Six major factors threaten the safety of bridges

Traffic volume is continuously increasing

The standard for bridge construction is relatively low

Construction quality issues

Overweight and oversized vehicles

Natural disaster

Natural aging of materials and structures

The significance of bridge health monitoring

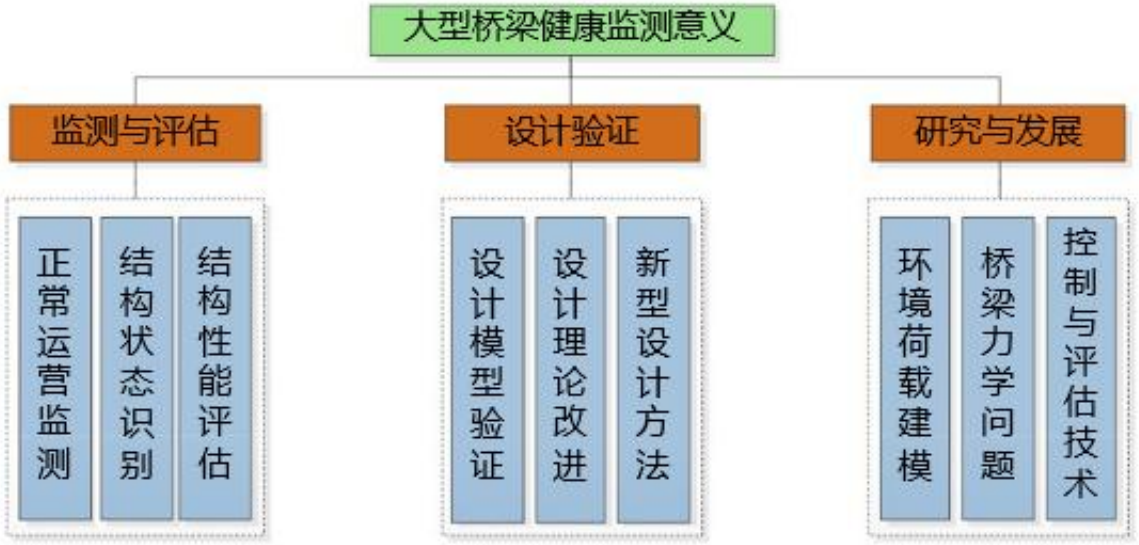
Design flaw - Tacoma Narrows Bridge

Overload - Baoshansi Bridge

Ship collision accident - Jiujiang Bridge

For important bridge structures, if the health status of the bridge structure is not monitored in real-time over a long period of time, it will be difficult to timely detect and eliminate potential safety hazards in the structure. Once the structure experiences partial failure or insufficient overall bearing capacity, it will inevitably affect the normal use of the bridge structure, and even cause catastrophic major accidents.

Therefore, to ensure the safety and durability of large bridge structures and reduce or avoid significant damage to national property and people's lives, it is a general trend and of certain significance to carry out health monitoring of large bridge structures.



The necessity of health monitoring

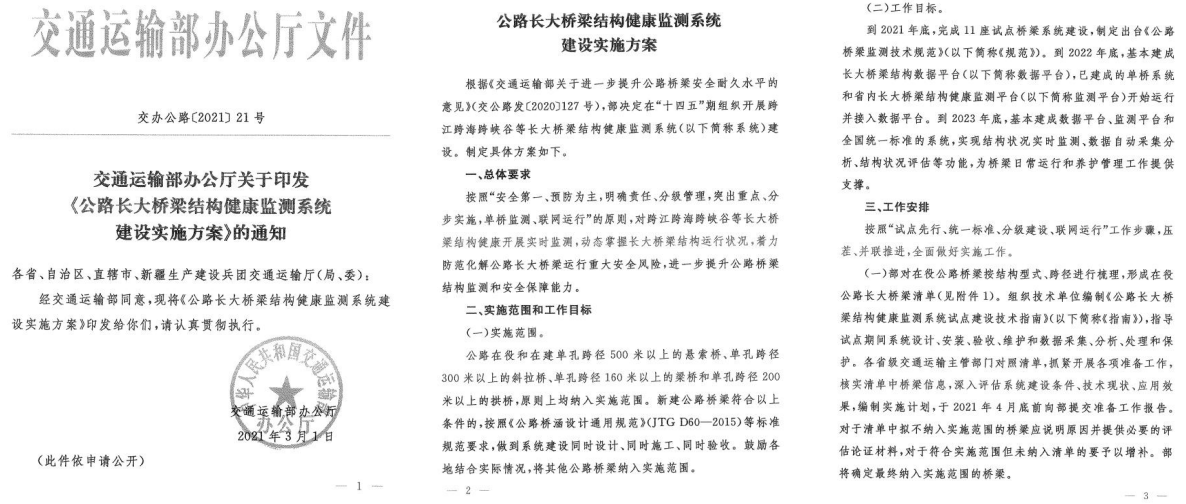
The traditional inspection method has many shortcomings, which limit its direct and effective application to the health inspection of large bridges. (i) It requires a large amount of manpower, material resources, and financial resources, and has many inspection blind spots; (ii) it is highly subjective and difficult to quantify; (iii) it lacks comprehensiveness; (iv) it affects normal traffic operation; (v) it has a long cycle and poor real-time performance

monitor check diagnosis repair

Monitoring requirements

According to the requirements of the specifications, the following bridge…

serial number	bridge type	span
1	girder bridge	＞ 150 meters
2	cable-stayed bridge	>300 meters
3	suspension bridge	>500 meters
4	arch bridge	>200 meters



交通运输部办公厅文件

交办公路〔2021〕21号

交通运输部办公厅关于印发《公路长大桥梁结构健康监测系统建设实施方案》的通知

各省、自治区、直辖市、新疆生产建设兵团交通运输厅（局、委）：

经交通运输部同意，现将《公路长大桥梁结构健康监测系统建设实施方案》印发给你们，请认真贯彻执行。

交通运输部办公厅

2021年3月1日

（此件依申请公开）

— 1 —

公路长大桥梁结构健康监测系统建设实施方案

根据《交通运输部关于进一步提升公路桥梁安全耐久水平的意见》（交公路发〔2020〕127号），部决定在“十四五”期组织开展跨江跨海跨峡谷等长大桥梁结构健康监测系统（以下简称系统）建设。制定具体方案如下。

一、总体要求

按照“安全第一、预防为主，明确责任、分级管理，突出重点、分步实施，单桥监测、联网运行”的原则，对跨江跨海跨峡谷等长大桥梁结构健康开展实时监测，动态掌握长大桥梁结构运行状况，着力防范化解公路长大桥梁运行重大安全风险，进一步提升公路桥梁结构监测和安全保障能力。

二、实施范围和工作目标

（一）实施范围。

公路在役和在建单孔跨径500米以上的悬索桥、单孔跨径300米以上的斜拉桥、单孔跨径160米以上的梁桥和单孔跨径200米以上的拱桥，原则上均纳入实施范围。新建公路桥梁符合以上条件的，按照《公路桥涵设计通用规范》（JTG D60—2015）等标准规范要求，做到系统建设同时设计、同时施工、同时验收。鼓励各地结合实际情况，将其他公路桥梁纳入实施范围。

— 2 —

（二）工作目标。

到2021年底，完成11座试点桥梁系统建设，制定出台《公路桥梁监测技术规范》（以下简称《规范》）。到2022年底，基本建成长大桥梁结构数据平台（以下简称数据平台），已建成的单桥系统和省内长大桥梁结构健康监测平台（以下简称监测平台）开始运行并接入数据平台。到2023年底，基本建成数据平台、监测平台和全国统一标准的系统，实现结构状况实时监测、数据自动采集分析、结构状况评估等功能，为桥梁日常运行和养护管理工作提供支撑。

三、工作安排

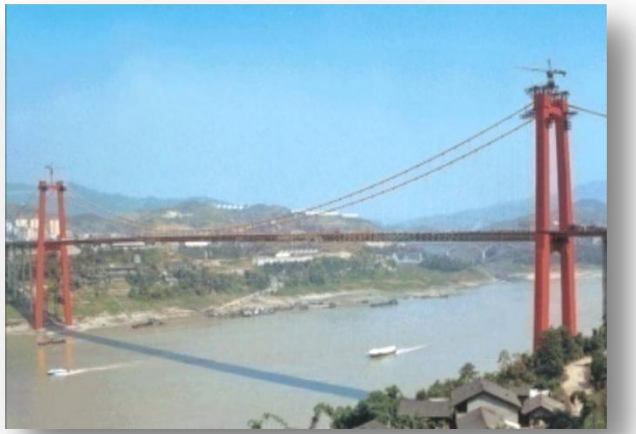
按照“试点先行、统一标准、分级建设、联网运行”工作步骤，压茬、并联推进，全面做好实施工作。

（一）部对在役公路桥梁按结构型式、跨径进行梳理，形成在役公路长大桥梁清单（见附件1）。组织技术单位编制《公路长大桥梁结构健康监测系统试点建设技术指南》（以下简称《指南》），指导试点期间系统设计、安装、验收、维护和数据采集、分析、处理和保护。各省级交通运输主管部门对照清单，抓紧开展各项准备工作，核实清单中桥梁信息，深入评估系统建设条件、技术现状、应用效果，编制实施计划，于2021年4月底前向部提交准备工作报告。对于清单中拟不纳入实施范围的桥梁应说明原因并提供必要的评估论证材料，对于符合实施范围但未纳入清单的要予以增补。部将确定最终纳入实施范围的桥梁。

— 3 —

Beam bridge (cantilever beam)

cable-stayed bridge

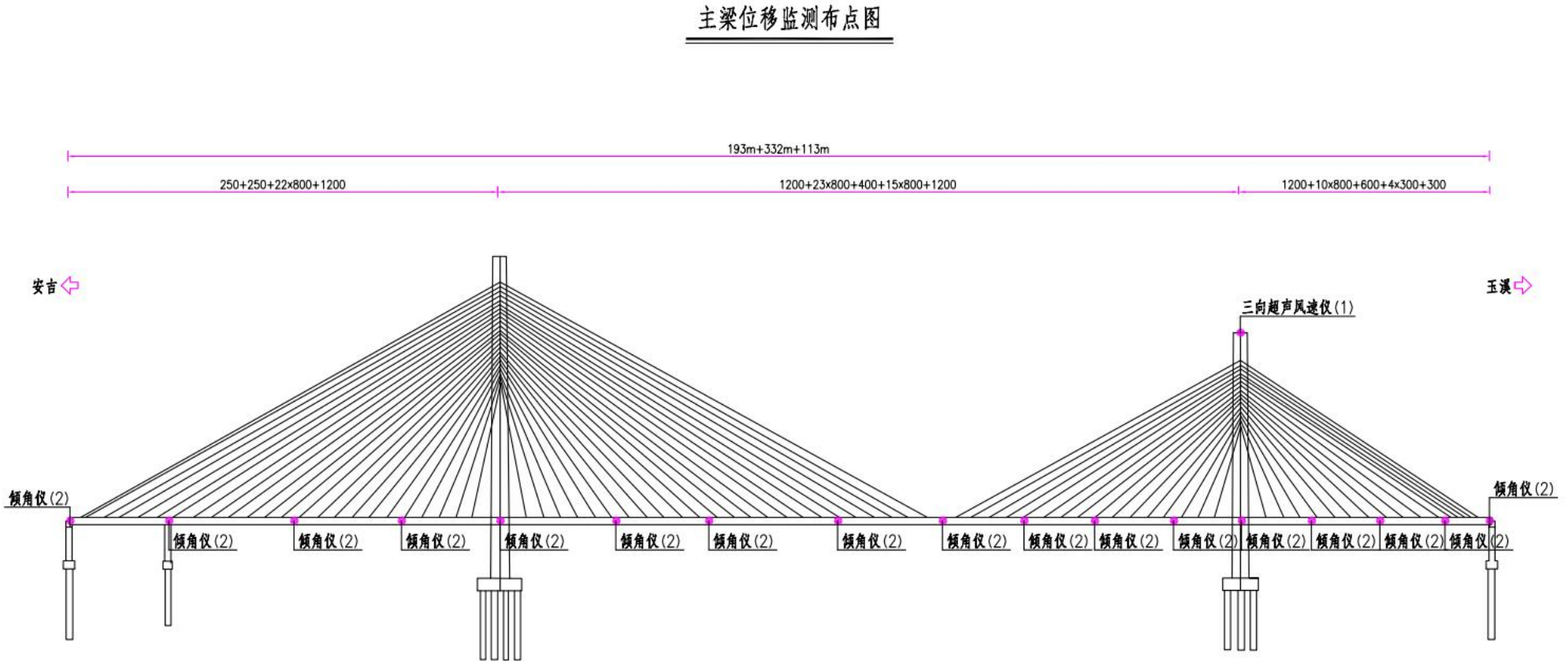


suspension bridge

Arch bridge (masonry arch bridge)

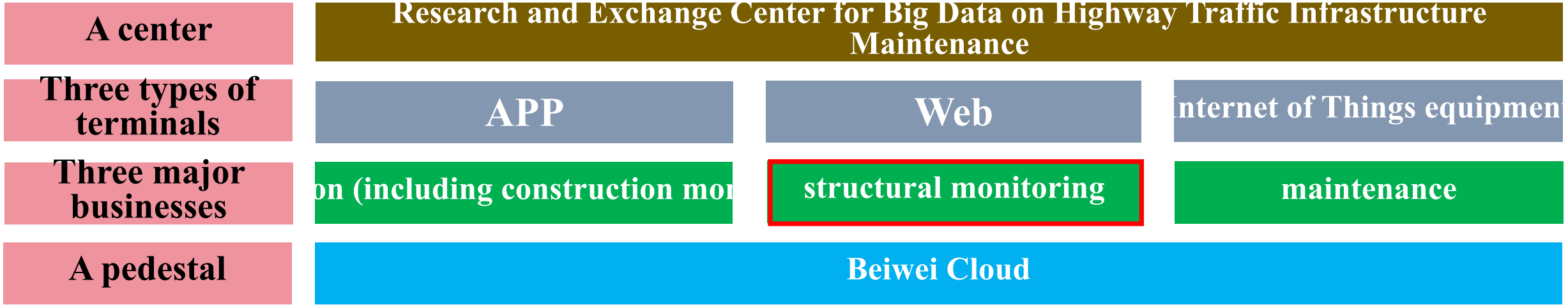
Main monitoring items

- Vehicle load, wind speed and direction, temperature and humidity, rainfall, earthquake/ship collision, structural vibration spatial displacement
- Spatial displacement, main beam deflection, inclination, expansion joint displacement, structural strain, cable tension



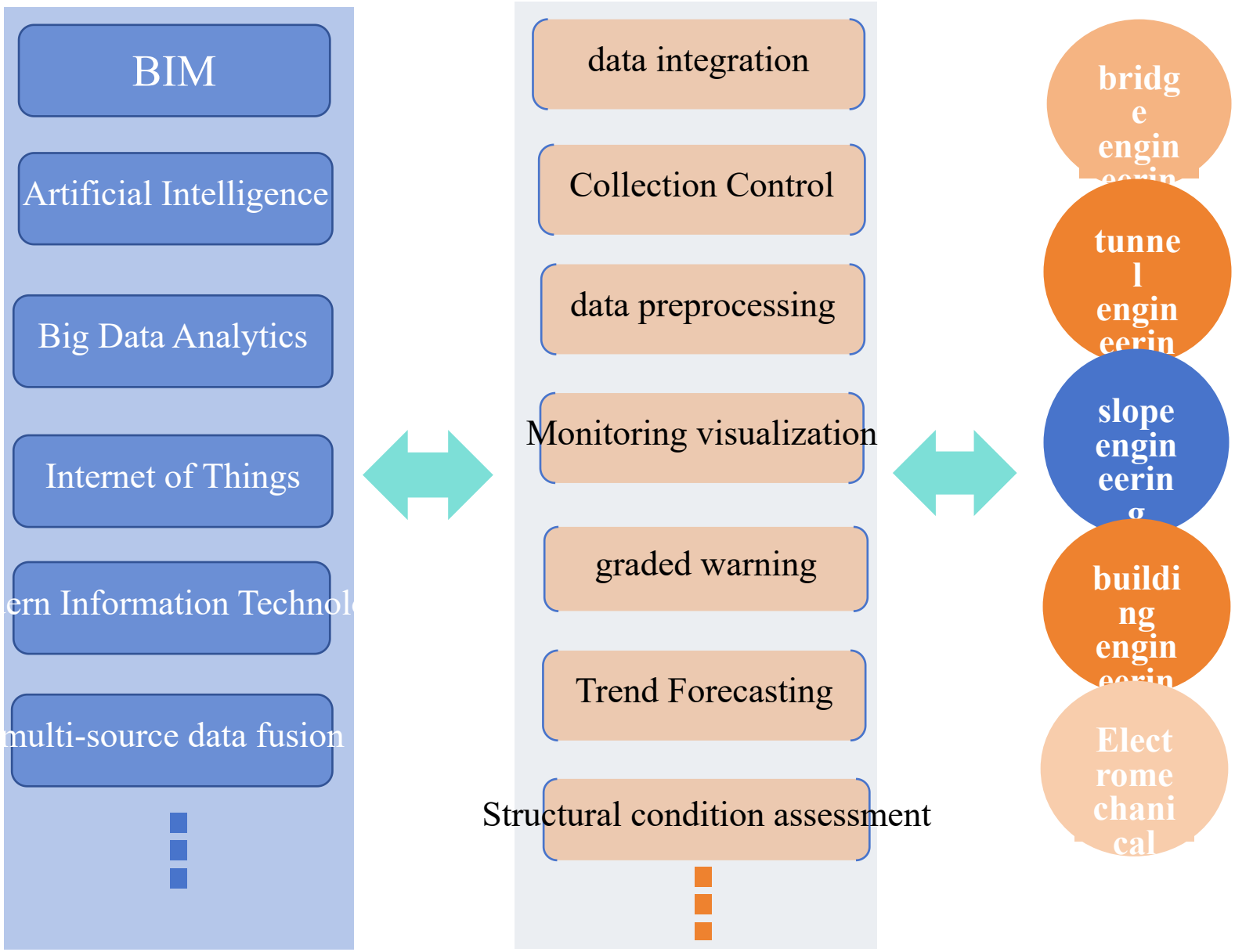
IoT Cloud Platform

Under the "1331" unified business architecture system, the IoT cloud platform integrates and fuses monitoring data with detection and maintenance data, achieving collaborative work, data connectivity, and flat management on the same platform, and laying the foundation for life cycle data analysis.



Highlights of IoT cloud platform

The IoT cloud platform, independently developed by Beimicro, integrates versatility, openness, universality, and AI+IoT+BIM.



Characteristics of IoT cloud platform

Feature 1: Versatility - A versatile Internet of Things (IoT) cloud platform integrating online monitoring for large structures such as bridges, tunnels, roadbed slopes, and architectural venues;
Feature 2: Openness - open platform integration, open data encryption, open algorithm expansion, and open device access;

Characteristics of IoT cloud platform

Feature 3: Universality - It can be widely integrated with structural monitoring devices of all types, from all manufacturers, and in all hardware networking (DTU, gateway, communication module, cloud-cloud docking) forms;

Feature 4: AI+IOT+BIM - Internet of Things + Artificial Intelligence + BIM Application Platform;

Digital Understanding of Road Management and Maintenance Business

管理和技术体系为核心，数字化平台和专业团队为支撑，实现安全通畅与增值保值！

公路运行安全通畅 | 养护资源优化配置 | 公路资产增值保障

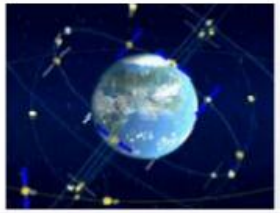
↑ 价值体现

公路资产数字化 | 路况检查智能化 | 养护决策科学化 | 养护管理精细化 | 养护作业标准化 | 服务职工人性化

↑ 具体问题

公路交通基础设施养护技术体系 | 公路交通基础设施养护管理体系

↑ 优化重构

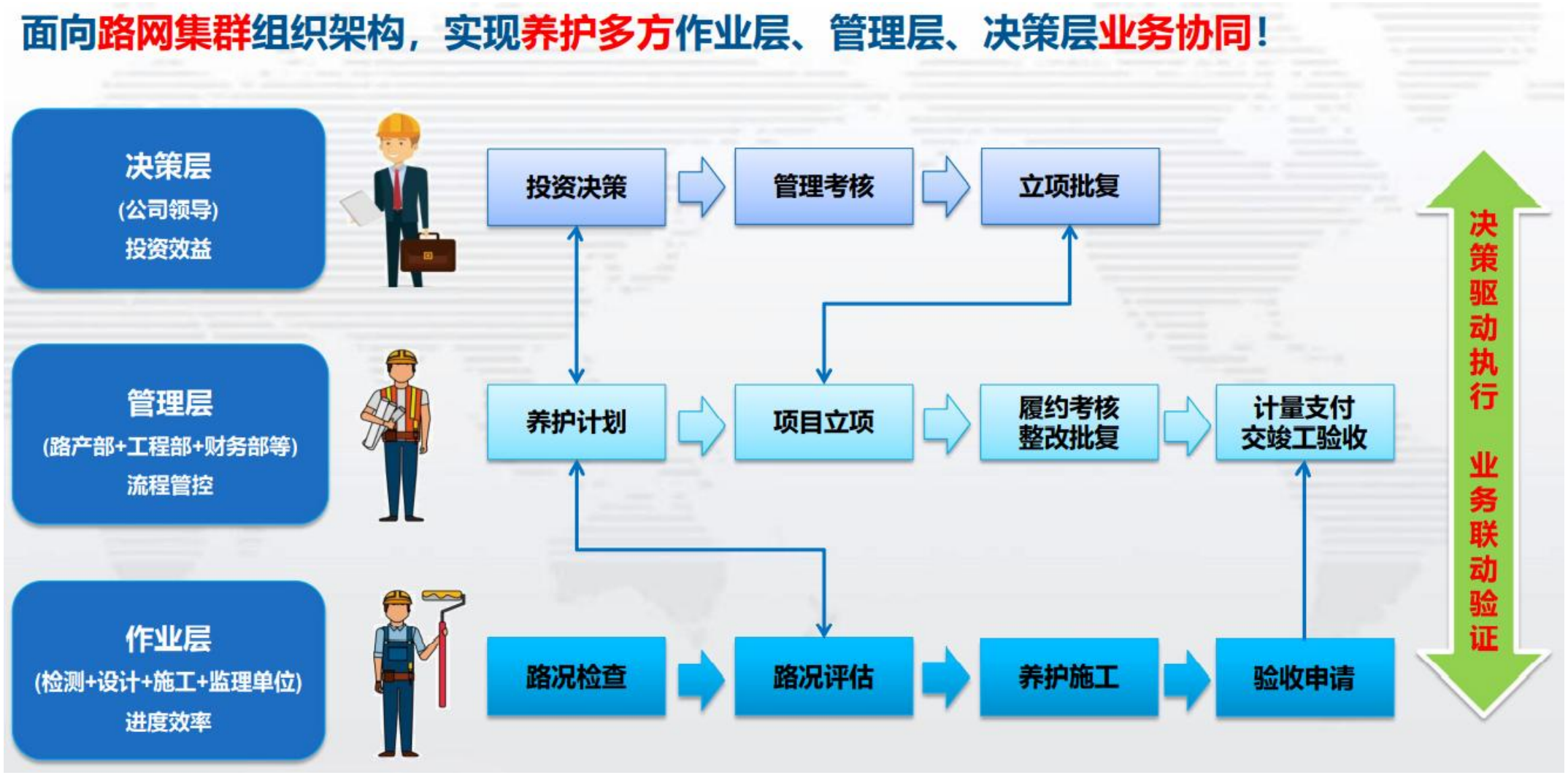




↑ 统一领导、行业监管、专业养护、质量考核

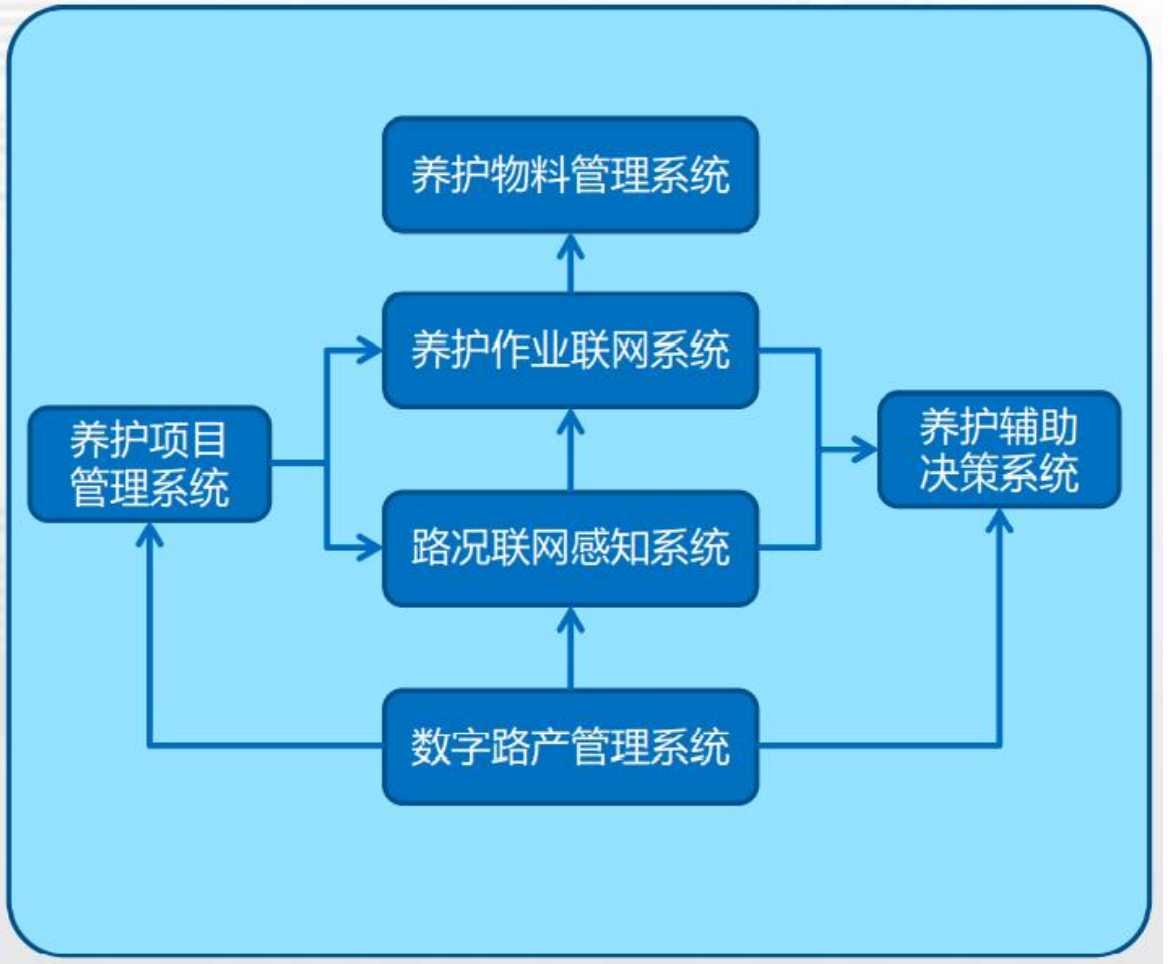
路基 | 路面 | 边坡 | 桥梁 | 隧道 | 交通工程及附属设施

Road management and maintenance business system architecture



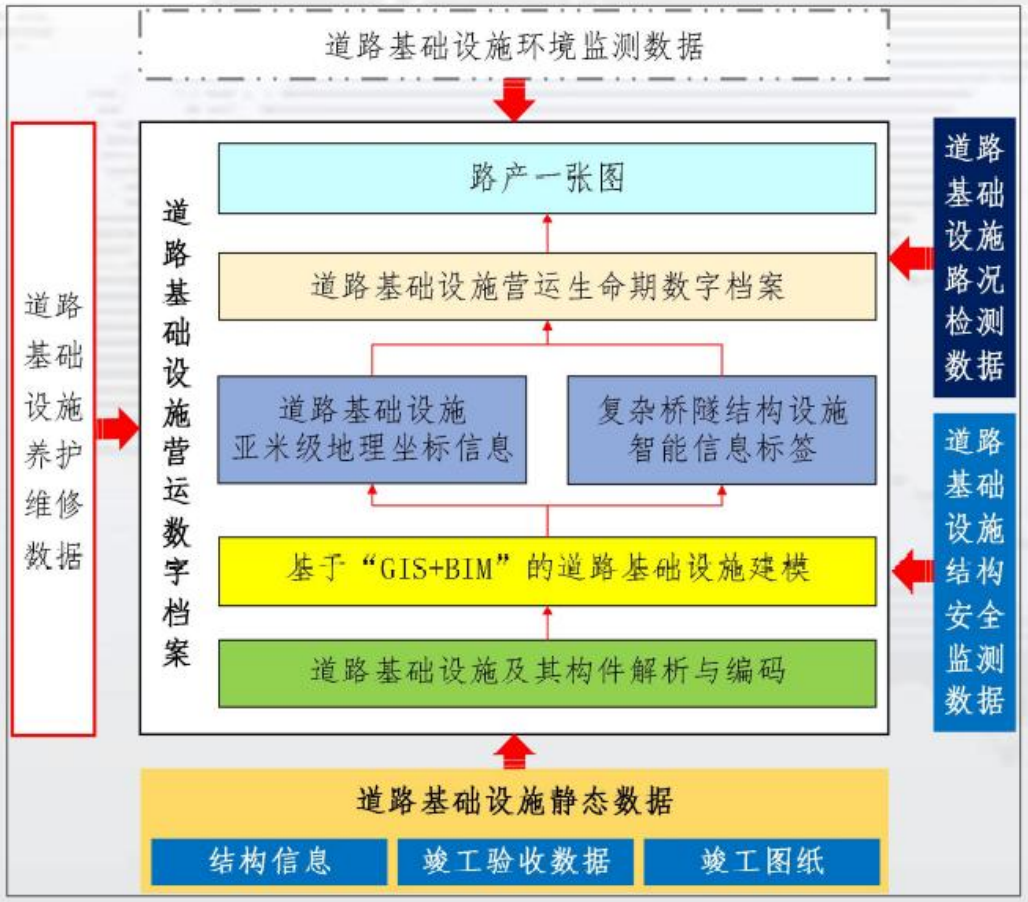
Digital platform architecture for road management and maintenance operations

面向路网集群场景，一个门户，三大终端，六大系统，实现“一网统管，一网通办”！



Digital road asset management system

全生命期数字档案：基础数据+构件编码+高精位图+智能标签+路况检测、养护维修、环境监测。



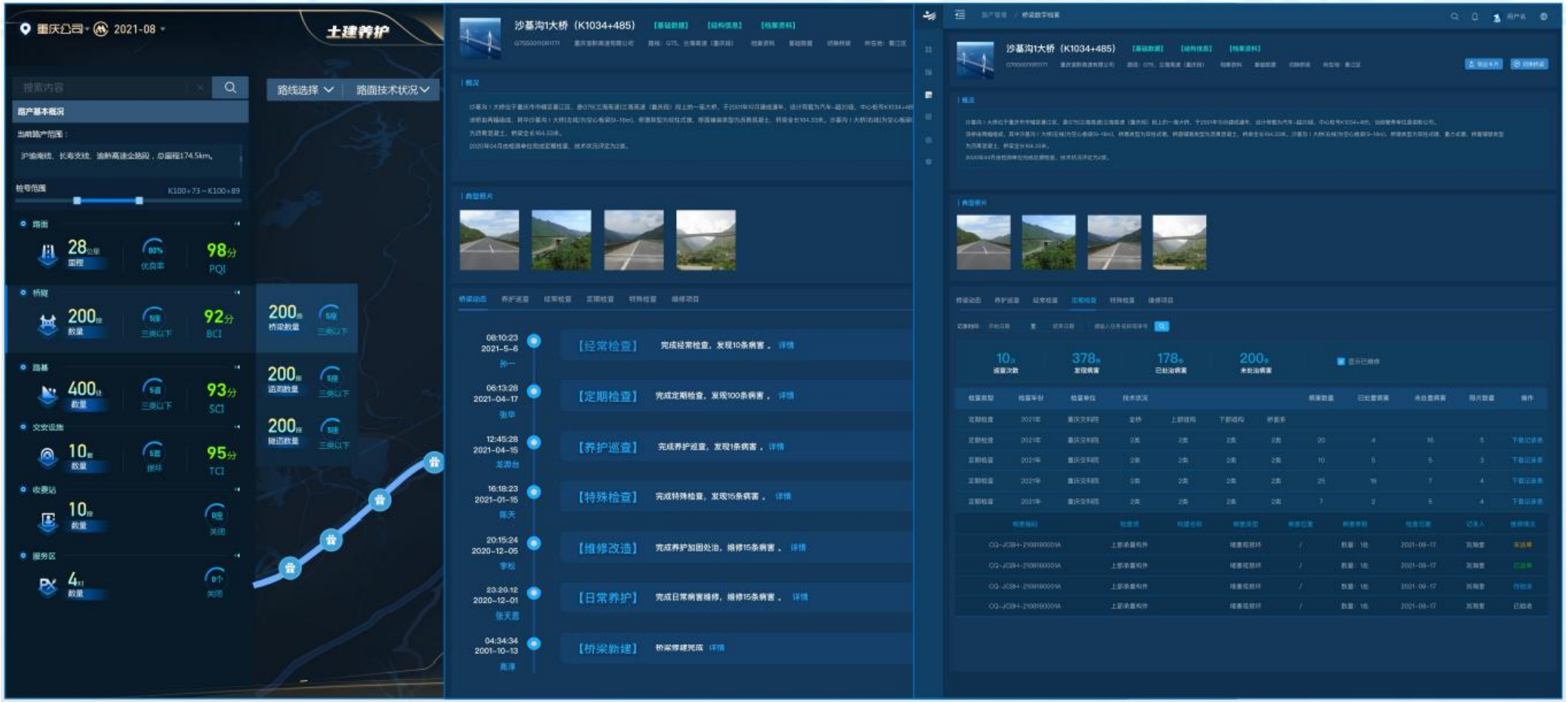
中建标标准：建设构建级主数据：道路、桥梁、隧道、交安、机电等

二维码标签

高精GIS标点

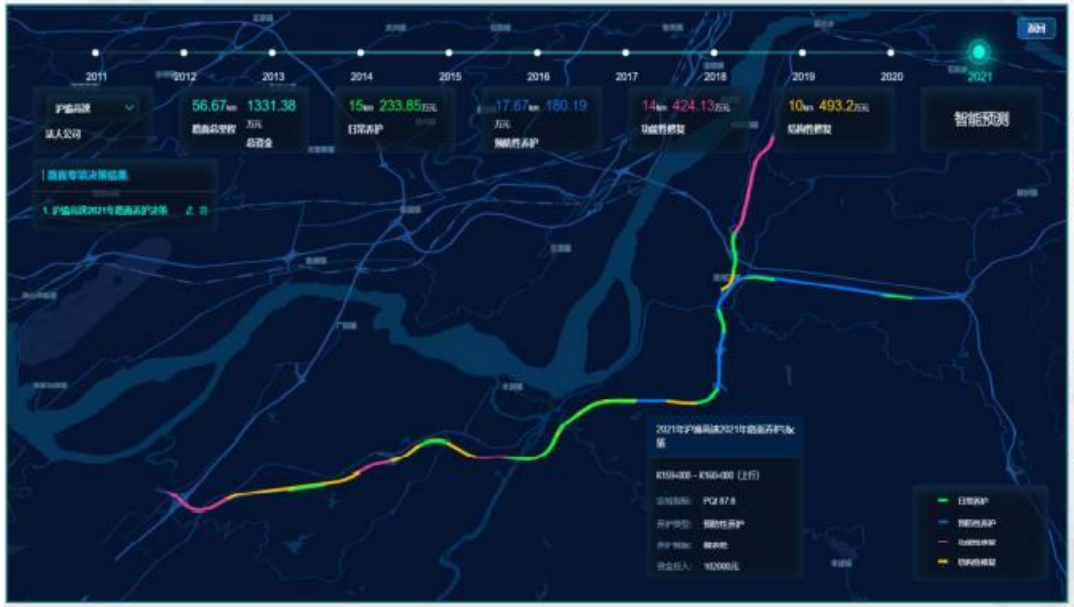
Digital road asset management system

数字路产：路况分布+养护巡查+经常检查+定期检查+特殊检查+养护维修。



Digital road asset management system

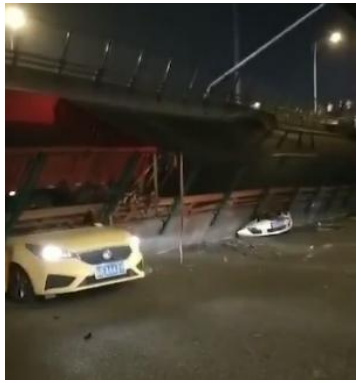
数字孪生：利用公路基础设施的GIS地图与BIM模型，结合数字档案数据，通过虚拟空间映射，实时动态反映公路基础设施全生命周期变化过程，实现公路基础设施数字孪生，实时可视、可查、可统计。

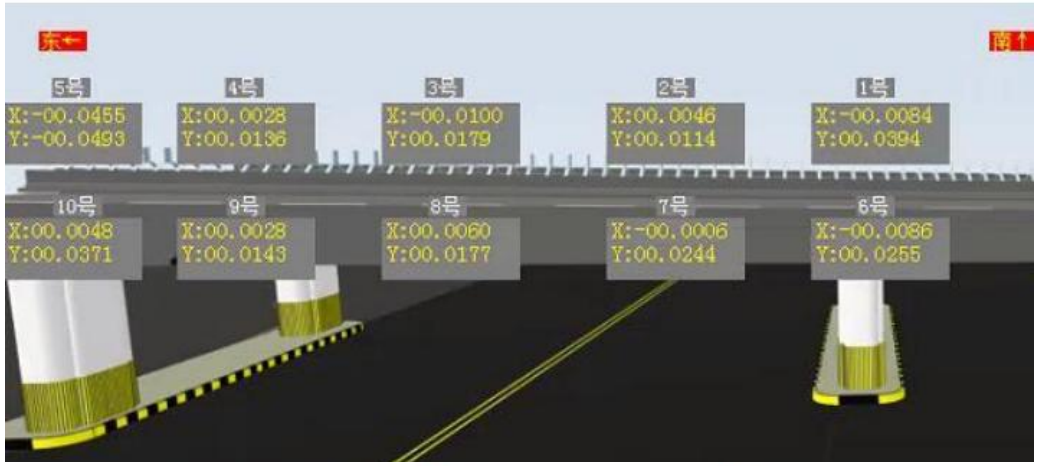


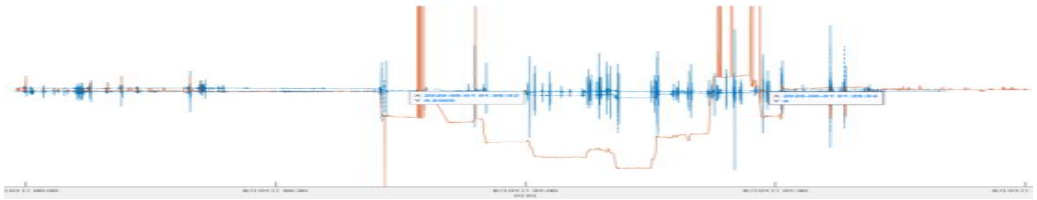
道路基础设施数字孪生

桥梁基础设施数字孪生

Typical application case - Wuxi Xicheng Road Viaduct







Project Overview

The overpass bridge on the main line of Tongjiang Avenue and Xicheng Road is located in Wuxi City and serves as an important access route to the north of the city. An auxiliary road is set up under the bridge, with a width of 9.5 meters and a clearance of 4 meters. The total length of the main overpass bridge is 1456.1 meters. Tongjiang Avenue adopts a prestressed concrete continuous box girder, which is a single box with double sections. The central pier is equipped with two independent supp…

Solution

- Product: Real-time feedback of bridge data through inclinometer equipment;
- Data: By combining on-site video footage and meteorological data, potential safety hazards can be promptly identified and early warnings issued;
- Cloud platform: Collect data through products, integrate big data platforms, and provide securit…

customer value

- Based on the angle change data, the overload status of vehicles can be known in real-time and intuitively
- Analyze deflection data to predict health conditions in advance and provide scientific reference for maintenance…

Typical application case - Jiangyin Yangtze River Bridge

Project Overview

The Jiangyin Yangtze River Bridge serves as a river-crossing passage connecting Jingjiang City and Jiangyin City in Jiangsu Province, China. It was a key construction project during China's "Ninth Five-Year Plan" period and acts as a "throat" project for the Tongjiang-Sanya National Highway Trunk Line and the Beijing-Shanghai National Highway Trunk Line in China's "two vertical and two horizontal" highway backbone network. Beiwei Sensing, in collaboration with Jiangsu Jiaotong Science and Technology Group, has established a comprehensive set of effective safety monitoring measures for bridge monitoring, ensuring the safety of the bridge.

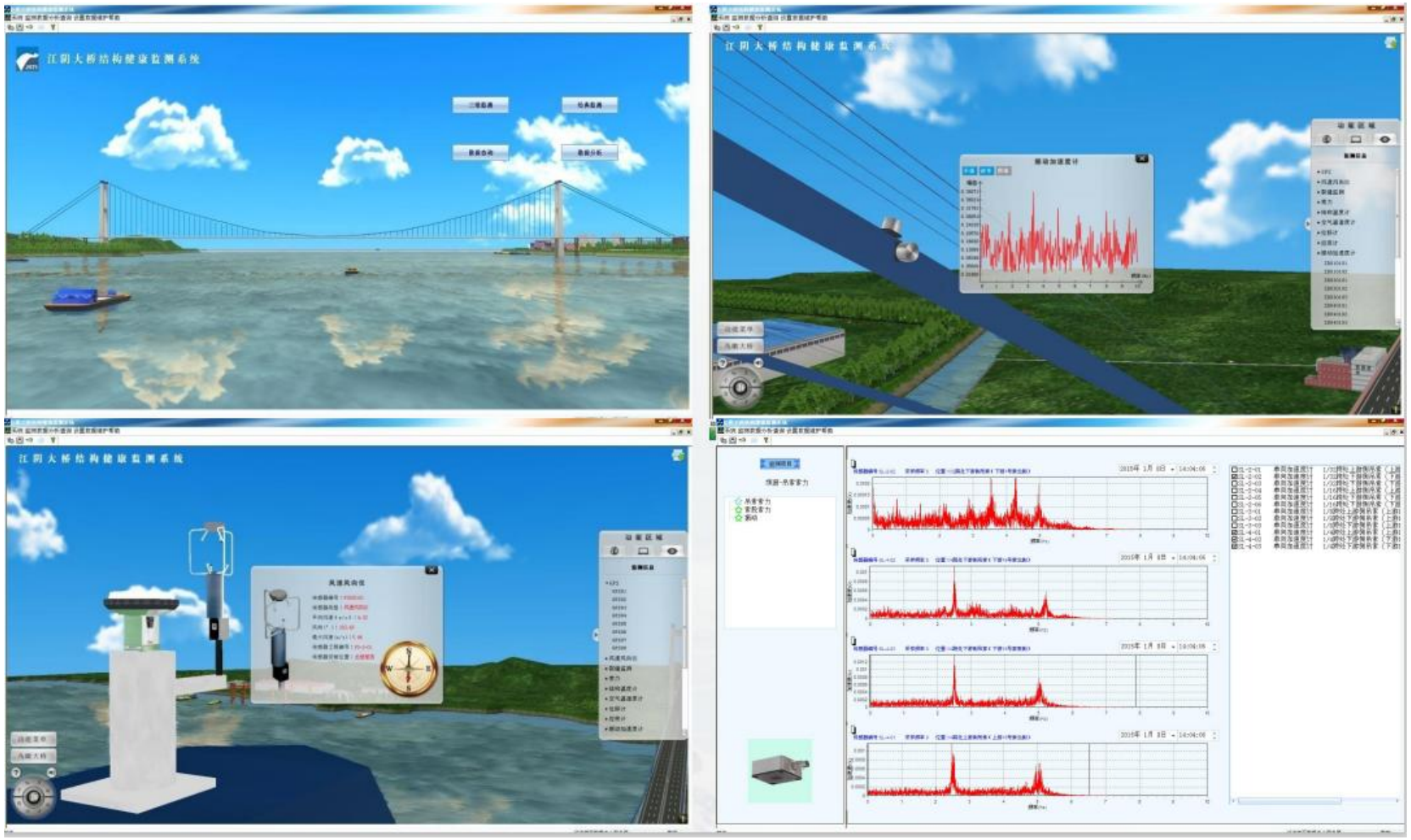
Solution

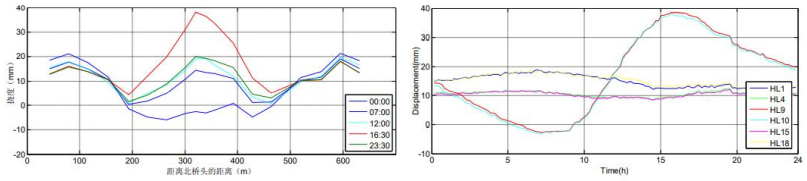
- Product: Real-time feedback of bridge data through inclinometer equipment;
- Data: By combining on-site video footage and meteorological data, we can promptly identify and issue warnings for potential safety hazards;
- Cloud platform: Collect data through products, integrate big data platforms, and provide data for security analysis and early warning

customer value

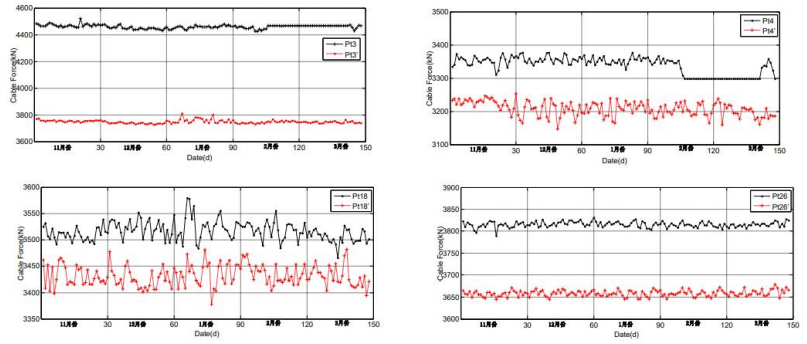
- It reduces the workload of manual patrol inspection and ensures personnel safety
- Standardized personnel and equipment management, with informationization and real-time management
- Provide early warnings to prevent safety accidents caused by hidden dangers

Typical application case - Jiangyin Yangtze River Bridge





Main beam deflection



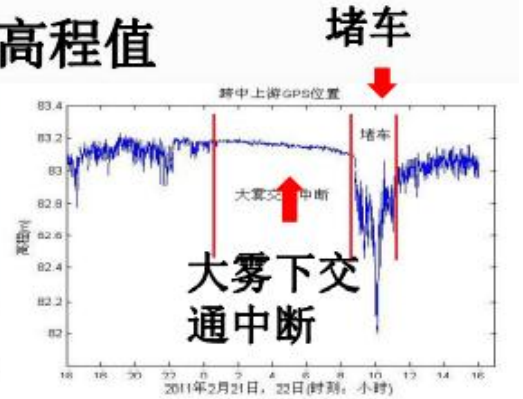
Cable force variation

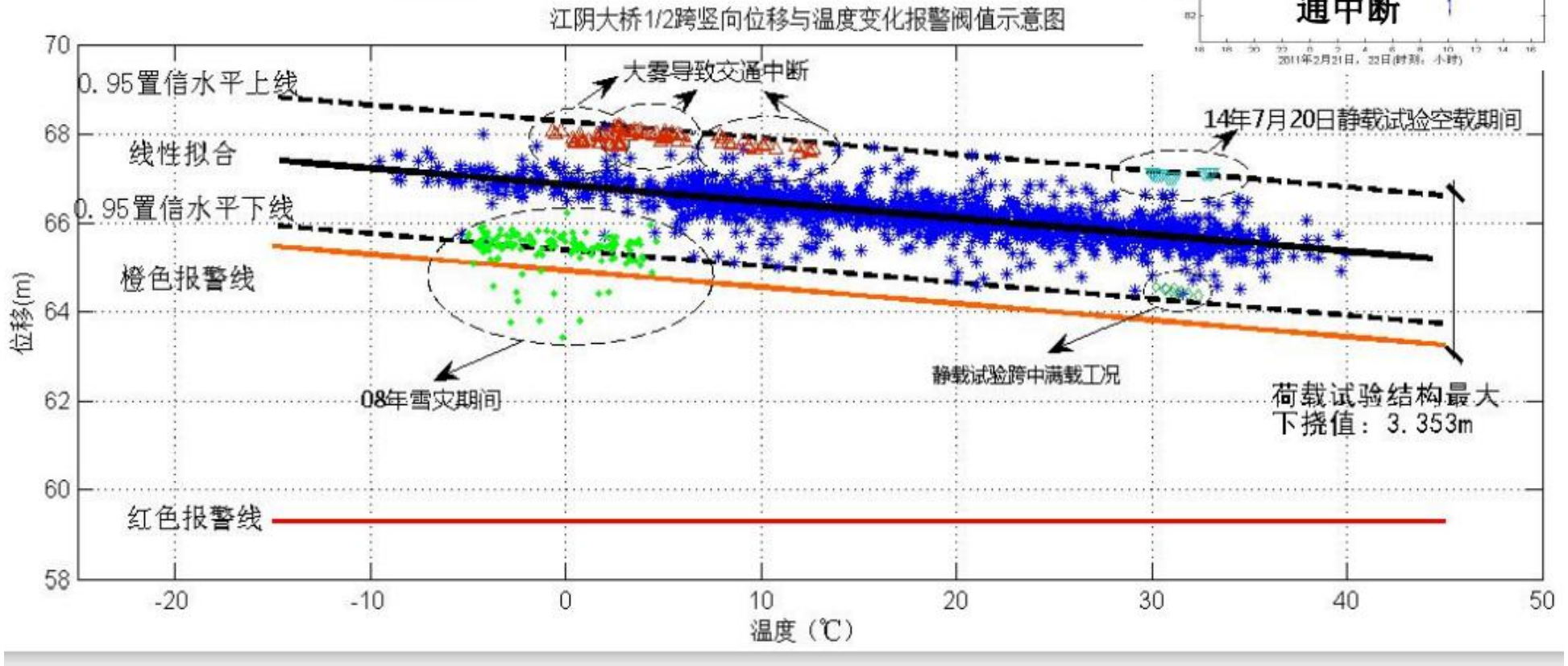
Jiangyin Yangtze River Bridge Anomaly Event - Mid-span Deflection Warning

橙色报警阈值：同环境条件下按规范最不利布载下的高程值

困难：如何消除环境影响以得到“同环境条件下”

影响因素：风、温度、车辆荷载

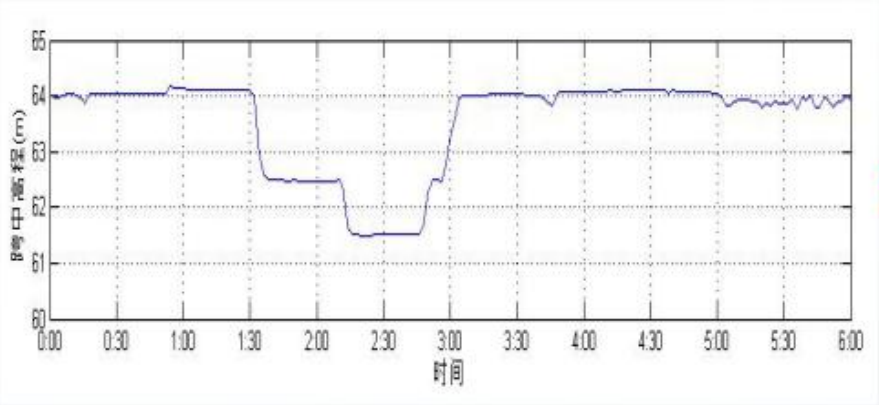


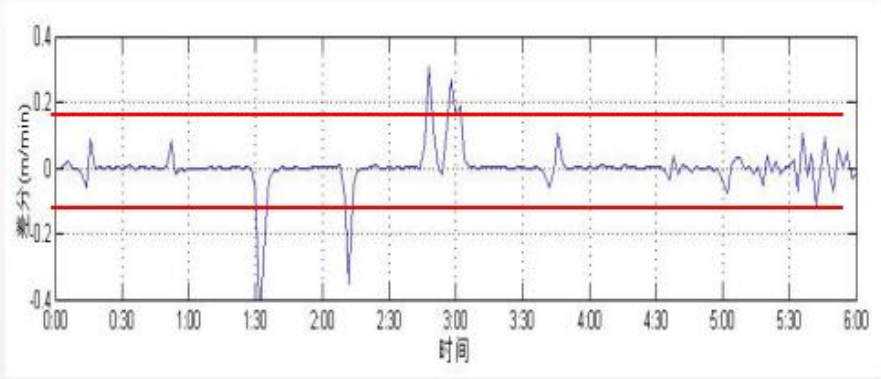


Jiangyin Yangtze River Bridge Anomaly Event - Mid-span Deflection Warning

黄色报警：每分钟挠度增长量

提高实时性的同时减少了误报率

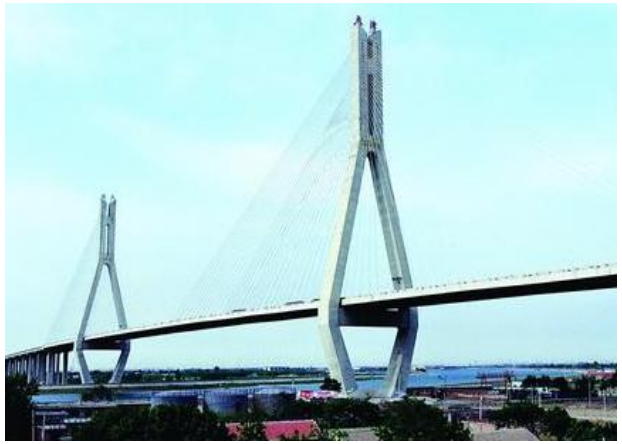




报警等级	报警指标	养护管理要求
黄色报警	挠度下降过快（堵车）差分δ>0.15m/min	1. 加强交通疏导
橙色报警	剥离温度影响后的挠度值>荷载实验值	1.暂时禁止车辆上桥，加强交通疏导 2.检查挠度过大原因，并做特殊事件分析
红色报警	规范或设计文件规定最大挠度值	1.静止车辆通行 2.对桥梁进行全面检查和安全评估

Other application cases

• Beipanjiang Bridge in Guizhou (the world's highest bridge)



• Tianjin Binhai Bridge

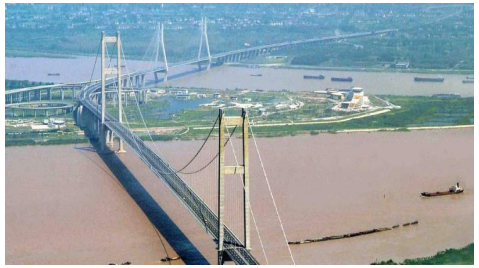
• Wuhai Lake Bridge

• Guizhou Yachi River Bridge

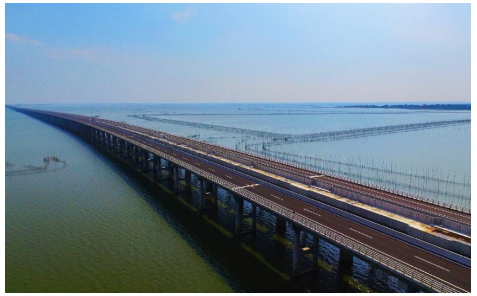
Overview of other projects

Other bridge projects that Beiwei Sensing has participated in include the Beipanjiang Bridge in Guizhou, the Yachi River Bridge, the Wuhai Lake Bridge, the Tianjin Binhai Bridge, the Dachong Yongjiang Extra-large Bridge, the Chu River Bridge in Nanjing, and so on. Based on the specific conditions of each bridge, we ensure their safety and health.

• Xintongyang Canal Extra-large Bridge



• Runyang Yangtze River Highway Bridge



• Shijiu Lake Extra-large Bridge

• Xuzhou Heping Bridge

Other application cases

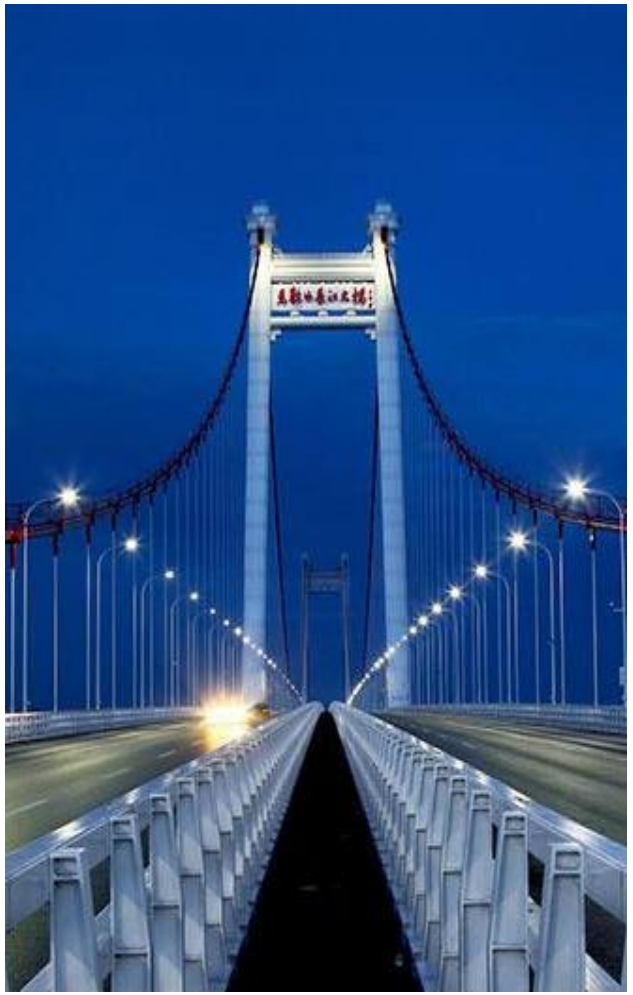
Yangzhou Beichengzi River Bridge

Guizhou Azhui River Bridge

Dachong Yongjiang Extra-large Bridge

Nanjing Chuhe River Bridge

Other application cases

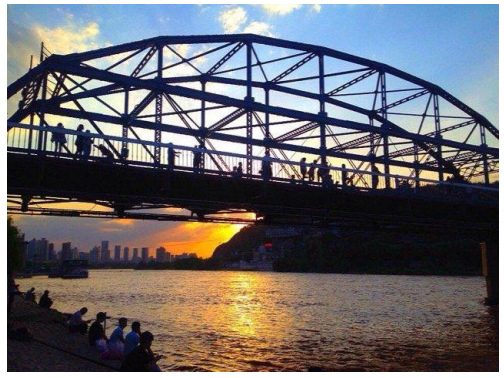


Ma'anshan Yangtze River Highway Bridge

Wuhu Second Yangtze River Highway Bridge

Changzhou Weidun Bridge

chongqi bridge



Jinta Bridge

Wuxi Huaqing Bridge

Professional evaluation

客户反馈

我们 2014 年开始与北微传感合作，构建桥梁神经系统，保障了数十座大桥的安全与健康，布设北微传感的超高精度倾角仪、并结合多年来我们开发的结构健康在线监测技术，实现了对桥梁精确的量化评价，对“疑难病症”的损伤进行早期诊断和提前发现。

——— 苏交科集团股份有限公司结构监测中心主任 赵亮

华设设计集团股份有限公司，前身为江苏省交通规划设计院；北微传感的倾角仪主要用于我司的桥梁挠度实时监测，通过倾角来计算成实时挠度。项目监测要求达到 0.1mm 的精度。这样就需要倾角传感器的精度高，长期稳定性好。北微传感的倾角仪符合我们项目的使用预期。

——— 华设设计集团股份有限公司 陈工

招商局重庆交通科研设计院有限公司是交通行业重要的科技创新型企业。招商交科下设的招商检测 - 研发中心自成立以来一直致力于交通基础设施建设和运维期在线监测领域。在此期间，与北微传感建立了深入的合作。其产品精度高、稳定性强，为基础数据的采集提供了强有力的保障。

——— 招商局重庆交通科研设计院监测中心主任 韩坤林

我单位以隧道及地下工程、工程地质与地灾防治工程、桥梁及结构工程等为优势专业，在与北微传感合作期间，在桥梁在线监测、边坡在线监测及桥梁转体过程监测中均有使用北微的倾角传感器。该公司产品精度高、性能稳定，为我单位监测平台提供了可靠、有效的数据支撑。

——— 中铁西南科学研究院有限公司 项目经理 邓长军
