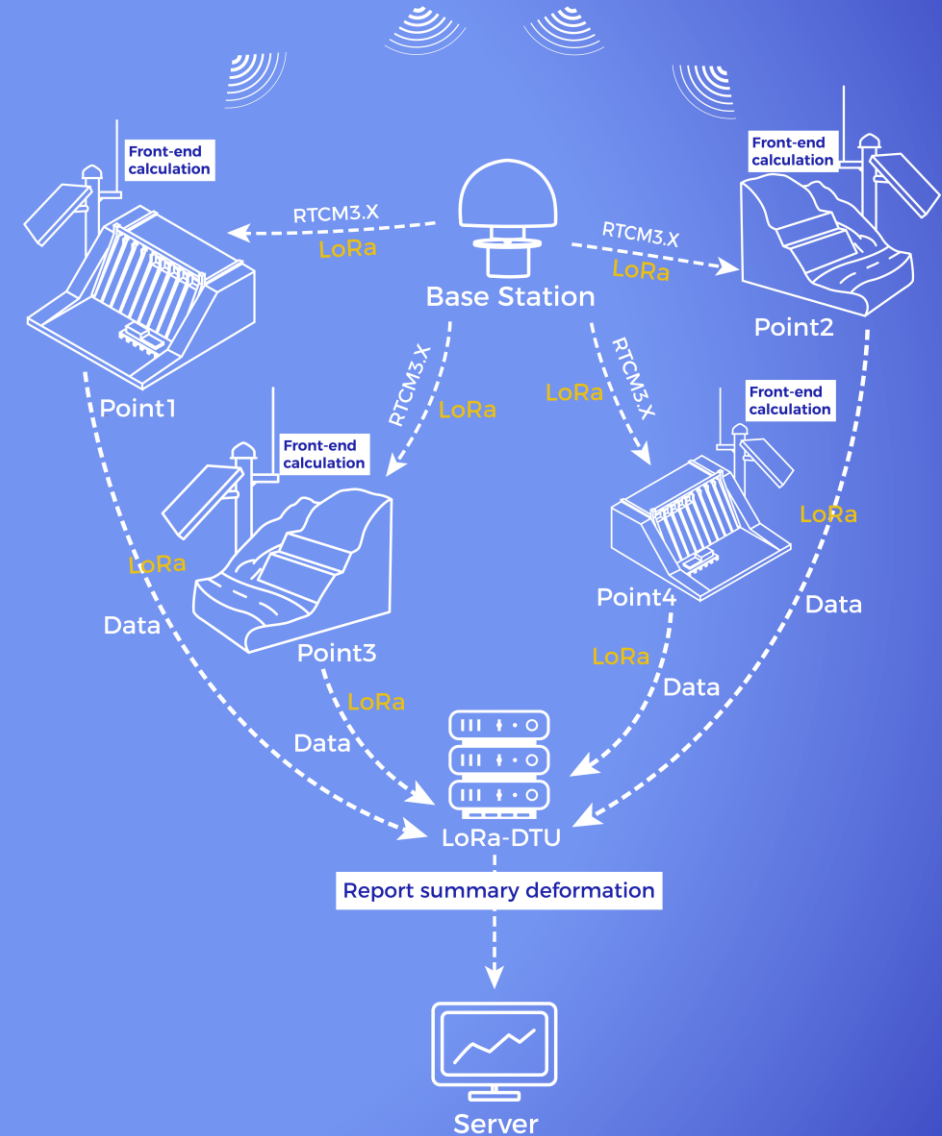Website：www.toknav.cn   Email: info@toknav.cn

4.2 Solution Schematic Diagram

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Lora radio network front-end solving program - Solution 1

For places with poor mobile network, we have introduced a network solution based on Lora radio, which uses Lora radio to transmit RTCM differential data between the base station and the measurement station, and then transmits the results of the local front-end solving to the outside via Lora after the station has finished solving the data.

Front-end calculation

Front-end calculation

RTCM3.X
LoRa

RTCM3.X
LoRa

Base Station

Point2

Point1

RTCM3.X
LoRa

LoRa

RTCM3.X

Front-end calculation

Front-end calculation

LoRa

LoRa

Data

Point3

Point4

LoRa

Data

LoRa

Data

Data

LoRa

LoRa-DTU

Report summary deformation

Server

4.2 Solution Schematic Diagram

Lora radio network front-end solving program - Solution 2

For places with poor mobile network, we have introduced a network solution based on Lora radio, which uses Lora radio to transmit RTCM differential data between the base station and the measurement station, and then transmits the results of the local front-end solving to the outside via Lora after the station has finished solving the data.
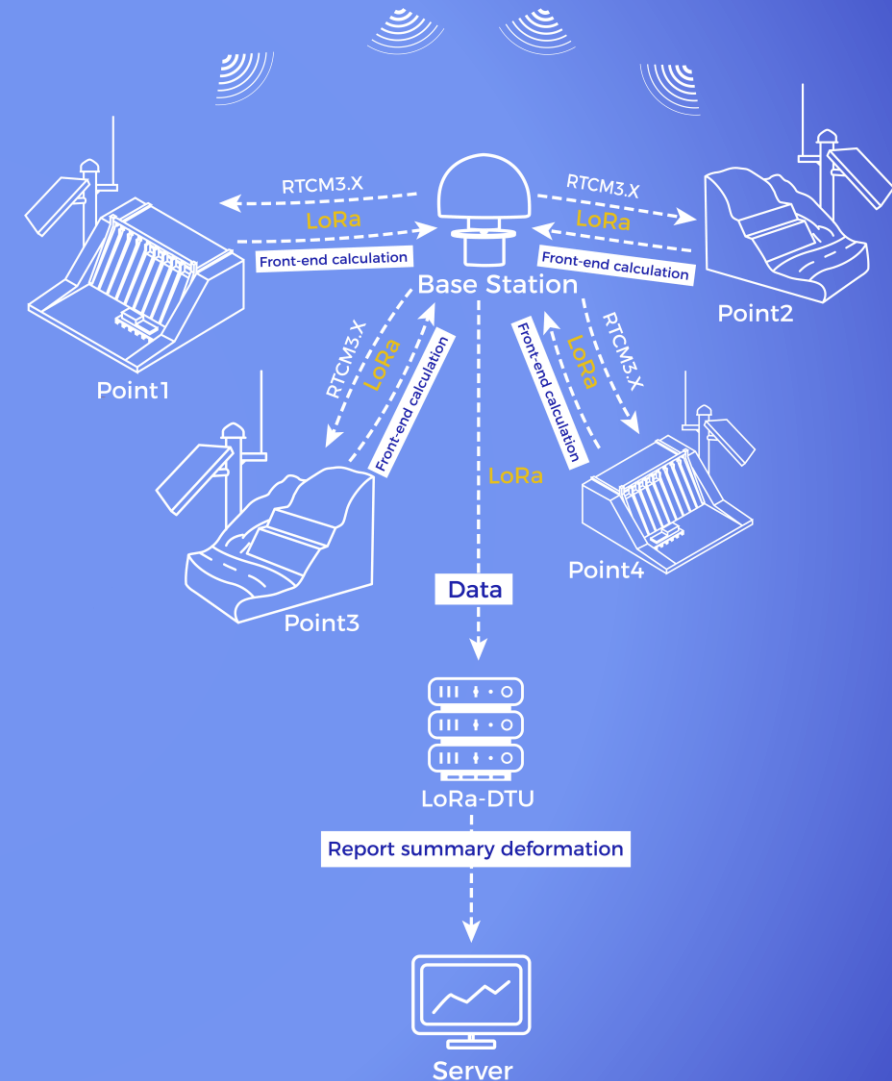
RTCM3.X
LoRa
Front-end calculation
Base Station
Point2

RTCM3.X
LoRa
Front-end calculation
Point1

RTCM3.X
LoRa
Front-end calculation
Point3

Front-end calculation
LoRa
RTCM3.X
Point4

LoRa
Data

LoRa-DTU

Report summary deformation

Server

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4.2 Solution Schematic Diagram

Lora radio network front-end solving program - Solution 3

For places with poor mobile network, we have introduced a network solution based on Lora radio, which uses Lora radio to transmit RTCM differential data between the base station and the measurement station, and then transmits the results of the local front-end solving to the outside via Lora after the station has finished solving the data.
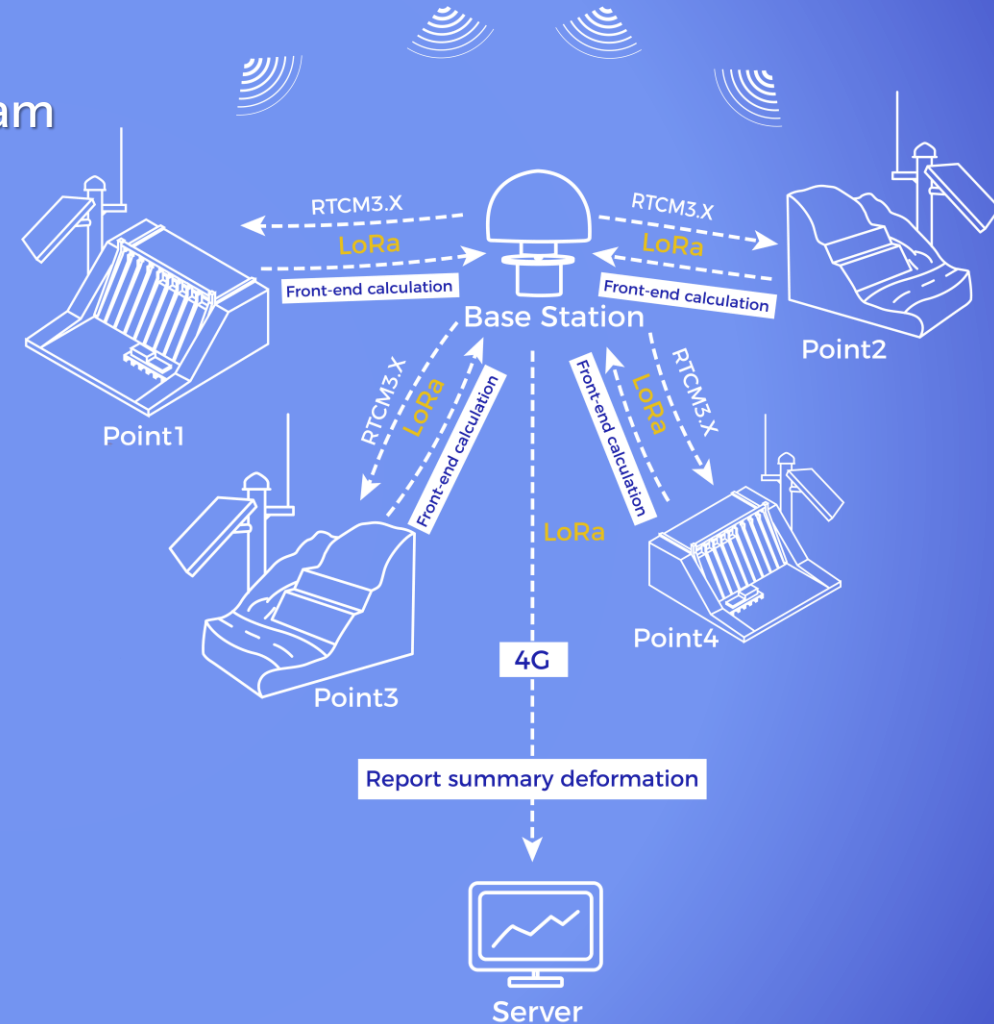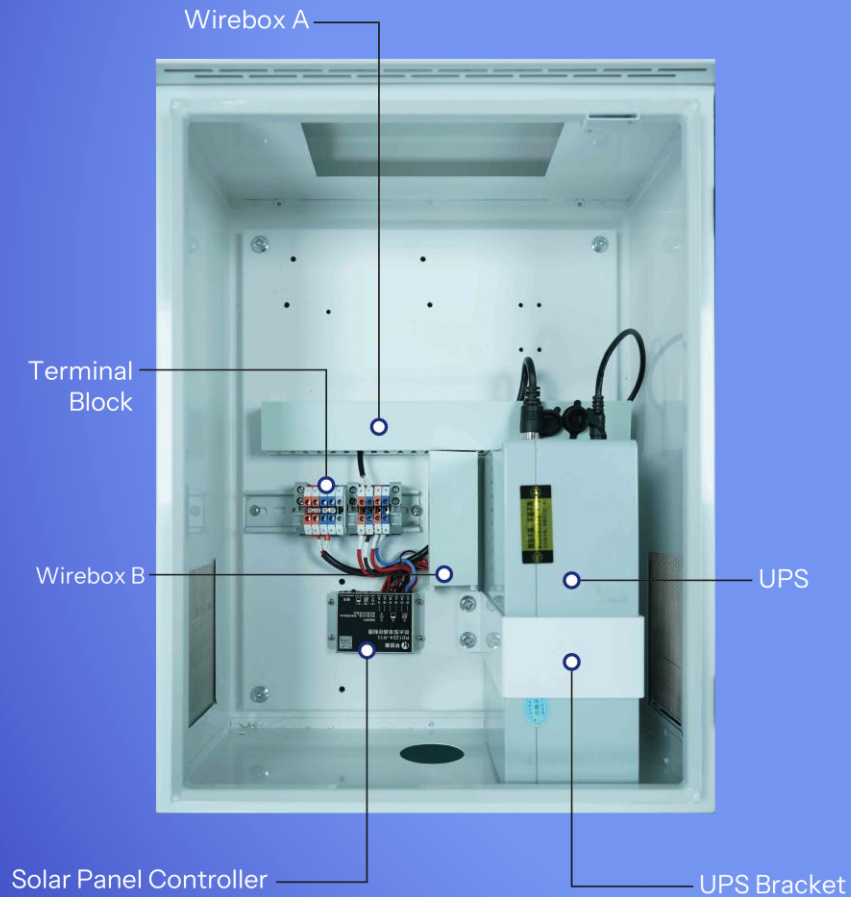
RTCM3.X LoRa
Front-end calculation

RTCM3.X LoRa
Front-end calculation

Base Station

Point1

Point2

RTCM3.X LoRa
Front-end calculation

Front-end calculation LoRa RTCM3.X

LoRa

Point3

Point4

4G

Report summary deformation

Server

4.3 Assembly Solution

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- **U6-A Kit**
  Solar Energy + Gel Battery

Lightening Rod

U6

Solar Power Panel

Solar Power Panel Bracket

Column

Ground Box and Gel Battery

Ground Cave

Lightning Grounding Rod

4.3 Assembly Solution

U6-B Kit Solar Energy + UPS

Wirebox A

Terminal Block

Wirebox B

Solar Panel Controller

UPS

UPS Bracket

Lightning Rod

U6

Solar Panel

Solar Panel Bracket

Chassis

Box Holding Hoop

Cage

Pole

Lightning Rod

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4.3 Assembly Solution

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U6-C Kit Utility + UPS

Wirebox A

Terminal Blocks

Wirebox B

Charger Bracket

UPS Charger

Air switch

UPS

UPS Bracket

Lighning Rod

U6

Upright Poles

Chassis Hoops

Chassis

Ground Cage

Lightning protection grounding pin
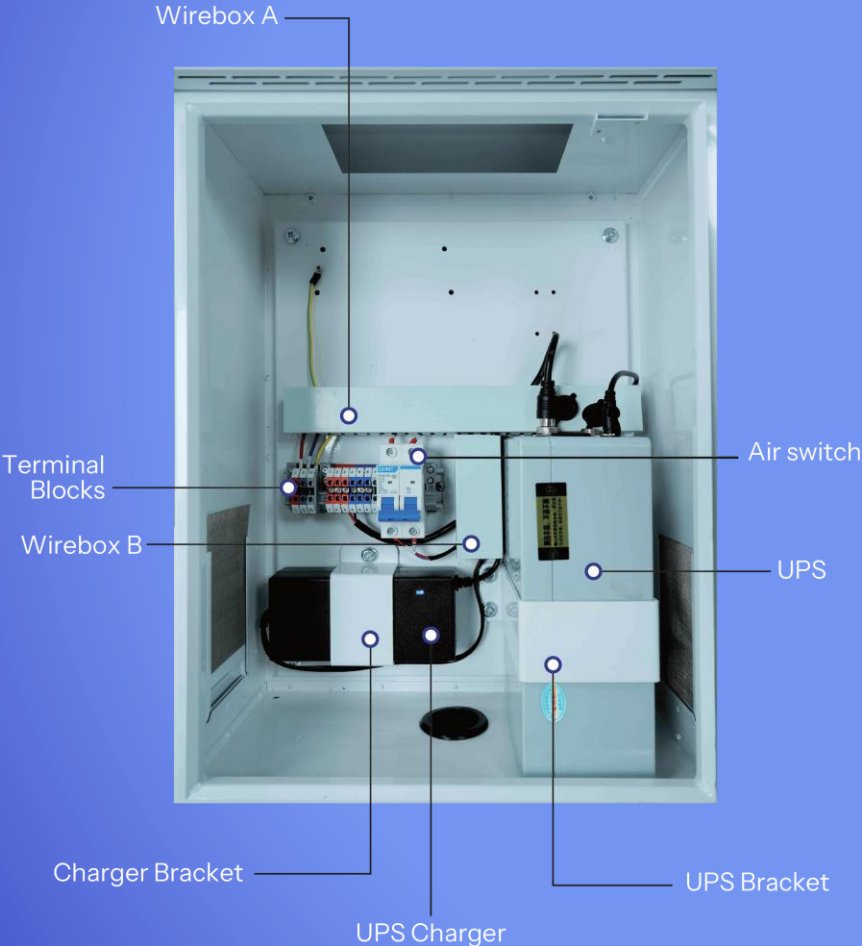
4.4 Millimeter cloud solving engine

Poor accuracy in complex environments?

1. Establishment of terrain environment modeling around the station

It is proposed to use the altitude angle and azimuth angle information of navigation satellite signals for complex environment sensing and modeling, and to ensure centimeter-level real-time monitoring accuracy through model compensation.
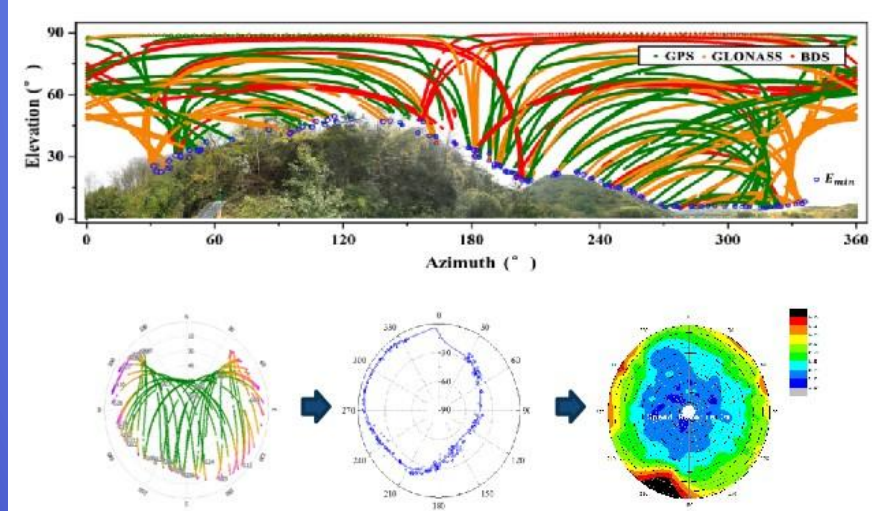
Pic 4-1 Making navigation satellites sense the environment
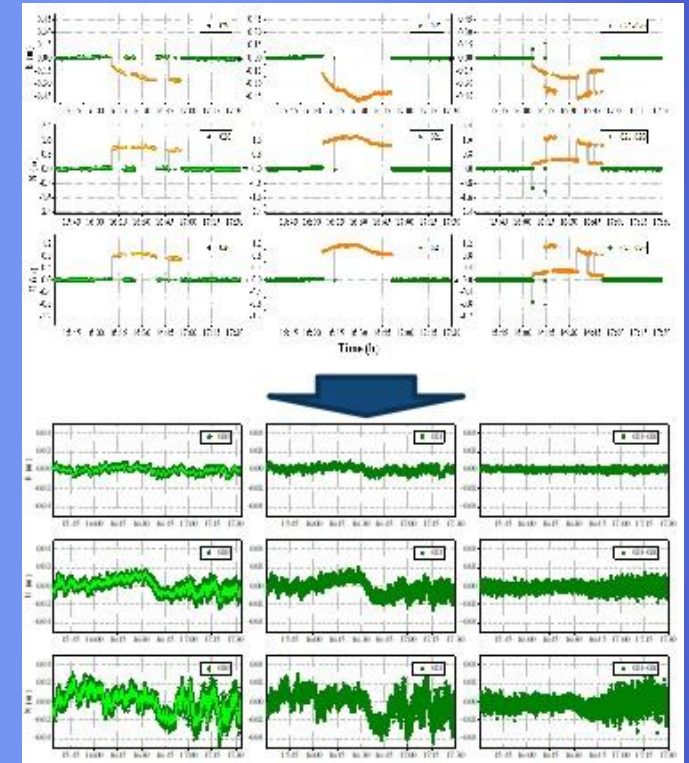
Pic 4-2 From centimeter level to millimeter level

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4.4 Millimeter cloud solving engine

- **Poor accuracy in complex environments?**

2. Occluded Satellite Ephemeris Forecasting

Utilizing the spatial correlation between satellites to virtualize the observations of the occluded satellites, an algorithm for compensating the double-difference observations of the GEO satellite carrier phase is proposed, and the Douglas-Pook algorithm is introduced to judge the receiver motion state in real time to reduce the influence of the compensation bias. On average, the positioning performance under the occlusion environment is improved by *64%*.

New discovery: available!
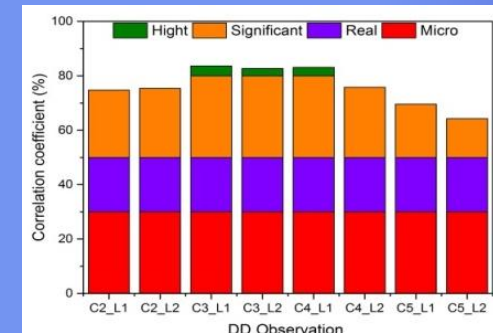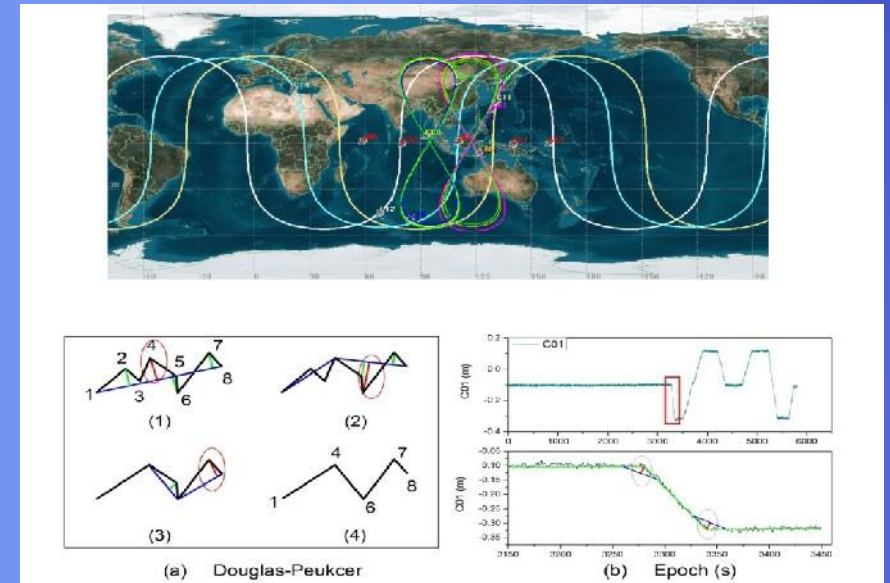
Pic 4-3 Making Occluded Satellites Usable

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Application

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Automatic Monitoring of Geological Hazards

Safety Monitoring of Water Conservancy Dam

Safety Monitoring of Slopes Along Highways

Mine Safety Monitoring

Bridge Structure Monitoring

High-rise building Structure Monitoring

6. Practical example in China

Qinghai-Tibet Railway CORS

Longgang Reservoir

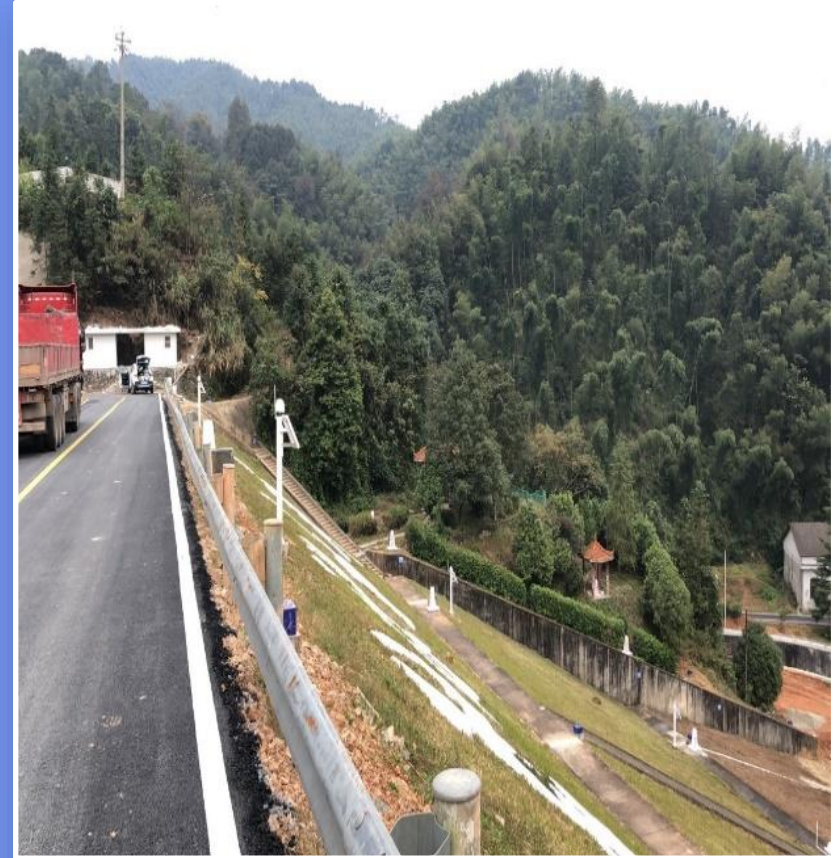Lavasi Hydropower Station

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Xiajiang Water Conservancy Hub

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Daguang Expressway–Shaoguan Section

6. Practical example in China

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Monitoring of a Geological Hazard in Panzhihua

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