Smart Systems for Water Management

Standardization activities and gaps for Smart Sustainable Cities (SSC)

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EURECAT TECHNOLOGY CENTRE

Public System R&D

Generation of Knowledge

Applied research and technological development

450 professionals

♂ 60%

♀ 40%

Production System

Generation of Value

2016 €60M*

2015 €40M

2014 €32M

+ **1,000** Business clients

– **160** Large R&D projects

+ **73** Patents

– **7** Spin-offs

80% R&D Projects

50% International Projects

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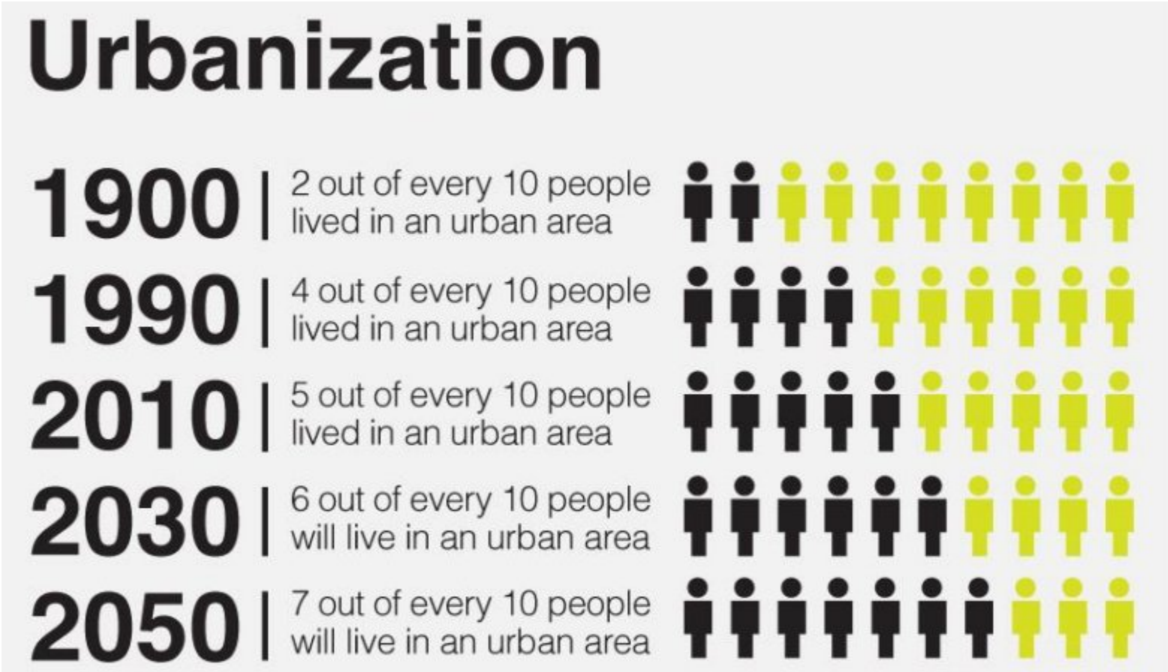
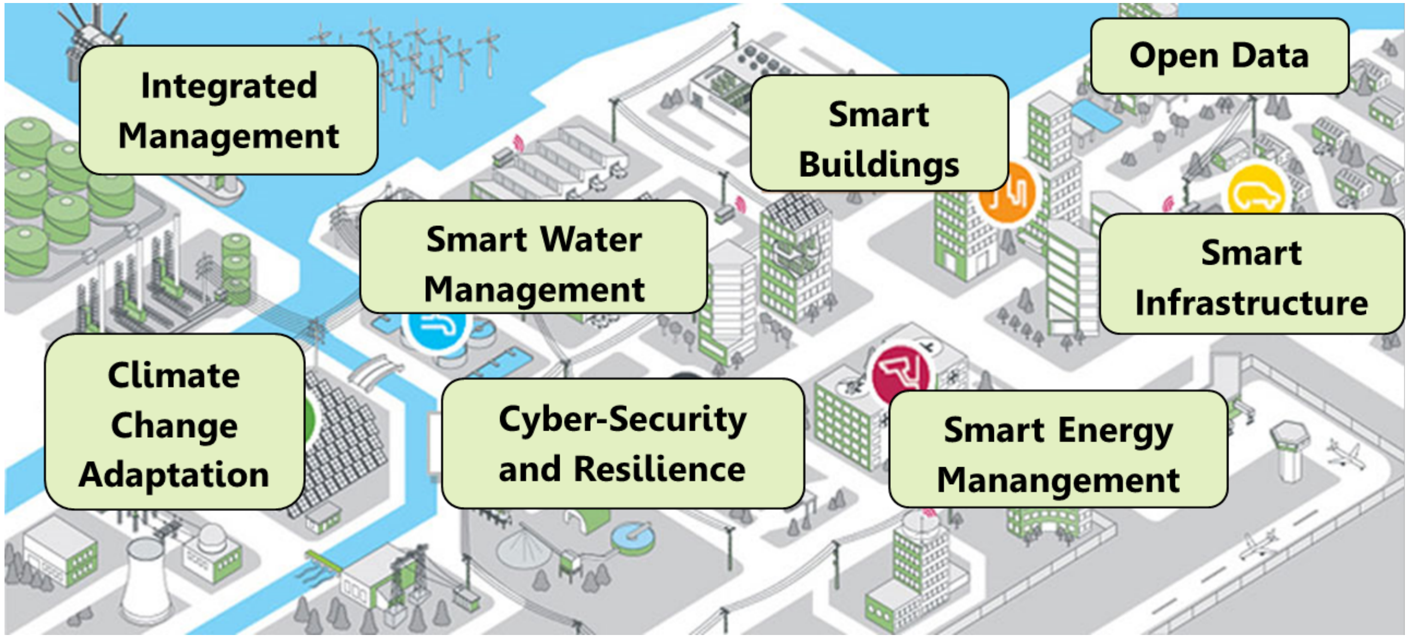
Current situation (1)

Within an increasingly inter-connected world, **rapid urbanization** constitutes one of the most challenging facets of the 21st century. 54% of the world's population resides in urban areas, a percentage that is expected to reach 66% by 2050. The growth of the world's urban population is evidencing the need to **re-think traditional approaches to sustainable development and urban planning**.



Current situation (2)

Despite the recent emergence of smart cities initiatives around the globe, **efforts to realize an integrated vision based on the notions and implications of 'smartness' and sustainability, including** the standardization efforts needed to assess their efficiency, are still in the early stages.



Smart Sustainable City (SSC)

Decision-makers are facing the pressing need to re-think and re-define the way in which **infrastructure is built, services are offered, citizens are engaged, and systems linked**, with the aim of transforming cities into more sustainable and robust living environments.

While technology is an essential component of strategies to develop and implement SSC, cities are about *people*. Any strategy should be focused on ultimately **improving the quality of life of the city's inhabitants** through novel, more efficient, and increasingly inclusive ICT-enabled approaches.

SSC **uses ICTs and other means to improve quality of life, efficiency of urban operation and services, and competitiveness** ensuring that it meets the needs with respect to **economic, social and environmental aspects.**

WHY STANDARISED APPROACH? (1)

- **Scalable and more reliable** to connect different software and hardware systems.
- Facilitates **modular composition of complex systems** from separate parts and also the later addition or exchange of specific modules.
- Improves **sharing of data and knowledge** between organizations and projects allowing a greater exploitation of the information.
- Makes **easier the market entry** for small and medium-sized companies.
- **Support the internationalization** of smaller and innovative companies.
- Aligns thinking and understanding which leads to a **deeper shared system**.
- Network, protocol and data-format standardization are **a central element of more efficient system interoperability**.

WHY STANDARISED APPROACH? (2)

For moving into an operational phase, the introduction of standards in the following areas is considered likely to facilitate the deployment of solutions:

- **Interoperability of:**
    - Hardware and software: **Architectures, Data models, interface & designs**
    - **Data interchange formats**
    - **Communication protocols**
    - **Semantics**
- Interchangeability and replacement
- **Comparability of: o Data o Processes o Procedures**
- Quality and reliability/resilience
- Security and Safety
- Environmental, Legal and competitive issues

Standards for Smart SSC categories:

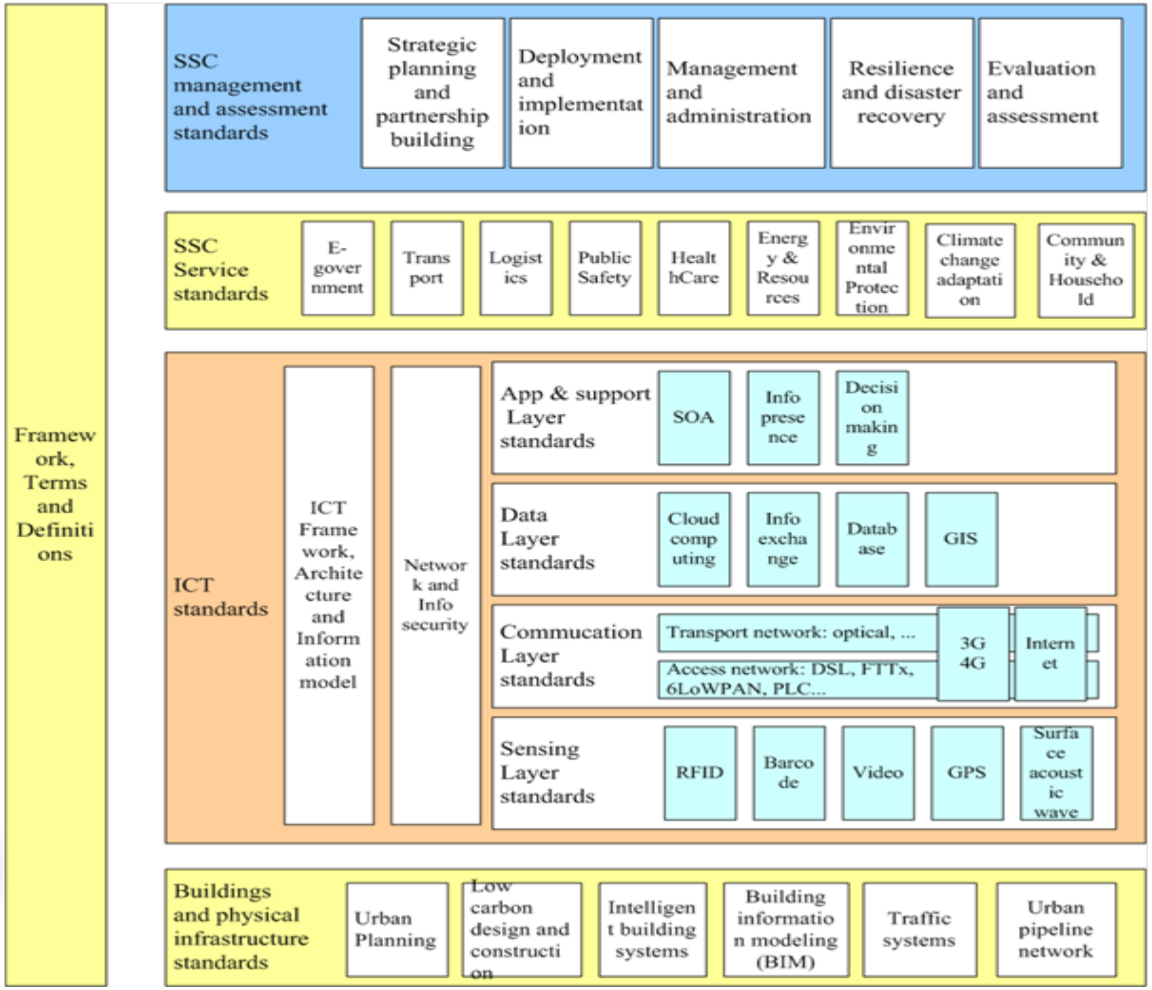
Smart City management and assessment: strategic planning and partnership building; deployment and implementation; management and administration; resilience and disaster recovery; evaluation and assessment.

SSC services: e-government; transport; logistics; public safety; health care; governance of urban infrastructure; energy and **resources (water) management**; environmental protection; climate change adaptation; community and household.

ICT: ICT framework, architecture and information model; network and information security, availability and resilience; application and support layer; data layer; communication layer; sensing layer.

Buildings and physical infrastructure: urban planning; low carbon design and construction; intelligent building systems; building information modelling (BIM); traffic systems; urban pipeline network.

Important to develop a set of definitions for key terms within and across



Standards current situation (1)

Currently standards related to SSC have been mostly developed by **technical-specific organizations through "vertical" approaches**. As a result, those standards only cover the technical aspects of SSC.

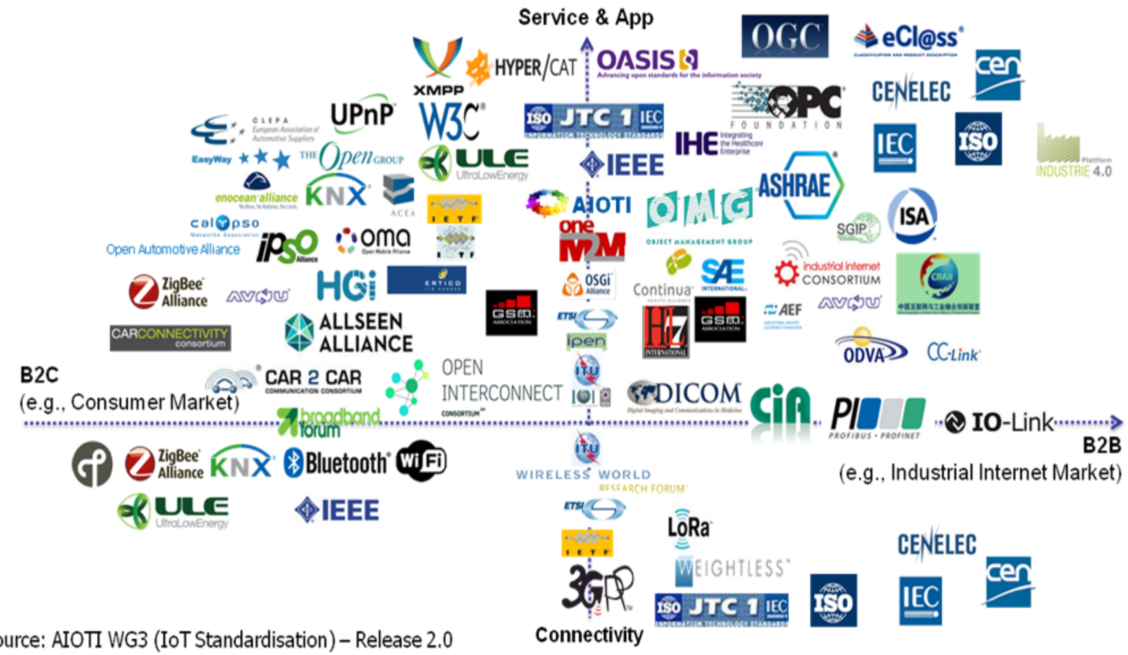
Moreover, the original models of the "digital city", "wireless city", "broadband city" or "optical city" had a **strong technical focus on information and communication technologies (ICTs)**. These models were not following a broad and horizontal strategy, and sector-specific vertical approaches were based on separate infrastructures, **not interworking with each other while often physically overlapping (isolated islands)**.

The development of SSC standards can be accomplished through cooperation among standards organizations and the adaption of existing standards, **fulfilling the principle of openness, compatibility and versatility.**

Standards current situation (2)

Key issues :

- A **number of important standards bodies** are working to scope out and develop SSC standards.
- While SDOs are developing standards, those standards may not necessarily reflect the **complexity of dealing with a SSC as a system of systems**, and the specific challenges that this brings.



Source: AIOTI WG3 (IoT Standardisation) – Release 2.0

Development of broader perspective and coordination and collaboration among SDOs will enable earlier and more effective development of ICT infrastructure.

Challenges to be addressed:

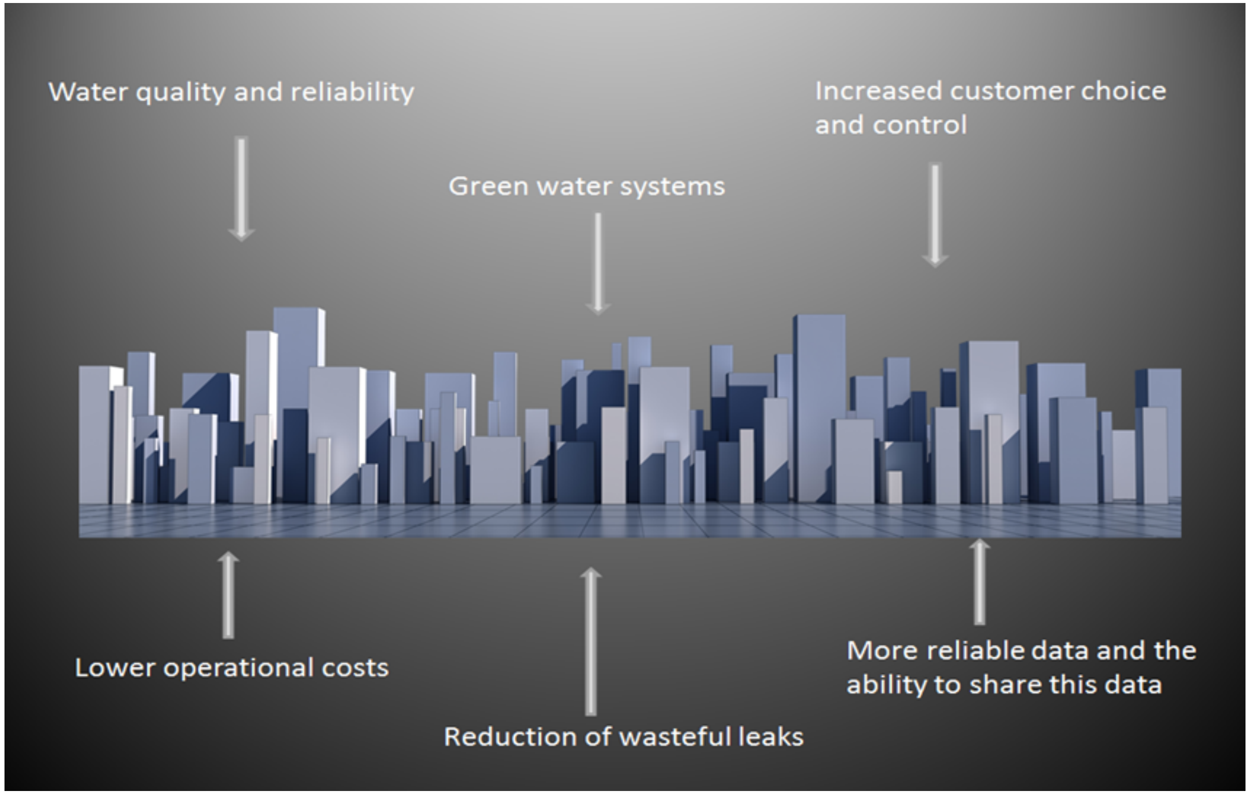
- To fulfil the needs of city sustainability in **social, economic and environmental aspects**.
- To ensure **interoperability** between different city systems.
- To take into account the challenges of **complex organizational requirements** (including interfaces between the public sector and commercial organizations, and among commercial organizations).
- To manage issues such as privacy, cyber-security, resilience, and data flows on a **whole-system basis**.
- The need of **non-specialist city leadership to be able to understand the many, complex and interrelating ICT issues** relating to the move towards a smarter and more sustainable city and how to put together the right portfolio of standards requirements to ensure that their projects are able to succeed.
- To ensure **consistency with SSC standards among international standards bodies**.
- To ensure **SDOs are connected with basic (non-ICT) technical areas** to understand their needs and develop proper solutions.

Smart Water Management (SWM)

SWN interoperability is also crucial and standardization is an essential component for ensuring that ICT products, tools, and systems.

SWM technologies:

- Sensors and sensor networks
- Smart pipes, Smart metering
- Geographic information systems
- Cloud computing (Big Data, IoT)
- Monitoring & Ctrl (SCADA)
- Models, optimization tools and decision support
- Web-based communication and information system tools



SWM -SDOs

Standards are certified by a variety of organisations such as:

ISO W3C CEN ITU IEC OGC Making location count.

In addition to those mentioned above, it has already adopted standards covering sensors, web services and other related standards in preparation within the open standard (and open source) communities.

INSPIRE · Infrastructure for Spatial Information in Europe

Aims to create a European Union (EU) spatial data infrastructure, enabling the sharing of environmental spatial information among public sector organisations and better facilitate public access to spatial information across Europe.

WaterML- Suite

WaterML2Part1: **Timeseries** Observation (OGC IS 10-126r4)

WaterML2Part2: **Ratings, Gaugings** (OGC IS 15-018r1)

WaterML2Part3: **Surface Water** Features (OGC IS 16-XXX)

WaterML2Part4: **Groundwater** Features (OGC IS 16-XXX)

SOS 2.0 **Hydrology Profile** (OGC BP 14-004r1)

Suite of Water Information Standards:
towards the identification, observation and representation of hydrologic features using standards

WaterML2Part5: **Water Quality** Observation (OGC BP 14-003)

TimeseriesML 1.0 **Timeseries** (OGC IS 15-042r3) (OGC IS 15-043r3)

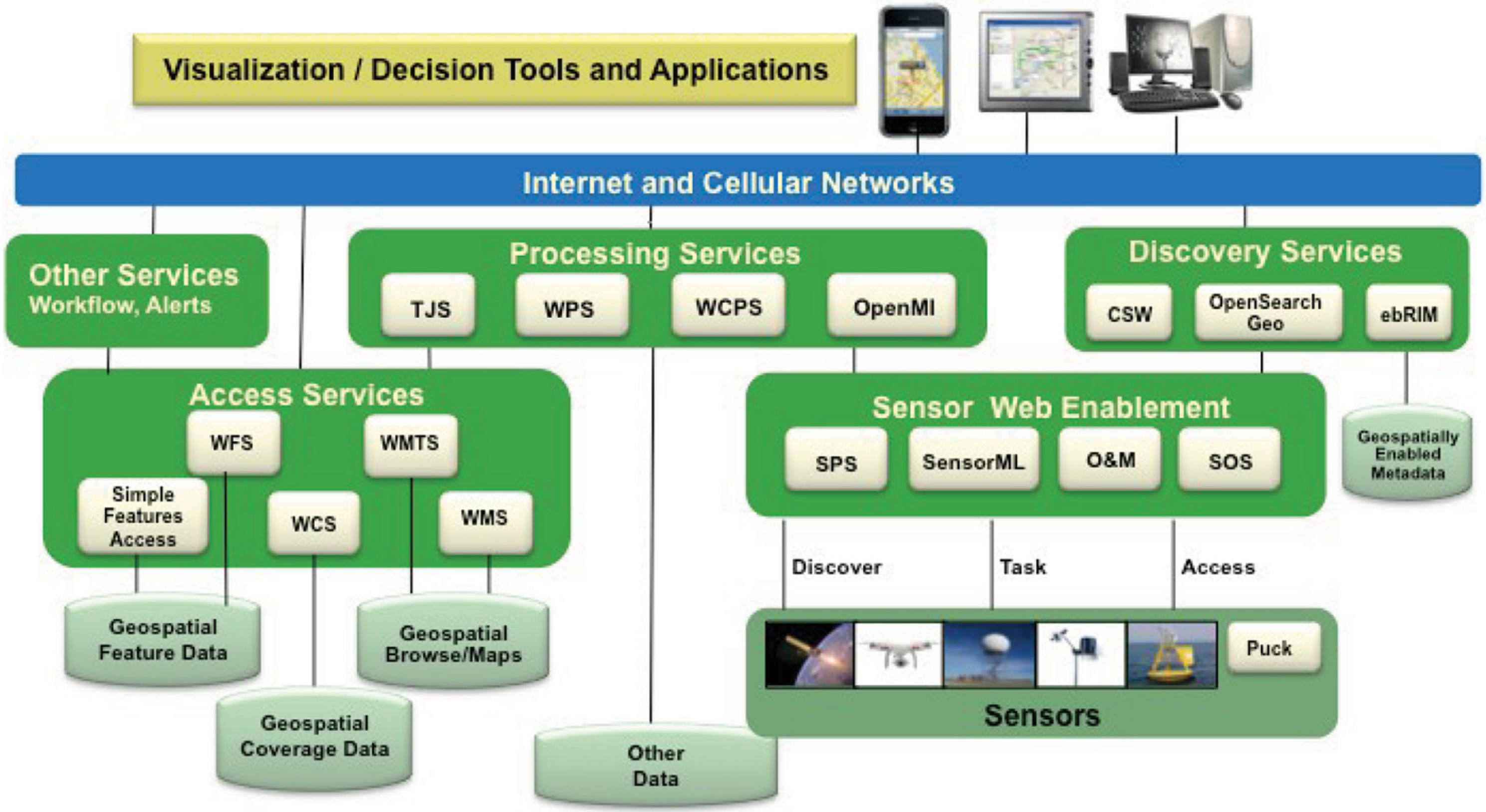
SoilML component: **Soil-water** (collaboration tbd)

CSML3 component: **Atmospheric-water** (collaboration tbd)

RiverML component **Channel geometry** (initiated, continuation tbd)

OGC Services Architecture for interoperable access and processing of geospatial information.

OGC Web Services (OWS Context).
The OGC Smart Cities Spatial Information Framework provides critical guidance on how to **plan and implement open spatial standards architectures** that guide deployment of interoperable information system components.
https://portal.opengeospatial.org/files/?artifact_id=61188



Interoperability

Organizational	• Communicate and transfer (meaningful) data (information) among information systems over different infrastructures, regions and cultures
Semantical	• Meaning of the content • Common understanding between people (information)
Syntactical	• Data formats • Syntaxes and encoding of messages transferred
Technical	• Hardware/software/platforms • Centred in communication protocols and infrastructure for them

Interoperability is "the ability of two or more systems or components to exchange data and use information" [1] .

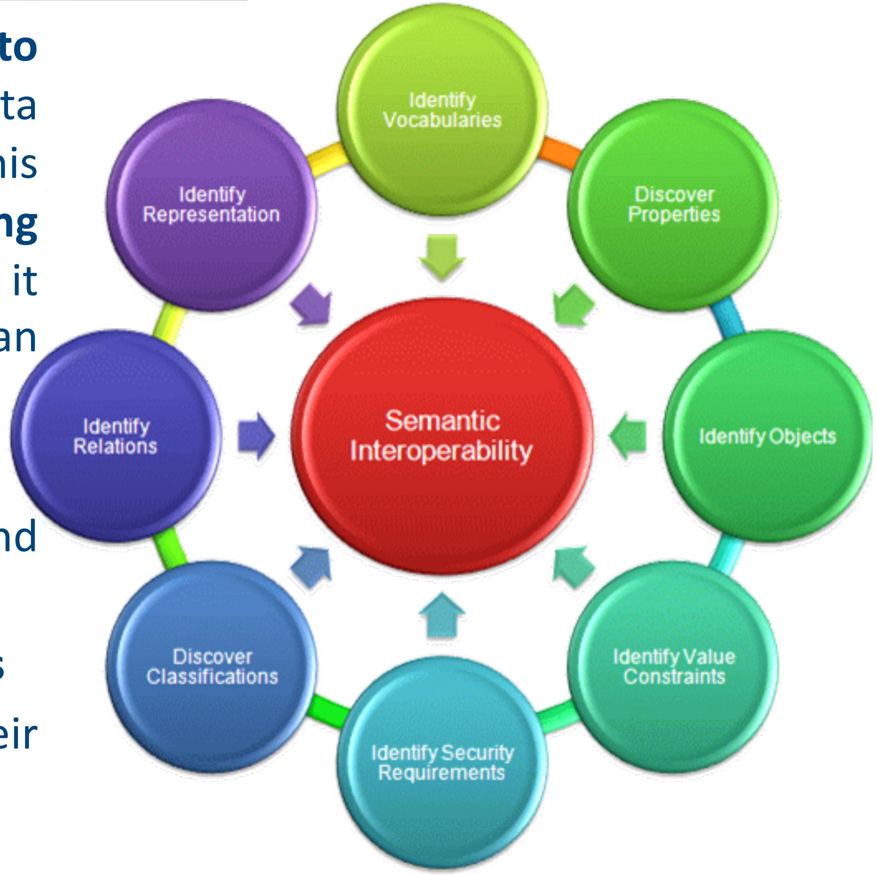
[1] Van der Veer, H., Wiles, A. *Achieving Technical Interoperability - the ETSI Approach*. 3rd Ed. 2008. ETSI. [ONLINE] Available at: http://www.etsi.org/images/files/ETSIWhitePapers/IOP%20whitepaper%20Edition%203%20final.pdf [Accessed 15 March 2016].

Semantic Interoperability

Achieved when interacting systems attribute the **same meaning to an exchanged piece of data**, ensuring consistency of the data across systems regardless of individual data format. This consistency of meaning can be **derived from pre-existing standards or agreements on the format and meaning of data,** or it can be derived in a dynamic way using shared vocabularies in an **ontology-driven approach**.

Key challenges:

- Ontologies that **formalize the meaning** of domain data and information models
- **Ontology merging, matching and alignment of cross domains**
- **Semantic discovery** of services, devices, things and their capabilities
- **Semantic metadata**



Ontologies

The formalism and meaningfulness of the shared vocabulary can vary, from very simple controlled vocabularies (set of predefined words) to much more complex ones. **Ontologies are a type of shared vocabulary with a high level of formalism**, allowing **reasoning** processes to be performed on it. An ontology is a knowledge representation modeling an identified domain of knowledge (sensors, web services, people, authoring of a document...). Semantic Sensor Network (SSN), a sensor and observation ontology, will serve as an example. An ontology is composed of:

- **Concepts**: Sensor, Observation, Device...
- **Relations** between concepts: observes, hasOperatingProperty, attachedSystem...
- **Logical axioms**: Any **Sensor** that **observes** a **Temperature** is a **TemperatureSensor**

Ontologies, as vocabularies, are used to describe data. Together, an **ontology and the data it describes** is called a **knowledge base**. Knowledge bases are usually expressed using W3C's standard languages (OWL, RDFS, RDF...), based on description logics.

Water Ontologies (1)

Ontology Name	Subject Areas	Representation Language
Organisation Ontology	Management of the Water Cycle in Industry; Customer Relationship	RDF
OTN	Wastewater and Storm Water Collection (including Flood RiskManagement); Data Management and Smart City Services	OWL
Ordnance Survey Hydrology Ontology	Water Supply and Distribution	OWL
NNEW weather ontology	Wastewater and Storm Water Collection (including Flood Risk Management); River Basin Management	OWL
USGS CEGIS	Wastewater and Storm Water Collection (including Flood Risk Management); River Basin Management; Water Scarcity and Droughts	OWL
Ordnance Survey Buildings and Places Ontology	Data Management and Smart City Services	OWL
h-TechSight Technologies	Management of the Water Cycle in Industry	RDF,DAML+OIL
GWSW TopBas	River Basin Management	OWL
SWEET	Wastewater and Storm Water Collection (including Flood Risk Management); River Basin Management; Water Scarcity and Droughts Sea Water; Sustainable Development, Circular Economy, & Ecosystem Services	OWL
CUAHSI	Quality of Water; Sustainable Development, Circular Economy, & Ecosystem Services; Drinking Water Production; Water Reuse and Recycling; Wastewater Treatment (including Recovery of Resources)	OWL

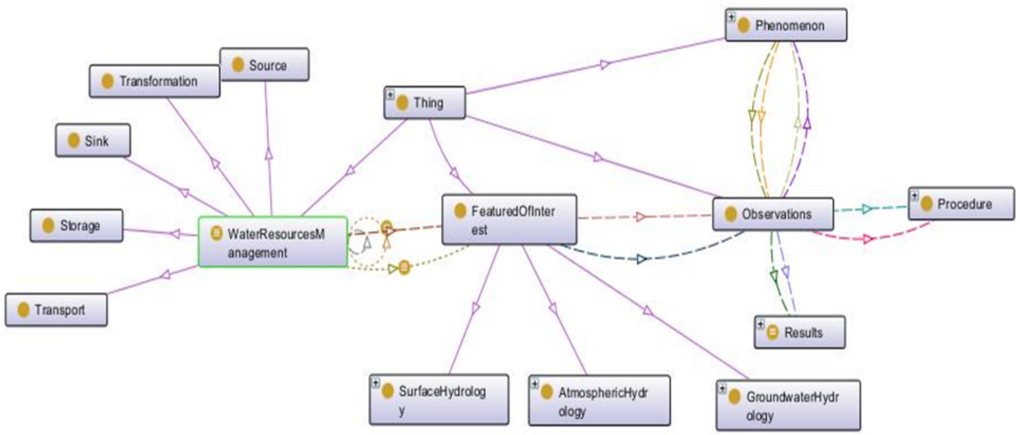
Water Ontologies (2)

Ontology Name	Subject Areas	Representation Language
INWS	Quality of Water	OWL
SemantEco	Quality of Water; Sustainable Development, Circular Economy, and Ecosystem Services	N/A
WaWO	Wastewater Treatment (including Recovery of Resources); Water Reuse and Recycling	N/A
EHMP	Data Management and Smart City Services; Quality of Water; River Basin Management	OWL
DOLCE-ROCKS	Wastewater and Storm Water Collection (including Flood Risk Management); River Basin Management; Water Scarcity and Droughts Sea Water; Sustainable Development, Circular Economy, & Ecosystem Services	OWL
hydrOntology	Wastewater and Storm Water Collection (including Flood Risk Management); River Basin Management; Water Scarcity and Droughts Sea Water; Sustainable Development, Circular Economy, & Ecosystem Services	OWL
WatERP Ontology	Water Supply and Distribution; Data Management and Smart City Services Sustainable Development, Circular Economy, & Ecosystem Services; Water-Energy Nexus; River Basin Management; Water Reuse and Recycling; Management of the Water Cycle in Industry; Water Scarcity and Droughts	OWL
OGC® HY_Features	Water Supply and Distribution; Data Management and Smart City Services Sustainable Development, Circular Economy, & Ecosystem Services Water-Energy Nexus; River Basin Management; Water Reuse and Recycling; Management of the Water Cycle in Industry Water Scarcity and Droughts	OWL/RDF

Water Ontologies ⇔ Standarization (1)

OGC® HY_Features

Standard information model for the identification of hydrologic features independent from geometric representation and scale. The conceptual model describes hydrologic features by **defining the fundamental relationships among major components of the hydrosphere**. This includes relationships such as the hierarchy of catchments, the segmentation of watercourses, and the topological connectivity of hydrologic features.



Allows information systems, web services, and ontologies to be linked using a common reference model.

Move from syntactic interoperability to a more semantic interoperability

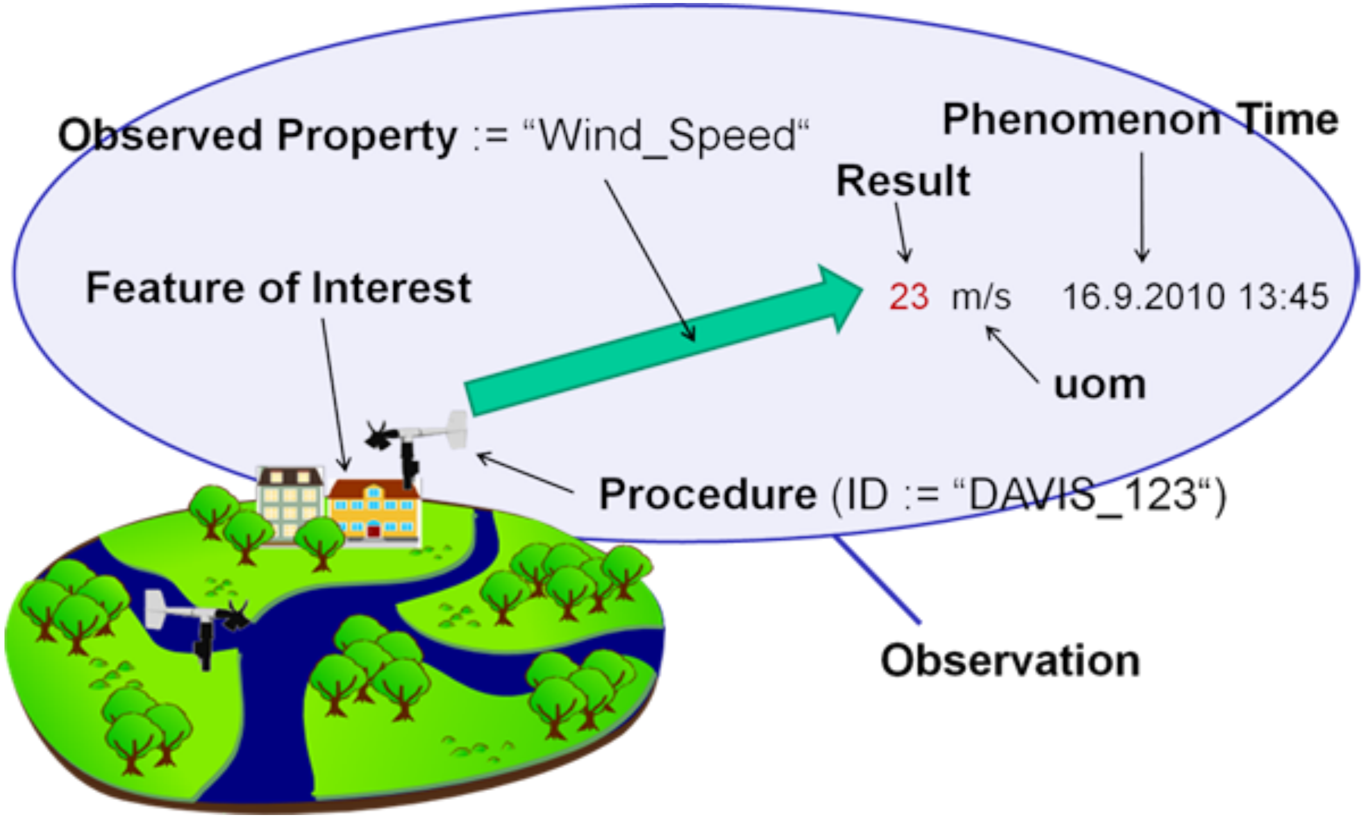
Water Ontologies ⇔ Standarization (2)

Hydrologic feature types are defined **OGC® General Feature Model** (ISO 19109:2006)

Definitions within the **International Glossary for Hydrology (WMO/UNESCO)**.

Expressed in the ISO 19103:2005 using the **Unified Modeling Language** (UML).

- to **link hydrologic observations to their feature-of-interest**, e.g. link a streamflow observation to the river or catchment being observed;
- to allow **aggregation of cross-referenced feature**s into integrated datasets and data products on global, regional, or basin scales;
- to enable information systems to unambiguously **link data across distributed systems and domains**;
- to enable cross-domain or multi-discipline services to **communicate through reference to standard concepts**.


Observed Property := "Wind_Speed"
Phenomenon Time
Result
Feature of Interest
23 m/s
16.9.2010 13:45
uom
Procedure (ID := "DAVIS_123")
Observation

Challenges in the context of standards

1. Adopting/developing **vocabularies and ontologies** so that there is semantic clarity;
2. Developing a **common ICT architecture** for integrated resource management;
3. Identifying/adopting/developing **critical interface standards** so that:
   - users can confidently and easily **assemble systems** from interconnecting components sourced from multiple suppliers
   - **barriers** to new entrants joining the **market place** are reduced
   - **competition is increased**
   - new **opportunities for innovation** are created
   - **synergies and coordination among stakeholders/sectors** can be improved;

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WatERP

Physical Representation (Karlsruhe)

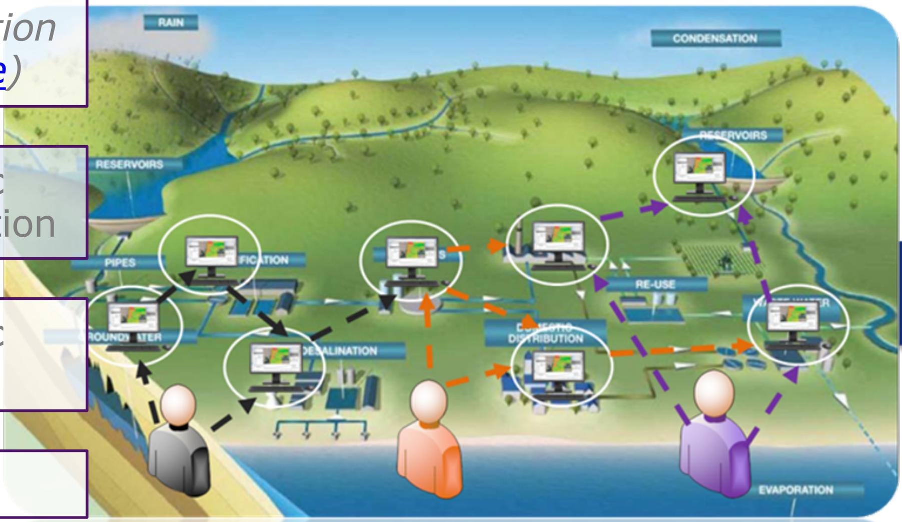
Semantic Representation

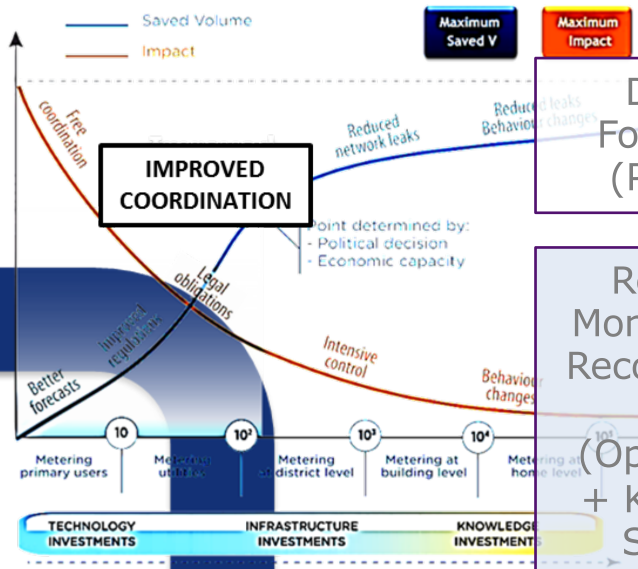
Hydraulic Model

Alerts

DSS / Simulator

Meteorological Forecasting





Demand Forecasting (Patterns)

Real-Time Monitoring vs. Recommendation (Optimization + Knowledge Storage)

AI-Optimization (Water-Energy)

SOA-MAS

8% Water Saving

Scarcity Regions

5% Energy Saving

Abundance Regions

Where water supply meets demand

WatERP

W3C · Semantic Web · OGC · Jadex

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European Commission

ict4water.eu

The vision:

to establish a thriving and interconnected **ICT for the Water Community** with **the main objective of promoting synergies and knowledge exchange among all actors involved in water sector**.

This vision is twofold:

- in one hand, contribute to advance in the **consolidation of an ICT for the Water Community** that will be better informed, defined and integrated than today;
- on the other hand, will help the **results and outcomes from current research projects improving their exploitation plans and increasing their dissemination potential**.

The target community will be mainly composed by different stakeholders including **Water Authorities, Water Operators, System Integrators, ICT for Water technologies professionals, Policy Makers, and the relevant industry at large**.

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ict4water.eu EIP Water

Development of the Roadmap " *Emerging Topics and Technology Roadmap for Information and Communication Technologies for Water Management*" 2014/2015/2016

Actions

- Exchange of information- Common **website**-Contacts
- **Special sessions** in Conferences/Publications
- Common development of **standards and standardisation**
- Common papers
- Links with/participation in Water EIP relevant **action groups**
- **Lots of synergies**

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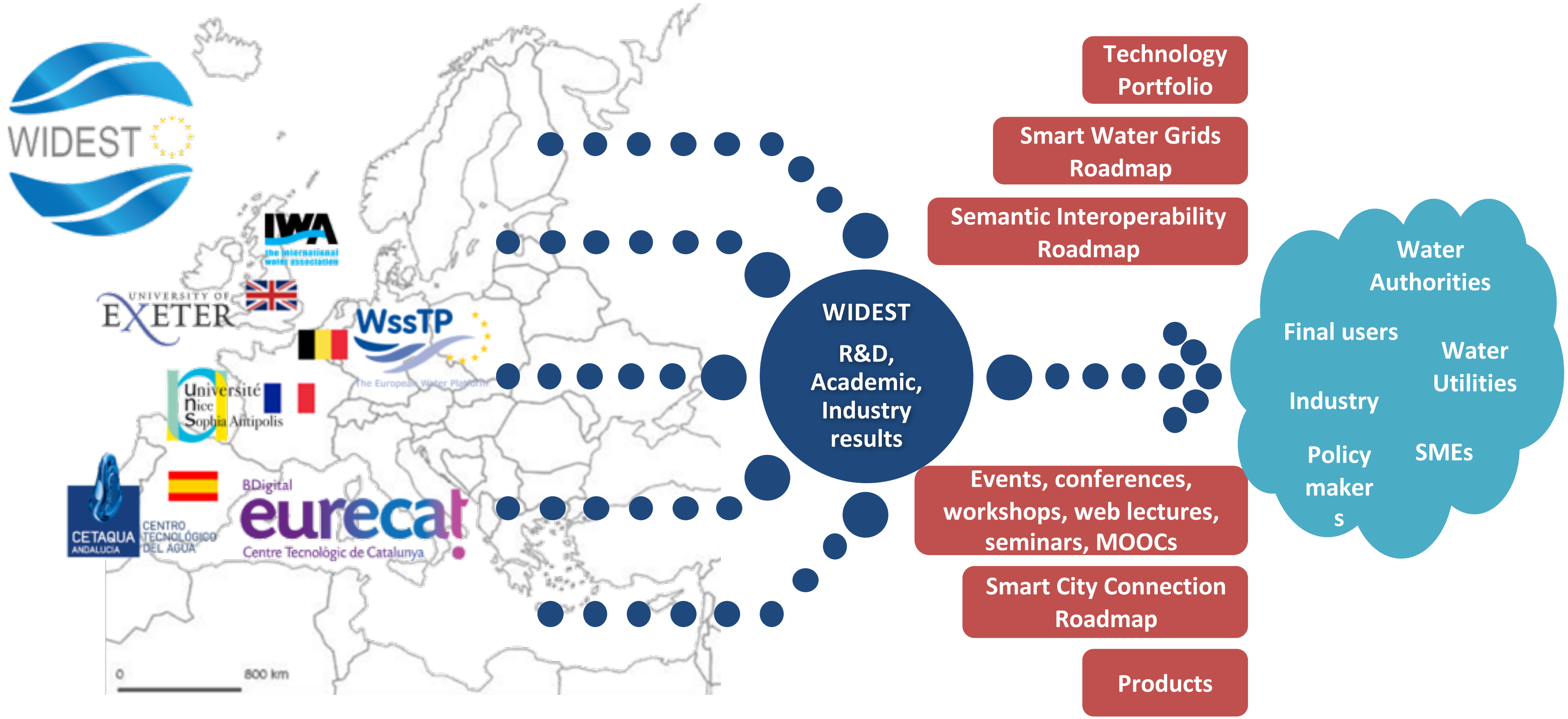

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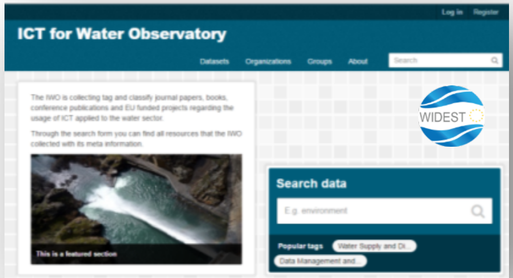
Conclusions

Identifying/adopting/developing critical interface standards so that:

1. users can confidently and easily **assemble systems from interconnecting**,
2. components sourced from **multiple suppliers**,
3. barriers to new entrants joining the marketplace are reduced and competition is increased,
4. new opportunities for **innovation** are created,
5. **synergies and coordination among stakeholders** can be improved,
6. easy connection and **exchanging data and metadata (knowledge)** can be provided;

Information Sources



(http://iwo.widest.eu)

(http://www.widest.eu)

2016 Rolling Plan on ICT Standardisation

Recommendations for Standards and Standardisation in the European SMART Water Market

Smart Systems for Water Management

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THANK YOU
FOR YOUR ATTENTION

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