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NPP RP Digital Transformation Implementation Path and Application

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1.Introduction

Q：Why should we carry out digital transformation？

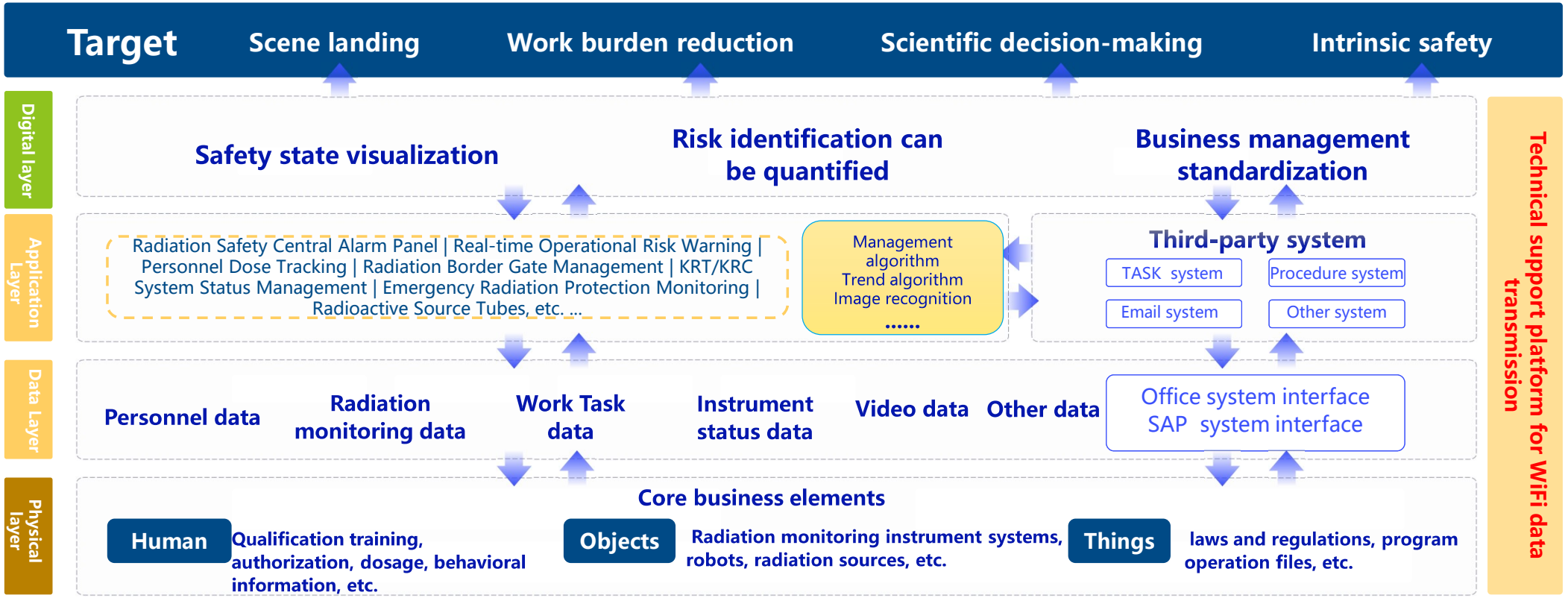
A：The core is to address **the pain points** of traditional manual management—lag, blind spots, and low efficiency. Digital technologies enable **real-time monitoring, accurate early warning, and intelligent optimization of radiation protection**, which not only strengthens the safety bottom line (reducing accidents and radiation doses) but also **improves efficiency and cuts costs**, while adapting to regulatory upgrades and industry development needs.

Useful for me! 为我所用

问题：我们为什么要进行数字化转型？

回答：核心是破解传统人工管理“滞后、有盲区、效率低”的痛点，以数字技术实现辐射防护“实时监测、精准预警、智能优化”，既筑牢安全底线（降事故、减剂量），又提效降本，同时适配监管升级与行业发展需求。

2.Path and Architecture



With the core philosophy of "data-driven, model-supported, and scenario-based implementation," Taishan Nuclear Power Plant has built a digital system from three dimensions: data acquisition networks, decision systems, and business scenario reconstruction, achieving intelligent upgrades throughout the radiation protection process.

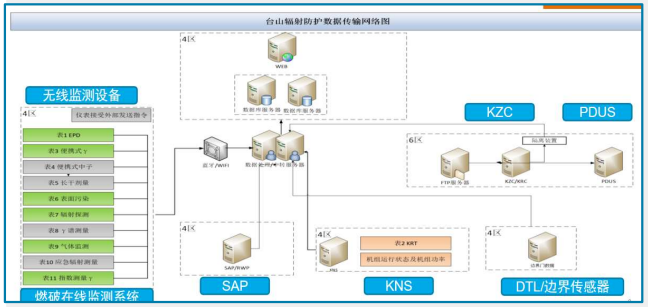
2.Path and Architecture

以“数据驱动、模型支撑、场景化实施”为核心理念，台山核电厂从数据采集网络、决策系统和业务场景重构三大维度构建起数字化体系，实现辐射防护全流程的智能化升级。

2.Path and Architecture

数据网络

Construction of Data Acquisition Network



智能平台

Intelligent Decision Support System

业务场景

Radiation Management Business Scenarios

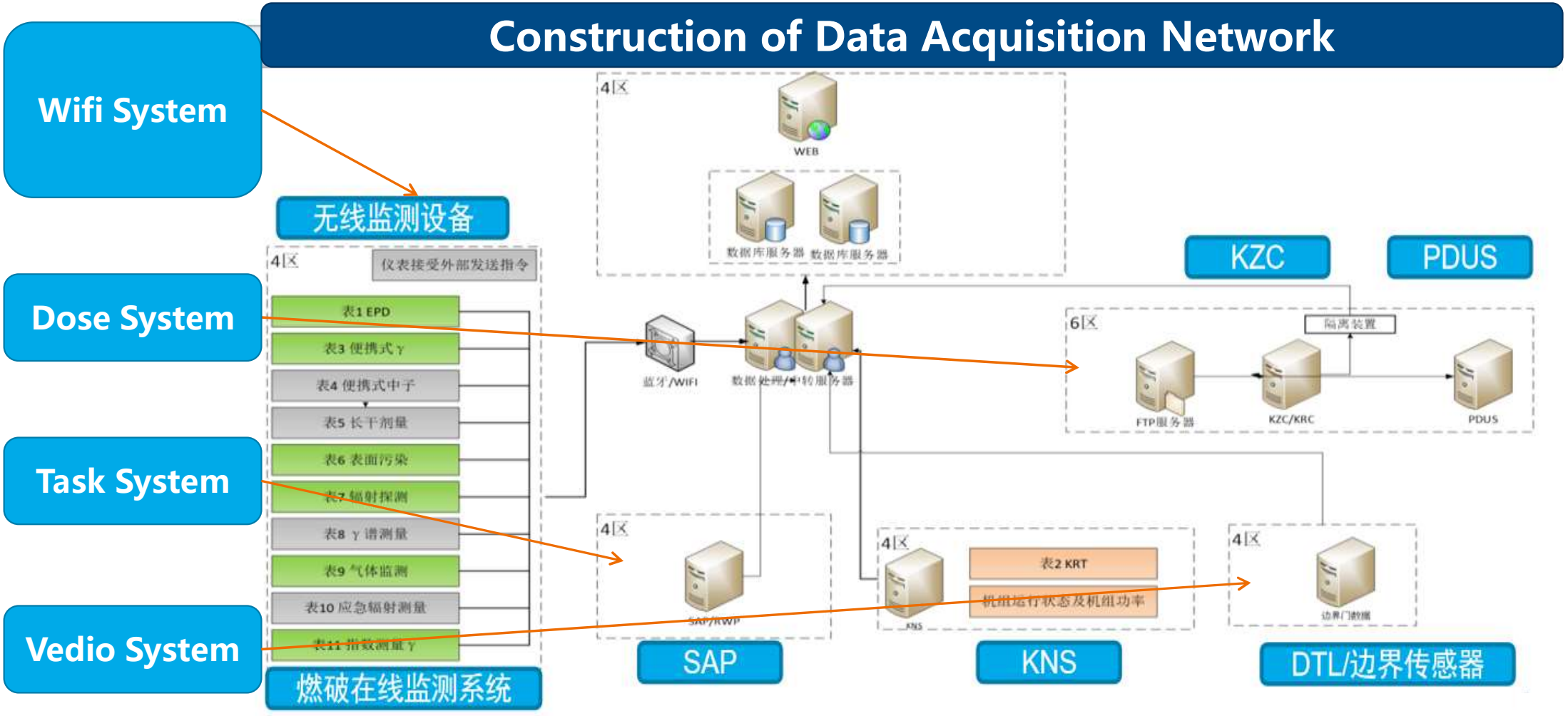
- Automated Radiation Protection Inspection and Measurement
- Radiation Protection Emergency Response and Evaluation
- In-depth Mining of Radiation Protection Data

Taishan Nuclear Power Plant has established a data foundation, aiming to address practical challenges in business operations by building an integrated platform and ultimately achieve digital transformation of its business.

台山核电厂按照“数据为底座，通过建设集成化平台解决业务场景中的实际问题”的路线，实现业务的数字化转型

2.Path and Architecture

Construction of Data Acquisition Network



2.Path and Architecture

i_RP Management Platform

轻量化3D (V-R)

KRC

RWP

RP授权系统

职业安全管理系统/其他

打通数据链路

辐射防护智慧管理平台

无线设备

C1/C2门

人员或设备实时定位

个人剂量数据实时无线传输

剂量率数据实时无线传输

防护装置数据实时无线传输

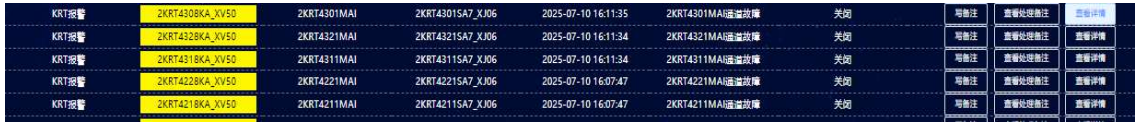
空气污染监测/报警数据实时无线传输

2.Path and Architecture

Radiation Safety Central Alarm Panel
报警盘

This platform integrates **9 key radiation protection modules** to enable centralized monitoring and backend response, achieving intelligent and digital management of radiation protection operations. Key functionalities include:

- Real-time monitoring of surveillance targets
- Recording & tracking of anomalies, with supporting evidence uploads
- Electronic document archiving to build a historical database



"One person monitoring, Multiple people responding"　一个人监盘，一群人响应

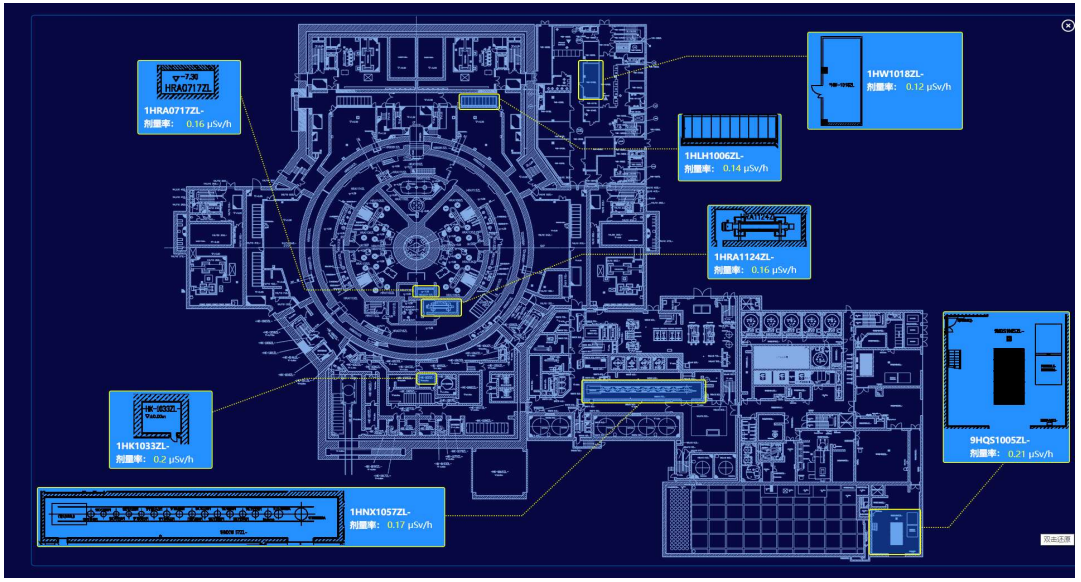
Main control room for RP　辐射防护主控室

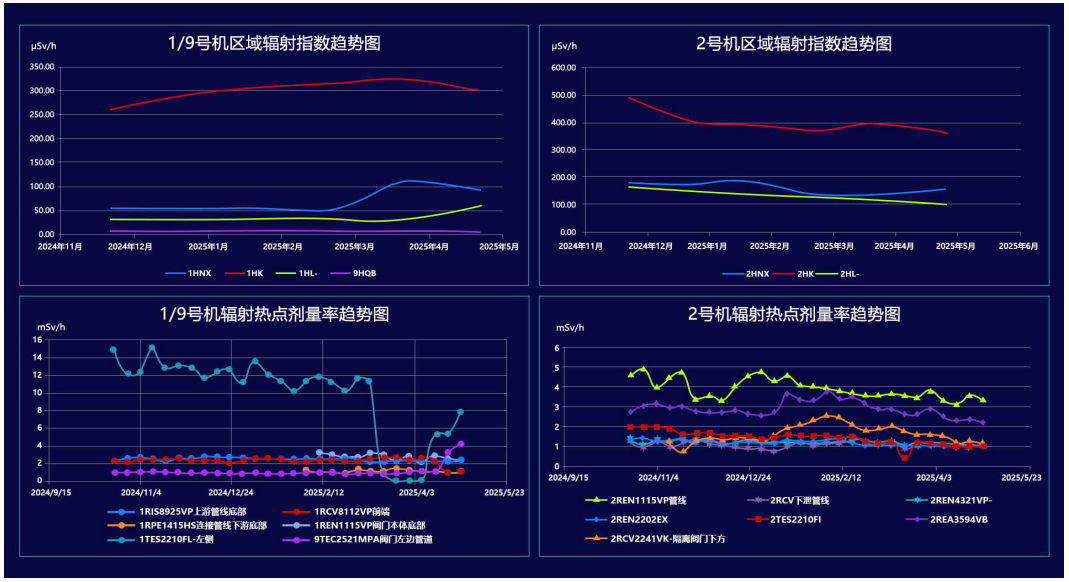
2.Path and Architecture

Radiation Management Business Scenarios

Fixed automatic monitoring terminals are installed at key points in the radiation control area (such as channel entrances, around high-radiation equipment, maintenance work areas, etc.), and the real-time uploaded measurement data provide dynamic data sources for the status monitoring panel of the i_RP platform.

在辐射控制区的关键点（如通道入口、高辐射设备周边、维修作业区等）安装固定式自动监测终端，实时上传的测量数据为i_RP平台的状态监控界面提供动态数据源



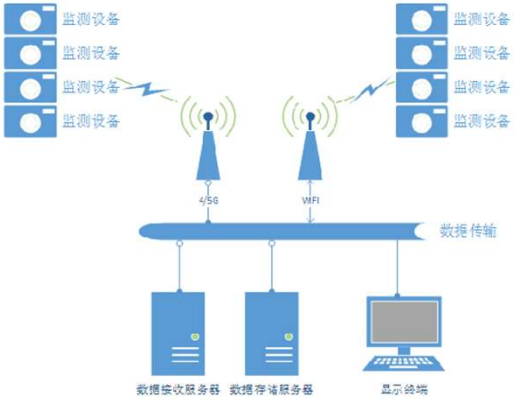


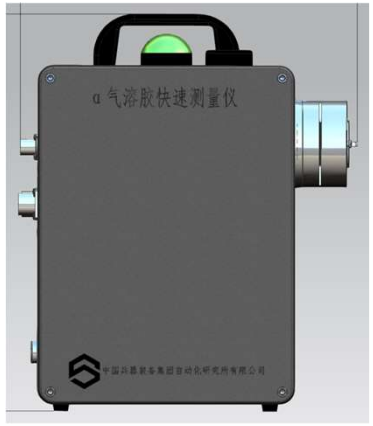
2.Path and Architecture

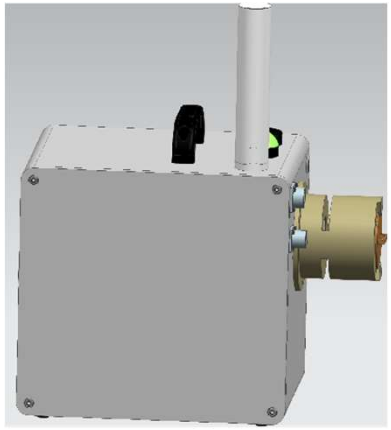
Radiation Management Business Scenarios

Taishan Nuclear Power Plant has developed a digital emergency response module and supporting rapid radiation monitoring equipment dedicated to nuclear accident emergency, which can quickly complete on-site radiation level monitoring, impact range analysis, and safety evaluation in the event of a radiation accident. Through digital means, the efficiency and accuracy of emergency response have been significantly improved, gaining critical time for accident disposal.

台山核电站开发专用于核事故应急的数字化应急响应模块，并配套建设快速辐射监测设备，能够在发生辐射事故时迅速完成现场辐射水平监测、影响范围分析及安全评估工作。借助数字化手段，显著提升了应急响应的效率和准确性，为事故处置赢得了宝贵的时间。

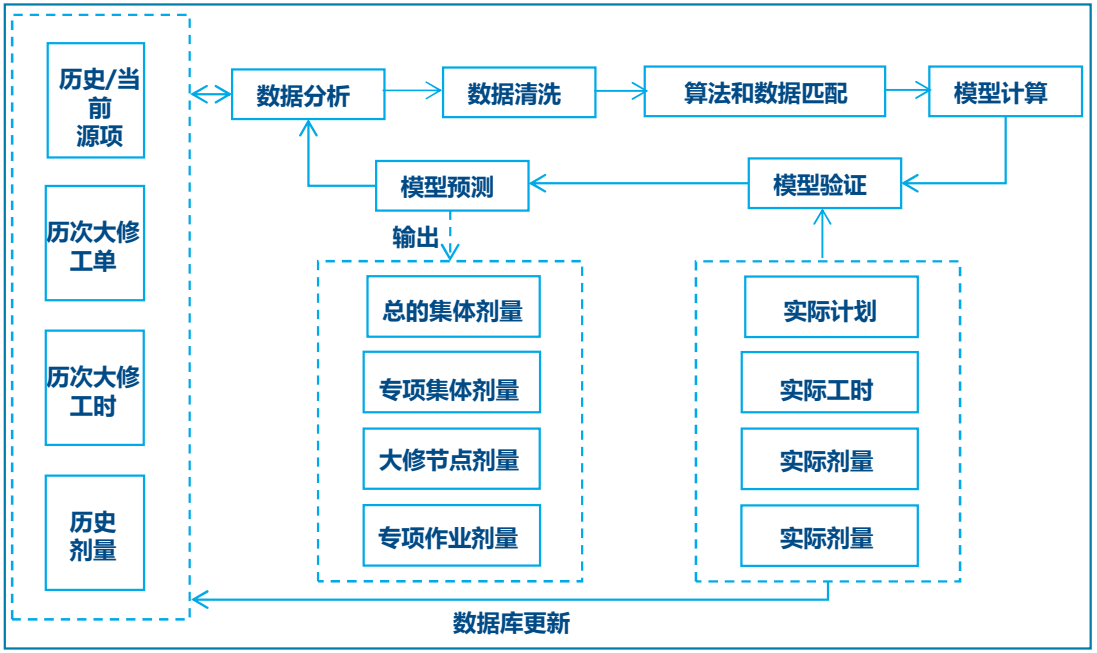






2.Path and Architecture

Radiation Management Business Scenarios



History Data | **AI**

LLM
Neural Net

Pre-Overhaul: Total Collective Dose for Overhaul
Overhaul Execution: Milestone Dose Tracking
Post-Overhaul: Analytical Summary Report
Evaluation Metrics:

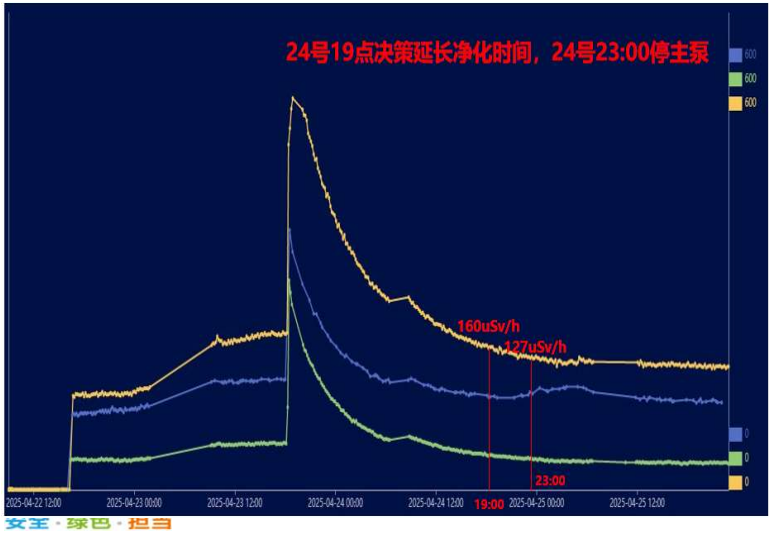
- High-Dose Task Differentiation Assessment
- Departmental Dose Control Performance Quantification
- Radiation Protection Optimization Initiatives & Proposals

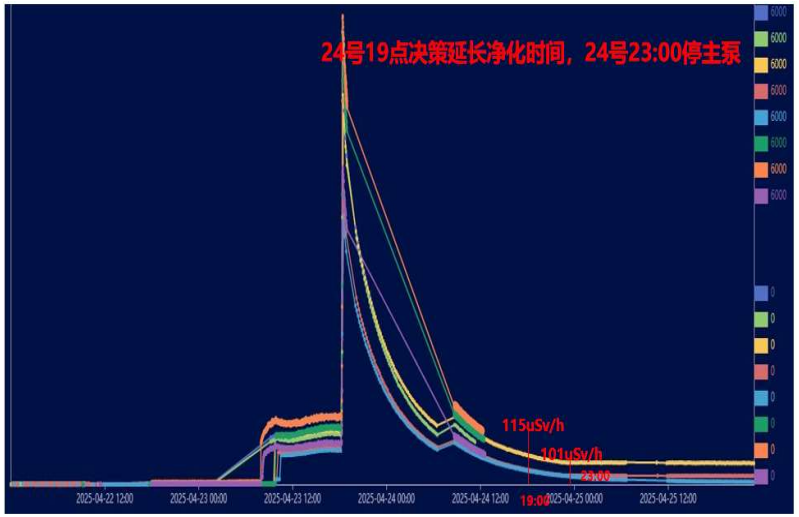
3.Effects and Values

Case 1: Wireless Monitoring for Source Term Control

During overhaul periods, the effectiveness of oxidation purification directly impacts unit radiation levels, with the duration of primary loop purification driven by the main pump being the key factor. Traditional approaches typically rely on empirical estimates of purification time, adjusted dynamically by monitoring radiochemical parameters. However, this heuristic method has a critical flaw—it lacks real-time radiation data during actual purification, making it difficult to provide scientific justification for extending main pump downtime.

The radiation source term decision-support module of the smart platform effectively addresses this issue. For example, during an overhaul at a nuclear power plant, the platform’ s **wireless monitoring module** aided in extending oxidation purification from the planned 25 hours to 29 hours (a 4-hour extension). P**ost-calculation showed a >13% reduction in unit radiation levels**, demonstrating the value of data-driven decisions in optimizing overhaul strategies and enhancing radiological protection.





Type	25h	29h	Reduction ratio
RCP index	160uSv/h	127uSv/h	20.6%
RIS index	115uSv/h	101uSv/h	13.9%
Primary Coolant Total Radioactivity	5910MBq/t	3970MBq/t	32.8%
	8413MBq/t	5790MBq/t	31.2%

Case 2: Dose tracking for important task

- The dynamic dose management during work processes is achieved through the integration of personal dose monitoring locators and the dose tracking function of the smart platform. This feature consolidates work location data with radiation monitoring equipment readings, capturing real-time cumulative dose and ambient radiation rates in the worker’ s area.
- Radiation protection engineers can use this function to track dose accumulation and regional radiation levels for specific tasks. By analyzing historical data, they can optimize protective measures, such as: Adjusting maintenance windows, Enhancing local shielding, or Deploying lead garments to high-risk zones—effectively reducing worker exposure.

RWP编码: 日期 2025-06-03 RWP分级: 请选择 作业类型: 请选择 搜索 剂量总和：4.071 剂量单位：mSv

序号	RWP编码	工单	工作内容	工作位置	执行部门	RWP分级	作业类型	本次剂量率	本次剂量
1	3762993	800006230387	TS103（总票）控制区保温总票---适用于需要申请许可证的...	TS-1-H	OPG	3		0.306	1.13
2	3831141	800006749493	反应堆压力容器卸料至装料期间工作（15.5）--下部构件吊...	TS-1-H-RA-11-01ZL	OPM	3		0.581	0.908
3	3762968	800006230388	TS103（总票）控制区脚手架总票---适用于需要申请许可证...	TS-1-H	OPG	3		0.15	0.631
4	3763786	800006225163	【T103】配合性渗透/目视/磁粉检查合票	TS-1-H-RA	OTS	3		0.243	0.22
5	3763523	800006230293	TS103：控制区场地布置及现场服务支持总票	TS-1-H	OPG	3		0.19	0.193
6	3763511	800006230292	TS103：控制区内SAS搭拆总票	TS-1-H	OPG	3		0.239	0.125
7	3837152	800006854419	【切割打磨一级作业】【T103】核级焊缝排查RT发现1RCP...	TS-1-H	OPM	3		0.075	0.117
8	0000189		（大修）安全人员专用（RP/IS/专职安全员）					0.439	0.078
9	3770528	800006239167	【子票】【仿A】配合：静机冲洗管线，请配合拆装MD	TS-1-H-NX-01-59ZL	OPM	1		0.077	0.076
10	3832315	800006776795	【预案】【T103子票】静机重新设置1RRI8221VN-请仪表...	TS-1-H-LI-10-04ZL	OPI	0		0.173	0.076
11	3799632	800006466333	【简单工单】HBC放射性废物卸车、打包、装箱、钢箱吊装...	TS-0-H-BC-04-36ZL	OPG	3		0.133	0.062
12	3795441	800006355067	【预案】【T103】配合：T1RCV6220EX-内部VT检查需割...	TS-1-H-RA-11-24ZL	OPM	3		0.516	0.061
13	3828774	800006750855	T103：核岛QC辐射防护RWP总票	TS-1-H	OPM	3		0.159	0.061

Case 3: Work burden and Human Error reduction

For Example：

■ **KRT Automatic Patrol System**

- **Legacy mode:** Manual log compilation/review required ~2 man-hours/day (730 man-hours/year).
- **Smart platform:** Automated email alerts reduce approval time to negligible levels, achieving >98% efficiency gain.

■ **Overtime Personnel Management**

- **Legacy mode:** Daily manual checks via KRC system consumed ~2 man-hours/day (730 man-hours/year, intensifying during outages).
- **Smart platform:** Real-time alarm panel monitoring eliminates manual intervention, delivering ~100% efficiency improvement.

■ **Dose Management**

- **Legacy mode:** SAP-based manual dose aggregation (e.g., daily/individual/project-specific doses) required ~20 man-hours/day (1,800 man-hours/year during outages).
- **Smart platform:** Rule-based auto-calculation (RWP/date/personnel filters) provides instant visualization, achieving >99% time savings.

4.Conclusion and Outlook

The practice of Taishan Nuclear Power Plant demonstrates that the digital transformation of nuclear radiation protection must follow a **"data-driven, model-supported, scenario-implemented"** approach. By integrating technologies and restructuring operations, it achieves dual enhancement in both safety and efficiency.

Looking ahead, with further breakthroughs in advanced detection technologies, **precise positioning systems, and AI/machine learning**, nuclear radiation protection will evolve toward predictive protection and zero-intervention management. This will drive the industry to establish smarter, more efficient radiation protection frameworks, providing robust safeguards for the safe and stable operation of nuclear power plants.

台山核电站的实践表明，核电站辐射防护的数字化转型需以“数据驱动、模型支撑、场景落地”为路径，通过技术融合与业务重构，实现安全与效率的双重提升。未来，随着新型检测技术、精准定位技术及人工智能机器学习的进一步突破，核电站的辐射防护将朝着“预测性防护”和“零干预管理”方向演进，推动行业构建更加智能化、高效化的辐射防护管理模式，为核电站的安全稳定运行提供坚实保障。

Thanks