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Foreword

This Technical Report (TR) has been produced by ETSI Technical Committee Smart Machine-to-Machine communications (SmartM2M).

Modal verbs terminology

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Introduction

The present document was drafted by ETSI Technical Committee SmartM2M as a starting point for the development of an extension of the SAREF ontology for the Water domain (SAREF4WATR). The present document includes the first outcomes of a Specialist Task Force (STF) requested by ETSI SmartM2M; it gives insights into the current landscape of initiatives in the Water domain, identifies a set of relevant use cases for such domain, and extracts from those use cases the requirements that should be satisfied by the SAREF4WATR extension.

1 Scope

The present document provides the requirements for an initial semantic model in the Water domain based on a limited set of use cases and from available existing data models. The present document has been developed in close collaboration with different initiatives in the water domain. Further extensions are envisaged in the future to cover entirely the water domain. The associated ETSI TS 103 410-10 [i.1] will specify the extension (i.e. the semantic model) for the water domain based on the requirements and use cases specified in the present document.

2 References

2.1 Normative references

Normative references are not applicable in the present document.

2.2 Informative references

References are either specific (identified by date of publication and/or edition number or version number) or non-specific. For specific references, only the cited version applies. For non-specific references, the latest version of the referenced document (including any amendments) applies.

NOTE: While any hyperlinks included in this clause were valid at the time of publication ETSI cannot guarantee their long term validity.

The following referenced documents are not necessary for the application of the present document but they assist the user with regard to a particular subject area.

[i.1] ETSI TS 103 410-10: "SmartM2M; Extension to SAREF; Part 10: Water Domain".

[i.2] CEN/CLC/ETSI/TR 50572:2011E: "Functional reference architecture for communications in smart metering systems".

[i.3] ETSI TR 103 249 (V1.1.1) (2017-10): "Low Throughput Network (LTN); Use Cases and System Characteristics".

[i.4] ETSI TS 103 264 (V2.1.1) (2017-03): "SmartM2M; Smart Appliances; Reference Ontology and oneM2M Mapping".

[i.5] ETSI TR 103 411 (V1.1.1) (2017-02): "SmartM2M; Smart Appliances; SAREF extension investigation".

[i.6] ISO/IEC 30128:2014: "Information technology - Sensor networks - Generic Sensor Network Application Interface".

[i.7] Recommendation ITU-T F.744: "Service description and requirements for ubiquitous sensor network middleware".

[i.8] M/441 Standardisation mandate to CEN, CENELEC and ETSI in the field of measuring instruments for the development of an open architecture for utility meters involving communication protocols enabling interoperability. European Commission. 12th March 2019.

[i.9] Council Directive 80/778/EEC of 15 July 1980 relating to the quality of water intended for human consumption.

3 Definition of terms, symbols and abbreviations

3.1 Terms

For the purposes of the present document, the following terms apply:

ontology: formal specification of a conceptualization, used to explicit capture the semantics of a certain reality

3.2 Symbols

For the purposes of the present document, the following symbols apply:

GHz	Gigahertz
Kbytes	Kilobytes

3.3 Abbreviations

For the purposes of the present document, the following abbreviations apply:

3D	3 Dimension
3GPP	3rd Generation Partnership Project
ADE	Application Domain Extension
AI	Artificial Intelligence
AIOTI	Alliance for the Internet of Things Innovation
CEN	Comité Européen de Normalisation (European Committee for Standardization)
DG	Directorates-General
EEA	European Environment Agency
EIP	European Innovation Partnership
EMC	Electromagnetic Compatibility
EPA	Environmental Protection Agency
EU	European Union
FACC	Feature and Attribute Coding Catalogue
FD	Floods Directive
FUOTA	Firmware Updates Over The Air
GEOSS	Global Earth Observation System of Systems
ICT	Information and Communication Technology
IEC	International Electrotechnical Commission
IGN	Instituto Geográfico Nacional (National Geographic Institute)
IMTA	Integrated Multi-Trophic Aquaculture
IoT	Internet of Things
ISO	International Organization for Standardization
ITU-T	International Telecommunication Union - sector Telecommunication
IWA	International Water Association
IWO	ICT for Water Observatory
JPI	Joint Programming Initiative
JTC	Joint Technical Committee
OGC	Open Geospatial Consortium
OWL	Web Ontology Language
PLT	Power Line Telecommunications
SAREF	Smart Applications REFerence ontology
SAREF4WATR	SAREF extension for Water
SC	Subcommittee
SME	Small and Medium Enterprise
SRD	Short Range Device
STF	ETSI Specialist Task Force
SWEET	Semantic Web for Earth and Environmental Terminology
SWQP	Semantic Water Quality Portal
TC	Technical Committee

TR	Technical Report
UNESCO	United Nations Educational, Scientific and Cultural Organization
USN	Ubiquitous Sensor Network
WaWO	Waste Water Ontology
WEF	Water Energy Food
WFD	Water Framework Directive
WG	Working Group
WISE	Water Information System for Europe
WITS	Water Industry Telemetry Standards
WssTP	Water supply and sanitation Technology Platform

4 SAREF extension for the Water domain

SAREF [i.4] is a reference ontology for the IoT that contains core concepts that are common to several IoT domains and, to be able to handle specific data elements for a certain domain, dedicated extensions of SAREF can be created. Each domain can have one or more extensions, depending on the complexity of the domain. As a reference ontology, SAREF serves as the means to connect the extensions in different domains. The earlier document ETSI TR 103 411 [i.5] specifies the rationale and methodology used to create, publish and maintain the SAREF extensions.

The present document specifies the requirements for an initial SAREF extension for the Water domain. This initial SAREF extension will be based on a limited set of use cases and existing data models identified within available initiatives that will be summarized in dedicated clauses of the present document. The work conducted in the present document has been developed in the context of the STF 566 (https://portal.etsi.org/STF/STFs/STFHomePages/STF566.aspx), which was established with the goal of creating SAREF extensions for the following domains: Automotive, eHealth/Ageing-well, Wearables and Water. This work is expected to be developed in close collaboration with ETSI, oneM2M, AIOTI, and water-related H2020 and EU projects. However, other initiatives coming from the industrial world and alliances have also been investigated.

STF 566 consists of the following two main tasks:

1) to gather requirements, collect use cases and identify existing sources (e.g. standards, data models, ontologies, etc.) from the domains of interest (Automotive, eHealth/Ageing-well, Wearables and Water) in order to determine the requirements for an initial semantic model for each of the aforementioned domains, based on at least 2 use cases and existing data models, and

2) to specify and produce the extensions of SAREF for each of the aforementioned domains based on these requirements.

The present document focuses on analysing sources, collecting use cases and gathering requirements for an extension of SAREF for the Water domain. The document sets the requirements of an initial semantic model that will result in a new SAREF ontology extension for the Water domain, called SAREF4WATR, that will be published as part of the SAREF extensions technical specifications.

5 Related initiatives

5.1 Standardization initiatives

ETSI STF 534 was launched by ETSI with the goal to create SAREF extensions to the domains of smart cities, smart industry and manufacturing and smart agri-food, turning SAREF into the umbrella that enables better integration of semantic data from and across various vertical domains in the IoT. This STF produced three new extensions of SAREF (SAREF4CITY, SAREF4INMA and SAREF4AGRI) which will be taken into account, along with the other existing extensions, during this work.

CEN/CENELEC/ETSI. Smart Meters Coordination Group. The standardization work under mandate M/441 [i.8] involves different Technical Committees within CEN, CENELEC and ETSI and needs to benefit from existing and on-going standardization activities and deliverables within these committees. To ensure this and to create a common focus on the mandate, four co-ordinating TCs were identified to provide co-ordination of standardization activities as regards smart metering systems: CEN/TC 294: Communications systems for meters and remote reading of meters with liaison with CEN/TC 237 (Gas meters), CEN/TC 234 (Gas infrastructure), CEN/TC 92 (Water meters) and CEN/TC 176 (Heat meters); CENELEC/TC 13: Equipment for electrical energy measurement and load control with liaison with CENELEC/TC 57 (Power systems management and associated information exchange) and IEC SC77A (EMC - Low frequency phenomena); CENELEC/TC 205: Home and Building Electronic Systems with liaison with CEN/TC 247 (Building automation, controls and building management) and CENELEC/TC 57 (Power systems management and associated information exchange); and ETSI SmartM2M: Machine to Machine Communications with liaison with ETSI/SCP (Smart Card Platform), ETSI/MSG (3GPP) (Mobile Standards Group), ETSI/ERM TG28 (EMC and radio spectrum matters on SRD), ETSI/ATTM (Access Terminal Transmission and Multiplexing). TC ATTM incorporated the activities of the closed ETSI TC PLT (Power Line Telecommunications).

CEN/TC 164. Water supply. The European Committee for Standardization created the CEN Technical Committee (CEN/TC) 164 to establish standards for the installation and performance requirements of systems, constructions of components used for the water supply from the production facility, including the treatment of the water, to the taps attached or unattached to a sanitary appliance with the view of maintaining the quality of water as stated in Directive 80/778/EEC [i.9]. Eleven working groups were set up, ranging from external systems and components to security of water drinking supply.

CEN/TC 230. Water analysis. CEN Technical Committee 230 (CEN/TC 230) on water analysis is working on European standards to support the Water Framework Directive with the elaboration of standard test methods for physical, chemical, biochemical, biological, microbiological examination of water quality. Included are as well methods for sampling, quality assurance, and classification aspects.

CEN/TC 294. Communication systems for meters. The work of CEN/TC 294 encompasses standardization of communication systems for meters for all kind of fluids and energies distributed by network and not limited to household meters. The standards of CEN/TC 294 are based on generic descriptions and communication protocol specifications based on a layered communication model ranging from physical to application layer specifications. These standards should guide Member States in the implementation of their national smart metering programmes taking into account distinctions between battery and mains-powered meters and differences between architectures that are linked to the particularities regarding the distribution in Member States. CEN/TC 294 is also responsible for the support of secure communication covering data privacy as an inherent property, providing a scalable mechanism for security services, data integrity, authentication and confidentiality.

OGC. The Open Geospatial Consortium has defined WaterML 2.0, an information model for the representation of water observations data, with the intent of allowing the exchange of such data sets across information systems (https://www.opengeospatial.org/standards/waterml). Moreover, the latest version of WaterML 2.0 (part 3) includes the informational model called HY_FEATURES that is focused on representing hydro-science and water network topology. Complementing this information, the OGC also offers CityGML ADE, for the representation of utility networks in 3D city models (http://www.citygmlwiki.org/index.php/CityGML_UtilityNetworkADE).

ISO. Different Technical Committees inside ISO are relevant for this work. ISO/TC 224 deals with the standardization of the management concepts for service activities relating to drinking water supply, wastewater and stormwater systems; ISO/TC 282 deals with standardization of water reuse of any kind and for any purpose, covering both centralized and decentralized or on-site water reclamation, and direct and indirect reuse applications, taking into consideration the potential for unintentional exposure or ingestion; ISO/TC 30 deals with standardization of rules and methods for the measurement of fluid flow in closed conduits.

ISO/IEC 30128:2014 [i.6]. Defined by the ISO/IEC JTC 1/SC 41 (Internet of Things and related technologies), ISO/IEC 30128:2014 specifies the interfaces between the application layers of service providers and sensor network gateways. The standard covers: description of generic sensor network applications' operational requirements, description of sensor network capabilities, and mandatory and optional interfaces between the application layers of service providers and sensor network gateways.

WITS. The WITS Protocol Standards Association has defined WITS-DNP3, a protocol that defines a standard method to achieve the utility industry telemetry control and monitoring requirements, in particular interoperability between equipment from different manufacturers, and WITS-IoT, a protocol aimed at lower power, less expensive devices that provides an application layer covering standard IoT technology (http://www.witsprotocol.org/).

Recommendation ITU-T F.744 [i.7]. Service description and requirements for ubiquitous sensor network middleware. The purpose of Recommendation ITU-T F.744 is to describe ubiquitous sensor network (USN) services and requirements for ubiquitous sensor network middleware. This is achieved through an intermediate entity (USN middleware) that provides functions commonly required by various ubiquitous sensor network services.

5.2 Associations

AIOTI. The Alliance for Internet of Things Innovation (AIOTI) is a multi-stakeholder platform for inspiring IoT Innovation in Europe that combines together large and small companies, academia, start-ups and scale-ups, end-users, policy makers and representatives of society in an end-to-end approach (https://aioti.eu/). Two of the AIOTI working groups are relevant for this work: WG10 on Smart Water Management and WG3 on IoT Standardization.

WssTP. The Water supply and sanitation Technology Platform (WssTP) was initiated by the European Commission in 2004 for Research and Technology Development in the water industry and was transformed into an independent legal entity under Belgian Law in 2007 (http://watereurope.eu/). The mission of WssTP is to foster collaborative, innovative and integrated European research and technologies development, to ensure the European growth and competitiveness of the water sector, to provide global answers to global challenges for the next generations, and to address the challenges of an integrated and sustainable management of water resources.

EIP Water. The European Innovation Partnership on Water (EIP Water) is an initiative within the EU 2020 Innovation Union that facilitates the development of innovative solutions to address major European and global water challenges (https://www.eip-water.eu/). At the same time, the EIP Water supports the creation of market opportunities for these innovations, both inside and outside of Europe. The EIP Water aims to remove barriers by advancing and leveraging existing solutions. Its implementation has started in May 2013 with the main objective to initiate and promote collaborative processes for change and innovation in the water sector across the public and private sector, non-governmental organizations and the general public.

Water JPI. The Joint Programming Initiative "Water challenges for a changing world" (Water JPI) deals with research in the field of water and hydrological sciences (http://www.waterjpi.eu/). The availability of water in sufficient quantities and adequate quality is indeed a public issue of high priority and addresses a pan-European and global environmental challenge. The Council of the European Union decided to launch the Water JPI December 2011 as a contribution to the reduction of fragmentation of efforts by Member States and mobilization of skills, knowledge and resources, with a view to strengthening Europe's leadership and competitiveness on water research and innovation.

ICT4Water cluster. The ICT4Water cluster is a hub for EU-funded research and innovation projects developing digital innovations for the water sector (https://www.ict4water.eu/). It brings projects together supporting them to: exchange information and best practices, disseminate and exploit project outputs, contribute to defining digital water strategies, and contribute to policy development in digital and water domain.

IWA. The International Water Association (IWA) is an open platform in which both innovators and adopters of new technologies and approaches can generate creative friction; it is a place for diffusion, benchmarking and evidence (https://iwa-network.org/). The IWA develops research and projects focused on solutions for water and wastewater management, organizing events that bring the latest science, technology and best practice to the water sector at large, and working to place water on the global political agenda and to influence best practice in regulation and policy making.

5.3 European projects

H2020-STOP-IT (https://stop-it-project.eu/). Water infrastructures are essential for human society, life and health. They can be endangered by physical or cyber threats with severe societal consequences. To address this, the H2020 funded STOP-IT project works in identifying current and future risks and co-develops an all-hazards risk management framework, for the physical and cyber protection of critical water infrastructures.

H2020-SIM4NEXUS (https://www.sim4nexus.eu/). Water, land, food, energy and climate are interconnected, comprising a coherent system (the "Nexus"), dominated by complexity and feedback. SIM4NEXUS aims to predict society-wide impacts of resource use and relevant policies on sectors such as agriculture, water, biodiversity and ecosystem services through a model-based analysis. This project aims to adapt existing knowledge and develop new expertise on the Nexus; to reduce uncertainty, and to show the implementation by a network of regional and national cases.

iBATHWATER (https://www.ibathwater.eu/). iBATHWATER is a real-scale demonstration project for a new integrated management system for the urban sewerage network. Its application is expected to reduce the impact of discharged untreated rainwater on the natural environment, thereby improving the quality of bathing water during and after episodes of intense rainfall. It aims to demonstrate how integrated management of urban drainage helps to reduce the impact of discharged untreated urban rainwater on the natural environment and public health.

iFishIENCi (http://ifishienci.eu/). The iFishIENCi EU funded project aims to develop and demonstrate disruptive IoT/AI based innovations, considering the feeding value chain as a whole, and addressing four commercially-important species, with fish quality as focus. The main aim of the project is to identify new value chains for the valorization of specific waste (dirty water, sludge) from different production systems, leading to zero-waste target and value creation. It also demonstrates how strain selection and smart breeding can support optimizing the feeding efficiency for alternative feeds in African catfish.

IMPAQT (https://impaqtproject.eu/). The project aims to develop and validate in-situ a multi-purpose, multi-sensing and multi-functional management platform for sustainable Integrated Multi-Trophic Aquaculture (IMTA) production. The main aim of this project is to design and implement new efficient and cost-effective technologies in monitoring and management systems for IMTA production; to demonstrate an optimal sustainable IMTA development in a holistic perspective based on ecosystem services; to validate the IMPAQT system and IMTA model in-situ and the fish/seafood product in laboratory; to promote an effective transfer of knowledge derived by IMPAQT activities to the EU aquaculture stakeholders.

Fiware4Water. This project will began in June 2019 and intends to link the water sector to FIWARE© by demonstrating its capabilities and the potential of its interoperable and standardized interfaces for both water sector end-users (cities, water utilities, water authorities, citizens and consumers), and solution providers (private utilities, SMEs, developers).

Aqua3S. This project will begin in June 2019 and will target water safety and security, aiming to standardize existing sensor technologies complemented by state-of-the-art detection mechanisms for drinking water networks.

5.4 Ontologies

hydrOntology. hydrOntology (http://mayor2.dia.fi.upm.es/oeg-upm/index.php/en/ontologies/107-hydrontology/) has the main goal of integrating different information sources coming from heterogenous cartographic agencies and other international resources. Initially, this ontology was designed as a local ontology that provided mappings between multiple Spanish National Geographic Institute (IGN) data sources (gazetteers, feature catalogues, etc.); the purpose of hydrOntology was to provide a harmonization framework among the producers of Spanish cartographic. This ontology has emerged into a global domain ontology and it makes efforts to cover most of the hydrographical domain. For the development of this ontology several knowledge models (such as the Alexandria Digital Library, the Water Framework European Directive, the UNESCO Thesaurus, Getty Thesaurus, and FACC codes, GeoNames, EuroGlobalMap, EuroGeonames, EuroRegionalMap and several Spanish Gazetteers) were examined. The main aim was to cover most of the Geographic Institution sources and develop an extensive global ontology which contains hydrography related content (lake, channel, reservoir, river and others).

InWaterSense ontology. The InWaterSense ontology (https://inwatersense.uni-pr.edu/Outputs_Software.aspx) allows describing three aspects of water quality, such as: regulations for the act of safe drinking water published by authorities; water domain knowledge handled by scientists (e.g. water bodies and water-relevant contaminants etc.); and observational data items (e.g. the quantity of ammonia in water) acquired by sensing devices. The InWaterSense ontology consists in four ontology modules, namely: the core ontology, the regulation ontology, the polluters ontology, and water expert rules. The core ontology allows describing observational water quality data such as; Alerts, BodyOfWater, Device, DeviceType, Element, Event, Property, Region etc. together with the corresponding descriptive metadata, including the type and unit of the data item as well as the provenance metadata. The regulations ontology module deals with permitted water parameter thresholds regulated by different authorities; this module also has different classes for maintaining Property, Standard and Status etc. which are modelled to follow different authoritative water quality regulations. The polluters ontology, a module representing polluter entities and their attributes, allows representing the attributes of Pollutants (Ammonia, Litter, Nitogen, Oil, Soil, Sewage, Sulphate, Solids etc.) and Pollution Sources (Mining, Fish Farming, Landfill Sites, Organic Waste, Contaminated Land etc.). Finally, the rules module includes rules defined by water experts.

Ordnance Survey Hydrology ontology. The Ordnance Survey Hydrology ontology (https://github.com/vangelisv/thea/blob/master/testfiles/Hydrology.owl) aims to describe in an unambiguous manner the inland hydrology feature classes surveyed by Ordnance Survey with the intention of improving the use of the surveyed data by our customers and enabling semi-automatic processing of these data. The scope of the ontology are permanent topographic features involved in the containment and transport of surface inland water of a size of 1 metre or greater including tidal water within rivers. Functional, topological and mereological relationships between these features are included. Physical characteristics are described just to a level sufficient to discriminate between the concepts.

SemantAQUA Water ontology. The Semantic Ecology and Environmental Portal (https://tw.rpi.edu/web/project/SemantEco) assimilates environmental monitoring and regulation data from different sources by following the principles of Linked Data. It acquires the domain knowledge semantics using a family of modular ontologies, retaining provenance metadata and interpreting environment pollution events. The portal combines domain ontologies and a general upper ontology for air and water for monitoring environmental pollution, enabling the discovery of polluted water, polluting facilities, health impacts, and specific contaminants.

SWEET ontologies. The Semantic Web for Earth and Environmental Terminology (SWEET) ontology (https://github.com/ESIPFed/sweet) presents an upper-level ontology that includes several thousand terms, spanning a huge extent of Earth system science and related concepts using the OWL language. SWEET consists of nine top-level concepts that can be used as a foundation for domain specific ontologies, namely, Realm (*Ocean, Atmosphere, Land Surface, and Terrestrial Hydrosphere, etc*.), Phenomena (*physical and macro-scale ecological*), Processes (*mathematical, micro-scale physical, chemical, biological*), Representation (*math, time, space, data and science*), and Human Activities (*Commerce, Decision, Jurisdiction, Research, and Environmental*).

SWQP Water ontology. The Semantic Water Quality Portal (SWQP) ontology is intended to support the identification of polluted water sources and potential pollution sources, also helping to control and alleviate related adverse health effects. It allows integrating water data from heterogeneous authoritative sources along with different regulation ontologies to provide pollution monitoring and detection. The ontology also enables capturing provenance to enhance transparency and enables highlighting potential impacts for the future of environmental systems. The ontology has four major classes: BodyOfWater, Facility, Measurement, and MeasurementSite. The BodyOfWater class has a sub-class WaterSite to measure the quality of water. The Facility class has a sub-class WaterFacility to record the water quality by the EPA or state agencies. The Measurement has a sub-class WaterMeasurement for a measurement of water samples. The MeasurementSite class has a sub class WaterSite, a site to measure the water quality.

Water Nexus ontology. The Water Nexus ontology (https://rioter-project.github.io/rioter-nexus-variables-ontology/) is aimed at linking water nexus variables to drive polities under a serious game environment. The proposed semantic model is an extension of the SAREF and Rioter models to represent the different variables and the measurements. Complementing these ontologies, the semantic model goes forward in the representation of serious game information and in linking water nexus variables according to different regions.

WaWO+ ontology. Waste Water Ontology (WaWO) (http://www.cs.upc.edu/~loliva/OntoWAWO+.owl) has been developed to model information about wastewater treatment tasks through the definition of the basic terms and relations comprising the vocabulary of the wastewater treatment area. It is the demonstration of a shared understanding of the wastewater domain that is agreed among several agents: mainly, experts in chemical, environmental and engineering. The main aim of the WaWO ontology is to design a model that: presents a vocabulary for the wastewater domain that all agents can jointly use and understand by describing the meaning of each term in an as unambiguous and precise manner as possible.

WEFNexus ontology. The WEFNexus ontology (https://github.com/mizanur3/WEFNexus) represents the dynamic and structural elements of the water-energy-food systems from the complex system and ecological prospectus. The ontology models the semantics of the water-energy-food (WEF) systems' phenomena, events, elements, and the planned and natural tasks that lead to depict transitions in the elements. It specially models the nonlinear, emergent, and scale invariant behaviours of the WEF networked systems over different organizational levels. The ontology aims to provide interoperability and integration of diverse WEF nexus data which lead to the reduction of environmental stress and improvement of the chances of sustainable growth. The nexus approach aims to identify trade-offs and synergies of water, energy, and food systems, internalize social and environmental impacts, and guide development of cross-sectoral policies.

5.5 Other Initiatives

5.5.1 Directives

INSPIRE. The INSPIRE Directive aims to create a European Union spatial data infrastructure for the purpose of EU environmental policies or activities which can have an impact on the environment (http://inspire.ec.europa.eu/). This European Spatial Data Infrastructure will enable the contribution of environmental spatial information among public sector organizations, providing public access to spatial information across Europe and assisting in policy-making across boundaries. INSPIRE is based on the infrastructures for spatial information established and operated by the Member States of the European Union. The Directive addresses 34 spatial data themes required for environmental applications; of relevance for this work are the following themes: Utility and governmental services (https://inspire.ec.europa.eu/Themes/136/2892) and hydrography (https://inspire.ec.europa.eu/Themes/116/2892).

EU WFD and FD. The EU Water Framework Directive (WFD), adopted in 2000, requires effective water management and helps Member States prepare for extreme weather events which, due to climate change, are becoming more frequent and cause tremendous damages (http://ec.europa.eu/environment/water/water-framework/). To complement the WFD, the Floods Directive (FD) was adopted in 2007 and requires Member States to assess and map flood risks and hazards and to manage them by putting in place flood risk management plans (http://ec.europa.eu/environment/water/flood_risk/).

5.5.2 Data repositories

European Environmental Agency. The European Environment Agency (EEA) is a European Union agency, which aims to provide sound and complete information on the environment. The EEA also supports development by helping to obtain measurable and significant advancement in Europe's environment, through the provision of timely, targeted, reliable and relevant information to the public and policymaking agents. The EEA offers a broad range of datasets, most of them are environmental datasets (including water-related datasets), available in all important formats (https://www.eea.europa.eu/data-and-maps).

WISE. The Water Information System for Europe (WISE) is a partnership between the European Environment Agency and European Commission (DG Environment, Joint Research Centre and Eurostat) (https://water.europa.eu/). It is a collective database created around the subject of water management in Europe that holds all the significant information on this matter, hence composing a new, comprehensive, shared EU data and information system for water, with river basins. It presents water-related information and data organized in four broad areas: projects, policy, links, themes, and data. WISE aims: to provide a single entry point to acquire integrated and high quality European water data and information provided by mainly Member States; to assess the compliance with and implementation of European water legislation and national laws and inform the citizens thereof; to compare and assess environmental trends and status linked to water and their associated pressures and impacts from human activities including the underlying socio-economic driving forces; and to use the gathered information to analyse the effects and the effectiveness of the EU water policy.

GEOSS. The Global Earth Observation System of Systems (GEOSS) is a collection of independent, coordinated, Earth observation, information and processing systems that relate and provide access to heterogeneous information for a huge range of users in both private and public sectors (http://www.geoportal.org/). GEOSS relates these systems to empower the observations of the state of the Earth. It provides the contribution of environmental data and information gathered from the large array of observing systems shared by organizations and countries. GEOSS assures that these data are usable, of described quality and provenance, and interoperable to support the tools development and the information delivery services.

Copernicus. Copernicus is a European system for controlling the Earth and is coordinated and maintained by the European Commission (https://www.copernicus.eu/). The development of the observation infrastructure is processed under the aegis of the European Space Agency for the space segments and by the European Environment Agency and EU countries for the in situ component. It is a collection of complex systems which gather data from different sources: earth observation satellites and in situ sensors such as airborne sensors, sea-borne sensors, and ground stations. It prepares these data and serves users with relevant and up-to-date information through a group of services associated to the security and environmental issues. These services focus on six thematic areas: marine, land, climate change, emergency management, security and atmosphere.

IWO. The main aim of the ICT for Water Observatory (IWO) is to allow the community to take benefit of all EU funded activities and existing technologies in academy, industry and other sources (http://iwo.widest.eu/). In the water sector, there are several stakeholders and actors with different requirements and IWO serves relevant and concrete information to each of them and makes observation more focused and effective.

6 Use cases

6.0 Introduction

A comprehensive set of smart water uses cases are given in Annex A of [i.2]. Other relevant use cases for smart water metering are introduced in clause 5.1 of [i.3].

For the purposes of the present document, a focus on two of the most common smart water metering uses cases will be presented, as well as two other use cases with a focus on cross-domain interoperability.

6.1 Use case 1: Remote reading of metrological registers

Meter readings and other metrological data recorded are transmitted to the application server following a scheduled (daily/hourly) or on-event scheme. This could be based on a 1-way (Uplink only) or a 1,5-way (following [i.3] terminology) communication. Following this transmission, a "reception window" could be opened to enable the application server to send an acknowledgement.

For battery powered wireless communication modules, a small quantity of data is transmitted/received. A 50/100 bytes payload during transmission is considered as reasonable.

This mode is suitable for the billing use case.

6.2 Use case 2: Advanced meter reading and configuration

Some use cases require a higher quantity of data exchange/lower latency to enable quick reactivity. Among others, the following uses cases could be mentioned:

- Precise Billing (Variable tariff)
- Quality Monitoring (Reverse flow, Low temperature)
- Asset Monitoring (Tamper/Fraud, Reversed/Blocked/Incorrectly sized meters, Freeze detection)
- Water Network efficiency (Consumption/Supply monitoring, Leak detection, Permanent flow)
- Remote configuration/monitoring (Manage metrological/system parameters, meter and system status monitoring, Clock synchronization, FUOTA, Security key updates, Flow/supply disconnection/limitation)

To fulfil the requirement of these use cases, a 2-way communication is needed. The triggering of data exchange sequences could be initiated either by the meter (by transmitting a message) or by the application server if the meter allows periodic/scheduled reception windows. The quantity of data to be exchanged could vary from a typical 100 bytes payload up to 100 Kbytes in case of FUOTA.

6.3 Use case 3: Risk Management over water critical infrastructure

There exists the need to integrate the management of the water critical infrastructures (risks) in the overall water management. Specifically, there is the envision to categorize the different physical and cyber threats to establish strategic and tactical risk management. For that, the approach is to merge some measurements of the ICT water systems (sensors, actuators, decision support tools, early warning systems, databases, etc.) that compose the entire water infrastructure in order to determine when a risk will be materialized. There is the intention to have a common risk repository to query an offer to the critical infrastructures. Moreover, the integration of different risks will serve to cross-domain integration of the critical infrastructures and analysing cascading effects between infrastructures.

Taking into consideration these aspects, there is the initial intention to integrate information from the already developed Risk Identification Database, the Risk Reduction Measures Database, and systems to the water infrastructure (databases, sensors, actuators, etc.).

6.4 Use case 4: Interrelation of cross-domain variables and models for policy-making

This use case is motivated by the need to integrate information from different data sources (systems, IoT, static information) referring water, energy, food, land use and climate change of different agencies and uses-cases around EU. Under this framework there is a need to harmonise the high variability of terms referring to the same "IoT-Thing". Considering these aspects, it is important to represent the information from multiple systems that are observing a heterogeneous number of water, energy, food, land use and climate change variables. These variables will conform some policy evaluation scenarios. The type and the number of these variables will vary from one scenario to others. So, one of the main aspects is to make understandable the collected information from the scenarios and the subsequent models and variables that conform the Nexus models. Based on that, there are required standard definitions and terms adoptions.

7 Requirements

The requirements presented in this clause have been derived from the previously presented use cases. Even if not every requirement is useful for every use case, the different categories of requirements taken into account are expected to support these and other use cases in the water domain.

The associated requirements have been grouped in different categories and are presented from Table 1 to Table 7.

Table 1: Requirements for the "Water infrastructure" category

Id	Competency Question/Statement	Answer
WATR-1	Which assets compose a water distribution infrastructure?	Catchment well, raw water pipe, reservoirs, etc.
WATR-2	A catchment well is a well that has been constructed to collect water.	
WATR-3	A wastewater treatment plant is a facility where contaminants are removed from wastewater or sewage.	
WATR-4	Which types of sensors are used in water infrastructures?	Water quality sensors, capacity sensors tank level sensors, etc.
WATR-5	Which types of actuators are used in water infrastructures?	Pressure regulators, pumps, valves, etc.

Table 2: Requirements for the "Water meter" category

Id	Competency Question/Statement	Answer
WATR-6	A water meter is a device that measures different aspects of a water infrastructure.	
WATR-7	What is the type of the water meter?	It is a cold-water meter.
WATR-8	What is the fabrication number of the water meter?	4837QW.
WATR-9	What are the manufacturer and the model of the water meter?	It is a Meterall, model Turion.
WATR-10	What is the version of the water meter?	Version 1.2.
WATR-11	What is the hardware version number of the water meter?	23.5b.
WATR-12	What firmware version is the water meter using?	The metrology (firmware) version is 123.7.
WATR-13	What has been the on time for the water meter?	15 days.
WATR-14	What is the operating time of the water meter?	5 hours.
WATR-15	What is the operating time of the water meter's battery?	4 months and 4 days.
WATR-16	When was the battery of the water meter previously changed?	On February 23rd 2019, at 13:45.
WATR-17	What is the remaining battery time of the water meter?	27 months.
WATR-18	What is the power of the water meter?	24 volts.
WATR-19	What is the radio frequency level of the water meter?	2,4 GHz.
WATR-20	What is the geolocation of the water meter?	Latitude 40.4165 and longitude -3.7025.

Table 3: Requirements for the "Meter measurements" category

Id	Competency Question/Statement	Answer
WATR-21	What is the volume being measured by water meter 243?	127 litres.
WATR-22	Which was the flow of water meter 44 on January 15th 2019 at 12:30?	32 litres per hour.
WATR-23	How many water meters are measuring an external temperature greater than 23ºC?	5 meters.
WATR-24	The maximum temperature limit of the water meter is of 49ºC.	
WATR-25	Water meters can provide measurements according to different temporal settings: current values, periodical values, set date values, billing date values, minimum values, and maximum values.	
WATR-26	Measurements can be related to a specific date and/or time, to some duration, or to a temporal interval.	

Table 4: Requirements for the "Infrastructure measurements" category

Id	Competency Question/Statement	Answer
WATR-27	What is the current level of the reservoir?	200 litres.
WATR-28	What are the inflow/outflow rates of the water reservoir?	500 litres.
WATR-29	What is the current water flow in water pipe 212?	250 litres per second.
WATR-30	What is the current water leak rate in water pipe 212?	0,4 litres per second.
WATR-31	Which systems had the water pressure lower than 100 on August 15th?	Pump 123 and pump 145.
WATR-32	What is the maximum discharge flow of water pump 8?	500 litres per minute.

Table 5: Requirements for the "Water measurements" category

Id	Competency Question/Statement	Answer
WATR-33	What are the physical properties of water?	Temperature, conductance, turbidity, etc.
WATR-34	What are the chemical properties of water?	pH, total hardness, concentration of different chemical components, etc.

Table 6: Requirements for the "Indicators" category

Id	Competency Question/Statement	Answer
WATR-35	Is the minimum pressure level maintained everywhere the water distribution infrastructure?	Yes.
WATR-36	What is the capacity of wastewater treatment plants in Madrid?	12 Megalitres per day.
WATR-37	Which water indicators are defined for Burgos?	Number of connected residential properties, annual maintenance costs, volume of potable water supplied.

Table 7: Requirements for the "Tariff" category

Id	Competency Question/Statement	Answer
WATR-38	What is the start date and time of the tariff in use in the water meter?	1st January 2019.
WATR-39	What is the duration of the current tariff of the water meter?	1 year.
WATR-40	What is the tariff period of the water meter?	1 month.
WATR-41	What is the maximum contracted consumption of the water meter?	1 200 litres.
WATR-42	What is the billing date of the water meter?	31st March 2019.
WATR-43	What is the billing date period of the water meter?	1 month.

8 Conclusions

The present document describes the use cases taken into account for the development of the SAREF4WATR extension as well as the 43 final requirements defined to be implemented in such extension. These requirements are split into the following categories: Water infrastructure (5), Water meter (15), Meter measurements (6), Infrastructure measurements (6), Water measurements (2), Indicators (3), and Tariff (6).

Finally, during the "SAREF4WATR Validation Workshop" held at the ICT4Water Cluster annual event at Brussels on 11th June 2019, different feedback was gathered such as the need to take into account the provenance of values, the geolocation of meters, and leaks in the water infrastructure; and the relevance of connecting information from the water domain with information from other domains such as weather or irrigation.

Annex A: Bibliography

- ETSI TS 103 267: "SmartM2M; Smart Appliances; Communication Framework".
- oneM2M TS-0001: "Functional Architecture".
- oneM2M TS-0002: "Requirements".

History

Document history		
V1.1.1	October 2019	Publication