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ISO 24591-1

Smart water management —

Part 1: **General guidelines and governance**

Gestion intelligente de l'eau —

Partie 1: Lignes directrices générales et gouvernance

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Foreword

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This document was prepared by Technical Committee ISO/TC 224, *Drinking water, wastewater and stormwater systems and services*.

A list of all parts in the ISO 24591 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

In recent years, governments, enterprises and researchers have shown increasing interest in incorporating digital and smart approaches, including sensor monitoring, real-time data transmitting, data processing, artificial intelligence (AI) and real-time controlling, into water systems. The worldwide demand for water from the growing population, increasing urbanization and maintaining the cost of ageing infrastructure drive the growth of the smart water management market.

With the development of smart water management, water utilities are facing increasing challenges in developing an appropriate digital strategy for water, wastewater, stormwater systems and service. First, data silos and electro-mechanical rotating equipment with various communication protocols block systems integration and interoperability. Second, cybersecurity and user data protection are critical considerations when deploying smart water management. Third, managing data for valuable information is the key element in designing and managing a smart water system. Fourth, adopting digital technologies can bring up human resources concerns related to skills gaps, workforce transition and change management.

The digital maturity of water utilities is different but they all need to have digital architecture and general guidelines to develop value systems and governance to adapt to the changing environment and face these new challenges.

While there are some standards on data exchanging and data sharing relating to smart city and smart community infrastructures, standards on smart management in the water and wastewater domain have still to be developed.

This document provides principles and guidelines for smart water management relating to drinking water, wastewater, stormwater systems and services. It is intended to help water utilities decrease operational expenditure, increase workforce efficiency and increase user engagement and satisfaction. It also helps guide a new generation of water utilities during their uptake of digital strategy and integration into water services adapted to their context, and accelerates collaboration with public agencies and other businesses in the smart cities field.

Smart water management —

Part 1:
General guidelines and governance

1 Scope

This document provides principles and guidelines for smart water management relating to drinking water, wastewater, stormwater systems and services.

The following are within the scope of this document:

— principles and guidelines for design of smart water management system;

— principles and guidelines for operation and maintenance of smart water management systems;

— principles and guidelines for governance of smart water management system.

This document applies to all sizes of public or private water utilities that want to design, develop, implement, operate and/or maintain smart water management systems.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 24513:2019, *Service activities relating to drinking water supply, wastewater and stormwater systems — Vocabulary*

3 Terms, definitions and abbreviated terms

3.1 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 24513 and the following apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

3.1.1
controller
piece of equipment that combines the function of at least the input elements, the comparing elements and the amplifying and signal processing elements for a process control system

[SOURCE: ISO 1213-1:2020, 11.2.5]

3.1.2
cybersecurity by design
approach to developing systems, applications or processes with security measures and hardware architecture embedded from the outset, prioritizing the prevention, detection and mitigation of cyber threats throughout the entire life cycle of the system

3.1.3
data management
process of keeping track of all data and/or information related to the creation, production, distribution, storage and use of e-media, and associated processes

[SOURCE: ISO 20294:2018, 3.5.4]

3.1.4
data repository
functional unit that stores and retrieves data

EXAMPLE A data repository can support services such as search, indexing, storage, retrieval and security.

[SOURCE: ISO/IEC 20944-1:2013, 3.21.13.15]

3.1.5
governance
system of directing and controlling water utilities, corporate governance systems, responsible bodies, relevant stakeholders, relevant authorities and responsible authorities

Note 1 to entry: This includes all of the processes of governing – whether undertaken by the government of a state, by a market or by a network – over a social system (e.g. family, tribe, formal or informal organization, territory or across territories) and whether through the laws, norms, power or language of an organized society.

[SOURCE: ISO 24540:2023, 3.2]

3.1.6
integration by design
approach where systems, hardware, applications or processes are developed and deployed with seamless interoperability and communication between components from the outset, fostering efficient and cohesive connections among elements throughout their entire life cycle

3.1.7
industrial internet of things
IIOT
industrial infrastructure of interconnected entities, people, systems and information resources, together with services which process and react to information from the physical world and the virtual world

Note 1 to entry: Industrial internet of things is used to identify the industrial specializations of the *internet of things* (3.1.8).

3.1.8
internet of things
IoT
infrastructure of interconnected entities, people, systems and information resources, together with services which process and react to information from the physical world and the virtual world

[SOURCE: ISO/IEC 20924:2021, 3.2.4]

3.1.9
sensor
detector or transducer normally used for measuring quantities and qualities or detecting occurrences

Note 1 to entry: Analogue transducers are sometimes called sensors.

[SOURCE: ISO 1213-1:2020, 11.2.1, modified — Definition revised.]

3.1.10
smart city
city that increases the pace at which it provides social, economic and environmental sustainability outcomes and responds to challenges such as climate change, rapid population growth and political and economic instability by fundamentally improving how it engages society, applies collaborative leadership methods, works across disciplines and city systems, and uses data information and modern technologies to deliver better services and quality of life to those in the city (residents, businesses, visitors), now and for the foreseeable future, without unfair disadvantage of others or degradation of the natural environment

Note 1 to entry: A smart city also faces the challenge of respecting planetary boundaries and taking into account the limitations these boundaries impose.

Note 2 to entry: There are numerous definitions of a smart city; however, the definition that is used within TC 268 is the official one agreed to by the ISO/IEC Technical Management Board.

[SOURCE: ISO 37122:2019, 3.4]

3.1.11
smart water management
the activity of planning, developing, distributing and managing the use of water resources using an array of information, operations and IoT technologies which are designed to enhance the quality, quantity, efficiency and transparency of the drinking water, wastewater, stormwater and associated services, and make more reasonable and sustainable usage of water resources

Note 1 to entry: Smart water management can be configured selectively or integrally for drinking water, wastewater and stormwater, depending on the situation in each country.

Note 2 to entry: It integrates information and communication technology to monitor water resources, diagnose problems, improve efficiency and coordinate management, transforming the management mode of water business from experience management to data and experience management to help overcome the challenges and provide every citizen with a sustainable water supply.

3.1.12
supervisory control and data acquisition
SCADA
system operating with coded signals over communication channels in order to provide control of equipment and to acquire information about the status of the equipment for display or recording functions

[SOURCE: IWA 33-1:2019, 11.6.1.29]

3.2 Abbreviated terms

ADSL	asymmetric digital subscriber line
AI	artificial intelligence
CAPEX	capital expenditure
CMMS	computerized maintenance management system
DCS	distributed control system
DMZ	demilitarized zone
EPON	ethernet passive optical network
FTTB	fibre to the building
FTTC	fibre to the curb
FTTH	fibre to the home

FTTO	fibre to the office
GIS	geographic information system
HDSL	high-speed digital subscriber line
HSE	health, safety, environment
ICT	information and communication technology
IT	information technology
LAN	local area network
MSTP	multi-service transport platform
NFC	near field communication
OPEX	operating expenditure
OT	operational technology
PI	performance indicator
PLC	programmable logic controller
PON	passive optical network
PPP	public-private partnership
RTU	remote terminal unit
VDSL	very-high-bit-rate digital subscriber loop
VPN	virtual private network
WLAN	wireless local area network
WPAN	wireless personal area network
WWAN	wireless wide area network

4 General

4.1 Scope for smart water management

Smart water management covers the entire water cycle, linking the source water, water supply networks, drinking water treatment, distribution networks, users, wastewater collection networks, wastewater treatment plants and the receiving water body. It may also include the collection, decentralized treatment and utilization of stormwater, as well as the reuse of the treated wastewater. Digital technologies and smart solutions can be integrated at every main point to enhance the reliability, safety and efficiency of water management. Figure 1 gives an illustration of the scope for smart water management.

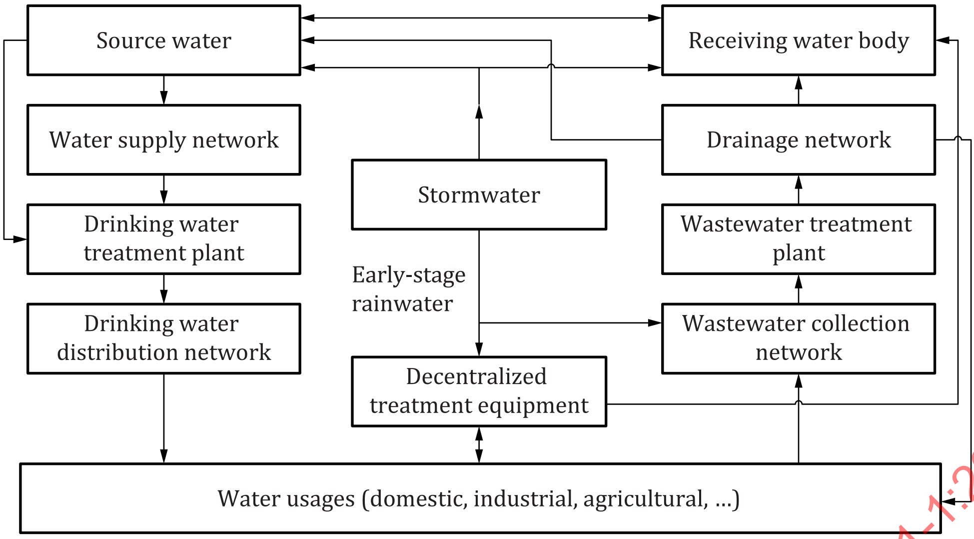

Figure 1 — Illustration of the scope for smart water management

4.2 Challenges and constraints

4.2.1 Stakeholders

The stakeholders typically comprise three categories:

— governments or public agencies (international, national, regional or metropolitan areas and cities) acting with legal or legislative authority;

— water utilities (e.g. international, regional or multinational and national), including drinking water, wastewater or stormwater utilities and their staff;

— users.

Involvement, interaction and coordination between all three of these stakeholder groups is key for qualifying local needs and thus contributing to a successful design and implementation of a smart water management system.

4.2.2 Considerations and challenges

With the increase of the digitalization of smart water services management, water utilities are facing increasing challenges to developing an appropriate digital strategy, implementing appropriate and flexible smart drinking water, wastewater or stormwater treatment and management systems, developing data analytics and decision-making and ensuring sufficient cybersecurity protection.

The digital maturity of each water utility is unique; however, the maturity assessment is based on a common set of principles and guidelines which are adapted to their context to develop value and ensure appropriate governance. This is the most efficient way to mitigate environmental, technical and financial risks in a context of rapidly developing technology, changing user expectations and an increasing need for collaboration with other businesses within a smart city.

For more than 10 years, smart water platforms and smart water management systems have been deployed in various countries and contexts.

Intelligent warning systems, water loss detection, operation optimization, emergency management and performance assessment are examples of use cases where water authorities and water utilities have deployed smart water management systems.

The deployment of these systems requires the integration of several key digital functions, including sensing, monitoring and control, integration by design, data and information management, modelling and optimization, and cybersecurity requirements. Interoperability is key for implementing, expanding or updating any integrated smart water information management system. Such an integrated system needs to address functionality considerations through effective design.

In the context of drinking water, wastewater and stormwater services' contracting and operational requirements particularly, the impact of smart water management is primarily relevant to governance, data ownership, standards and cybersecurity policies.

There is an increasing need for stakeholder (e.g. user, relevant authority, responsible body, operator, community, environmental association, financial institution) transparency through this sharing of data. The data are typically internal sources, for example PIs, online sensors with external data (e.g. weather forecast, open data), with a growing requirement for these data to be readily shareable in a secure manner with entities outside the water utility.

4.2.3 Constraints

Constraints on smart water management include water resources, water rights, proposed modes of service, funders and installation. Different types of constraints and the main concerns are listed in Table 1.

Table 1 — Types of constraint and main concerns

Types of constraint	Main concerns
Regulatory or institutional constraints	— Laws — Regulatory obligations — Slow administrative procedures
Technical constraints	— Ability to retrofit technology — Longevity of existing assets and high cost of replacement
Financial or economic constraints	— Budget programming of a project and ability to provide a robust business case — The funding criteria
Human resources constraints	— Lack of trained staff with enough expertise, e.g. IT staff
Social constraints	— Awareness of the population

4.3 Stakeholder expectations relating to smart water management

Smart water management is expected to facilitate the integration of stakeholder expectations. Table 2 represents the corresponding expectations. The list is not exhaustive and should be considered based on local contexts and introduction of future innovations.

Table 2 — Stakeholders and corresponding expectations

Types of stakeholder	Expectations (examples)
Governments or public agencies	— Protect the environment — Meet regulatory compliance — Minimize supply disruption — Ensure public and worker health and safety — Minimize risk of cyberattacks — Optimize CAPEX and OPEX
Water utilities	— Provide safe and reliable products — Make process excellence — Deliver proactive maintenance — Deliver customer expectations — Meet regulatory compliance — Workforce education and training — Brand awareness and innovation — Minimize risk of cyberattacks — Minimize long-term CAPEX and OPEX — Propose new services — Chemical dosing optimization — Reduce water loss in drinking water pipe network and overflows in wastewater network — Procurement management — HSE management
Users	— Optimize drinking water delivery and consumption (quality, volume and cost) — Optimize wastewater and stormwater removal (quality, volume and cost) — Deliver reliable and safe services (e.g. real-time water consumption and leak alarms, wastewater and stormwater backups) — Timely notification of service-related events — Reduce technical and financial impacts of water shortage, wastewater collection blockages or environmental (including stormwater) events

5 Principles and guidelines for the design of smart water management system

5.1 General

The design of smart water management systems should meet the following principles:

— Consistency – select and configure hardware and software equipment duly adapted to local context (e.g. expertise, regulation, technical support, ease of integration).

— Reliability – the systems should be able to provide continuous and stable water service.

— Compatibility with legacy, current and future digital systems, built in different periods, to the maximum extent possible.

— Resilience – the systems should have the facility for ongoing development and enhancement.

— Robustness – the systems should have sufficient backup and be designed in a manner that enables quick recovery from damage and continued operation during emergencies and natural disasters.

— Cybersecurity – using reasonable measures to safeguard digital assets, including the ability for regular security updates and patches to be installed and security settings to be adjusted by the user, in accordance with relevant policies.

5.2 Design scheme for smart water management systems

When designing a smart water management system, water utilities need to clarify the smart development vision, overall objectives and implementation path, and design the logical architecture (see 5.3 and 5.4) of a smart water management system that meets their demands. This should be accomplished in combination with the practice of smart water management in the water sector, coupled with the overall analysis of the latest developments and trends of information technology.

Smart water management is not only about designing a set of systems but also about designing the in-depth integration of information technology and business (see 5.5), the rationalization of business and processes and the clarity of organizational responsibilities, management innovation and change. Water utilities should consider setting up a special smart water management leadership group internally, responsible for technical, business, network security and other guidance.

It is vital that the smart water management systems have a champion in the senior leadership team (see 7.2).

5.3 Logical architecture for smart water management systems

The logical architecture shown in Figure 2 provides a reference model for the implementation and construction of smart water management systems. It consists of four layers, which are described in detail in 5.4.1 to 5.4.4, respectively.

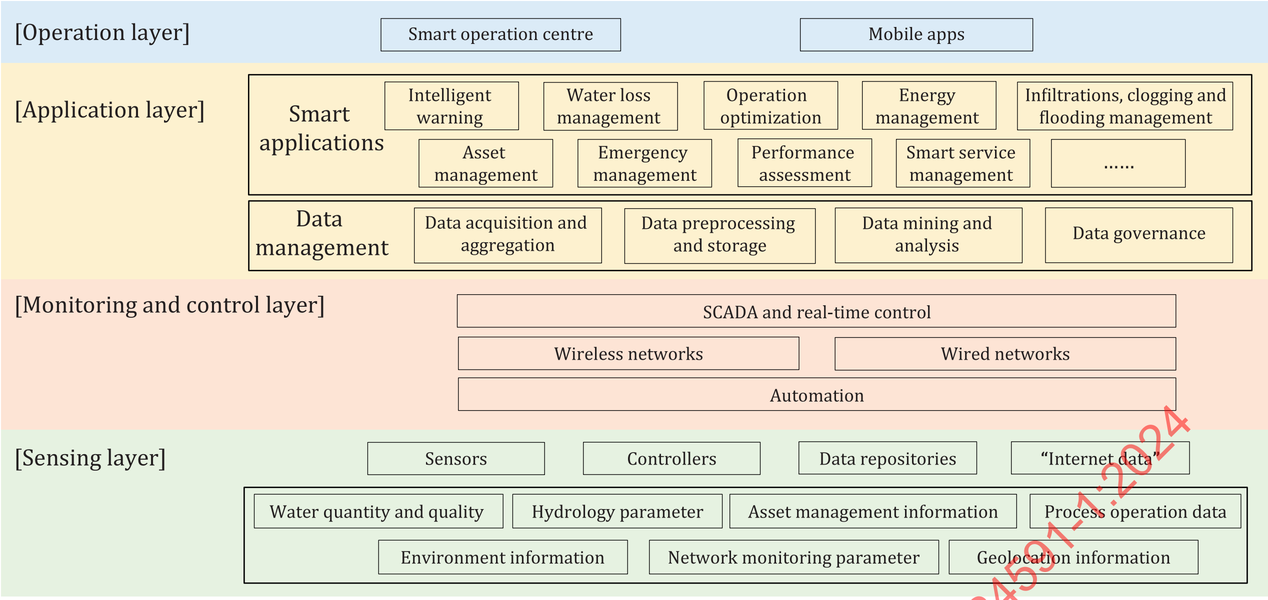

Figure 2 — The logical architecture of smart water management systems

5.4 Design of logical architecture

5.4.1 Sensing layer

The sensing layer is the source of raw data that feeds the smart water management system.

It is a key layer for guaranteeing the performance and quality of smart applications and operations.

It is mainly composed of sensors, data repositories and external data. It also includes a "controllers" component that is used for applying results of calculations coming from the "monitoring and control layer", "application layer" and "operation layer" to pumps, valves and other actuators.

Sensors are the devices in charge of collecting the measurement value and transmitting it to the "monitoring and control layer". Sensors can be deployed anywhere on the water cycle, such as water resources, pumping stations, pump gates, storage tanks, valves, the pipe network, direct rainwater drainage outlets, combined overflow outlets, drinking water treatment plants, wastewater treatment plants, flood-prone points, drainage households or meter readings. They also include innovative sensors, such as industrial IoT devices and nanosensors, and should be capable of gathering data from any new innovative technology capable of being securely and safely connected to the smart water information system.

The most commonly measured values are about water quantity and quality, hydrology parameters, asset performance, process operation, environmental monitoring, network monitoring and geotracking information.

An overview of types of online measurements is shown in Annex A, Table A.1. In this example, some of the online measurements for water quality in water treatment are adapted from ISO/TS 24541.

Data repositories are key components of any information system and a source of data for the smart water management system.

A data repository is a reference data set that is valuable and available for all the businesses of the utility. Examples of data repositories include the asset descriptor (the main source of data for CMMS), other data repositories containing customer or consumer data (with specific data privacy provisions), geographical databases (the main source of data for GIS) and shared addresses and operation data repository.

Data repositories are most of the time outside the smart water management information system and can also be used in other businesses, for instance by multi-utilities in charge of water, wastewater, electricity or public lighting, or when a water utility is operating more than one contract.

External data refers to other data sources coming from external information systems and requiring a highly secure level of connectivity (see, for instance, DMZ zone in Figure 3). Examples of these data include meteorological data and maps, cloud-based data sources, results of external AI applications and models, as well as manual-entered data and file-imported data (see sensing layer in Figure 3).

5.4.2 Monitoring and control layer

The monitoring and control layer is the layer between the sensing layer and the application layer. It manages real-time information. It comprises automation devices and networks, supervisory control and data acquisition (SCADA) software (including alarms management) and a communication sub-layer.

This layer is the most critical in terms of cybersecurity, as any security breach can impact process control and lead to a major threat to water operation.

This criticality also concerns the communication sub-layer in charge of managing data exchange between sensors, process automation, local and central SCADA via wireless and/or wired networks.

Traditionally, “monitoring and control layer” and “application layer” have been physically separated for protecting critical computer systems or data from potential attacks ranging from malware and ransomware to keyloggers or other attacks from malicious actors. However, they are becoming more interconnected. Serious consideration needs to be given to how this interaction is managed. Physical separation remains an option. The alternative is to use multiple firewalls and/or to separate the “active directory” of the two systems to avoid a compromise of one system being able to exploit the vulnerabilities of the second. The exact nature of the solution will depend on the compliance requirements of the utility.

Examples of communication media and related requirements are listed in Table 3.

Table 3 — Requirements of networks

Components		**Requirements**
Wireless network	Examples: WLAN, WWAN, WPAN, 3G, 4G, 5G, Satellite, Radio, NFC, VPN, WMBus, LoRaWAN, NB-IOT, WiFi	— Support a variety of wireless access modes — Support network multi-standard integration from 3G, 4G, 5G to LTE standard smooth evolution
Wired network	Examples: HDSL, VDSL, ADSL, LAN, FTTH, FTTO, FTTB, FTTC, PON, EPON, MSTP	— Support copper wire, optical fibre, coaxial cable and various network access media — The capability of high-speed data transmission — Support network virtualization technology, so that the physical network can be virtualized into multiple logically independent virtual networks

5.4.3 Application layer

5.4.3.1 General

The application layer combines basic calculations, advanced data modelling and management technologies (deep learning, AI, virtual reality, augmented reality, digital twin, blockchain) and other added-value technologies. The goal is to calculate PIs, detect malfunctions by a cross-analysis of all the data sources (beyond the alarms), anticipate problems and mitigate risks in a comprehensive approach to the water cycle. Typically, these are integrated into enterprise-wide or whole-of-business systems.

The application layer consists of two parts: data management and smart applications.

5.4.3.2 Data management

The sensing layer provides high-quality raw data (see 5.4.1) and real-time data are transported and managed at process level or through the SCADA (see 5.4.2).

The application layer also uses high-quality real-time data and combines these with all the data sources for feeding models and applying the results of the modelling process manually or automatically to optimize water operation.

Data are the core link to promote the construction of a smart water management system. Smart water management gathers data related to the whole water cycle as well as various data fed back by production, treatment, operation and water users. It involves a wide range of data, a large number of data and the ability to face the fast growth rate of data quantity .

Although a large number of data can be accumulated in the construction of water information systems, a large portion of these data may be isolated ("data silos" or "data islands"), which could lead to limitations for an efficient use of these data in the smart water management system.

The recommended practice for smart water management systems is to build a central database (CDB), integrating basic geographic data, monitoring data and business data, to break through data barriers between various platforms, realize data interconnection between multiple platforms and eliminate the "data island" between various departments. Based on the applicable hydraulic models, pipe burst analysis models, pressure analysis models, water quantity trend models, big data analysis models, and so on, in-depth mining and analysis of water data are carried out to realize knowledge reconstruction, enable the smart decision-making ability of data and provide fast and effective decision-making support for the business management of water utilities (see 5.4.3.3 for partial smart decision-making applications).

Data management and governance principles are detailed in ISO 24591-2.[1)]

5.4.3.3 Smart applications

Smart applications are solutions and software platforms which comprehensively combine multi-source data and provide professional business application services for smart water management, based on the data management principles as introduced in 5.4.3.2.

Smart applications can include:

— Intelligent warning – the system can track the production and operation status of water utilities at any time and realize remote monitoring and early warning of abnormal conditions.

— Water loss management – the system improves operation of drinking water pipeline networks through online monitoring of, for instance, flow and pressure.

— Infiltrations, clogging and flooding management – the system combines real-time data, weather forecasts and models for detecting water infiltrations and clogging risks as well as for preventing risks of flooding in wastewater and stormwater networks.

— Operation optimization – the system mainly uses mechanism and numerical models to simulate, predict and analyse production and operation data to promote process optimization.

— Energy management – the system realizes efficient energy control through the monitoring and analysis of energy data.

— Asset management – the system regularly records asset information such as equipment and spare parts to realize the informatization of water facility management, operation and maintenance. In advanced systems, it may predict when assets are nearing end of life and can be automated to directly order relevant parts as needed.

1) Under preparation. Stage at the time of publication: ISO/DIS 24591-2:2023.

— Emergency management – the system can be partially digitalized to provide functions such as digital collaborative management and intelligent display of emergency plans to support rapid response to emergency events.

— Performance assessment – the system evaluates various assessment indicators through statistical analysis, model simulation, comprehensive comparison and other methods to achieve fine-grained supervision.

— Smart service management – the system may include innovative smart services to operators, customers and stakeholders.

This list is not exhaustive and should be considered based on local contexts and introduction of future innovations.

5.4.4 Operation layer

The operation layer is a presentation layer, an interface between smart water management information systems and the operation teams. This layer is also key and needs to present the data to control centre operators and mobile teams so they can immediately understand the situation and decide on an appropriate action plan.

The operation layer consists of a set of mobile apps for interventions teams, as well as ergonomic and smart human–machine interfaces in SCADA, smart platforms and, whenever possible, smart operation centre design (the control tower of the water service), including screens, display walls and video management.

5.5 Integration of smart water management systems

Whatever the contract, whatever the context, the design and implementation of a smart water management system requires interoperability by design and physical integration into an existing ICT ecosystem made of various types of information systems.

Figure 3 is a schematic representation of physical integration of a smart water management system. It combines the layers-based representation as detailed in Figure 2 and 5.4 with cybersecurity zoning as presented in 6.2.2 and Annex B. It also highlights the position of operation and maintenance teams as well as end-users.

Figure 3 is aimed at illustrating how the concept of “integration by design” is key and critical and how the smart water management information system is positioned in the wider water company information system.

Data repositories are key components for all aspects of smart water management, see ISO 24591-2. The fundamental aspect of effective integration of data repositories is good shared address management.

For more mature water businesses, data repositories are located outside the smart water management system to enable sharing within the organization and externally.

A signification advantage and challenge is the use of external information systems for dynamic management and early warning modules (i.e. flooding anticipation, risk management, coastal or river pollution), advanced network and plant management (with AI components and IIOT external devices) and billing.

In addition, the smart water information system is a data source for external users and services, such as:

— crisis management (and coordination with external stakeholders);

— customer services (e.g. leak detection, valve shut-off, risk of backflow or flooding, billing services, innovative smart services, online environmental indexes, such as the water quality index and the air quality index);

— smart cities platforms (for municipalities willing to set up wider platforms combining water, gas, electricity, public lighting, traffic, car parks, etc.);

— mobile apps (for users);

— reporting and PI calculation (for contract managers and customers);

— any new service resulting from research and development programmes.

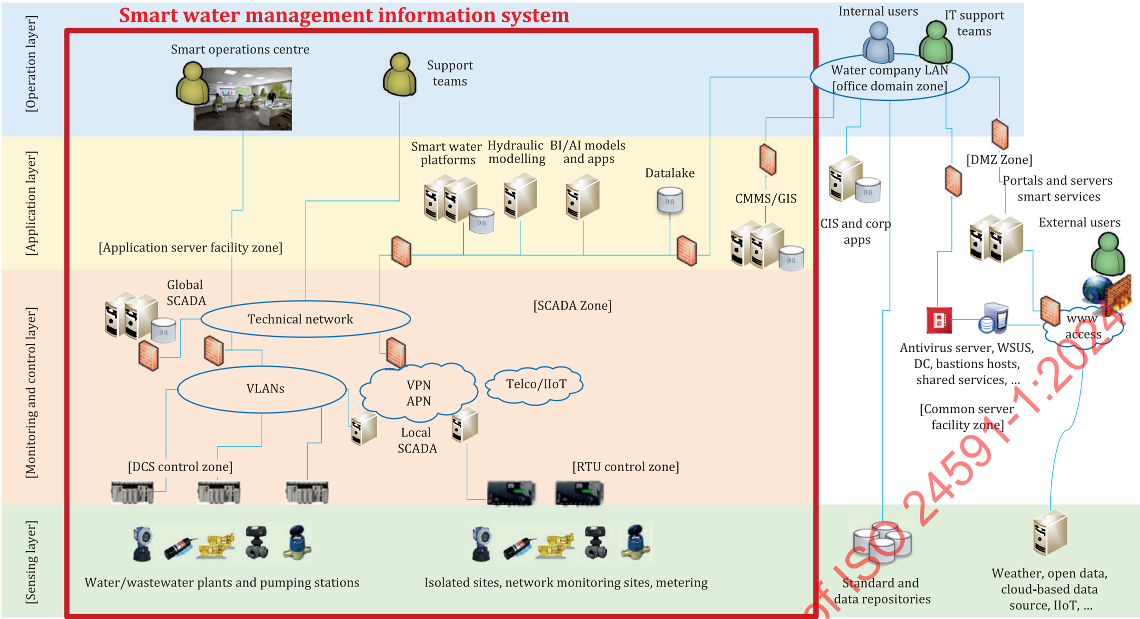

Figure 3 — Illustration of physical integration of a smart water management system

At the design phase, it is highly recommended that consideration is given to the integration of the monitoring and control layer with the data application layer, particularly regarding how the data will be managed across the organization, including the end use and presentation of the data, security constraints and interconnectivity between systems.

Integration by design and cybersecurity by design are major concepts for a successful implementation of a smart water management system.

6 Principles and guidelines for operation and maintenance of smart water management systems

6.1 General

Various technical means are used for monitoring operation, analysis and performance optimization of smart water management systems, detecting and dealing with safety defects in time and ensuring the continuous, stable and safe operation of the smart water management system.

6.2 Verification of system reliability

6.2.1 General

The smart water management system should develop trends and data points that represent typical, stable system operation. These data should be used to set critical limits that indicate whether the system is operating within specification. Any deviation away from the standard operating range should be capable of detection and result in immediate corrective action by the water utility.

6.2.2 Infrastructure security

Smart water management system infrastructure consists of the hardware, software and network that the smart applications depend on. It should conform to International Standards on infrastructure security (e.g. IEC 62443-1-1, IEC 62443-3-2, IEC 62443-3-3, IEC 62443-4-2). Infrastructure security policy should be validated by all stakeholders.

Physical security of office computer network equipment, including server rooms, facilities and other media, should be provided with protection from earthquake, fire, flood and other environmental accidents, as well as human error and criminal activity. Protection includes room safety, facility safety and power safety.

Communication security should be based on the security of the signal. It should also involve the specific data information content which provides a physical guarantee for the correct and reliable transmission of information. It also includes communication line security, communication integrity and communication confidentiality.

The overall cybersecurity system should be developed using the risk management approach detailed in ISO 31000 and the specific cyber security approach detailed in ISO/IEC 27001. Cybersecurity should take the network security architecture as the main body and on this basis, combined with the corresponding network equipment, security equipment and system hardware and software security deployment and configuration. For hardware and IoT devices, the use of the IEC 62443-1-1 cybersecurity reference model is recommended, as introduced in Annex B. It applies to smart water management information systems and should be included at design phase in any smart water management project. The architecture presented in Annex B should be completed with cybersecurity specificities and practices, including, for instance:

— the definition of security zones (see Annex B) such as DCS control zone, SCADA zone and DMZ zone, bearing in mind that:

  — a security zone is a logical group of physical, informational and application assets sharing common security requirements;

  — each security zone has different information security protection requirements due to the different functional goals of the domains or subdomains it contains;

— the definition of cybersecurity governance;

— the conduct of threat assessments for systems to determine their vulnerabilities and address any security gaps before the systems are installed;

— the conduct of pen tests (penetration testing) that have to be performed when there are major changes to systems, such as software modifications, as well as annually, to make sure that the systems remain robust against cyberattacks.

In terms of the sensing layer, to address cybersecurity concerns any direct connection between the sensing layer and the other layers needs to be undertaken with caution. It is not recommended that standard public IoT and other devices are connected to the smart water management information system directly. The deployment of industrial IoT devices (IIOT, such as smart meters and sensors) that are within the water supply system is accepted, provided the communication is encrypted and secure between the device and the data acquisition platform. At the data interface, the IIOT data integration should enter the smart water management information system via secure connection, through the DMZ zone, over the physical separation or by other suitable means (see Figure 3).

6.2.3 Performance indicators (PIs)

The reliability of the smart water management system should be assessed by metrics that present the overall system availability, fault levels and recovery from interruption. PIs should be established based on historic data and necessary system reliability constraints, as determined by the water utility.

6.3 Emergency response plans

Implementation of effective risk management for smart water management includes emergency response plans, which can lead to implementation of digital models and management methods, and defining emergency procedures, emergency responsibilities and emergency resources. The goal is to foster the decision-making process in emergency situations by providing efficient and straightforward information, tools and visual support.

Risk assessments and emergency response plans should be updated to consider all aspects of the smart water management system using the principles in ISO 31000. This will minimize the likelihood of incidents and the severity of their impact and improve the ability to recover and the timeliness of the recovery.

The formulation and implementation of emergency response plans for water utilities should conform to the requirements of ISO 24518. The technical requirements of emergency management should conform to the requirements of ISO/TS 24520.

6.4 Smart water management implementation strategy

The water authority or water utility should aim to deploy the best possible smart water management system and evolve efficiently year after year at an acceptable cost.

The smart water management implementation strategy is the reference document for the implementation of this system, along with piloting and controlling the way it evolves in time. It should be revised at regular intervals, such as once a year. The strategy relies on nine main parts:

— description of the existing situation at the start of the project;

— integration of what is important for the company, constraints and opportunities to come during the project period (e.g. geographical expansion, demographic aspects, changes in regulatory context, such as cybersecurity, telecommunications or environmental protection, integration to wider projects at smart city scale);

— definition of a target system at the end of the project period;

— incorporation of new and emerging innovations and issues or risks;

— the scope of works, with a description of the main tasks and key projects;

— time scheduling for the strategic implementation plan;

— project governance;

— funding and HR aspects;

— other supporting measures for reaching the target.

7 Principle and guidelines for the governance of smart water management system

7.1 General

The water sector is changing faster than ever. A corporate governance system can be implemented to support these changes. The needs and expectations of stakeholders should be taken into account.

Governance is established to ensure clarity of roles and responsibilities, allocation of tasks and ownership of different components of the system. In addition, effective governance enables changes to occur to the system over time to keep it current and assists with the management of incidents and the resolution of disputes. When establishing the governance model, it is recommended that all key stakeholders involved in the delivery of the smart water system are engaged with.

Specific governance principles are as follows:

— agree on specific responsibilities for each of the key stakeholders;

— determine meeting frequencies and terms of reference for relevant meeting groups with clear responsibilities;

— establish key goals, PIs and approaches to managing incidents, emergencies and resolution of disputes.

— anticipate collaborative governance of multiple sectors, such as power departments and traffic management.

7.2 Leadership, roles and responsibilities

7.2.1 The owner of the smart water management system

The owner decides on the nature of the smart water system, the expected outcomes that are required, the time frame to achieve these, the level of integration with the business and the delivery mechanisms, the expected levels of services, the means to allocate (e.g. infrastructure, human resources, funding) and strategic organization (e.g. in-house, public management, PPP).

7.2.2 The leadership team of the owner or water utility

There should be a designated champion from within the leadership team who leads the project and acts as a role model while leading the implementation of the system across the entire business.

7.2.3 The responsible body of the smart water management system

In charge of organizing the services according to objectives and guidelines.

7.2.4 The operator of the smart water management system

The operator (e.g. contractor, division within the owner organization) should apply what is decided by the owner according to the organization put in place by the responsible body.

7.2.5 Data management

Roles and responsibilities referring to data management are detailed in ISO 24591-2.

7.3 Workforce organization and change management

7.3.1 General

The success of the digital transformation requires acceptance and engagement by employees.[19] Adopting digital technologies can bring up human resource concerns relating to skills gaps, workforce transition and change management.[20] While enthusiasm for digitalisation is essential, so are the relevant knowledge and capabilities.[19] Effective employee training is an integral part of change management. In particular, focus should be put on cybersecurity awareness and associated best practices.

7.3.2 Workforce organization

Digital solutions for smart water projects should consider changes in the labour requirements that will occur and facilitate business change to foster relevant skills into the business, either through training or external hires.

The skills required include those for design, management, maintenance and operation of each component of the system. In addition, it is recommended that all staff involved in the smart water system are appropriately trained to avoid, identify and respond to cyber security threats. This should be part of ongoing risk awareness training for all staff.

7.3.3 Change management

Water utilities should periodically reflect on the level of service requirements, service achievements, adequate skills, capacity and asset management, and make appropriate improvements.

Effective change management aims to ensure a smooth transition from the current to the proposed future state.

It requires the following considerations:

- appointing a champion, as defined in 7.2;
- strong communication;
- strong HR strategy;
- effective personnel training programme.

Strengthening the relevant business training for employees can provide strong talent support for the construction, operation and maintenance of the smart water management system.[20]

Annex A
(informative)

Overview of online measurements of the sensing layer