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A New Solution for Occupational Exposure Management at Nuclear Facilities Using SMARP System

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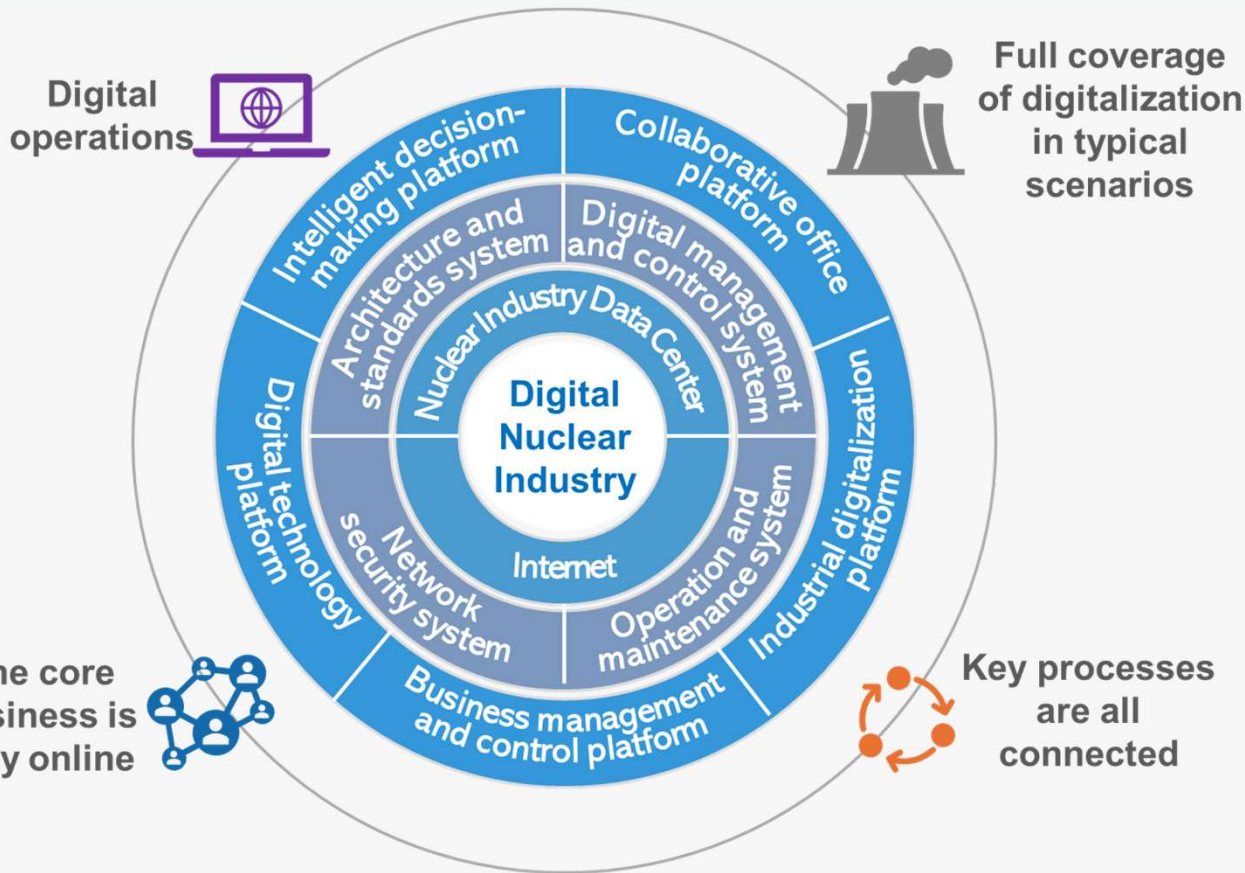
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1 Background

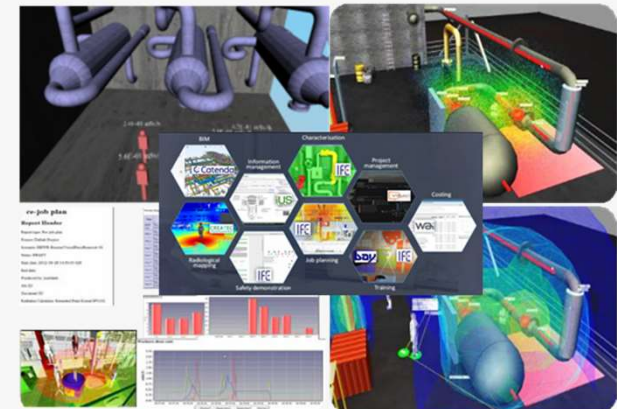
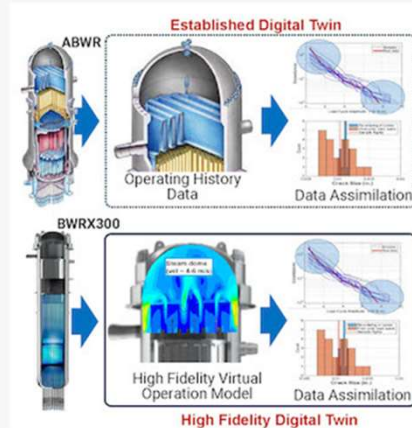
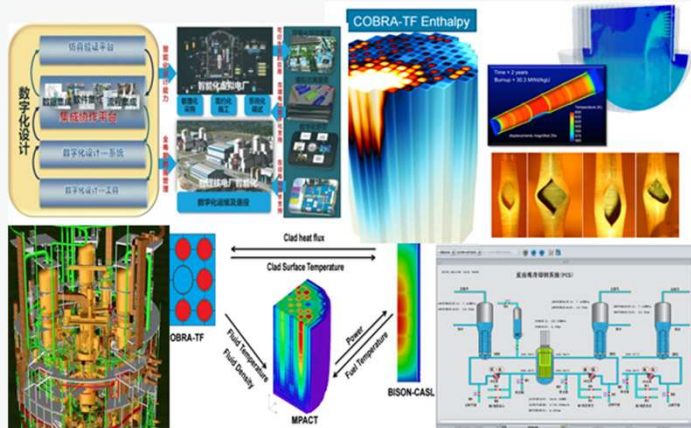
Digital Nuclear Industry



According to the digital transformation strategy of China National Nuclear Corporation (CNNC), the intelligent symbiosis between the nuclear industry and its DT in the real world is anticipated to be fully realized by 2035–2040.

1 Background

Digital technologies are used at all stages of the life cycle of nuclear facilities.



Design

- USA: CASL
- European: NURESIM
- China: Digital Reactor Project

O&M

- USA: GEMINA
- China: SMARP

Decommission

- VISIPLAN
- VRdose

Digital technology plays a significant role in improving efficiency, safety and reducing costs during the design, operation, maintenance and decommissioning of nuclear facilities.

1 Background

Radiation protection is involved in the operation and maintenance of nuclear facilities.

The main contents of radiation protection in NPPs

Radiation dose control

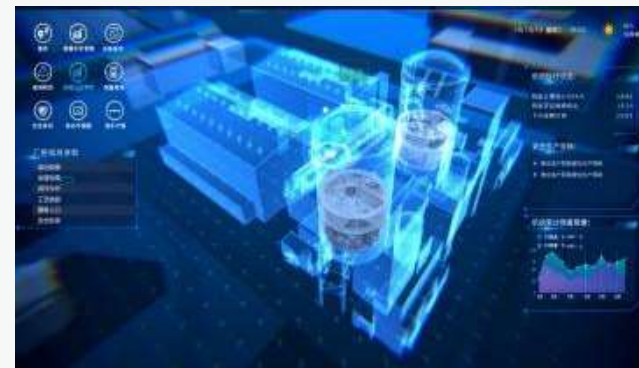
Radioactive contamination control

Radioactive material control

At present, nuclear facilities carry out radiation protection in the traditional way, and the enhancement of the effectiveness of on-site radiation protection has encountered bottlenecks. There is still much room for improvement in collective dose control, radiation risk identification and radiation protection management.



Digital Twin



Digital technology can provide strong technical support to help the radiation protection management to reduce costs, increase efficiency and improve quality.

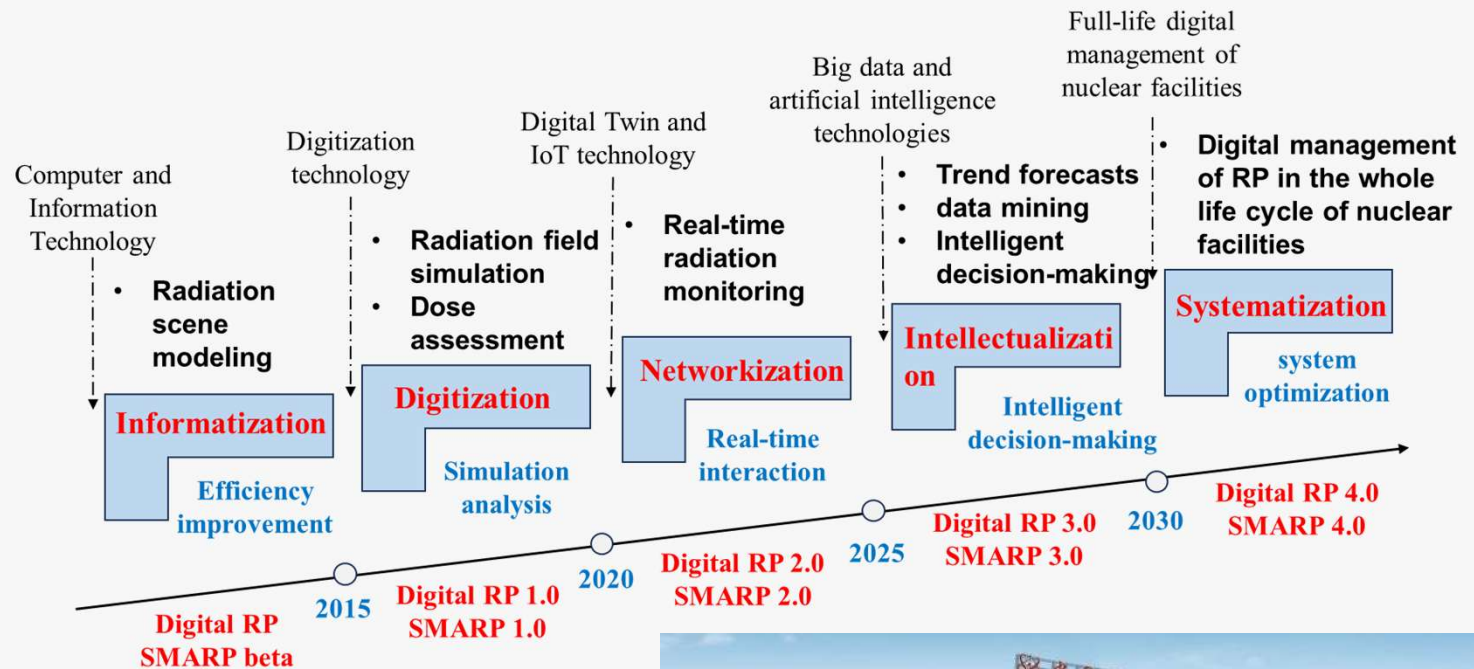
2 Digital Radiation Protection



Phased development plan of digital radiation protection

China Institute for Radiation Protection (CIRP) is the only comprehensive scientific research institution solely dedicated to the research and application of radiation protection in China since 1962.

Based on the research foundation and experience in the field of radiation protection, CIRP put forward a phased development plan for digital radiation protection, and developed a SMart Alara system for Radiation Protection, (SMARP).



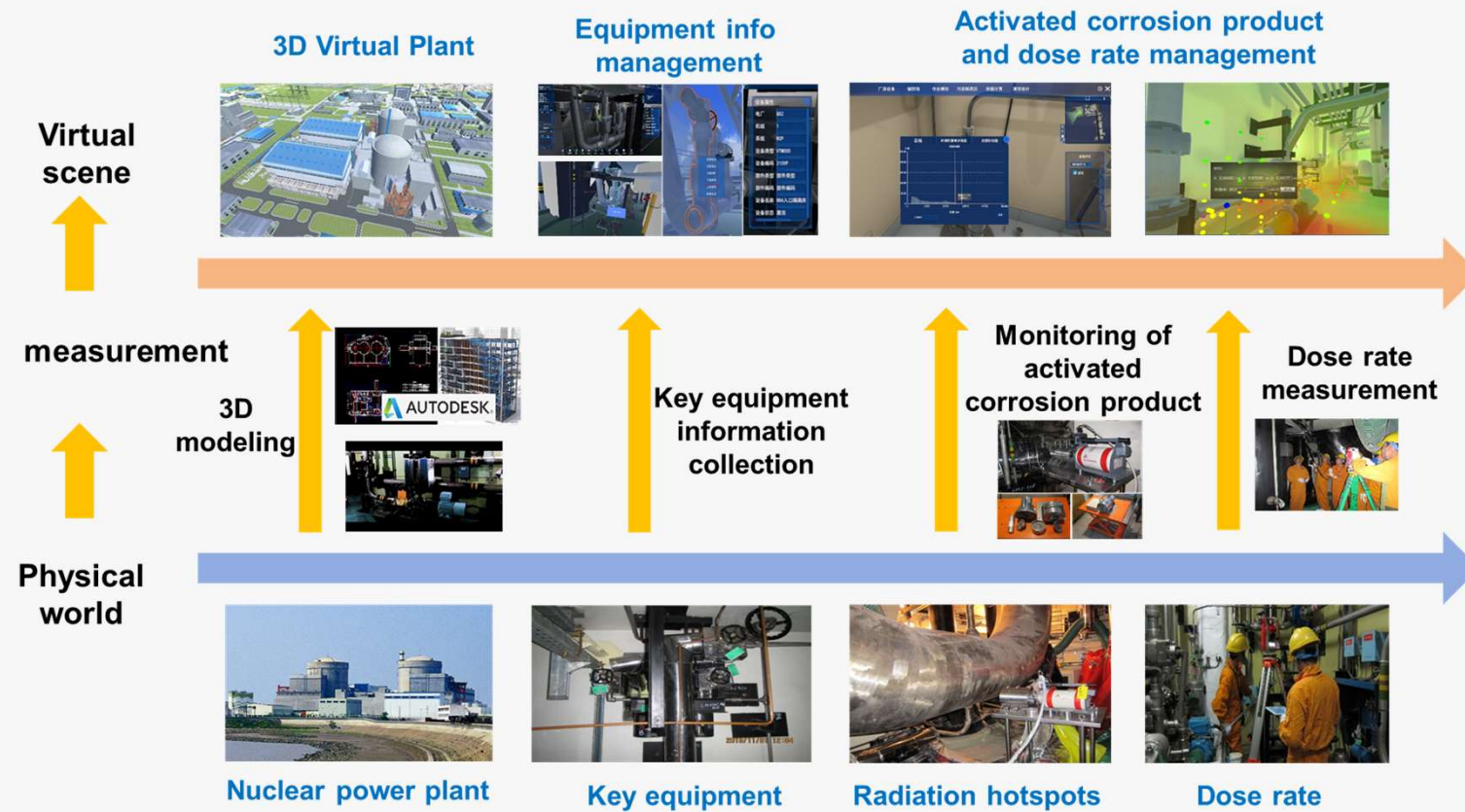
2 Digital Radiation Protection



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2.1 SMARP beta, informatization

The main work of the informatization stage is to establish a three-dimensional virtual scene through 3D modeling, visualization and other technologies, and realize the digital management of equipment, radiation hotspots, and dose rate of the nuclear facility, which effectively improves the efficiency of data interaction, display and reuse.



2 Digital Radiation Protection



2.1 SMARP beta, informatization

□ 3D modeling

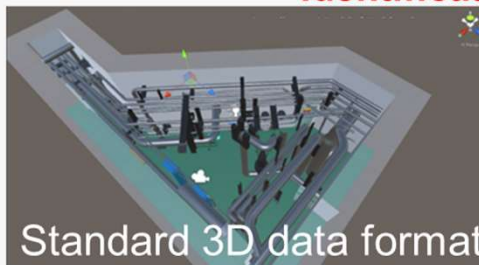
Employing 3D laser scanning technologies for visualizing and modelling the radiological working environment.



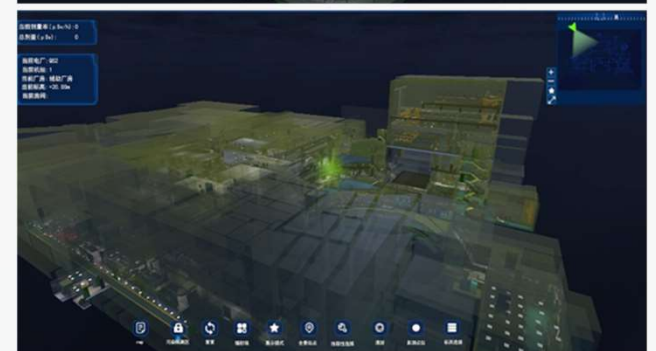
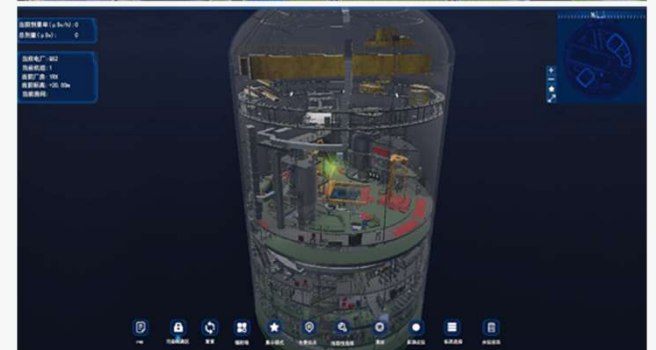
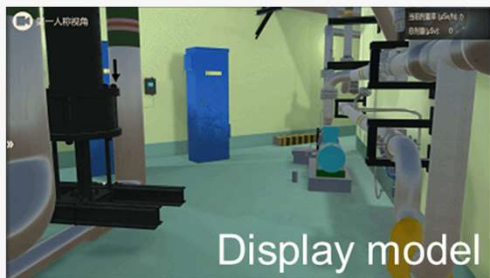
3D laser scanning



Parameter identification



Texture mapping, lighting, baking, etc



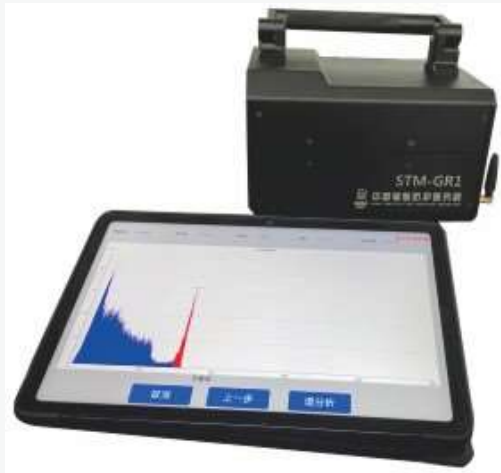
2 Digital Radiation Protection



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2.1 SMARP beta, informatization

□ Radiation field characterization



- Portable gamma spectrometer with the gamma spectrum analysis software.
- Obtaining the gamma source information in RCA.



- Radiation field measurement system consists of the total station, a dosimeter with wireless data transmission, and a PDA for data recording.
- Obtaining the dose rate of any spatial point with three-dimensional coordinate.

2 Digital Radiation Protection



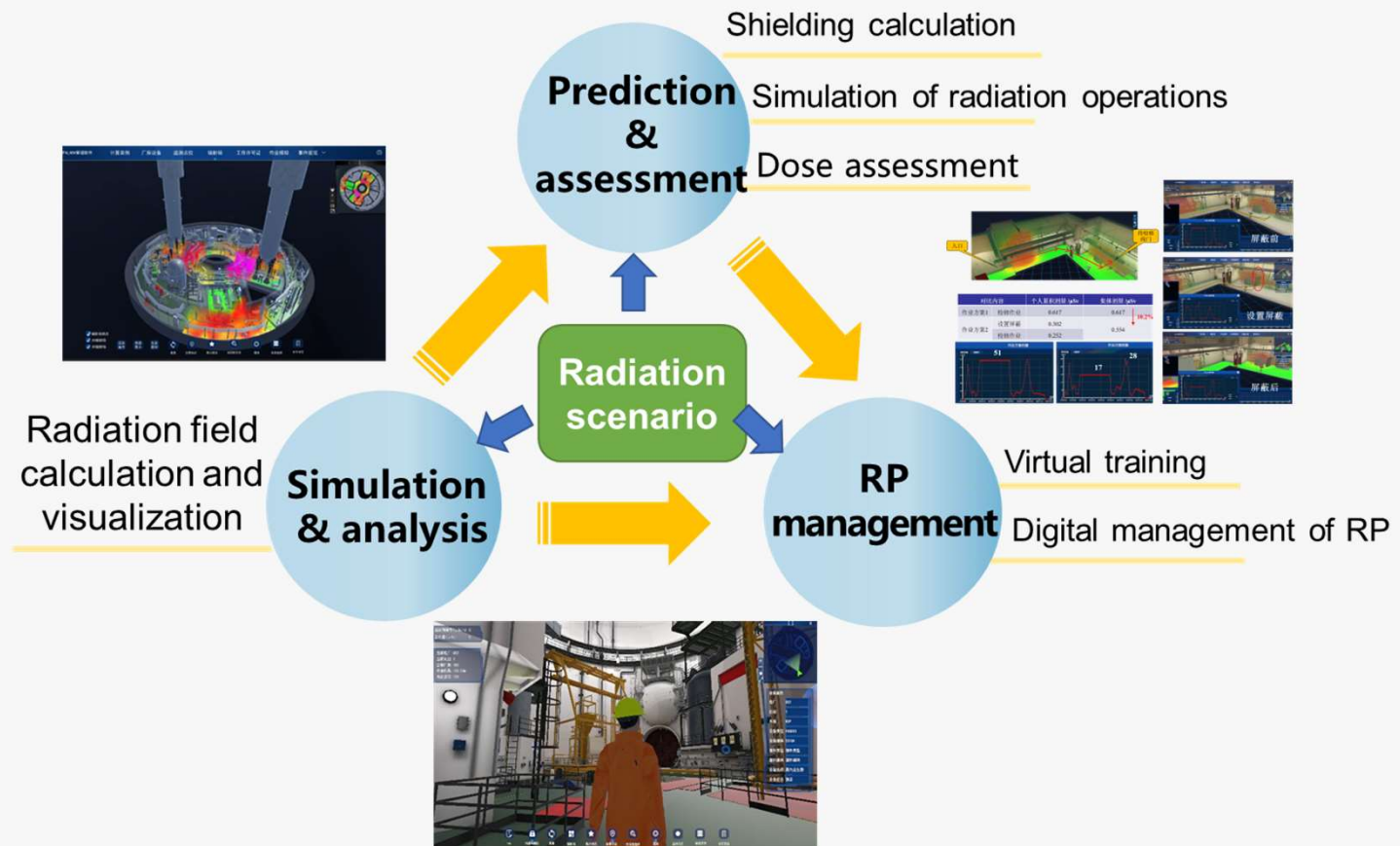
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2.2 SMARP 1.0, digitization

Based on the collected radiation information and 3D scene models, three functions are implemented in digital space:

- Simulation and analysis
- Prediction and assessment
- RP management

The main content of this phase are numerical calculations and simulations of radiation scenarios.



2 Digital Radiation Protection



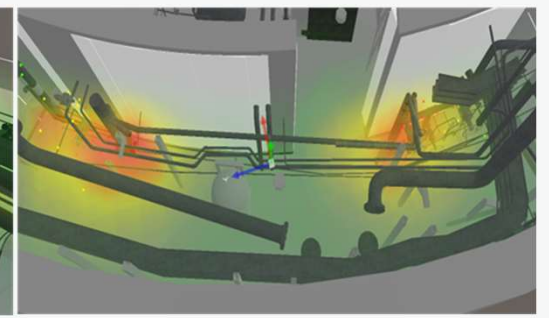
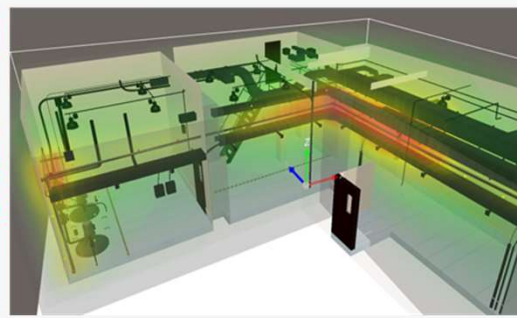
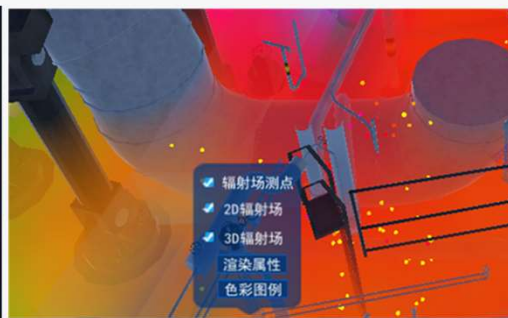
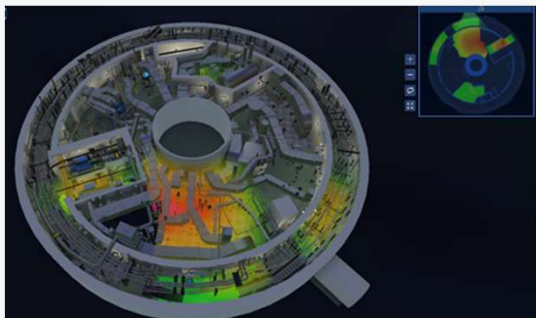
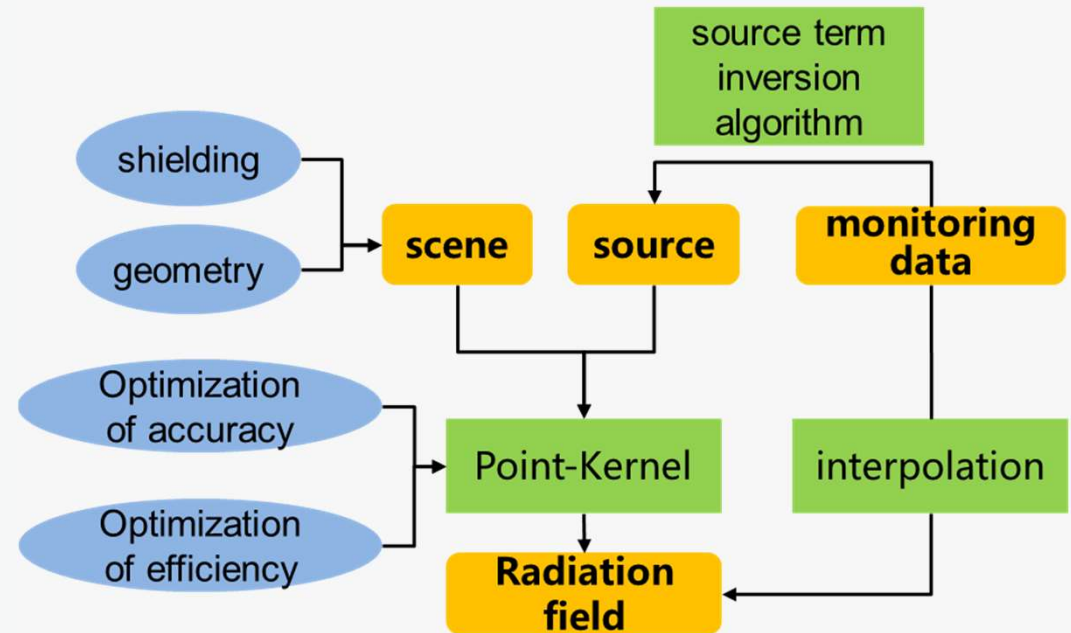
2.2 SMARP 1.0, digitization

Simulation and analysis

The transport process of gamma radiation in different media can be simulated by invoking three simulators.

- the point-kernel technique
- interpolation algorithms: IDW, Kriging
- source term inversion technique

A mapping relationship between dose rate and color is established, 2D and 3D.



2 Digital Radiation Protection



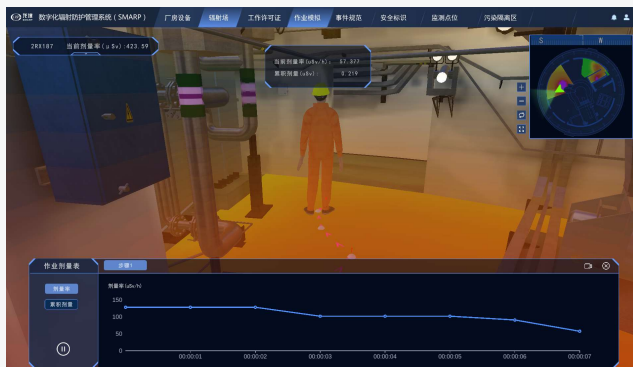
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2.2 SMARP 1.0, digitization

□ Prediction and assessment

The system allows for simulation of high radiation risk operations and pre-assessment of external exposure doses.

- shielding calculation
- dose assessment
- Job planning



2 Digital Radiation Protection



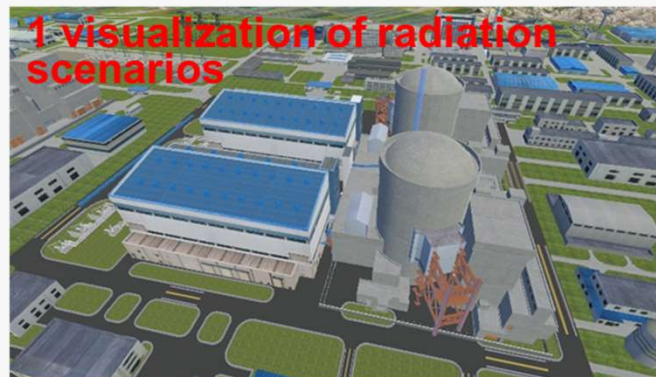
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2.2 SMARP 1.0, digitization

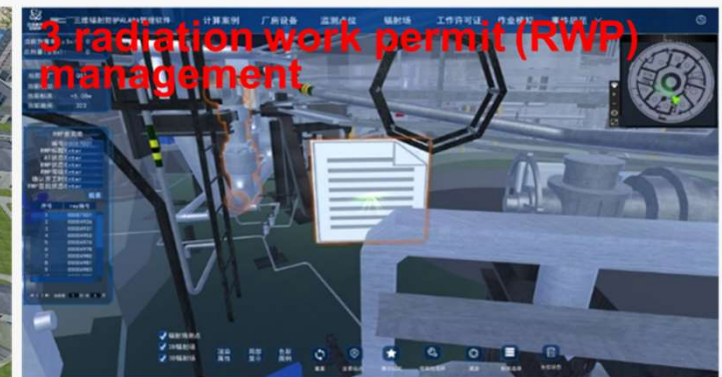
□ RP management

➤ digital management of RP

This system provides digital management functions such as visualization of radiation scenarios, equipment query, positioning and navigation, and management of radiation work permits (RWP). It offers advanced digital radiation protection support to different users.



1 visualization of radiation scenarios



3 radiation work permit (RWP) management



2 equipment query, positioning and navigation



4 Source term and measured data management

2 Digital Radiation Protection

2.2 SMARP 1.0, digitization

- RP management
- digital management of RP

Developed digital management functions nearly cover all RP related works, which are the key solutions to reduce occupational exposure management.



Nuclear Facilities 3D Display

Equipment Inquiry and Positioning

Plane Figure Dynamically Display



RWP Positioning and Visualization

Localization and Visualization of Radiation Monitoring points

3D Visualization of Radiation Field



Positioning and Viewing of Safety Signs

Positioning and Viewing of Abnormal Events

Creation and Display of Pollution Isolation Zones

2 Digital Radiation Protection



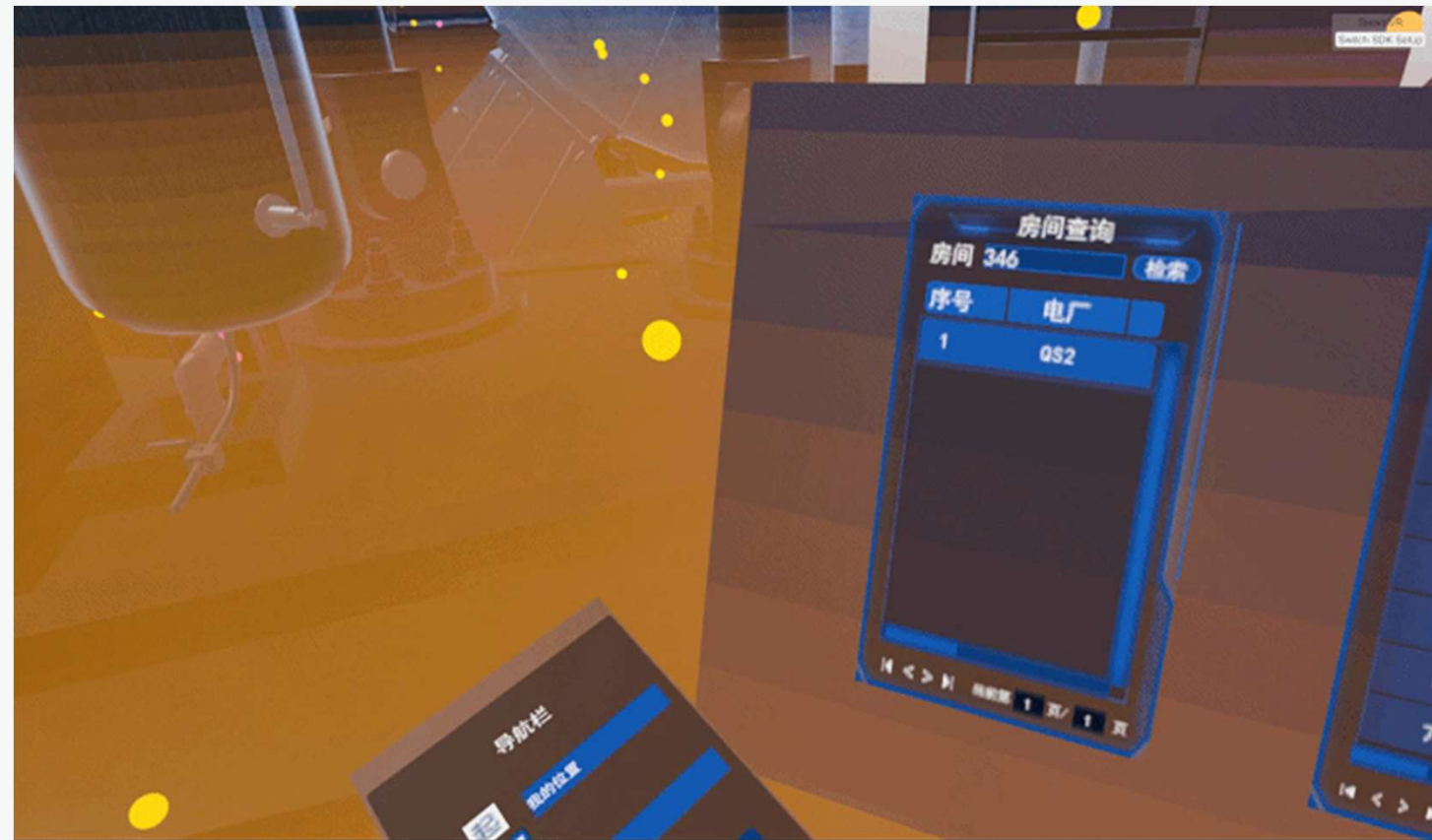
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2.2 SMARP 1.0, digitization

□ RP management

➤ virtual training

it support VR scene roaming and virtual training, user can freely check the layout of facilities and equipment and perform the work training in safe environment.



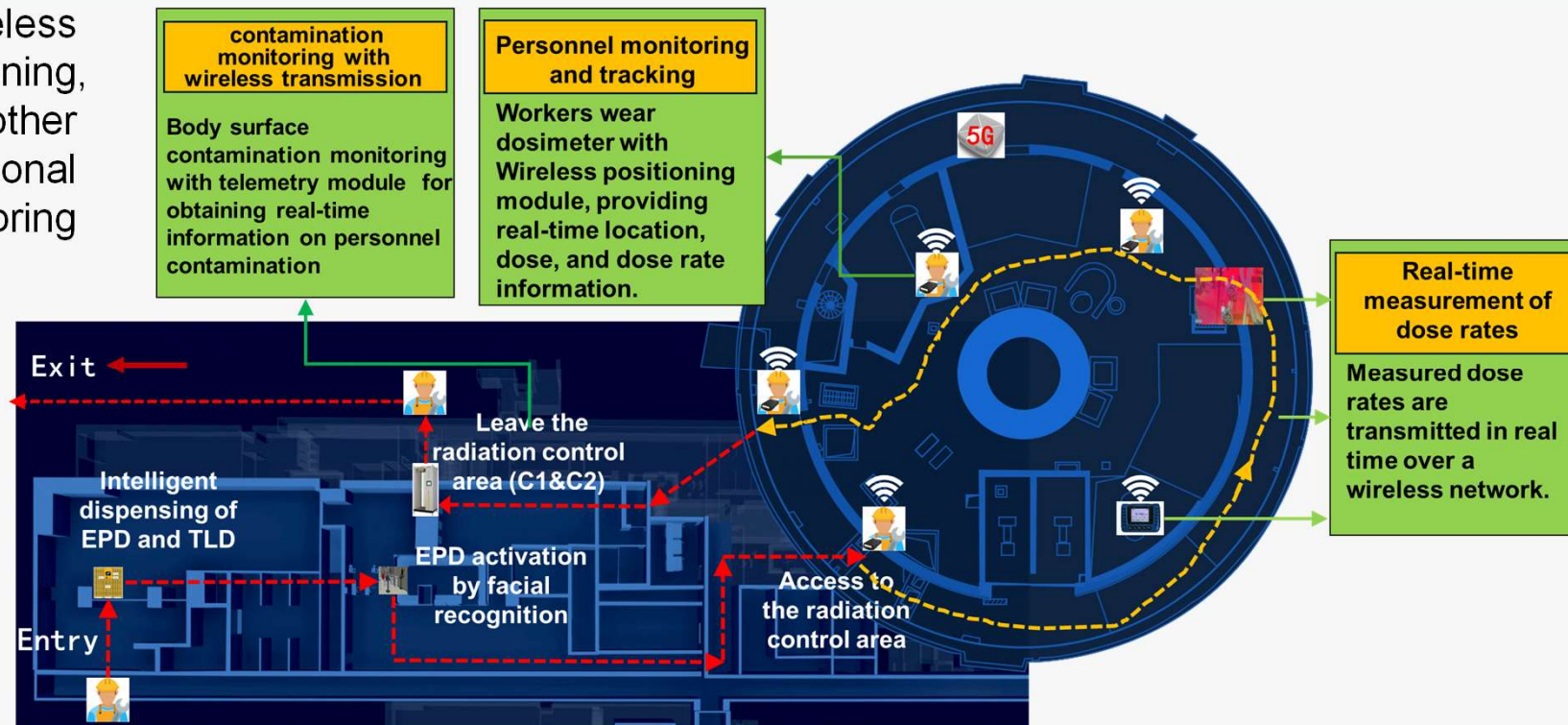
2 Digital Radiation Protection



2.3 SMARP 2.0, networkization

The main work of SMARP 2.0 is to combine wireless transmission, indoor positioning, face recognition and other technologies with traditional radiation monitoring instruments and systems.

- Providing real-time monitoring and remote control.
- Supporting for data-driven radiation protection management



3 Application



SMARP 1.0 will be deployed at 22 commercial nuclear power units in China by 2026.

This tool is supposed to facilitate risk-informed planning and work execution and to support the optimization of radiological protection for activities in nuclear environments and enhance safety in the nuclear industry.

It will contribute to improving safety in nuclear facilities by increasing stakeholders' comprehension of radiation risks.



Internal server



mobile terminal

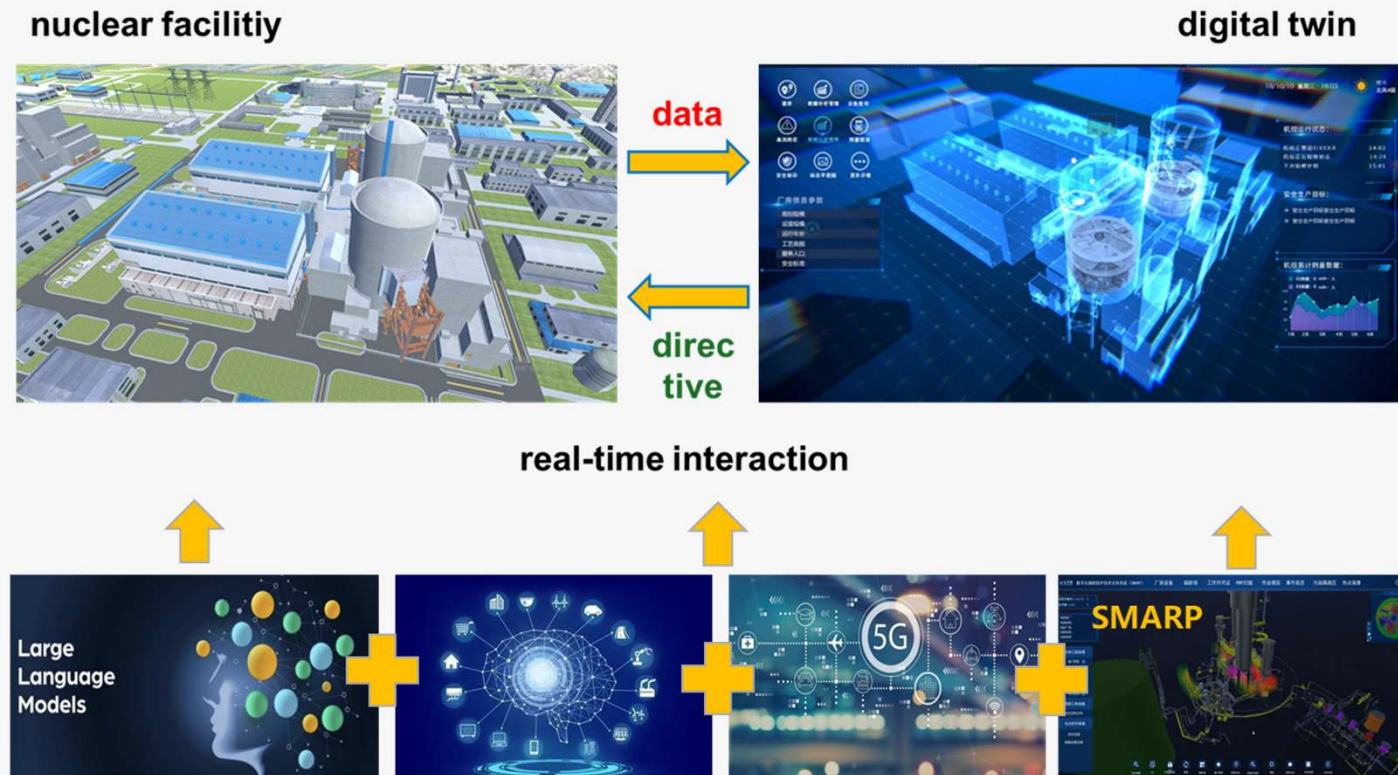


VR device

4 Summary



- The SMARP system is a successful demonstration in the field of digital radiation protection. And it gives us confidence in adopting digital technology to maximize efficiency of radiation protection management.
- In the future, SMARP will be combined with wireless communication, artificial intelligence (AI), large language models (LLMs) and other technologies to implement real-time interaction between nuclear facilities and digital twins, and promote the radiation protection management from digitalization to intelligence.





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**THANKS FOR YOUR
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