



THE 21ST INTERNATIONAL
OPERATIONS & MAINTENANCE
CONFERENCE IN THE ARAB COUNTRIES

Digital Transformation for Operation & Maintenance of HVDC Station

    #OmaintecConf

An Initiative by



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Personal Introduction

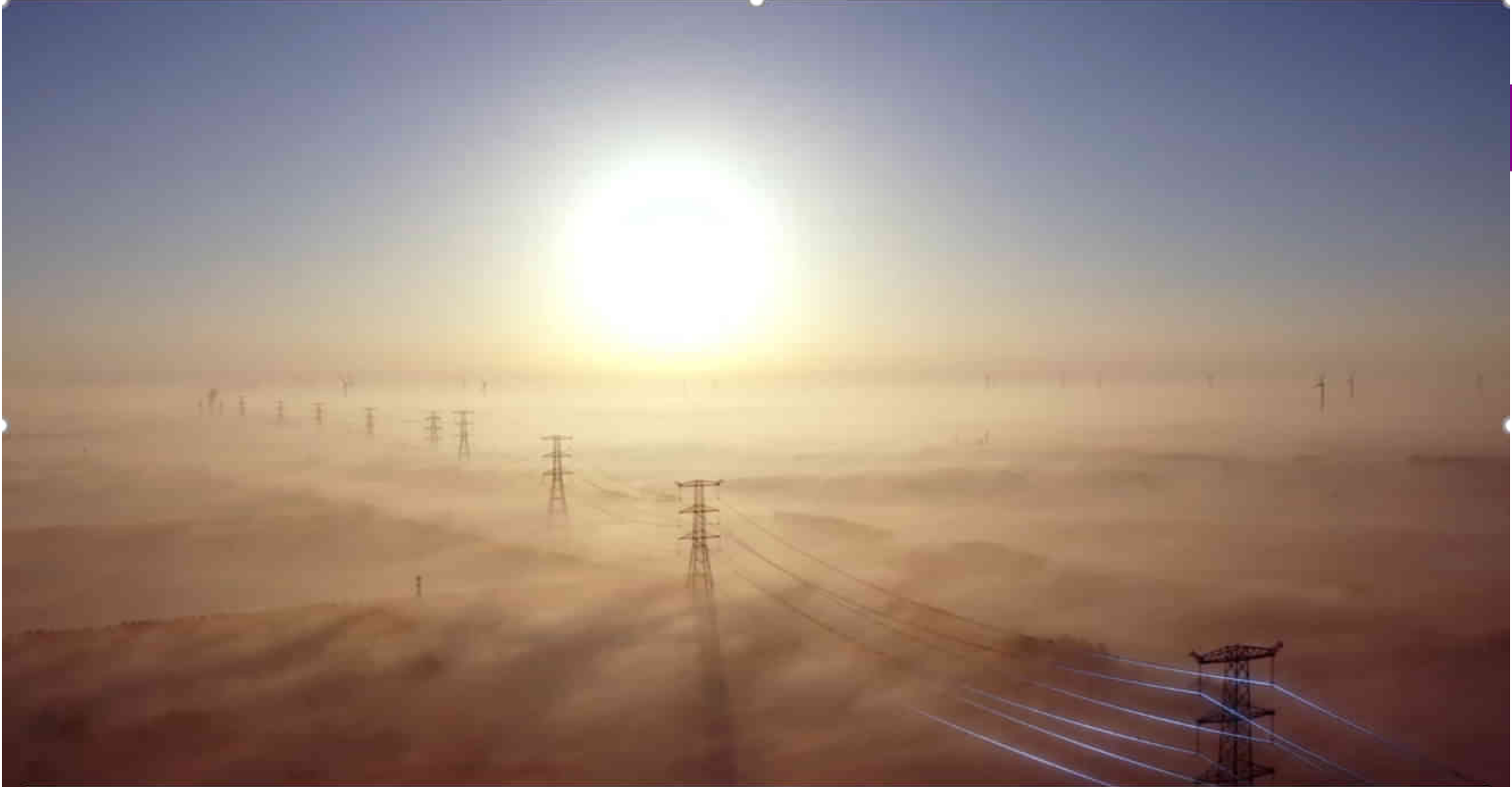


Li Gaowang

Department: Electric Power Digitalization BU, HUAWEI

Position & title: Digital Transformation Solution Director

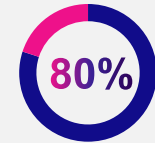
- Doctoral degree of power system automation.
- More than 10 years' experience in the electric power field, interested in digital transformation, power grid planning, HVDC system design, and large-scale electric vehicle connecting to power grid.
- Deeply involved in national key R&D programs of China and electric power standardization in and outside China.



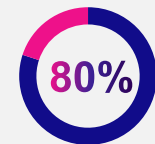
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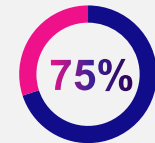
China's Energy Situation



Coal resources are mainly distributed in the west and north of China.



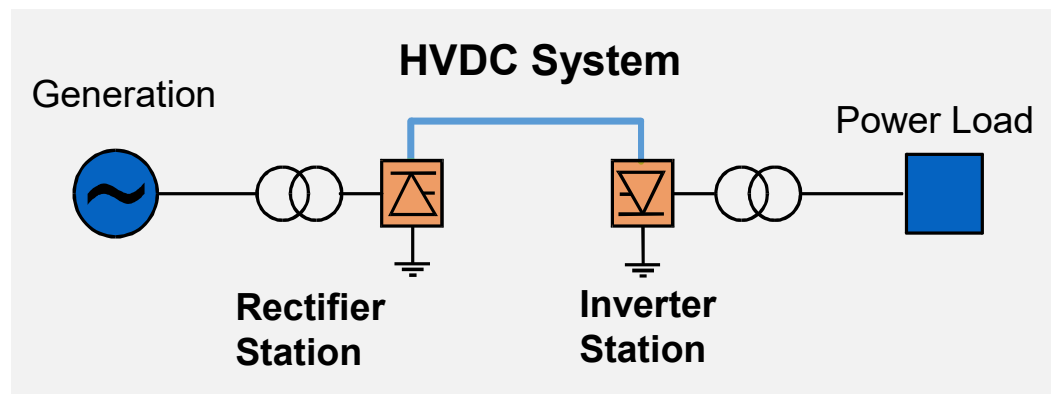
Hydro resources are mainly concentrated in the southwest.



The main power load is concentrated in the eastern and central China.

China is a benchmark in successful HVDC system operations

- Long-distance and large-capacity power transmission;
 - Cross-sea power transmission;
 - Connecting the power grids with different frequencies or asynchronous interconnection;
 - The measures to limit short-circuit capacity;
 - Power delivery for renewable energy base ;
 - Connection of offshore wind field.
- **40+ HVDC Systems are stably operating nationwide.**
 - **By 2030, more than 15 HVDC systems will be added.**
 - **The world's largest HVDC system is in China, with transmission power of 12000MW and voltage of $\pm 1100\text{kV}$.**

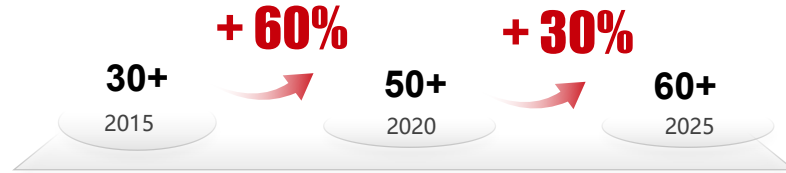




Challenge of Power Asset O&M in China

Trend 1: Accelerated Power Infrastructure Construction

Quantity of HVDC Converter Stations



Quantity of Substations



Trend 3: Slightly Increased Man Power

Number of Professionals

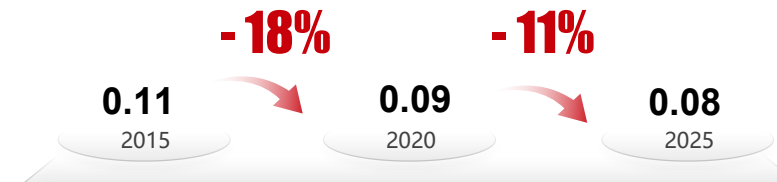


Trend 2: Increased Reliability Requirements

Forced Outage Rate of HVDC System (Times/Pole • Year)



Forced Outage Rate of AC Equipment (Times/100 Units per Year)



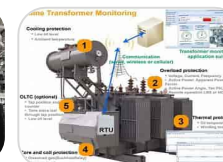
Trend 4: Increased Technical Complexity



UHV Technology



Power Electronic Technology



Equipment Monitoring Technology



New Material Technology



Energy Storage Technology

Challenges

Insufficient IT Support

- Siloed IT system;
- Long IT function rollout cycle;

Fragmented IoT System

- Low sensor deployment rate;
- Non-standard interface;

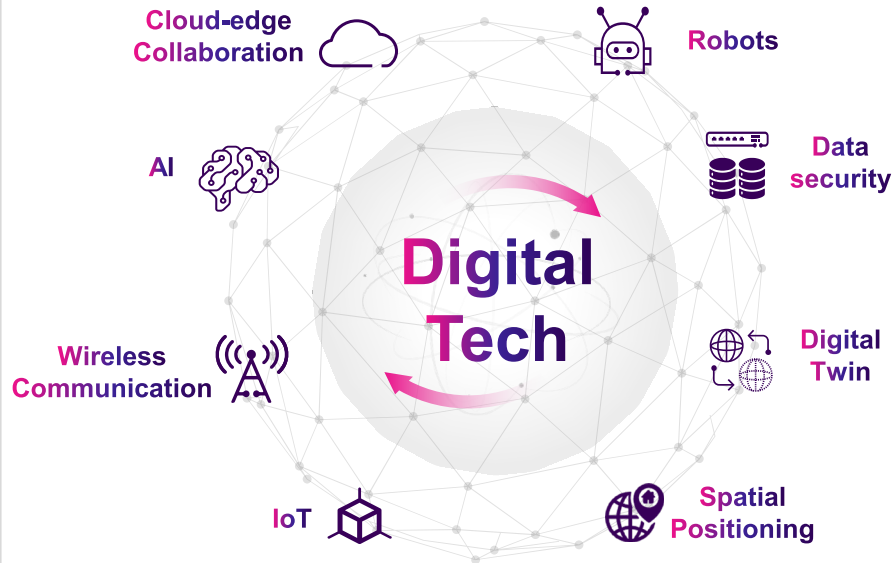
Low Efficiency

- Manual Recording;
- Manual inspection;

Non-explicit Process

- Processes Implicit in Regulations;
- Non-visible operation process;

Intelligent O&M



Target

Management and control platform

①

- Online information collection
- Standardization of control
- Full service collaboration

Comprehensive status awareness

②

- Online monitoring
- Unified IoT network
- Digital upgrade of sensors

③

Intelligent Maintenance

- Three-dimensional intelligent patrol
- Systematic equipment health assessment
- One-click sequential control

④

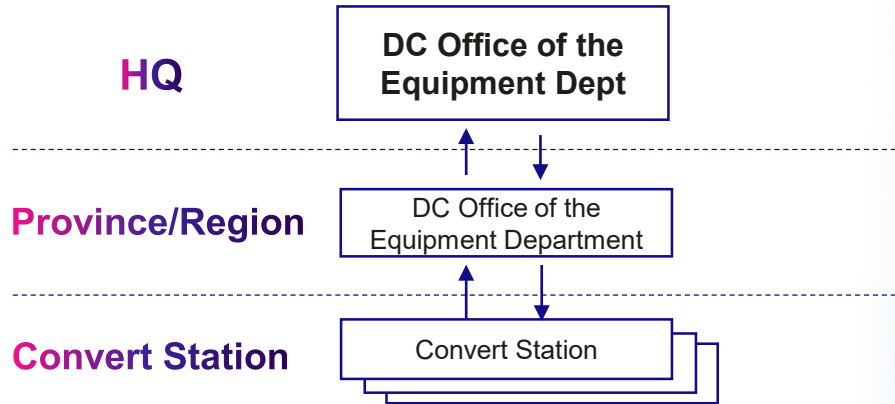
Lean Operation

- Process visualization
- Differentiation in the development of transportation inspection policies

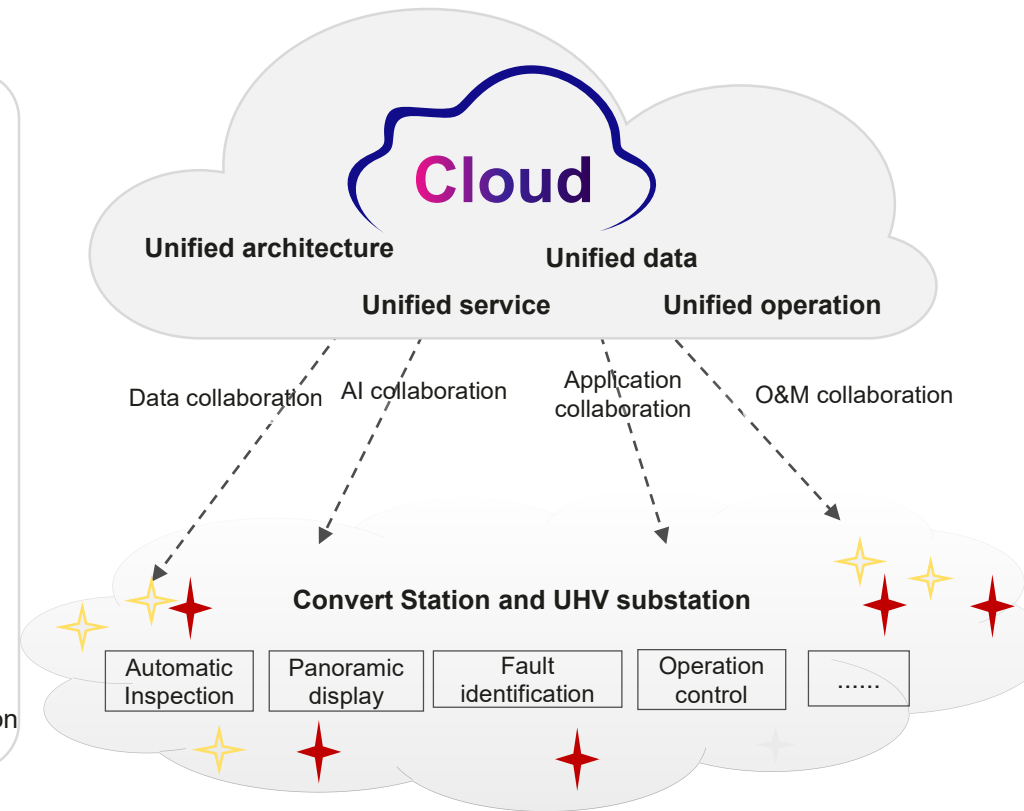
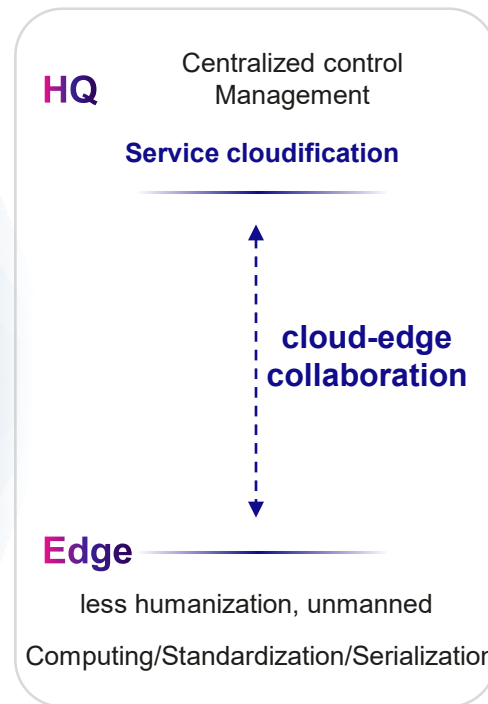
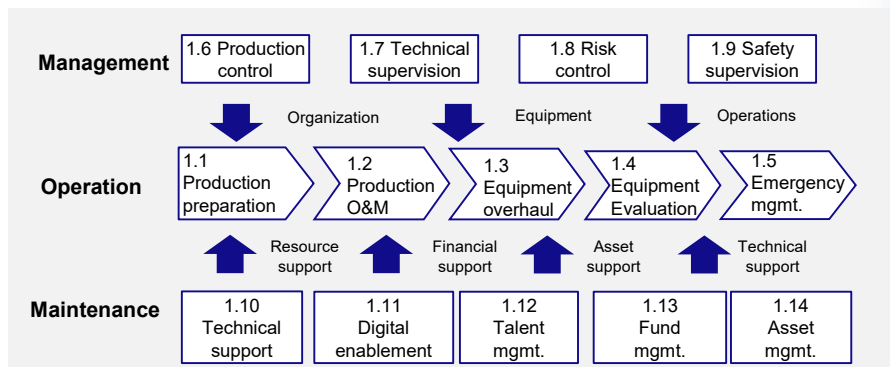


① Management and control platform: The Cloud-Edge Collaboration Architecture Supports all Services

Organization Structure:
Hierarchical Division and Vertical Management and Control



O&M Mode: "Centralized, Unified, and Penetrating"



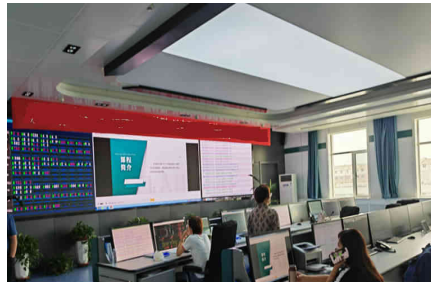


① Management and control platform: Platform Standardization, Software and Hardware Decoupling

"Chimneys" in the station

30+ auxiliary subsystems

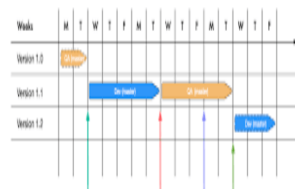
- DC control and protection system
- Valve cooling system
- Rainwater Pump Information
- Communication from the background
- Integrated power supply
- Electric energy measurement
- Valve Hall Fire
- Internal/external fault recording
- Battery online monitoring
- on-line monitoring of gas density
- Adjusting camera online monitoring
- Environmental monitoring system
- DC site surveillance video
- DC station access control system
- DC Station Lighting System
- DC station security protection
- Valve Hall Infrared
- Air conditioning system
-



Non-standard IT systems



Complex fault analysis process



Long function rollout period

Hardware Platform Standardization

Traditional Chimney Architecture

- Resource unbalance
- Difficult service expansion
- Independent O&M of each component

Computing and storage virtualization

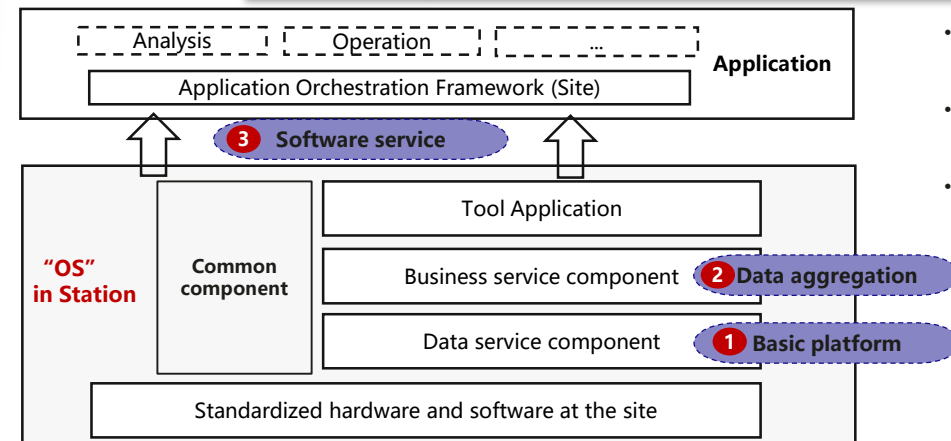
- ✓ Easy deployment
- ✓ Linear expansion
- ✓ Unified O M



All in One

- Virtualized
- Container
- Calculated
- Storage
- Network
- Security
- AI

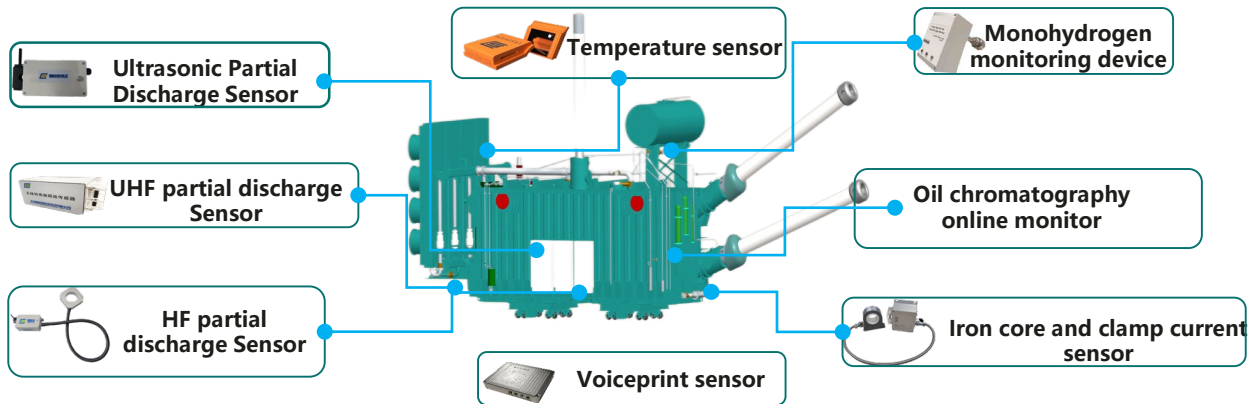
Open Software Architecture



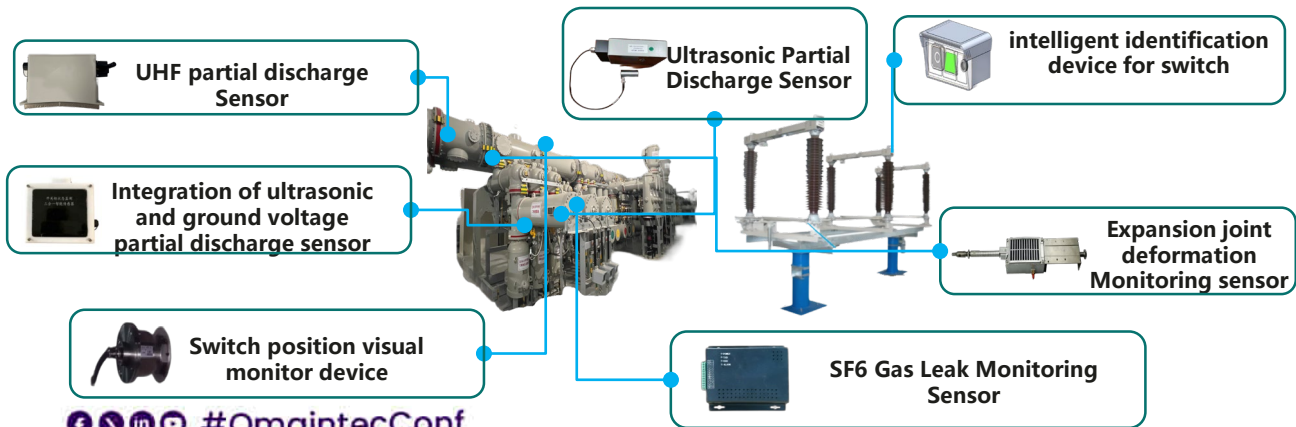
- Decouple hardware, services, and applications.
- Establish a unified data model.
- Define standard data interaction specifications and data acquisition interfaces.

② Comprehensive status awareness: Massive Sensors Need to Be Managed in A Unified Manner

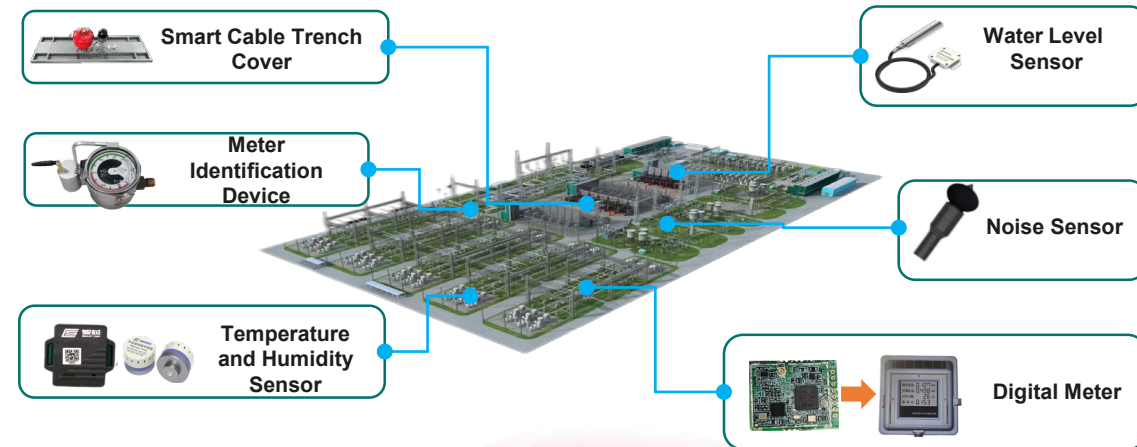
Scenario 1 – Multi-dimensional State Perception of Large Oil-filled Equipment



Scenario 2: Multi-dimensional State Perception of Switch Devices



Scenario 3 - Multi-dimensional state perception of Environments in the Entire Station



Wheeled Robot



Quadruped Robot



Drones



Infrared PTZ Dome Camera

② Comprehensive status awareness: Standardized IoT in the station

Fragmented IoT System

Scenario



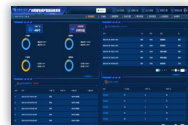
Intelligent Insepction



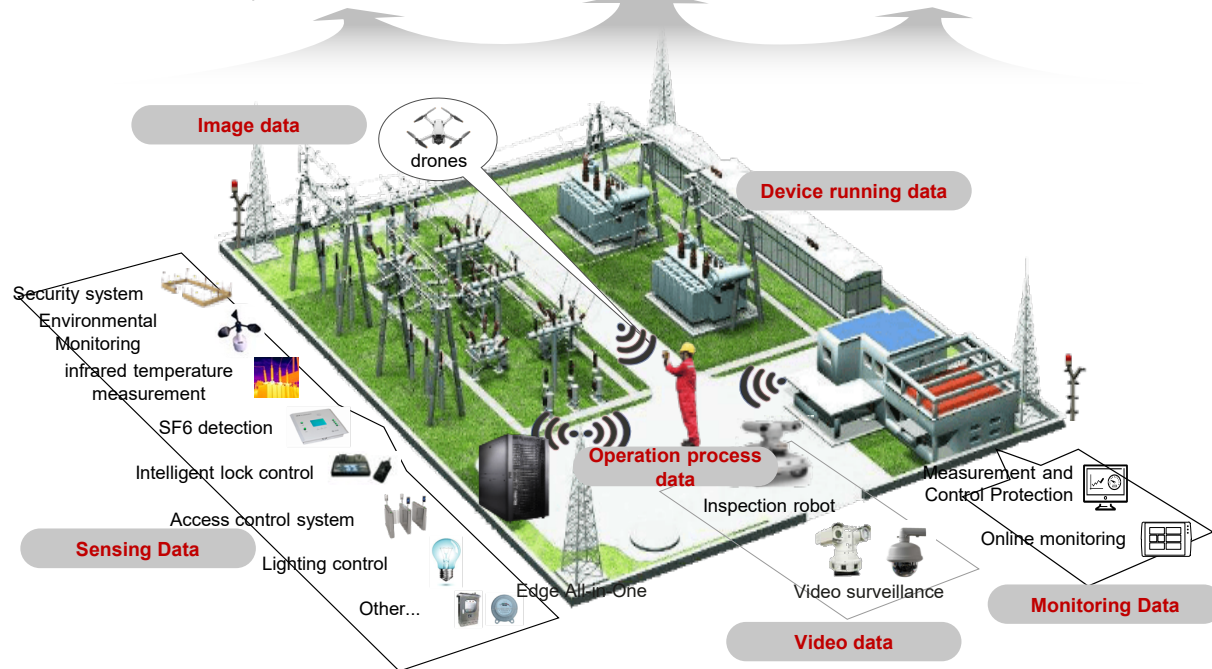
Onsite operation control



Emergency consultation



Device Status Analysis



IoT System Standardization

➤ Data Collection

Sensor deployment

Partner

Huawei

Sensor

Robots

Cameras

Drones

➤ Data Accessing

Standardization the data collection

WIFI (GWL)

POL

IoT gateway (61850)

➤ Data storage and application

Digital platform construction on site

Edge computing

Edge PaaS

(Edge All-in-One Edge AI inference
Edge video platform)

(Component/API GW/ access
component/DB etc.)

Data governance

Data access

Data access standard API

③ Intelligent Maintenance: AI instead of manual inspection



Scheduled Inspection



Patrol by Walking



Manual Data Recording



Judgment Based on Experience



Risks in Patrolling

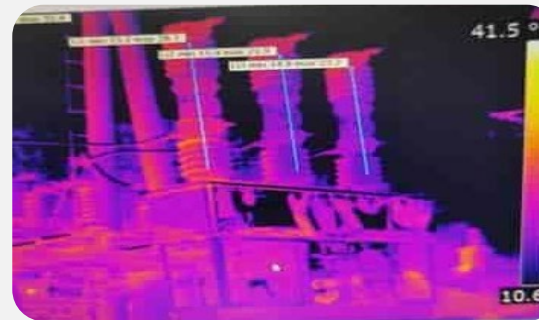


High Monitoring Pressure

HD Video Patrol



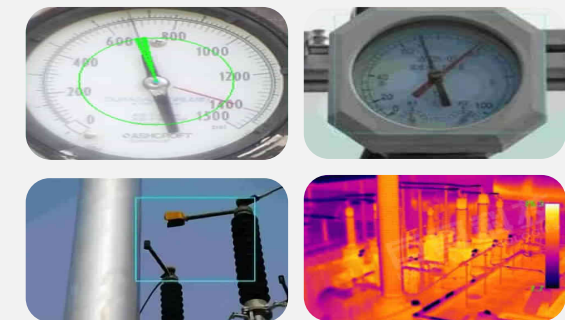
Infrared Accurate Temperature Measurement



Air-sky-earth Coordinated Patrol



AI



③ Intelligent Maintenance: Enhanced Functions for Digital Converter Station

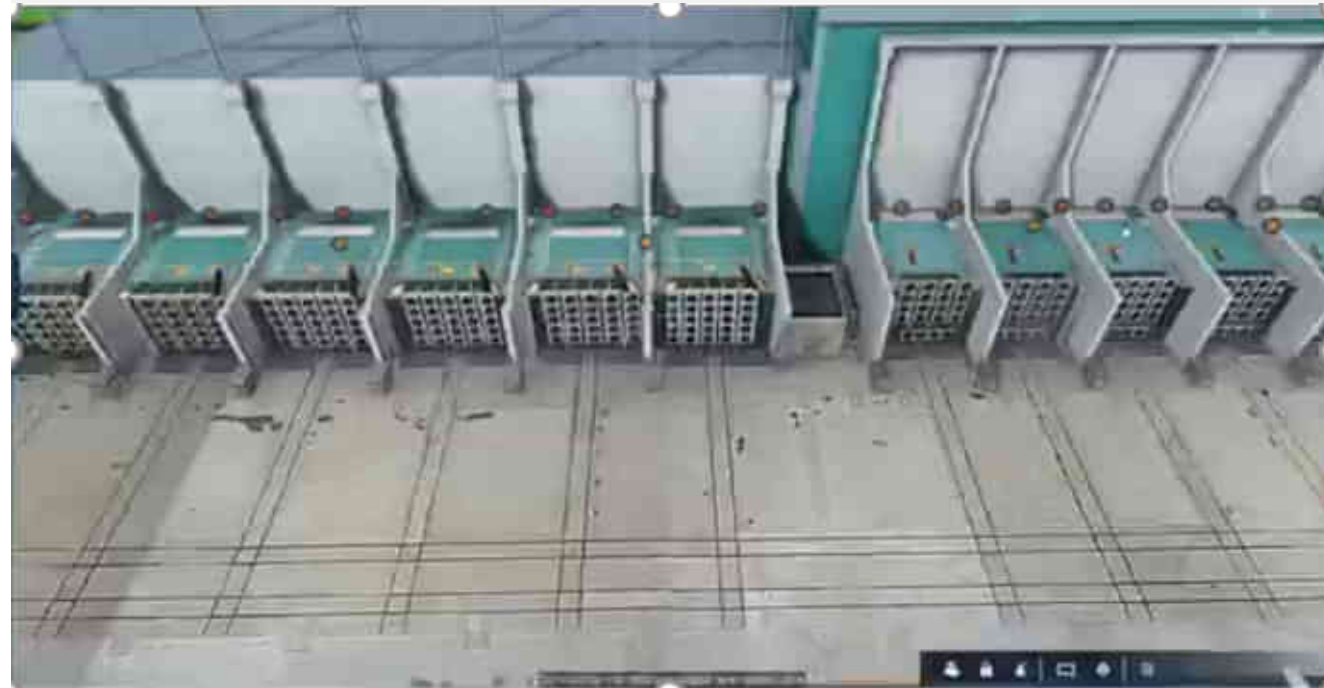
Automatic Inspection

The outdoor wheeled robot and HD camera are used to implement automatic inspection in the converter station, replacing manual routine inspection and comprehensive inspection, reducing the inspection burden of the on-duty personnel.



Collaborative Tracking of PTZ Dome Cameras

The system automatically rotates the PTZ of the four cameras after click object when abnormal event occurs. It provides multiple angles view of the video





④ Lean operation: Digital Technologies Empower Workers to Improve Efficiency and Safety

Multiple maintenance procedures

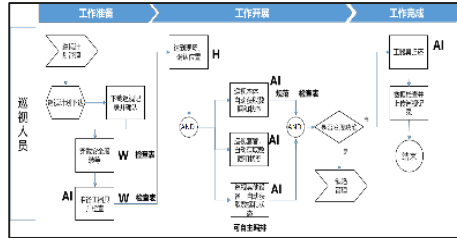
600+ maintenance procedures

根据流程切片模板，将现场作业流程工序按照原子级切片，支撑原子级流程梳理，和关键管控点识别。

流程切片	原子级工序																			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
清理切片实例-分程开关旁切检查	巡视人员	巡视人员	巡视人员	巡视人员	巡视人员	巡视人员	巡视人员	巡视人员	巡视人员	巡视人员	巡视人员	巡视人员	巡视人员	巡视人员	巡视人员	巡视人员	巡视人员	巡视人员	巡视人员	巡视人员

Multiple inspection steps

2000+ special inspection steps for a single large equipment



Digital operation

Cloud platform

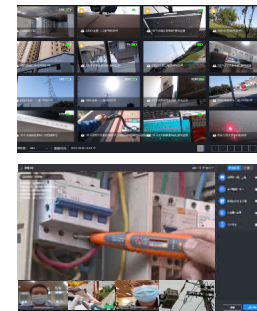


- Work order intelligent scheduling
- Work Order Bonus Point Operation
- Performance incentives
- Resource cloudification

Operation

- ✓ Service order-based
- ✓ Value-based work order
- ✓ Value performance
- ✓ Breaking the boundary of the supply zone

Station platform



- Individual three-dimensional combat equipment
- Inensible/One-click collection
- AI broadcast of operation process
- Voice search/Navigation entry
- AI monitoring in the job window
- On-site remote "graffiti" consultation

Safety supervision

- ✓ In-event pre-event control
- ✓ One-click video direct to the scene
- ✓ AI-assisted anti-violation

Job

- ✓ Job insensible record
- ✓ No text input throughout the process
- ✓ AI-assisted manual operations

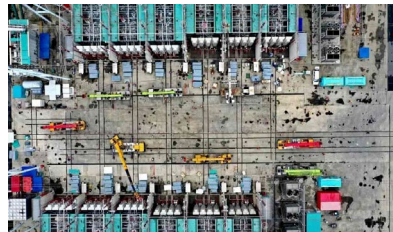
Many on-site maintenance and transcription points

About 300+ recording measurement points

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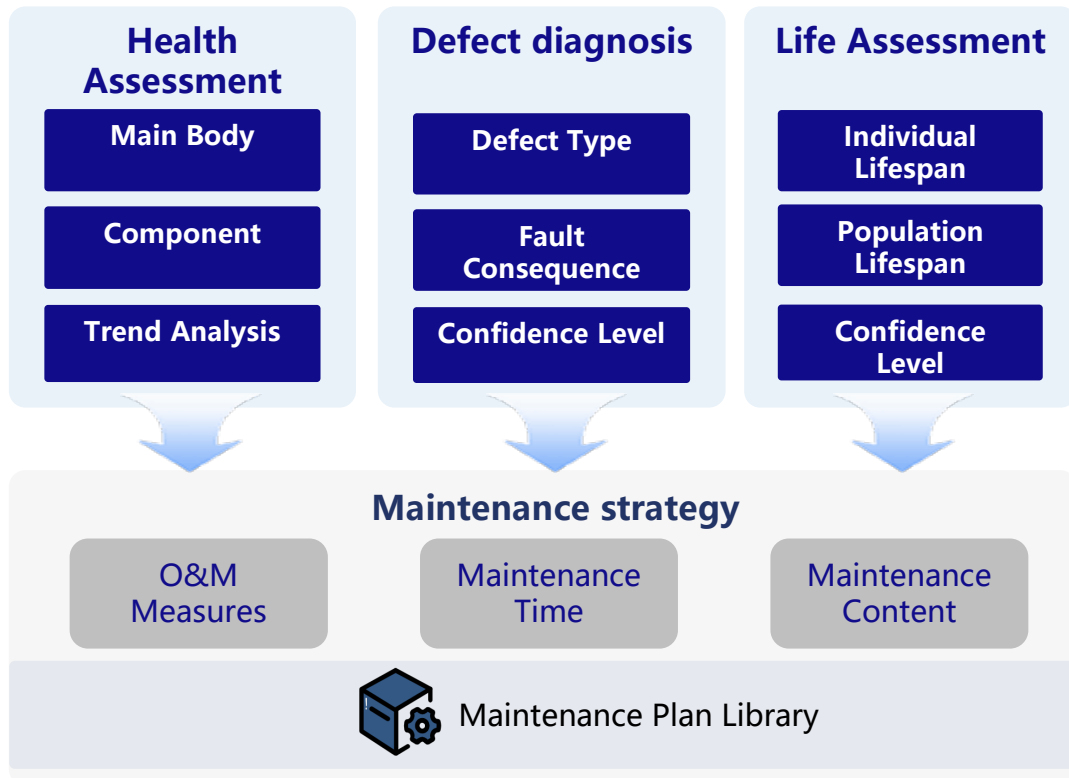
High pressure on annual overhaul

High-intensity work for 5 + days; 300 + items in the pre-test 100 + staff;

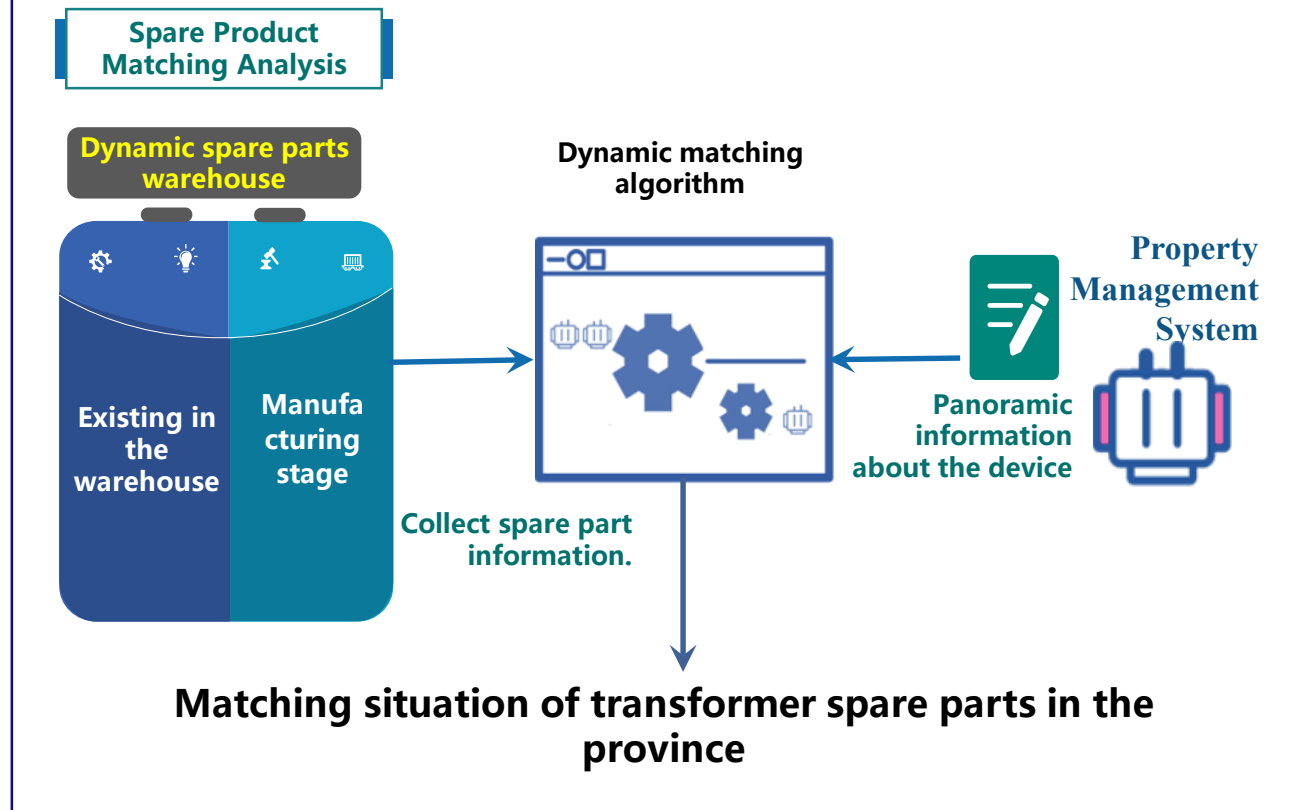


④ Lean operation: Improving Asset Management Level

Intelligent Decision-making Assistance



Decision on Spare Part Replacement





Steps of Digital Transformation for O&M of Converter Station

Phase 1

ICT Upgrade

Start with ICT upgrade, integrate digital technologies with services, and quickly build confidence through innovation pilots.

- Application of innovative ICT.
- Steady development of data governance;
- Continuously deepen technical solutions and continuously iterate technical specifications.

Technology-driven

Phase 2

Process Transformation

Digital technologies and business drive the development of each other. Digital technologies drive efficient business development, while business development drives the application of more advanced technologies.

- Continuously deepen ICT technologies, continuously improve data quality, and gradually restructure business processes.
- Continuously improve digital operation rules.
- The digital awareness of the work teams has been significantly improved.

Business-driven

Phase 3

Continuous Operations

Two-wheel driving has achieved remarkable results, with exponential improvement in service quality and efficiency, a healthy and orderly application ecosystem, and continuous digital innovations.

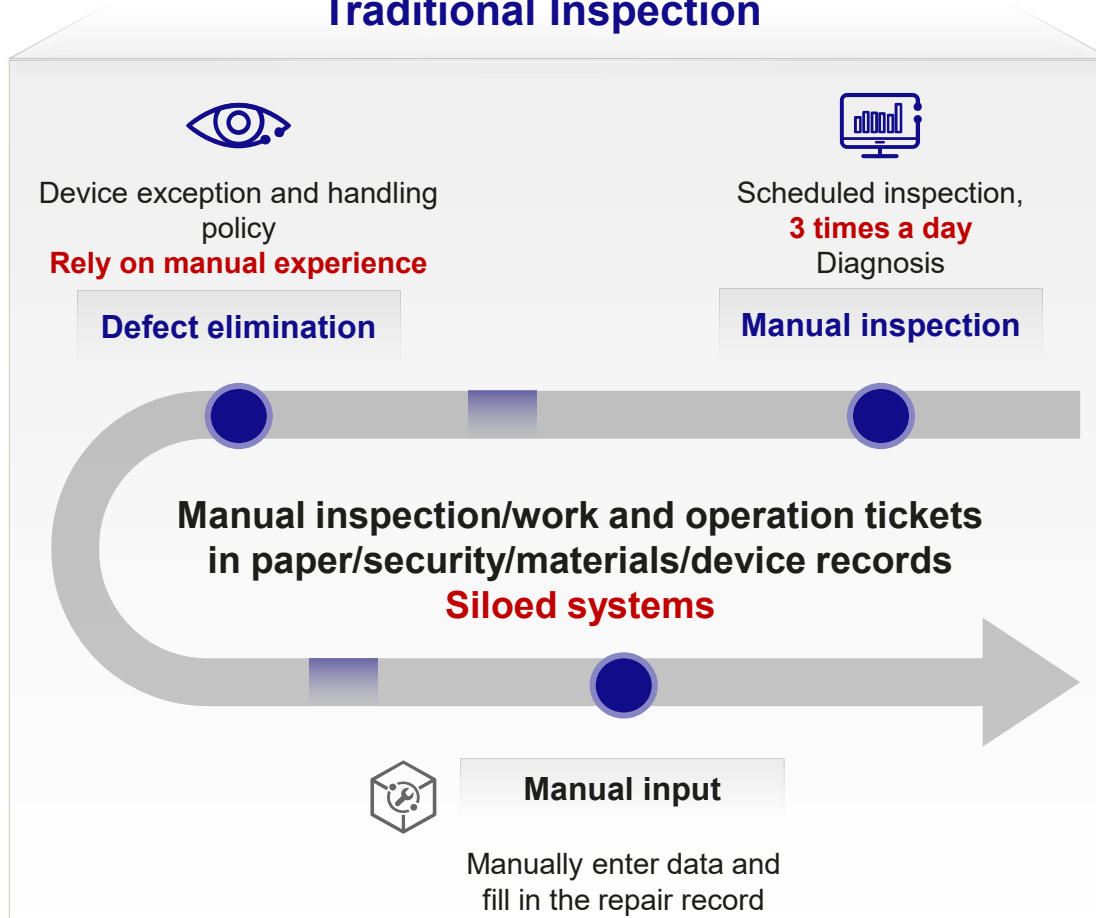
- Continuous architecture maintenance, continuous function optimization, and continuous accumulation of digital assets;
- The operation model is mature and effective, and the application ecosystem is flourishing.
- All employees are professional in digitalization and continue to carry out digital innovation.

Quality and Efficiency Improvement

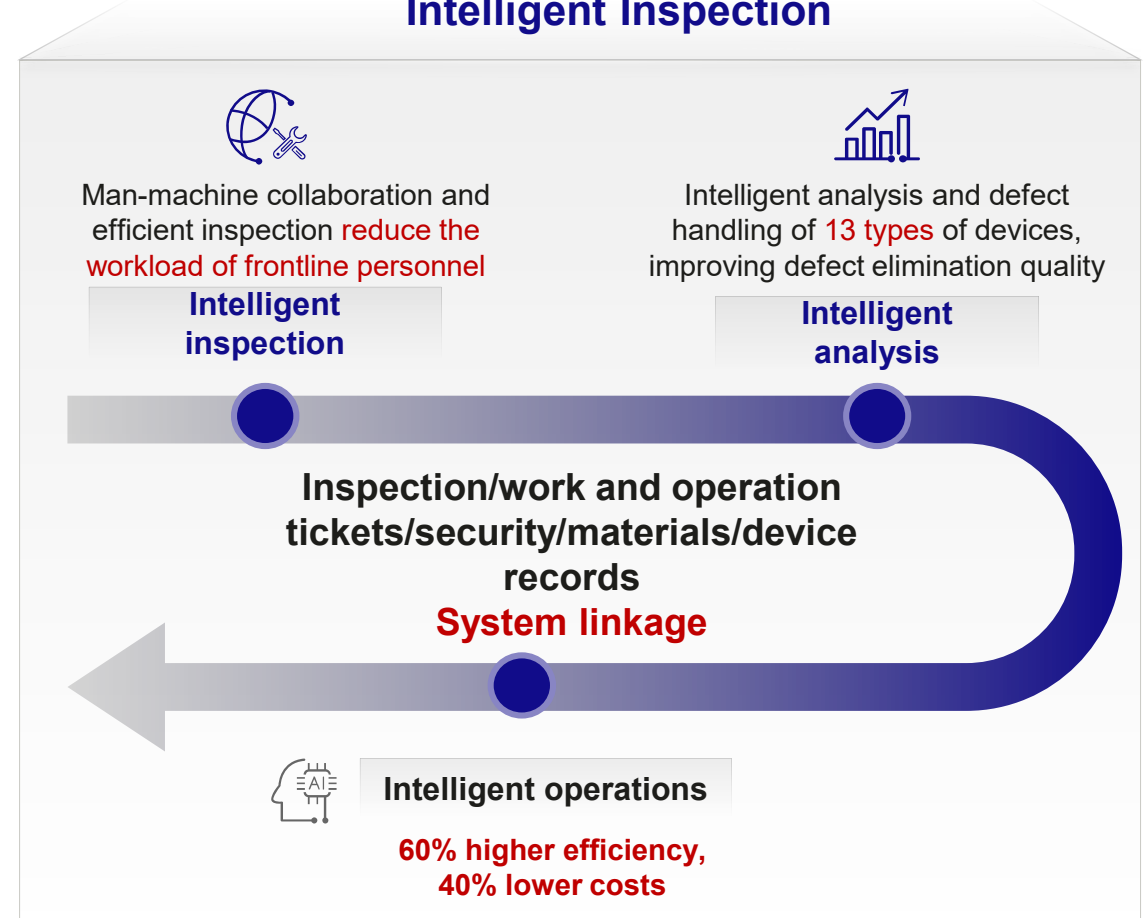


ICTs Transform O&M Processes, Technologies and Processes Need to Adapt to Each Other

Traditional Inspection



Intelligent Inspection





Standardized and Lean O&M Process

Solidifying best practices and promoting the standardization of grass-roots teams

换流变非电量定值单			
换流站	XX 换流站	定值单编号	0001
保护装置	811B、812B、821、822B	保护装置	换流变非电量保护
装置型号	XXX	制造厂家	南瑞继保
说明	本定值单根据换流变厂家提供的定值单编制，并经系统调试和试运行验证。		
序号	定值名称	整定值	整定项目说明
换流变本体瓦斯保护			
1	本体轻瓦斯报警	1.0m/s	投跳闸
2	本体轻瓦斯跳闸	250mL	投跳闸，轻瓦斯配置3副触点，每重瓦斯触点在跳闸前并接
3	4个套管升高电压瓦斯报警整定值	-	未设置
4	4个套管升高电压瓦斯跳闸整定值	-	未设置
5	3个分接开关升高电压瓦斯报警整定值	-	未设置
换流变分接开关压力和油流保护			
6	有载分接开关油流继电器	1.2m/s	投跳闸
7	压力继电器报警值	-	未设置
8	压力继电器跳闸值	-	未设置
换流变调羹管 SF6 压力保护			
9	SF6 密度继电器报警 I 段	240kPa	额定为 330kPa，报警只设置 I 段
10	SF6 密度继电器报警 II 段	-	
11	SF6 密度继电器跳闸	100kPa	
换流变油温温度保护			
12	油温停风冲 2	45℃	
13	油温停风冲 3	55℃	
14	油温报警 I 段	75℃	
15	油温报警/跳闸 II 段	85℃	投报警
换流变油温温度保护（包含调羹管和两侧绕组）			

变电站（发电厂）第一种工作票

单位：_____ 编号：_____

1. 工作负责人（监护人）：_____ 班组：_____

2. 工作班成员（不包括工作负责人）：_____

3. 工作的变电站名称及设备双重名称：_____ 共 _____ 人

4. 工作任务：
工作地点及设备双重名称 _____ 工作内容 _____

5. 计划工作时间：
自 _____ 年 _____ 月 _____ 日 _____ 时 _____ 分
至 _____ 年 _____ 月 _____ 日 _____ 时 _____ 分

6. 安全措施（必要时可附加安全措施）：
应拉开的断路器（开关）、隔离开关（刀闸）等 _____ 已执行*

第 1 页 共 4 页

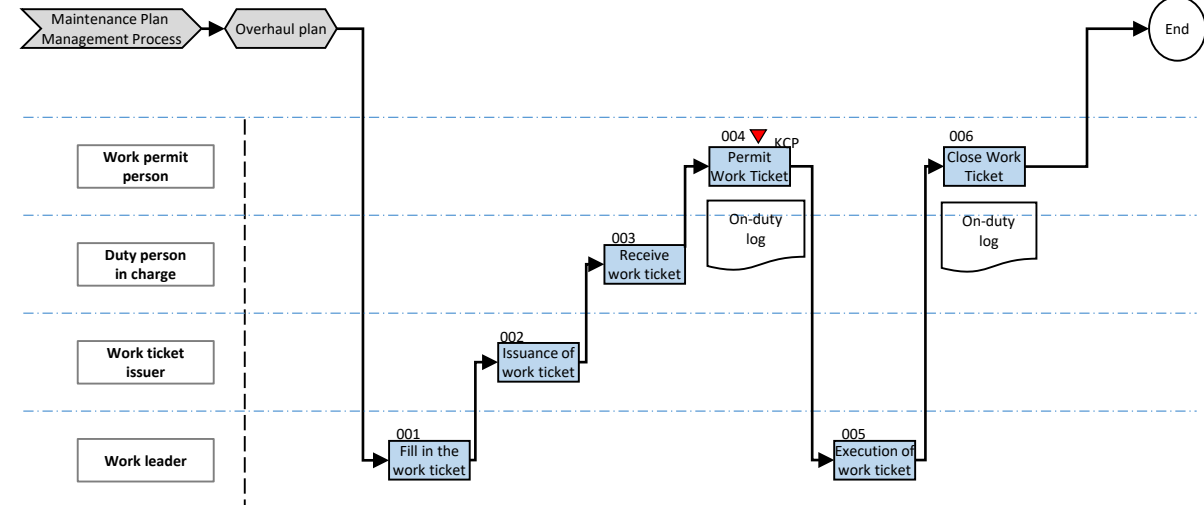


Unified management requirements
Establish standardized operation on-duty management

Strictly control error-prevention locks
Standardize the unlocking mechanism of the error prevention device.

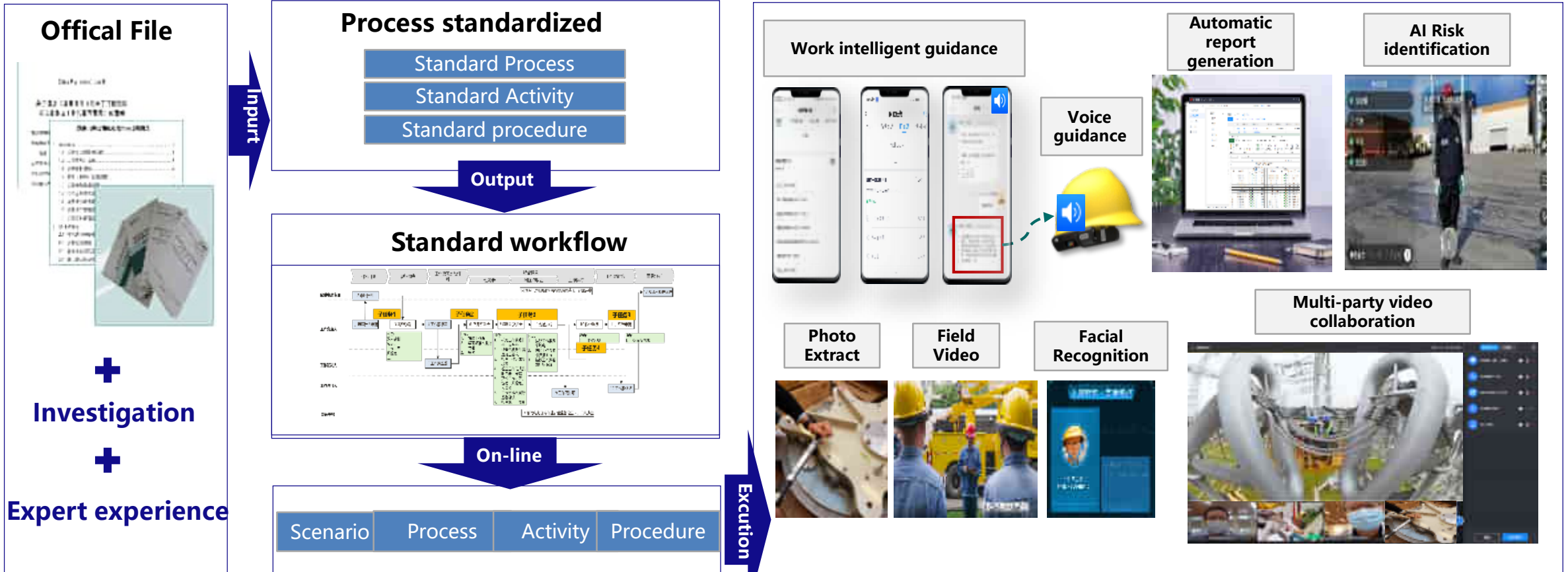
Promote standardized operations
Standardization of operation in all stages of inspection and maintenance

Build standardized O&M
Build a strong defense line for stable operations of equipment



Standardized workflow on-line

Standardized workflow execution and intelligent guidance





Case Study



Digital Converter Station Project in Power System Company



- Rheological Intelligent Analysis • Intelligent analysis of camera adjustment • Intelligent analysis of valve cooling system •

Improve the capability of the diagnose and analyze the equipment defects

One map to view measurement, running, ledger, alarm, and operation information of the equipment

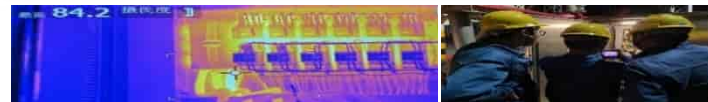
One click to evaluates device and component risks by performing AI analysis and prediction based data

Case1



May 19, 2022, one engineer on site compared data and found that slight water leakage at the fan pipeline. Prevented further spread of the defect after timely treatment on site.

Case2



July 7, 2022, it's found that the temperature of the power contactor in the control cabinet was high when viewing the intelligent inspection report of the digital station. The maintenance team fastened the crimping terminal on site and recovered

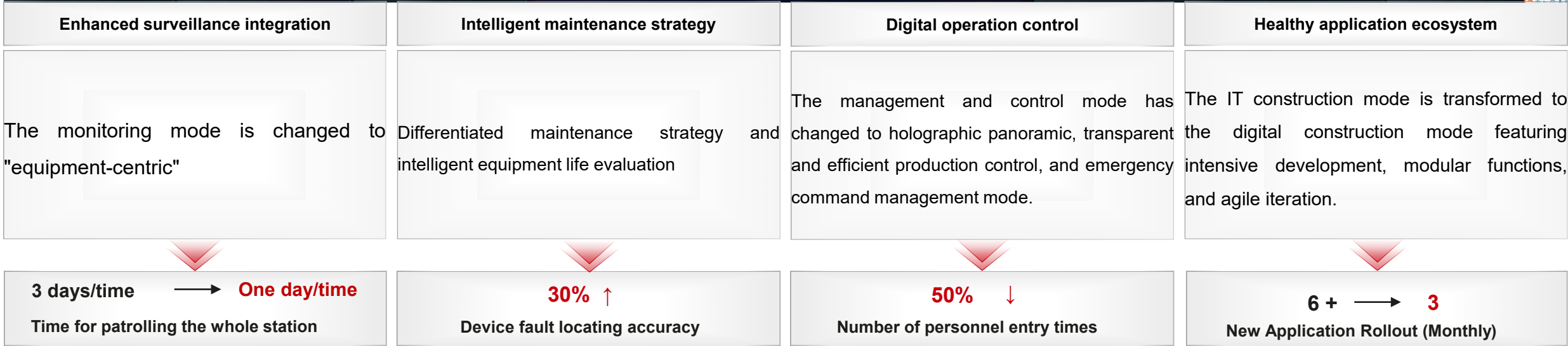
Case3



October 12, 2022, The value of oil chromatographic monitoring reached the shutdown threshold and spotted. The #1 low-end converter shutting down was applied and approved to avoid major accidents.



Digital Converter Station Project in Power System Company





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OPERATIONS & MAINTENANCE
CONFERENCE IN THE ARAB COUNTRIES

THANK
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An Initiative by



Organized by

EXICON.
International Group
مجموعة أكزيكون الدولية



ICTs enable field workers, reducing their workload

Management centered on manual supervision

Phone communication for help

Employees have different levels of skills

Offline process approval

After-event review and accountability

Manual data report development

Manual experience transfer

Traditional converter station

E2E risk control

Full-service quality and efficiency improvement

All-round operation transformation

Digital converter station

✓ Intelligent real-time inspection

✓ Near-far operation collaboration

✓ Voice navigation assistance

✓ Online operation standards

✓ Traces in the operation process

✓ Intelligent data operations

✓ Codeless orchestration service

Digital onsite operation management and control



Security check workload reduced by **85%**



Operation violations reduced by **85%**



Data is automatically updated every **15 minutes.**



100% traceability of operation problems



100% compliance of high-risk operations



The efficiency of operation report summary is **100%**.



Training time reduced by **30%**