UCchip Yuxin Micro

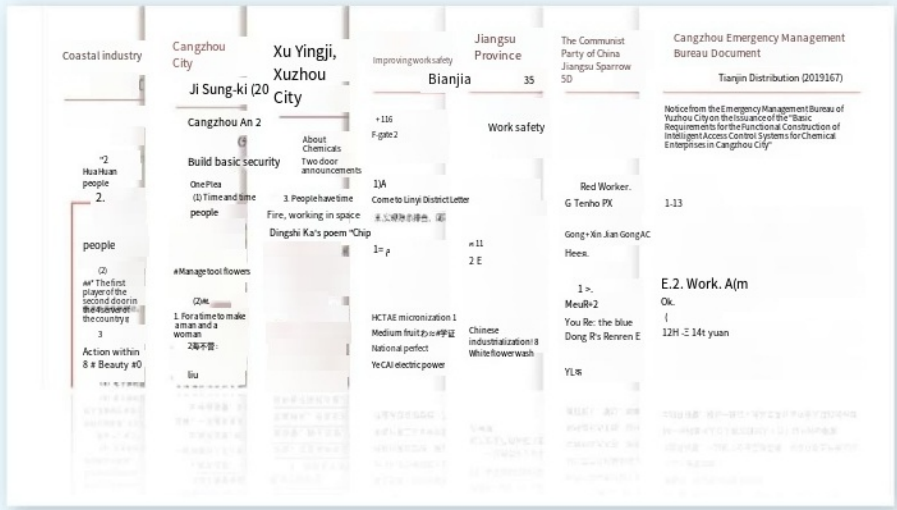
Chengke Center, China Academy of Engineering Physics

Suggestions for Internet of Things solutions in oil refining plants

2024.5

Industry Pain Points and Demands

Relevant policies



The Information Office of the State Council, the State Council Work Safety Committee, the Ministry of Industry and Information Technology, and the Ministry of Emergency Management have successively issued important instructions. In November 2023, the Ministry of Emergency Management issued a document requiring personnel positioning management.

Many provinces and cities have issued policy documents, guiding chemical enterprises and industrial parks to enhance the safety management level of chemical production through innovative applications such as personnel positioning, intelligent early warning, electronic inspection, and supervision of special operations, to prevent accidents and improve emergency rescue capabilities.

The current safety situation in the chemical industry

Safety management is a crucial issue in the operation of chemical enterprises. At present, the safety situation in the chemical industry remains severe. With economic growth and enterprise development, there is also a frequent occurrence of accidents.

The occurrence of chemical accidents not only brings about devastating economic losses to enterprises, even leading to production suspension and business closure, but also causes irreparable physical harm and psychological trauma to the victims and their families.

The explosion that occurred in Xiangshui County, Yancheng City, Jiangsu Province on March 21st resulted in 78 deaths, 76 serious injuries and 640 people hospitalized for treatment.

The explosion in the Texas plain on July 11th claimed 9 lives; the explosion in Cangzhou, Hebei Province on May 11th resulted in 5 deaths.

The explosion at Zhangjiakou Shenghua Chemical Co. on November 28th resulted in 24 deaths and 21 injuries.

More and more safety accidents have caused extremely adverse effects on society. Therefore, the government's regulatory requirements for enterprises are becoming increasingly strict.

The current safety situation in the chemical industry

Employee management

The real-time physical conditions of employees in high-risk positions are not clearly known.

The inspection process cannot be traced.

The inspection efficiency and quality control methods are outdated.

Management of Hazardous Operations

. Unclear definition of regional security boundaries

On-site control and monitoring were inadequate.

Contractor Management

. Ineffective control over contractors' permits and activity areas

The process monitoring is loose, and the precise working status cannot be known.

Vehicle management

There is a lack of management for speeding and prolonged stays in vehicle activity areas and high-risk zones.

The supervision and control of entry and exit in the factory area is lagging behind.

There is an urgent need for automated and Internet of Things (IoT) based management methods to respond quickly and reduce human errors.

The goal of security management in the Internet of Things (IoT) era

人的不安全行为　物的不安全状态　环境的不安全因素

正确的人(物）　正确的时间　正确的地点　做正确的事

厂内职工、承包商、来访人员

事前、事中、事后

身长设备、生产物资、安全物资运输

厂内职工、承包商、来访人员

事前、事中、事后

身长设备、生产物资、安全物资运输

Introduction to the Technical Solution

Traditional solution - LoRa communication + Bluetooth beacon positioning

A large number of Bluetooth beacons are deployed inside the device.

The beacon transmits signals approximately every 200 milliseconds.

After receiving multiple Bluetooth beacon signals and their signal strengths, the Bluetooth positioning terminal transmits the information back to the platform via communication technologies such as LoRa.

The platform determines the location based on the position of the Bluetooth beacon and the reported signal strength.

· Existing problems

The signal strength measurement is inaccurate (RSSI fluctuates frequently, with normal variations ranging from 10 to 100 times).

The position measurement is inaccurate, especially in the environment where the device is hollowed out, and the floor space information is not accurate.

· **Troublesome to install and maintain**

Complex calibration and road test analysis are required, which involves actually measuring the signal strength of each Bluetooth beacon at every location.

If there are any local changes to the device, it is necessary to remeasure and recalibrate it.

The production environment is unsafe.

A large number of battery-powered devices (Bluetooth beacons) installed in the equipment is also an unsafe factor, especially when the quantity exceeds 1,000, as it is difficult to predict individual explosion-proof issues.

Information security is not easy to guarantee.

Bluetooth beacons can send information to ordinary mobile phones.

The long-range communication technologies and chips such as LoRa all originate from the United States, and their underlying technologies are not disclosed. LoRa has the capability for long-range communication, and especially, LoRa base stations can be subject to long-range attacks.

Our proposed solution: WIoTa communication + WIoTa AoA/RFID/Beidou positioning

Device 1: Positioning Name Tag

Device 2: WIoTa AoA Locator

- **Positioning ID Card Type A - For park employees, visitors, vehicles, etc.**
  - Beidou positioning
  - WIoTa AoA positioning
  - WIoTa Communication - Communication range over 1km (depending on transmission power)
    - Voice intercom, emergency SoS, location information

  Vehicle speed detection alarm

  Standby for 1 to 3 months, explosion-proof treatment.
- **Positioning Badge Type B - For use by employees and inspectors inside the facility**
  - Includes Type A functionality
  - Add ultra-high frequency RFID readers (with a reading range of 1 to 3 meters)
  - Compatible with Bluetooth beacons

  Standby time is about one month (under normal usage scenarios).
- **WIoTa AoA Positioner**

  The arrival azimuth angle measurement is achieved through multi-antenna technology.
  - Long-distance azimuth measurement is achieved through the underlying technology of WIoTa.

  Deploy multiple locators around the device.

  The accurate position of the target can be determined through the cooperation of multiple locators.

  The positioning accuracy is achieved with an error of about 1 meter.

  By deploying several reference points around the device, automatic calibration is achieved, eliminating the need for manual calibration.

Our proposed solution: WIoTa communication + WIoTa AoA/RFID/Beidou positioning

Device 3: WIoTa Gateway

· **WIoTa Gateway**

A gateway is deployed approximately every 500 meters.

The data from the positioning badges, sensor DTUs, CPEs, and WiOta AoA locators are aggregated into the gateway via the WiOta communication protocol.

accesses the platform via Ethernet

Device 4: WIoTa DTU

· **WIoTa DTU (Data Transmission Unit)**

The data from sensors and CPEs is wirelessly transmitted back to the gateway via WIoTa.

Device 5: Anti-metal UHF RFID Tag · Gateway

Anti-metal ultra-high frequency RFID tags

Low-cost, passive tags that can be attached to metal surfaces

A large number of devices are deployed inside (approximately one every 3 to 5 meters).

· Read by the reader inside the employee ID card

The access card reader may simultaneously read data from multiple tags, and the signal strength is also one of the criteria for judgment.

Configuring WIoTa AoA positioning enables precise location tracking without the need for manual calibration.

Our proposed solution: WIoTa communication + WIoTa AoA/RFID/Beidou positioning

Equipment 6: Beidou Reference Station

- **Beidou Continuously Operating Reference Station (CORS)**

  One park is placed with a coverage radius of 30 kilometers.

  Provide reference information on Beidou signals.

  Reduce ionospheric error

  Differential positioning enhances the accuracy of the Beidou navigation system.

Equipment 7: Laser-Inertial Navigation

Automated mapping equipment

Laser-inertial navigation automated mapping equipment

Auxiliary equipment for the automatic positioning of RFID tag locations

The entire system is equipped with one or two sets for use as needed.

Our proposal suggests - protecting investment and being compatible with Bluetooth.

Equipment 6: Beidou Reference Station

- **Beidou Continuously Operating Reference Station (CORS)**
  - One park is placed with a coverage radius of 30 kilometers.
  - Provide reference information on Beidou signals.
    - Reduce ionospheric error
    - Differential positioning enhances the accuracy of the Beidou navigation system.

Equipment 7: Laser-Inertial Navigation Automated Mapping Device

Laser-inertial navigation automated mapping equipment

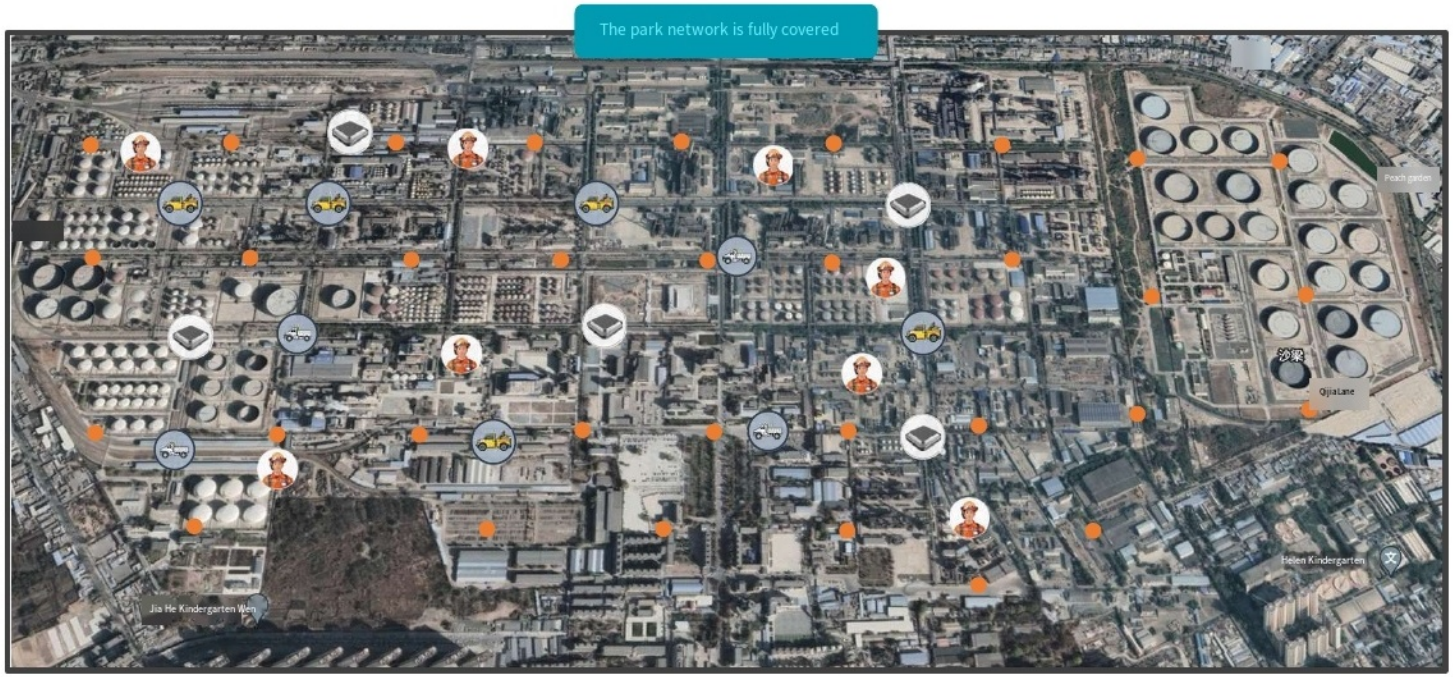
- Auxiliary equipment for the automatic positioning of RFID tag locations.
- The entire system is equipped with one or two sets for use as needed.

- **Protect investment and be compatible with the Bluetooth beacons that have been installed.**

For factory stations that have already installed Bluetooth beacons, we can offer a compatible Bluetooth beacon solution to protect previous investments.

Overall Plan One: Full coverage of the park with WIoTa to support comprehensive business operations.

The WIoTa system deployment solution enables large-scale flexible networking and autonomous control over network deployment. It features an outstanding coverage capability and lower deployment costs. It can achieve personnel positioning, vehicle positioning and speed measurement, as well as wireless voice intercom communication among personnel.



WIoTa AoA Locator

Mainly deployed around the equipment, and can also be deployed in conjunction with the WIoTA base station, serving as a supplement to the Beidou planar positioning in the park.

vehicle

The positioning terminal enables vehicle speed detection, location positioning and voice communication.

personnel

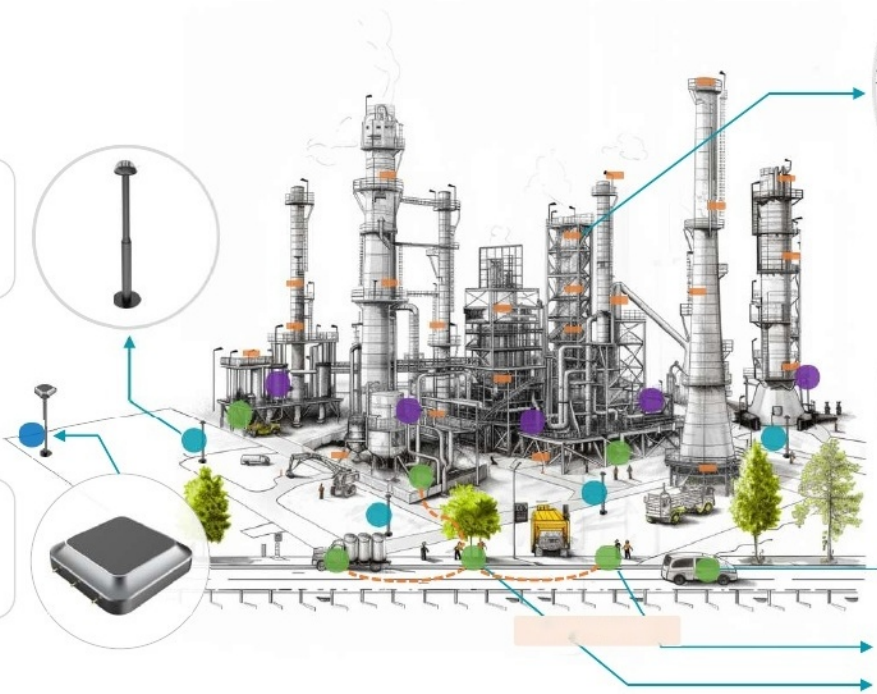
Wear a name tag and achieve personnel positioning through Beidou, WiOta AoA and RFID, including floor positioning and voice communication.

WIoTa base station

The entire park is covered by a 500m-interval WIoTa synchronization protocol, supporting comprehensive services such as personnel, vehicles, sensors, meters, and voice.

Overall Scheme Two: Positioning and Sensors within the Device

1. WloTa AoA device: Deployed around the periphery of the device (about 2 meters high)
2. Personnel name tag: Equipped with RFID reader and intercom function



RFID passive tag

Deployed in large quantities within the device for personnel floor positioning and to assist with WloTa AoA positioning

AoA positioning reference point

Fix to prevent a small number of terminals from being used as reference points to complete the automatic calibration of the AoA locator

Sensor (WloTa DTU)

The CPE devices collect sensor data and then transmit it to the server via the WloTa wireless network

WloTa AoA locator

Arrange at intervals of 50 meters around the park

Full coverage of the WloTa campus for positioning

Location terminal

Vehicle positioning, speed detection, Beidou positioning

Vehicle speed and positioning

Ultra-low power wake

WloTa base station

Full coverage of the WloTa Synchronization Protocol campus. Unified Network Transport center

WloTa campus coverage

It enables multiple services and provides flexible support for future needs

Name tag (reader and intercom function)

Read RFID tags, send AoA positioning signals and Beidou for combined precise positioning. It can also be used for personnel voice intercom communication, emergency response, etc

Personnel floor location positioning

Voice intercom

ultra-low power wake-up, frequent positioning on demand

WIoTa Internet of Things communication technology

WIoTa (Wide-range Internet of Things communication protocol) is a wireless communication LPWAN protocol customized for the Internet of Things, which is entirely owned by Yuxinwei in terms of intellectual property rights. It features wide coverage, low power consumption, large connection capacity, and low cost. It is also flexible and convenient to deploy and configure, and can meet the wireless connection requirements of self-organizing networks for the Internet of Things in various industries. It is an effective complement to 5G and others.

Core advantages

Medium and long-range autonomous network

(kilometer level)

Tested by Thiel LABS, performance indicates

Mark full iot communication protocol superior

Other technologies include

- Receiving sensitivity
- System capacity
- Communication rate

Totally independent intellectual property

Full-featured Soc

The chip contains multiple key independent components

- WloTa wireless communication
- Calculation, MCU control
- Voice compression
- Fully integrated SOC, available on a single chip

Digital intercom applications in multiple scenarios

Large capacity

Smart skipping rope group data statistics, big

Better than other wireless technologies

500 ~ 30000

WloTa capacity

Capacity: 500-5000

Security

PUF chip digital fingerprint encryption

National cryptography algorithm

The only bottom layer prevents cloning

Low power consumption

Automatically adjust transmission power, ultra-low power

Consume a single point of wake

Low-power sleep 1.5uA

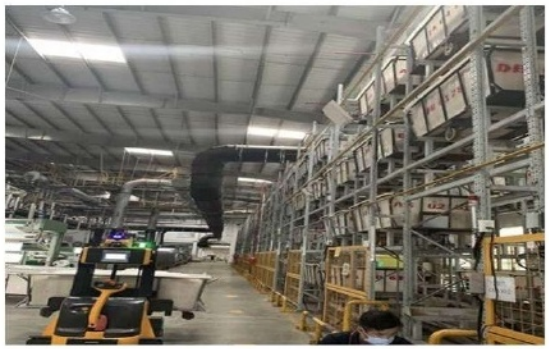
Low cost

Modules cost less than other technologies

30% to 50%

Based on the large capacity and long-distance features of WiOta technology, it can serve as the foundation for a dedicated IoT network in the park, achieving full coverage and supporting comprehensive services such as positioning and sensing. Meanwhile, the chips are all domestically produced, ensuring controllability and manageability.

Ultra-high Frequency Radio Frequency Identification (UHF RFID)



Ultra-high Frequency Radio Frequency Identification (UHF RFID) Technology

- Consists of a reader and a passive tag

The tag is activated by the radio frequency energy from the reader, and information such as the ID is transmitted through communication.

- Suitable for scanning large groups of tags and long distances, etc.

It is widely applied in fields such as warehousing, logistics, and clothing and hats.

Adjust the power of the RFID reader to achieve positioning assistance functionality.

The approximate location can be obtained by reading the ID of the nearby tags.

Based on the energy information returned by multiple tags, achieve more precise positioning.

Combined with WiOta AoA technology, more accurate positioning can be achieved.

The built-in employee badge can automatically read the information of nearby tags while walking.

- **Passive tags (no battery, no power supply)**

Easy to deploy

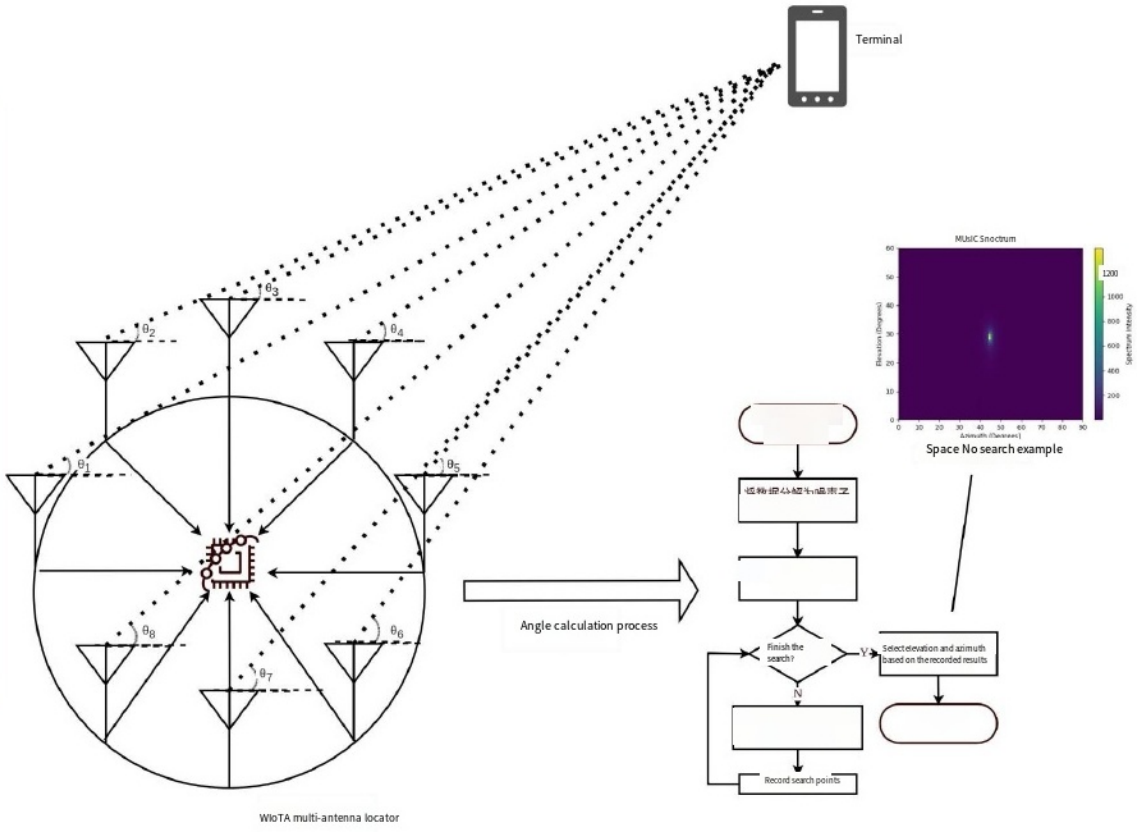
- Low cost
- Long service life (over 10 years)

Our self-developed ultra-high frequency RFID reader and writer chip is suitable for long-distance and dense scenarios. It can be adapted to devices such as employee ID badges and used by employees within the devices (perceptible-free usage).

Introduction to WiOta AoA Positioning

Multi-antenna angle of arrival (AOA) measurement is a mature indoor positioning technology. It determines the angle information between the locator and the terminal by analyzing the differences in the signals received by the antenna array, and accurately determines the position of the mobile device through the angle measurements of multiple locators.

Due to its simplicity and ease of operation, AOA has become one of the standard protocols for 5G and Bluetooth indoor positioning. Based on the core features of WIoTa such as low cost, low power consumption, and long transmission distance, AOA can be introduced into the WIoTa protocol to achieve integrated communication and positioning applications.



The WIoTa AoA (Angle of Arrival) positioning technology can achieve long-distance and high-precision positioning, facilitating and simplifying deployment.

Precise Positioning with Beidou Navigation Satellite System - CORS Reference Stations

System Overview:

The system achieves precise positioning of terminal devices through the collaborative work of multiple satellites and ground reference stations.

Key components and processes:

1.Satellite signal reception:

GNSS satellites in different orbits continuously transmit signals to the ground, including information on position, time and status.

2. CORS reference station:

The CORS stations on the ground receive signals from multiple satellites and perform initial processing, such as signal correction and synchronization.

3. Server processing:

The server receives the processed data from the CORS station, conducts further calculations and analyses, and generates correction information.

4. Correction information issued:

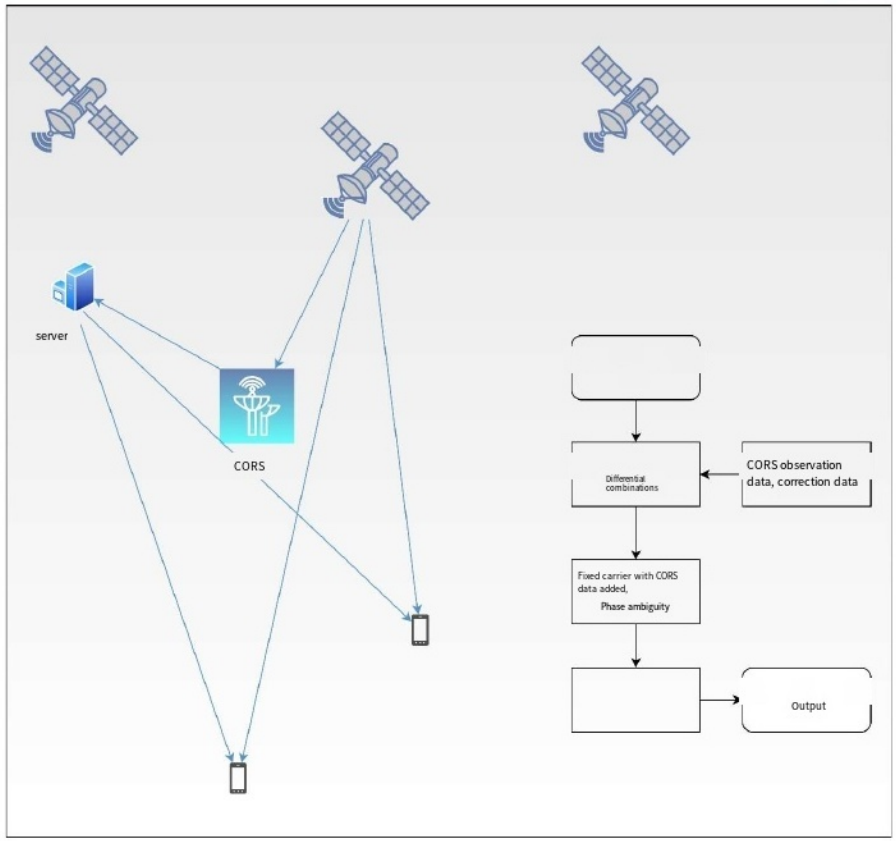
The server sends the correction information to the terminal device in real time to help improve the accuracy of the satellite signals it receives.

5. Mobile device positioning:

The terminal device calculates the precise position by using the received correction information and satellite signals through complex algorithms.

Data processing and output:

After precise calculation of the data, the device can achieve centimeter-level positioning accuracy (in an ideal environment without obstructions).



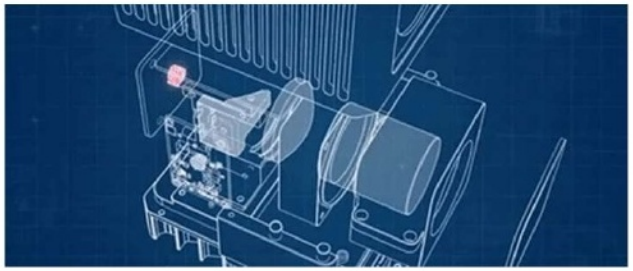
The Beidou satellite positioning system, in combination with reference stations, can achieve precise positioning within the park's plane and in some indoor facilities.

Lidar & Visual Mapping Technology - Automated Label Position Calibration within the Device

Technical description: Measuring distance using a laser beam.

Technical details: Based on the time-of-flight principle, pulsed laser is emitted and the time for the reflection to return is measured.

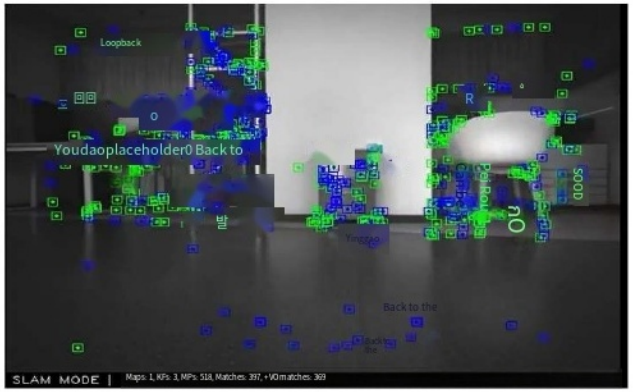
Advantages: High-precision distance measurement, suitable for various lighting conditions, and capable of generating detailed 3D maps of the environment.



Technical description: Visual data is captured using a camera.

Technical details: Analyze images through computer vision technology to identify features and estimate distances.

Advantages: It provides rich color information, which is helpful for object recognition. Its cost is lower than that of lidar. It benefits from the advancements in AI and machine learning.



By using mature technologies such as LiDAR, the positioning of tags within the device can be accurately calibrated, and this process can be automated, eliminating the need for manual mapping.

The relationship between this solution and other technologies

- **Beidou technology**

  This solution deeply integrates Beidou technology to achieve planar positioning.

  - WIoTa communication serves as the return channel for transmitting Beidou positioning information.

  The Beidou positioning information is integrated with multiple positioning technologies, and the complementary fusion achieves precise positioning.

- **5G technology**

  The internal environment of the stations and facilities is complex and not suitable for 5G deployment.

  The high capacity feature of 5G can be used as the backhaul path for WiOta gateways, especially in areas where it is not suitable to install network cables.

- **Bluetooth technology**

  Due to its short range and reliance on energy-based positioning, Bluetooth technology is inaccurate and unsafe for positioning purposes. Therefore, it is not recommended for large-scale deployment.

  Under the premise of having been deployed, compatibility can be considered.

- **LoRa technology**

  As a leading technology for long-distance Internet of Things (IoT), LoRa excels in point-to-point transmission.

  However, due to its simplicity in technology, it is not suitable for large-scale deployment scenarios.

  The use of foreign black-box technologies is also detrimental to information security.

The advantages of this plan

Safety

The device only deploys passive tags internally without batteries, ensuring production safety.

- No frequent maintenance and calibration of the device are required, reducing unnecessary safety accidents.

reliability

Reliable positioning is achieved through the integration of multiple technologies.

WiOta AoA locators are deployed around the device. Even if an accident occurs to the device, the external equipment can still perform the positioning function, ensuring strong reliability.

Confidentiality

- Self-developed core chips, 100% domestically produced, controllable and manageable
- Support for national cryptographic algorithms

Self-developed communication protocols ensure security and controllability, guaranteeing information security.

Economic efficiency

The employee ID card is multi-functional. One device can perform multiple functions, which is economical and practical.

The equipment is easy to install and maintain, and it is convenient to replicate in batches.

A complete system that offers integrated services and facilitates subsequent expansion for Internet of Things (IoT) applications.

Introduction to the Operations and Maintenance Platform

Operation and Maintenance Platform One: Safety Production Control Platform

An occupational safety and production control platform emerged in response to the pain points of the petrochemical industry.

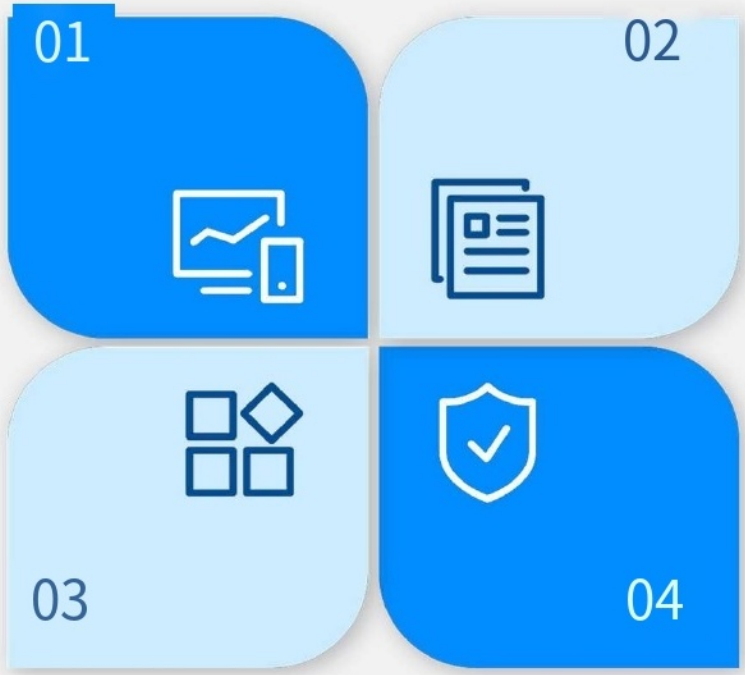
The concept of "One platform, two information sources, three major functions, and four As"

A set of platforms

Safety production control platform

(A picture of safe production)

(Intelligent Analytics Engine)



Two Important Messages

Real-time information of people/vehicles

Real-time regional information

Three core functions

Real-time location monitoring

Abnormal behavior alert
Intelligent inspection management

Four-dimensional security management concept

All elements

All process

All standard

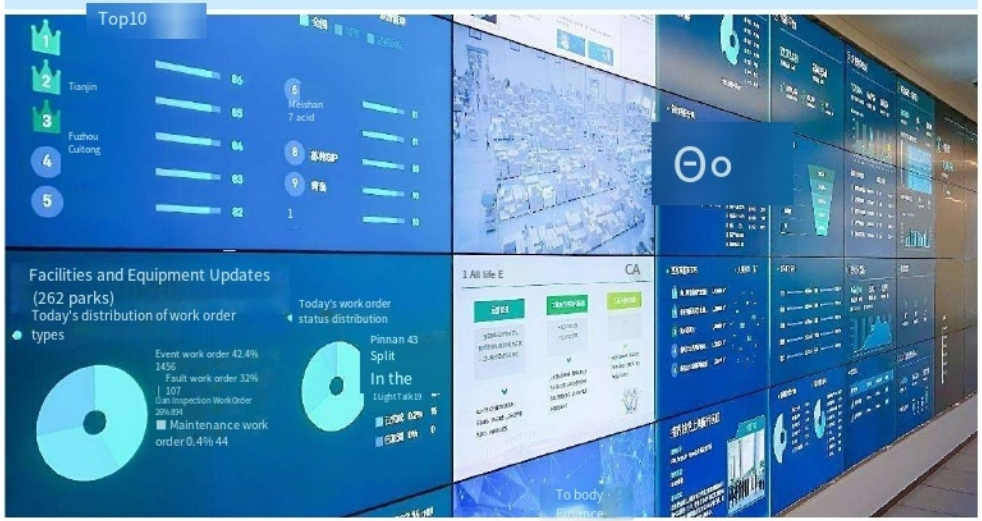
All marks

Operation and Maintenance Platform II: Building a Service Platform to Break Down Data Silos

One Map for Work Safety (One Map)

Centered on 3D maps and deeply integrating digital twin applications, it provides data display related to factory safety production through a visual panel and convenient operation, including personnel information statistics, real-time location viewing, abnormal situation alerts, and historical trajectory retrospection.

Intelligent Analysis Engine (One Brain)



Relying on self-developed communication protocols and high-precision positioning algorithms, and supported by the computing engine and service engine, various business functions are enabled. Positioning data is processed through positioning calculation, providing data presentation services for the final client.

Operation and Maintenance Platform III: Three Core Functions

Real-time location monitoring	Abnormal behavior alert	Intelligent Inspection Management
		
Empower production processes	Enable safety supervision	Empower Smart Factories
Based on real-time location supervision, managers can define, monitor and trace back production tasks through the platform, continuously optimize processes and improve production efficiency.	Managers can quickly handle multiple types of alarm information through the platform, and to the greatest extent in emergency situations. Ensure the safety of life and property.	Sub-meter precision positioning helps with the division of inspection areas, task assignment, personnel binding, and process traceability.

Operation and Maintenance Platform IV: Platform Architecture

Big data platform Big data platform	Big Data Intelligent Platform for Safety Positioning System in Chemical Plants				
Application Service Layer	Safety management	Emergency early warning	Work Management	View archive	Data Board
	Personnel positioning	SOS alarm	Inspection Management	Data entry	Map board
	Electronic fence	Emergency Notice	Regional statistics	Activity analysis	Organizational Kanban
	Video linkage	Abnormal alarm	Asset management	Data statistics	Process Kanban Board
	.....	.....	.....	.....	.....
Positioning solution layer	Open interface service for positioning platform			Location platform console service	
	Solution engine			Service engine	
	Algorithm model	Parallel framework	Positioning solution	Data processing	Information exchange	Network management
Basic equipment layer	Base station positioning		Location tag	System controller	server

Operation and Maintenance Platform VI: Function Benchmarkin

Official guidance and suggestions

Conduct in-depth analysis and assessment of safety risks in the hazardous chemicals sector.

-Draw profound lessons from the recent typical accidents.

Strengthen risk control over major hazard sources.

Strengthen safety guidance services and the investigation and rectification of potential hazards.

with stricter standards

More detailed measures

A more down-to-earth style

Resolutely hold the line on safety.

The supervision and inspection were not thorough.

Failure to take prompt emergency measures

Insufficient on-the-job confirmation

Functional application

	Functional applications
Safety management	Personnel positioning, electronic fences, video linkage...
Emergency warning	SOS alert, emergency notification, Anomaly alert, SOS alerts, emergency notifications, abnormal alarms...
Work Management	Inspection management, regional statistics, asset management...
View archive	Information entry, activity analysis, data statistics....

Operation and Maintenance Platform 7: Real-time Map

Real-time positioning and statistics

· Accurately track the real-time locations of people and vehicles,

Support the distinction of personnel and vehicle types by different label styles and colors.

Presentation of multiple map types

· 2.5D/2D

· 3D model

Oblique photography

· Oblique photography + partial 3D modeling map

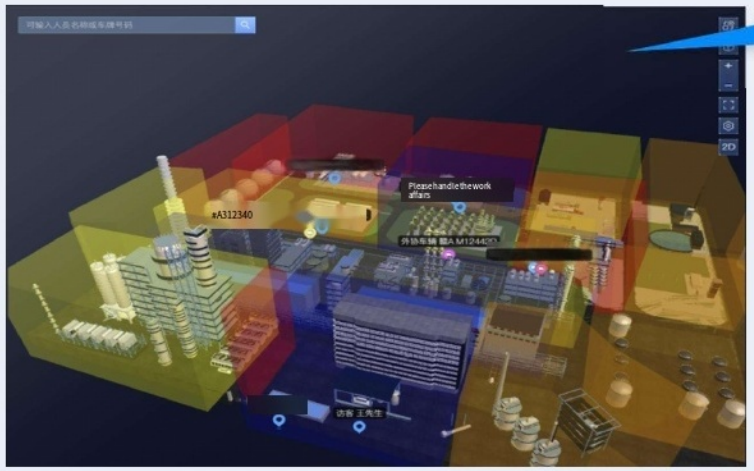
(3D maps support indoor and outdoor switching as well as floor-by-floor display.)

Ultimate interactive experience

· Monitoring large screen, application center, management center

Simple and convenient

Operation and Maintenance Platform 8: Four-color Risk Zoning Management



· Registration of potential risk sources

· Risk area control and management

· Regional visualization presentation

One-click export of data reports

Operation and Maintenance Platform 9: Electronic Fence Management

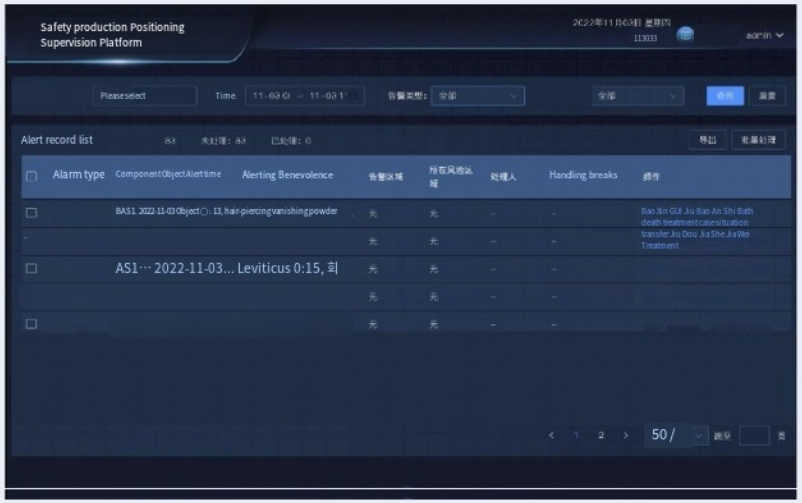
Electronic fence setting

Support the drawing of electronic fences in the form of polygons on the map, and also support binding restricted personnel, setting the start and stop time of the fence, as well as the start and stop rules.

Mobile electronic fence

For high-risk chemical operations that require frequent movement, a mobile electronic fence function is provided. It can generate a designated warning area at any location. When someone intrudes, an immediate electronic fence boundary-crossing alarm will be issued.

Operation and Maintenance Platform 10: Alarm Management



Personnel/Vehicle Boundary Crossing Alarm

Support automatic alarm for situations such as employees working in unauthorized positions and contractors entering non-authorized areas.

Stationary timeout alarm

Automatic alarm when personnel positioning remains stationary in a specific area for a time longer than the set duration or other similar situations.

Off-duty alarm

For on-site supervision of specific working areas, if the number of on-duty personnel is less than the set number and they are absent from their posts for a long time, an automatic alarm will be triggered immediately.

Vehicle speeding alarm

When a vehicle travels at a speed exceeding a certain limit within the park, an automatic alarm will be triggered.

Unaccompanied police report

When visitors or suppliers enter the production area, or when the supervised individuals enter the living area without the presence of the designated number or more supervisors in the same area, an unaccompanied alarm will be triggered.

Low battery label alarm

Real-time monitoring of the battery level of positioning tags is conducted. When the battery level drops below the set value, a low battery tag alarm is triggered.

Operation and Maintenance Platform 11: Trajectory Analysis and Tracking (Optional)

Multiple labels

Multi-label management, multi-speed playback, supports one-click full trajectory display.

Indoor Room

Seamless switching between indoor and outdoor trajectories, and continuous trajectories between floors.

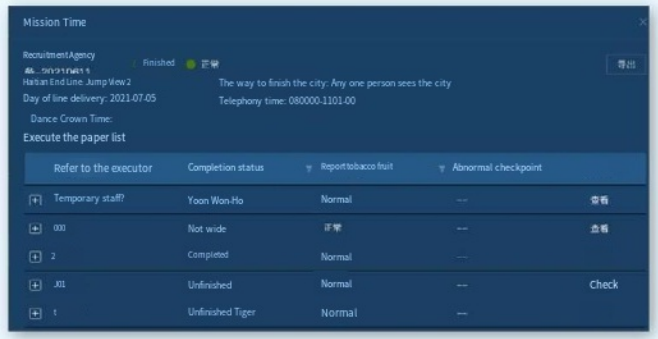
Support Press

Support playback of trajectories by positioning object or by area.

64x speed playback, second-level trajectory traceback

Real-time tracking of individual human or vehicle targets

Operation and Maintenance Platform Twelve: Intelligent Inspection



Rational allocation of inspection tasks

Support the setting of multiple inspection points and the allocation of different inspection routes, which are then issued in the form of plans to teams or individuals.

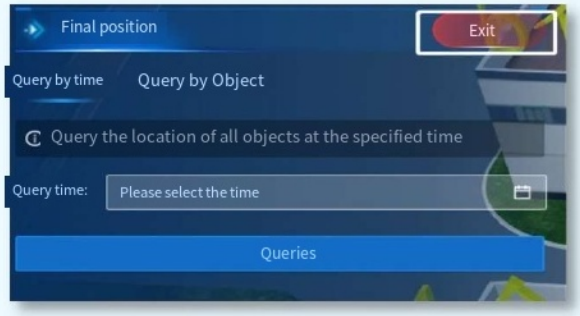
Visual presentation of inspection results

The intelligent inspection module quickly presents the completion status of daily inspection tasks, either completed or not. It supports querying inspection situations by day, task, or person through fuzzy search.

One-click export of quick reports

Support one-click export of inspection reports to facilitate work management.

Operation and Maintenance Platform 13: Final Position



Emergency Evacuation & Post-Accident Analysis

Conduct scenario-based analysis on the distribution of personnel or vehicles at a certain moment, query the location where the personnel sent their last message, and assist in formulating rescue plans after an accident.

Plan formulation

The last location where the inquirer sent a message is queried to assist in formulating the rescue plan after an accident.

Operation and Maintenance Platform 14: Trajectory Analysis and Tracking (Optional)

Multiple labels

Indoor Rooms

Support Press

Full trajectory playback, multi-speed playback, supports one-click full trajectory display.

Seamless switching between indoor and outdoor trajectories, and continuous trajectories between floors.

Support playback of trajectories by positioning object or by area.

64x playback speed, second-level trajectory traceback

Real-time tracking of individual human or vehicle targets

Looking forwa rd to cooperati ng with you.

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Official WeChat public account

Official WeChat account

Official Taobao Store