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1st WATER MONOGRAPHIC

FEBRUARY 2023

# Technology for integral water cycle management

Digitise with meaning

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# FOREWORD

## A step forward

New projects are exciting. And this one is. We have entered 2023 with a new initiative. We are launching the first issue of a monographs' series in which we aim to analyze different challenges, trends, expertise, and knowledge, through professionals and experts, linked to technology application in infrastructures management, related to sectors such as water, energy, industry, and cities.

Water is the central theme of this first publication. It is an indisputable fact that climate change is no longer silent, and technology contributes to designing and building a more environmentally, economically, and socially sustainable world. On this path, moving towards digital transformation entails improving water and wastewater services, and making appropriate use of data value is key to developing more efficient management of water resources and improving decision-making.

In this sense, we understand that the fulfilment of the Sustainable Development of the Sustainable Development Goals (SDGs) is achieved with joint solutions that contribute to change the current paradigm. Assimilate that there must be a collaboration between private companies and public administrations involved in the entire water life cycle management is essential in the whole process. A process in which technology becomes an indispensable tool.

This project motivates us, because it is an opportunity to speak about digital transformation and because, like everything else in life, it means evolution and moving forward. From Elliot Cloud we will continue to analyze the current affairs of the different sectors through their key players and we will present new technologies that help to digitize infrastructures, to optimize their different processes, to dynamize the business canvas and to improve citizens'service to. To all the people who have participated in this publication, to those who will collaborate, to those who read us, to those who trust us, and to those who count on us and believe in the project, thank you for sharing this journey with us.

Óscar Ruiz Chicote

**ELLIOT CLOUD CEO**

# INDEX



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# Elliot Water, technology for more efficient and sustainable water management

**In a context of climate change, water scarcity and concern for sustainability, technology and innovation become fundamental means to solve any challenges faced by organizations.**

**JOSÉ DÍAZ DE GREÑU, TECHNICAL DIRECTOR OF ELLIOT CLOUD**

Water is not an infinite resource and the efficient, rational and sustainable use of water supplies is necessary to provide health, quality of life, strong economy and social development to any country's citizens. Both technological development and greater distribution network management knowledge have opened up a new paradigm.

In this new scenario, the traditional water supply network has been transformed into a smart network, in which a holistic view of the operation is collected and an automated and efficient complete water cycle infrastructures and processes management is possible. This is all achieved thanks to solutions such as Elliot Water, based on IoT.

Water management digitalization is already true and has its raison d'être in the possibilities it offers to fight the effects of climate change, pollution and the continuous increase in population, on both the quantity and quality of available drinking water, forcing water distribution companies to adapt to these new challenges.

In the present context, it is necessary to have technological solutions such as Elliot Water prepared to offer a global vision and coverage of the complete distribution networks water cycle, optimizing processes and efficiency thanks to its software. This solution, focused on the water sector, allows to cover end-to-end process needs, understanding the particularity

of each problem aspects and proposing solutions that can be integrated into any a company or Administration ecosystem.

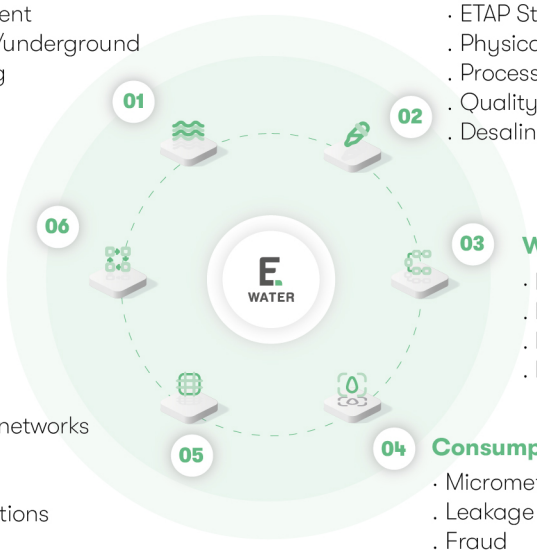
# Technology and innovation at the service of water

Elliot Water integrates into a single solution the different infrastructures, assets and systems that make up the complete water cycle operation, covering all processes involved:  raw water intake, treatment, distribution, consumption, storage and recycle. In this way, this platform contributes to minimize the complexity of managing all physical assets and infrastructures that compose the process, which translates into in operational costs savings and guaranteed efficient and quality controlled processes.

To achieve this, it has a robust and flexible technical architecture based on Open Source, accessible and transparent tools, and a functional base architecture where specific modules that respond to the problems and needs of water cycle management are integrated, relating and orchestrating water distribution companies procedures and operations of in a robust and powerful way.

Elliot Water contributes to solve any problems derived from unacknowledged water supply networks consumption and condition data, helping to

## Integral water cycle




**Catchment**
· Catchment
. Surface/underground
. Pumping
. Storage

**Treatment**
· ETAP Stations
. Physical processes (decanters, filters)
. Processes (Reagents)
. Quality control
. Desalination

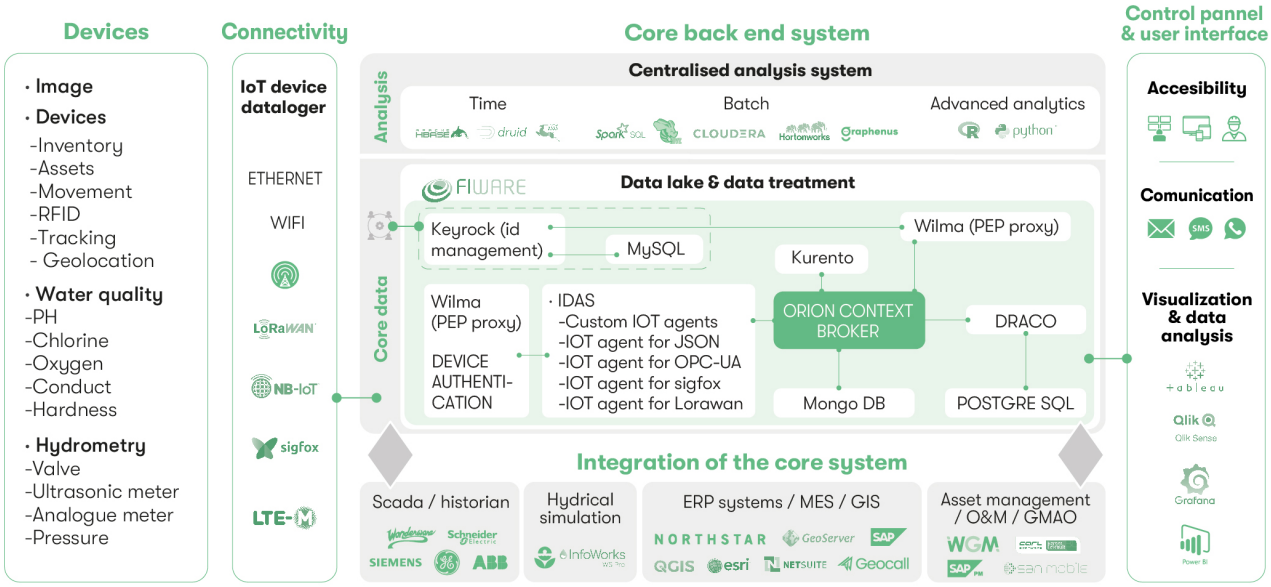
**Regeneration**
· WWTP Stations
. Physical processes
. Biological processes
. Chemical processes
. Sludge dewatering

**Wide distribution**
· Large pipelines
. Regulating Tanks
. Lifting Stations
. Macro-measurement

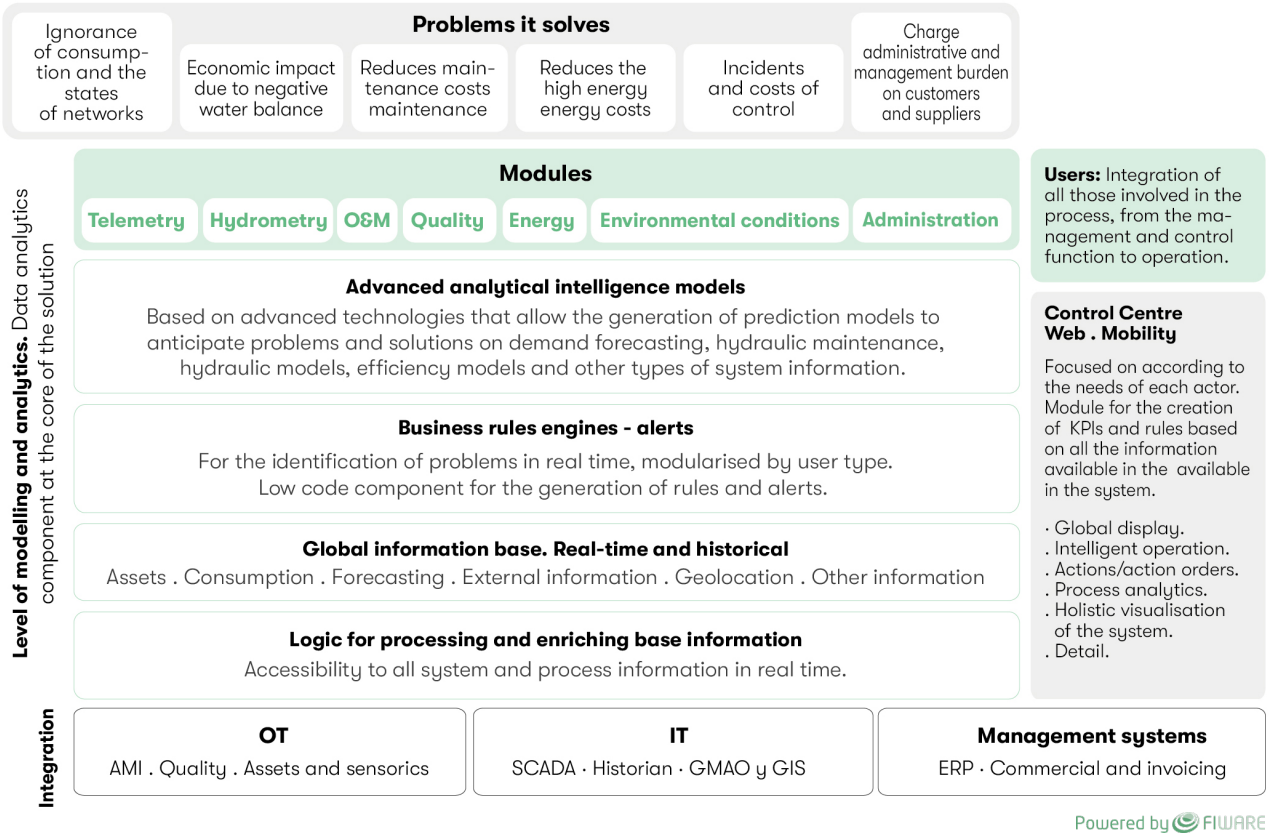
**Reservoirs**
· Wastewater networks
. Sewerage
. Storm tanks
. Pumping stations
. Wells

**Consumption**
· Micrometering
. Leakage
. Fraud

## Technical architecture




## Functional architecture



solve the economic impact of negative water balance, high energy and maintenance costs, while reducing the number of incidents and water quality control expenses.

# Intelligent data operation transforms the water cycle

To achieve this, the core of the solution consists in a data analytics component based on four pillars: an advanced analytical intelligence model that enables predictive representations generation that anticipate problems and their possible solutions thanks to demand forecasting, hydraulic and efficiency models implementation and predictive maintenance.

Furthermore, business rules engines – as integrated notifications within Elliot Water - allow incidence identification in real time and user typology classification with the help of a low code component for the generation of KPIs, rules and alerts.

Thanks to the complete monitoring of the integral water cycle, it is possible to access a global database of both historically and real time information that has been treated and enriched at every source, such as: assets, consumptions, predictions, geolocation or external information.

A solution that allows to integrate all those involved users in the process, from the management and control function to the operational and manual function, always oriented towards the needs of each stakeholder.

## *Process optimization and efficiency*

**The solution relies on software to meet the customer's needs end-to-end.**

## *Elliot Water knows the context and issues in great detail*

**Thanks to its experience in large international water management companies**

## *Comprehensive solution with a global vision*

**Going beyond a particular software or solution.**

## *Adapted platform to each process' needs*

**Focusing on the analytical component and efficient operation model.**

Building a comprehensive data management platform that allows water management companies to digitize their systems so they can achieve their specific objectives: optimizing their operating costs, active energy consumption management, fraud control, leaks and meter tampering, achieving compliance including sustainability and water quality principles.

# The faces of water

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# Water cycle digitalization: an inevitable decision

**World's global water demand is constantly growing, due to the increase in population and both industrial and social development. In the last decade it has expanded by more than 22% and despite all the technological and water-saving improvements applied to industrial processes, it has been foretoken that it will experience a further increase of at least 15% in the decade from 2020 to 2030.**

PALOMA BATANERO, BUSINESS DEVELOPMENT - INDUSTRY ADVISOR HYDRAULIC SECTOR AT ELLIOT CLOUD

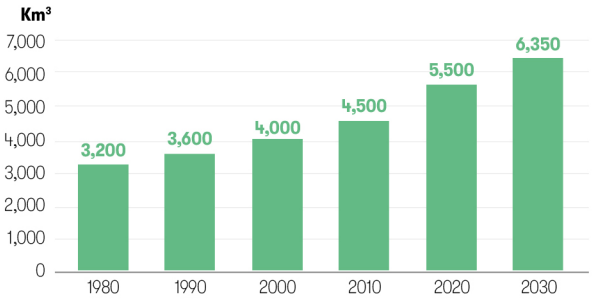
It may seem an unsolvable problem for human beings, but as at any other historical crisis, we must face this challenge as we have done since the beginning of humanity: with technology, work segmentation and cooperation. And we are at the right time to solve if we rely in water cycle digitalization.

On the other hand, the planet's water resource is not increasing, it remains constant; moreover, the available water, if we do not take the means to prevent it, is getting progressively polluted. There is 1400 million cubic kilometers of water on Earth. Only 2% of this serves as available fresh water for human consumption.

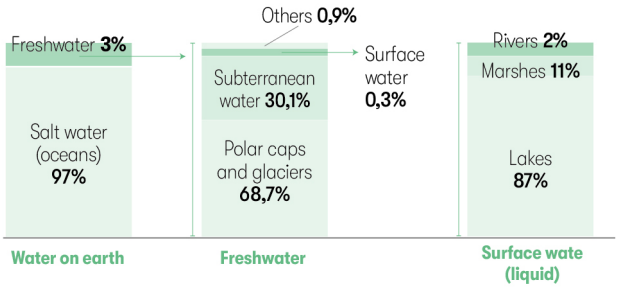
## Water is the most important resource

Water, increasingly regarded as an universal common good, is, jointly with air, the basis of life. Hence, its importance as a natural indispensable resource for survival and health, for food production and economic activities of all kinds, as well as for the well-being of individuals and societies cannot be highlighted enough. Water is therefore, a priori, a human right that must be fulfilled regardless of all considerations, including financial ones. In 2002, the United Nations Committee on Economic, Social and Cultural Rights, compelled by water physical scarcity of and its acquisition rising costs, stated that access to a sufficient quantity of safe water for personal and domestic uses is a universal fundamental human right. Therefore, ensuring water access, with all possible technical advances, is a social responsibility that engineers and managers cannot ignore, so an appropriate management of this resource must be pursued, trying to use all available resources.

Global water demand water demand from 1980 to 2030




Distribution of the resource on planet Earth




Source: https://es.statista.com/estadisticas/634459/agua-demanda-mundial-1980-2030/

# Where to act to maximize hydrological resources

In order to secure water supply while making it more accessible and affordable to the population, we can operate in the following three aspects of the hydrological cycle:

- Increasing resource availability.
- Avoiding further pollution of existing sources.
- Improving raw water intake, treatment and distribution infrastructures efficiency.

## Increasing resource availability

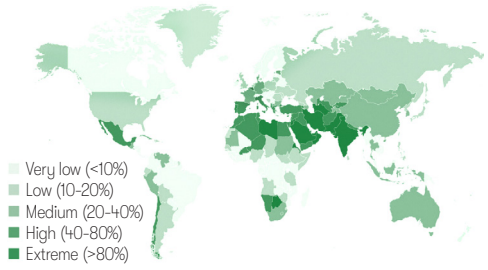
On our planet Earth, the absolute amount of freshwater remains roughly constant, but its distribution is modified by climate change, making it more extreme and irregular. We have a similar amount of precipitation, but it is unevenly distributed and more intense, with shorter storms, making it more difficult to be efficiently collected and stored, leading to more aggressive runoff, that mixes unwanted elements and leads to contamination.

Unfortunately, it is no longer possible to increase the availability of the resource except in very specific cases. Between 1960 to 2000, a great effort was made in this direction, by the construction of around 800 large new dams in Spain. In total, these reservoirs provide a capacity of some 56,000 hm3, compared to 99,000 hm3/year average rivers contribution and nearly 30,000 hm3/year necessary to meet all consumption demands[3] (67% for crops irrigation)[4 5]. Spain is the fifth country in the world after China, the United States, India and Japan in terms of reservoirs count[6].

However, it does not prevent us from suffering from water stress, i.e. when more freshwater is used than is available at certain periods, or when consumption is temporarily restricted. Since there are hardly any locations left for new reservoirs, it is only possible to expand this resource by means of:

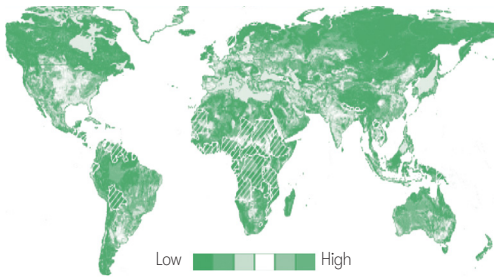
- Groundwater exploitation: however, increasingly scarce and in danger of subsidence if aquifers are overexploited.
- New desalinated water plants construction: which are very costly to build, both in terms of initial investment and production energy cost, and whose waste products can be highly polluting and harmful to the marine environment.

Water stress in the world, as a % of water consumed in period of scarcity




Source: https://es.statista.com/estadisticas/634459/agua-demanda mundial-1980-2030/

Map of potential global subsidence by groundwater abstraction




Source: https://www.ecoavant.com/medio-ambiente/primer-mapa-mundial-hundimientos-terreno-por-extraccion-agua-subterranea_5954_102.html

Both processes are already at the end of their theoretical extent, so we cannot count on much growth unless sophisticated systems are applied to fine-tune their operation by collecting and analyzing their operating parameters.

### Avoiding further pollution of existing sources

If we could at least manage to keep existing freshwater bodies clean or even improve already polluted water condition, we would be saving a great deal on further treatment. It is difficult to quantify the influence of an uncontrolled discharge in a surface watercourse[9], but the ratio is close to 1:100, i.e. one m3 of polluted water is capable of polluting around 100 m3 of clean water. To avoid this pernicious effect, it is necessary to manage prevention, using the following strategies:

- Treat the basin holistically, as everything that happens on its surface will affect it all over, specifically downstream.
- Include rainfall retention and infiltration systems in the upper part of the basin, through the implementation of sustainable drainage systems. These consists of surface permeable elements, sometimes vegetated, which are part of the urban-hydrological-landscape structure and retain rainfall prior to its arrival to the drainage system. They are designed to filter, retain, transport, accumulate, reuse and infiltrate rainwater into the ground, so water quality is not degraded and even restored in many aspects.
- Improve drainage systems maintenance, ensuring their optimal functioning, avoiding breakdowns and therefore, unnecessary economic resources expenditure.

- Water large roadways runoff purification and filtering systems inclusion, which have a much greater impact than is generally believed.
- Carrying out public awareness campaigns to avoid using sewage and rivers as dumping grounds.
- Inclusion of new storm tanks to store unclean rainwater, preventing its discharge into the natural environment.

### Fixing existing infrastructures performance

The efficiency of a process is defined as the ratio of the work done or energy developed by a machine, engine, etc., to the energy supplied to it, usually expressed as a percentage. In the mid-twentieth century, improvements were done mainly on water collection, treatment and distribution systems mechanical efficiency, which were already highly optimized in their industrial processes. This has led to a reduction in per capita consumption, but there is still room for improvement, as a contraction of 2-5% on at least five factors will result in a 15% global reduction. This can sometimes make the difference between maintaining a continuous water supply or stablishing periodic cuts. Some of these aspects are:

- **At the intake:** Obtaining the optimal mix from various sources, in order to secure a given chemical composition, pumping rate or water treatment.
- **At the treatment:** chlorine dosage revision, considering distribution network residence time.
- **At the distribution:** Leaks and non-revenue water reduction, velocities and pressures in the network optimization, adequate sectorization, breakdowns and programmed cuts fine operation, leakage losses quantification and controlled emptying and subsequent filling, time of re-pressurization of the network with consumption, in case of intermittent supply, pumping and network optimization and rationalization, localized losses micro power plants installation and carbon footprint (or of the energy consumed) reduction.
- **Regarding water quality:** Biofilm formation and removal processes characterization by irregular or low velocities, network cleaning and aeration campaigns optimization.
- **Regarding domestic consumption:** Remote meters reading, demand correlation to external variables such as temperature, special dates, holiday periods or pandemics, tests to adjust demand variation with pressure modification, consumption trends extrapolation and public awareness campaigns production to reduce consumption.

Once we have defined the problem and the possible levers for action, we will have to adopt as much technology as possible to solve it, now and forever.

[2]https://www.iemed.org/publication/el-derecho-de-acceso-al-agua/ | [3]https://www.wwf.es/nuestro_trabajo/agua/ahorrar_agua_en_agricultura/ | [4]https://www.ine.es/dyngs/INEbase/es/operacion.htm?c=Estadistica_C&cid=1254736176839&menu=ultiDatos&idp=1254735976602 | [5]https://www.iagua.es/blogs/pablo-gonzalez-cebrian/como-se-reparte-consumo-agua-espana
[6]https://hispagua.cedex.es/sites/default/files/suplementos/presas/presas.htm | [7]https://www.iagua.es/blogs/hector-rodriguez-pimentel/aguas-residuales-y-efectos-contaminantes

# Domingo Zarzo

**TECHNICAL AND INNOVATION MANAGER AT SACYR AGUA**

sacyr agua
SERVICIOS

*"Specialized companies in collaboration with administrations are the best tandem for water supply and sanitation management"*

Domingo Zarzo Martínez, Technical and R&D&I Director of Sacyr Agua, has over thirty-four years of experience in the water sector.

He has participated in and directed more than seventy desalination projects that have meant beyond 15 million m3 per day in constructed facilities for the water cycle sector.

With more than fifteen years of experience, Sacyr Agua manages the complete water cycle and the operation of water treatment and transport infrastructures in more than one hundred treatment plants at national and international level.

## INTERVIEW

**What are the main technologies being used and which will mark the future of sustainable management of the integral water cycle?**

The trend is clearly to move towards increasing the sustainability of all activities; water and CO2 footprint reduction, components recovery, recycle and every little thing related to circular economy, energy efficiency increase, renewable energies adoption and, of


course, digital transformation, which complements the tools to achieve these sustainability objectives.

*"The injection of Next Generation European funds will help companies and administrations to move more quickly towards their digital transformation"*

**What objectives has Sacyr Water's Innovation and Strategic Projects department set itself?**

Our department aims to develop or find in the innovation ecosystem - both internal and external - solutions to our clients problems and contracts, as well as to challenges posed by the future of water management and its scarcity. At our department, we develop all innovation initiatives within the company, but we also provide technical support in those projects which, due to their size, magnitude, client or country, are strategic for Sacyr Agua.

**What role does technology play in achieving this?**

Technology is the necessary tool to achieve efficiency and sustainability objectives and a technologies accelerator to all applied processes. In Spain we are making rapid progress in technological development and digital transformation and the injection of European Next Generation funds in calls such as the PERTE for Water Digitalization will help companies and administrations to advance more quickly towards their digital transformation.

**At Sacyr Agua, you work on the Water Positive concept. What does it mean?**

Water Positive arose as an idea to increase efficiency in the use of water resources in industry. At present, its development activity is being carried out in a working group within the IDA (International Desalination Association), in which I participate, and in which I am a member. We want to establish the basis for its determination, certification and perhaps in the future the establishment of a water rights market - similar to that of CO2 bonds - that will allow companies that consume a lot of

*"There is no going backwards for the digital transformation of the water sector. The use of new technologies increases efficiency in water infrastructures management, reduces costs and increases environmental sustainability"*

water to compensate this consumption with water production in other areas or industries that are more needed.

At Sacyr we have joined the working group from the outset and, at corporate level, last year we certified our water footprint through ISO 14046 for all Sacyr's activities in all the countries where we operate. It has been a very intense task given the size and diversity of the company, the difficulty of calculating direct and indirect water consumption through various systems that also analyze aspects of environmental impact, etc. And to say that, thanks to desalination, desalination, recycle and reuse activities of Sacyr Agua, the entire Sacyr Group is positive in water generation, it is Water Positive!

**One of the company's pillars of action is water desalination. What is the situation in Spain?**

Worldwide, there are some 20,000 desalination plants that produce around 100 million m3 of desalinated water per day. The largest producers, as might be expected, are the countries of the Persian Gulf, led by Saudi Arabia.

Spain, since the development of the 'Water' program, is the fifth country in the world in terms of installed desalination capacity, with approximately 5 million m3 of desalinated water per day, which could supply water to a population of over 30 million inhabitants and currently represents 9% of the drinking water supplied in the country, although there are some islands where the percentages can reach almost 100%.

It is also worth highlighting the strength of our industry, not only within Spain. 8 out of the 20 largest desalination companies in the world are Spanish.

At present, the development of new large desalination plants is not expected, but there are plans to expand some of Acuamed's desalination plants, such as Águilas and Torrevieja, and to implement renewable energies for their electricity supply and to reduce their $CO^2$ footprint.

**Therefore, according to your experience in several desalination projects, what are the barriers that this sector currently faces?**

Large desalination projects confront all kinds of obstacles: financial, certain countries uncertainties, construction risks, legislative, environmental, etc. Although perhaps the biggest challenge at present is to change the negative perception of desalination in society and in some administrations, which is based on prejudices and opinions with no scientific or technical basis. The three typical negative arguments against desalination are: water is very expensive, energy consumption is very high, or that it harms the environment. These are all mere opinions that are not based on reality.

In this regard, I would like to present some figures that give us an idea of these prejudices. For example, desalinated water including amortization price is approximately 1 euro/m3, which is equivalent

to 0.001 euro per liter; bottled water is paid at 500-1,000 euro/m3; a seawater desalination plant energy consumption is approximately 3 Kw-h/m3. Also, the energy needed to desalinate water for a family of four members in a year is equal to the consumption of their refrigerator. We can compare this to an energy consumption of 35 Kw-h/m3 that the association of water bottlers declares on its website.

When brine discharge is done correctly, by means of diffusers and prior dilution, there are no differences in salinity within a few meters of the discharge point. And the so-called brine is nothing more than concentrated seawater, with no other chemical or toxic components.

*"Spain is the fifth country in the world in terms of installed desalination capacity, which could supply water to a population could supply water to a population of around 30 million inhabitants"*

**What areas of innovation still need to be developed to make further progress in the digitalization of the management of the full water cycle?**

There have been many efforts in the water sector to increase the digitalization of water resources management, and while treatment facilities such as desalination, purification and water treatment plants are often highly gauged, with complex control systems and data collection, there is still a lot of work to be done in the water sector. Water treatment plants tend to be deeply gauged facilities, with complex control systems and data collection, there is still much to be done in the water cycle in terms of sensors connection, smart metering, consumption and demand predictive models, interaction platforms and apps for citizens, etc. And if there is much still to be done in supply, there is much more in the case of sewerage networks.

In both cases - in plants and networks - there is a huge amount of information, but there is a long way to go in data management and in intelligence and machine learning application to obtain full information potential.

**Sacyr Agua and Elliot Cloud developed the SOS Water project. How has the initiative contributed to improved water resources management?**

SOS Water XXI is an ambitious project involving a consortium of eight companies and six university research groups whose aim is to develop 21st century agriculture, that remains water sources exploitation and energy application efficient. The project has been under development for just over a year and includes 35 sub-tasks related to the use of non-conventional resources, irrigation water quality, nutrients recovery and other compounds of interest from agricultural drainage and desalination brine, water and energy consumption forecasting models, infrastructures extreme weather events effect, and economic and environmental assessment on solutions. A high technological component is always incorporated, such as aerial and underwater drones application, digital twins deployment, data management platforms, etc.

**Is there a lack of projects aimed at combating the impact of climate change and meeting agriculture water needs?**

*"The Water Positive concept arose as an idea to increase industry water resources efficiency"*

Of course there is. Any project that has an impact on increasing sustainability, mitigating climate change effects and efficiency, and on the use of water resources, such as the SOS Water XXI project, in which Sacyr Water and Elliot Cloud are participating, is very necessary, given that we are talking about such important things as food, health, sustainability and climate change; and agriculture is by far the activity that pulls the highest water consumption worldwide.

As said before, new technologies utilization is going to accelerate all technical and process advances and increase their efficiency, which is why projects that include advanced applied science and digital transformation are fundamental.

**How important do you consider public-private collaboration for water cycle digitalization growth and development?**

Public-private collaboration is essential in water cycle management. Specialized companies, in collaboration with the administrations, which are not water specialists but must provide quality service to citizens, are the best tandem for managing water supply and sanitation.

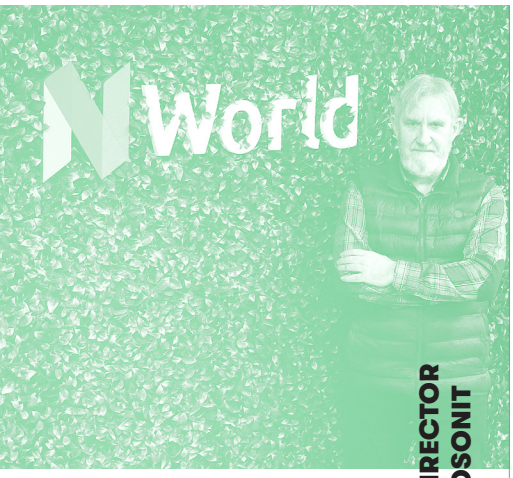
Specifically, this has been understood in the case of the PERTE for digitalization, where the terms of the call for proposals encourage private initiative to lead the proposals, due to its greater flexibility and knowledge of the market and technologies, with the necessary authorization from facilities and networks owners, which are administrations.

**What scenario do you envisage for the water sector in terms of digitalization and sustainability in the coming years?**

There is no going backwards for the digital transformation of the sector. The use of new technologies increases efficiency in water infrastructures the management, reduces costs and increases environmental sustainability.

In the case of sustainability, apart from increasing energy efficiency, reducing consumption and using renewable energies, there is a growing interest in concepts such as water footprint, even in sectors that are totally unrelated to water, like in technology companies.

# Detection of water leaks in distribution networks by photo interpretation




EDUARDO JOSÉ REMÍREZ MIGUEL, DIRECTOR OF INDUSTRY AND AEROSPACE AT BOSONIT

**Water leaks detection in distribution networks is an important task to ensure water supply efficiency and sustainability. Leaks can be costly, cause infrastructure and environment damage, and also affect water quality and its availability to consumers.**

'Classical' water leakage detection systems used so far, such as ultrasound or gap assessment systems, implemented in the volumetric and pressure meter network have been proved ineffective, either for early detection or for precise location. With the added disadvantage that they require a large amount of associated dedicated resources, both human and energy dependent, to power sensors involved.

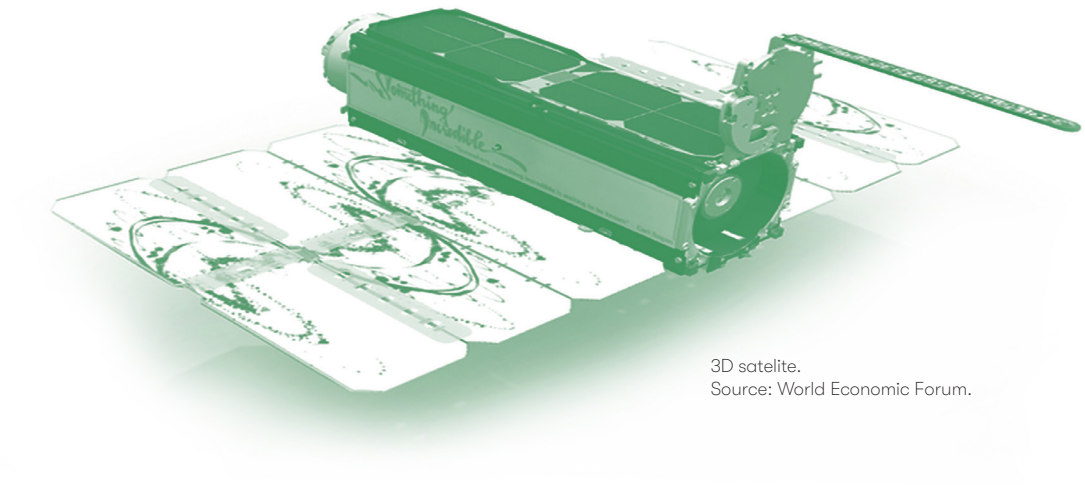
## Flight devices

An efficient way to detect water leaks in distribution networks is to use images taken from flight devices such as satellites or drones. These snapshots can provide a detailed, large-scale view of the distribution network, allowing the detection of abnormal areas that may indicate the presence of water leaks. This technique enables cost-effective analysis and its regular use facilitates the rapid location and leaks rehabilitation, helping to ensure water supply efficiency and sustainability.

There is different flight machinery operating at individual altitudes or orbits that are capable of carrying valid instruments to provide the specific kind of pictures that can detect water leaks:

There are different flight platforms operating at different altitudes or orbits that can carry valid instruments to provide the type of pictures needed for water leak detection:

- Satellites (large, medium and small), which typically operate in medium and distant orbits.
- Microsatellites and CubeSats, typically operating in low orbits (LEO).
- Atmospheric fixed-wing, rotary-wing, multi-copter and metrology airships.



3D satelite.
Source: World Economic Forum.

# Satellite imagery

High-quality, high-resolution imagery is essential for leak detection.

Satellite imagery is often higher resolution than drone imagery, but drones can provide more focused and detailed snapshots of specific areas due to their ability to fly at low altitude. Satellite imagery is often provided by space agencies:

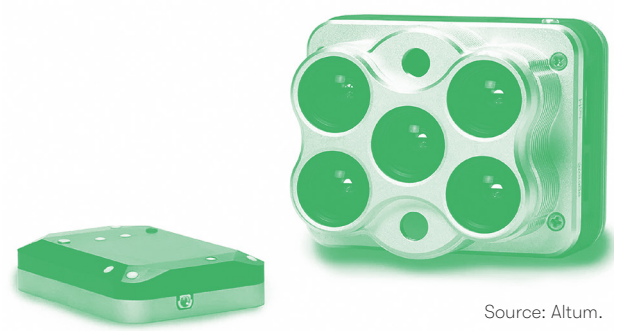
**European Space Agency** is a space agency that offers synthetic aperture radar imagery through its Sentinel program. They are available for free download through the ESA data portal.

The **Japan Aerospace Exploration Agency (JAXA)** offers synthetic aperture radar imagery through its website in the 'data and research products' section, available for download.

# Instruments

The main instruments on board aircraft that allow the acquisition of quality images valid for leak detection are mainly of two types:

**NIR (Near Infrared)** cameras are capable of detecting changes in surface temperature and use near infrared radiation, invisible to the human eye, to obtain images. These cameras can be lightweight and small in size, making them ideal for onboard microsatellites, CubeSats and drones.



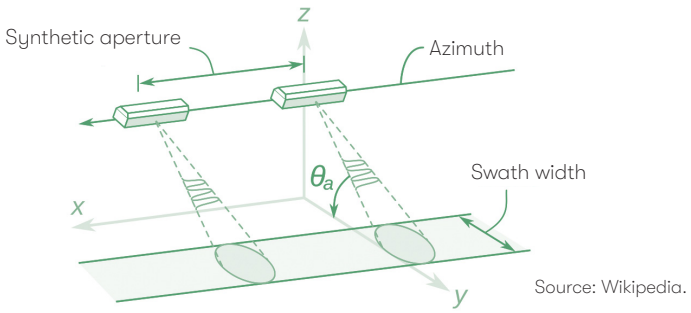
Source: Altum.

**Synthetic Aperture Radar (SAR)** is a radar technique that can also be used to detect water leaks in distribution networks. It has an antenna that transmits high-frequency radar signals and then receives the reflected signals from objects in the scanning area. The SAR is capable of provide high resolution images and has the advantage of being able to operate independently of ambient light, which is very useful for leak detection in dark or covered areas. It is commonly used in buried pipe detection applications as it can detect changes in the electrical resistance of the soil due to water presence.

Water is an electricity conductor and therefore affects the soil electrical resistance in which it is found. By detecting these changes in electrical resistance, SAR can provide accurate images and thus determine the leak location and size.

In addition, it can also detect changes in the water content of the soil, which can be useful for monitoring surface water distribution networks. To detect changes in the electrical resistance of the soil, SAR uses a technique called 'Ground Penetrating Radar with Polarization (GPR-P)'. GPR-P operates over a wide range of frequencies, typically between 100 MHz and 3 GHz. The selection of the appropriate frequency depends on the measurement purpose and the soil type. For example, low frequencies are used to detect objects and anomalies deep in the ground and higher frequencies are used to detect near-surface anomalies.

SAR Scheme




Source: Wikipedia.

# Crop moisture by remote sensing

The Normalized Difference Moisture Index (NDMI) is a good example of how these instruments work to provide a measure of the amount of water present in vegetation. It is calculated using satellite images that measure the reflectivity of the earth at different wavelengths. It is based on the idea that dry vegetation reflects more light in the near-infrared wavelengths and less light in the visible wavelength. Therefore, when vegetation is drier, the NDMI increases.

NDMI is used to monitor drought and assess the state of vegetation in different regions.

## Calculation of NDMI

| Sentinel - 2 bands | Sentinel - 2A | | Sentinel - 2B | | |
|---|---|---|---|---|---|
| | Central wave-length (nm) | Bandwidth (nm) | Central wave-length (nm) | Bandwidth (nm) | Spatial reso-lution (nm) |
| Band 1 - Coastal aerosol | 442.7 | 21 | 442.2 | 21 | 60 |
| Band 2 - Blue | 492.4 | 66 | 492.1 | 66 | 10 |
| Band 3 - Green | 559.8 | 36 | 559.0 | 36 | 10 |
| Band 4 - Red | 664.6 | 31 | 664.9 | 31 | 10 |
| Band 5 -Vegetation red edge | 704.1 | 15 | 703.8 | 16 | 20 |
| Band 6 -Vegetation red edge | 740.5 | 15 | 739.1 | 15 | 20 |
| Band 7 -Vegetation red edge | 782.8 | 20 | 779.7 | 20 | 20 |
| Band 8 - NIR | 832.8 | 106 | 832.9 | 106 | 10 |
| Band 8A - Narrow NIR | 864.7 | 21 | 864.0 | 22 | 20 |
| Band 9 - Water vapour | 945.1 | 20 | 943.2 | 21 | 60 |
| Band 10 - SWIR - Cirrus | 1373.5 | 31 | 1376.9 | 30 | 60 |
| Band 11 - SWIR | 1613.7 | 91 | 1610.4 | 94 | 20 |
| Band 12 - SWIR | 2202.4 | 175 | 2185.7 | 185 | 20 |

| Landsat 8 bands (Sensors OLI y TIRS)[2] | | | |
|---|---|---|---|
| Band | Name | Wavelength (µm) | Resolution (m) |
| 1 | Coastal - Aerosols | 0.435 - 0.451 | 30 |
| 2 | Blue | 0.452 - 0.512 | 30 |
| 3 | Green | 0.533 - 0.590 | 30 |
| 4 | Red | 0.636 - 0.673 | 30 |
| 5 | Near Infrared (NIR) | 0.851 - 0.879 | 30 |
| 6 | Shortwave Infrared 1 (SWIR 1) | 1.566 - 1.651 | 30 |
| 10 | (TIR 1) | 10.60 - 11.19 | 100 |
| 11 | (TIR 2) | 11.50 - 12.51 | 100 |
| 7 | Shortwave infrared 2 (SWIR 2) | 2.107 - 2.294 | 30 |
| 8 | Panchromatic | 0.503 - 0.676 | 15 |
| 9 | Cirrus | 1.363 - 1.384 | 30 |

$$NDMI = \frac{\text{Near Infrared - Shortwave Infrared}}{\text{Near Infrared + Shortwave Infrared}}$$

It is important to note that near infrared spectroscopy (NIR) and synthetic aperture radar (SAR) are barely tools that are available and should be used in conjunction with other techniques and methods to confirm the presence of a leak and determine the best way to repair it. Therefore, once the images have been obtained, they need to be processed and analyzed to detect possible anomalies.

Signs that may indicate the presence of a leak include increased soil moisture or excessive vegetation growth in areas where it would not be expected. Changes in surface color or temperature are also often detected and may be indicative of a leak.

After detecting a potential leak, it is always necessary to send an investigation team to the site to verify the leak and determine the cause. This may include checking the distribution network infrastructure through the use of flow detection equipment that can measure pipe pressure, water flow velocity and direction, while testing of the network is also prescriptive.

Some of the detection equipment involves the use of gas (helium) using a technique known as the 'helium pressurization test'. In this method, gas is injected into the pipeline or water distribution system and then a detector is used to discover helium presence in the area where a leak is suspected.

## Elliot Early Water Leaks Detection System EEWLDS

Elliot Cloud develops a state-of-the-art process based on multispectral imagery, proprietary treatment and depuration algorithms to provide its customers with a monitoring, discovery and early warning system that allows for maximum reactivity to a water leak event in their distribution networks.

- GIS satellite images collection at the geographical area involved.
- Satellite images processing and irrigation zones discovery.
- Drone images collection of the irrigation zones detected.

# Javier Ridruejo

**SECRETARY OF THE SPANISH NETWORK OF SMART CITIES NETWORK (RECI)**

*We live in a data driven era, so we need to be able to collect, refine, store, decipher and transform it into knowledge that leads to suitable decisions"*

The Spanish Smart Cities Network (RECI) is currently made up of 93 member cities, 44 friendly municipalities and two other associated entities, Red.es and the Telecommunications Engineers Association. All of them configure an ecosystem that contributes to automatic and efficient management of urban infrastructures and services, as well as public expenditure reduction and services quality improvement, aimed to achieve cities' improvement.

Francisco Javier Ridruejo Pérez is the secretary of RECI and is currently the general coordinator of Economic Promotion, Technological Modernisation and Professional Knowledge at Logroño City Council. Ridruejo lectures on how technology application supports integral urban water cycle management improvement and contributes to further progress in sustainability, conservation of water resources and citizen welfare objectives.

He also explains how shared data spaces and digital twins can become relevant tools for asset management in cities and, specifically, in the water sector.

# INTERVIEW

**How do you assess Spain's potential to accelerate the digital transformation process in the water sector?**

Spain is one of the most advanced countries in the world in water infrastructures management, such as irrigation, desalination, river basins transfers, reservoirs and urban water governance in municipalities that multiply their size several times over in the summer, without having provision problems and perfectly managing their entire life cycle: intake, treatment, storage, distribution, sanitation and recycle.

In addition, significant alterations that we are starting to suffer as climate change results are forcing cities, regions and the whole country to establish resource control and optimization policies, and infrastructures modernization with programs such as the Water Digitalization PERTE, promoted by the Ministry for Ecological Transition and Demographic Challenge with PRTR funds.

Spain has exported its successful model of infrastructure management, including water infrastructures, to other countries and we hold major world operators in the sector that control their own technology and an extensive experience in the sector.

**The Spanish Network of Smart Cities is a boost to accelerate this transformation process. Do you consider public-private collaboration to be a key factor for the successful implementation of water digitalization projects?**

Of course, public-private collaboration is always desirable, as it is difficult for municipal technicians to keep up to date with all the technologies, tools or best practices existing in the private sector, which has very different rhythms in the development of its solutions. On the other hand, it is always interesting to know the trends and optimisation processes carried out by other administrations supported by companies specialised in the water sector.

**We could state that data and information are key to success in order to improve decision-making. How does RECI view the ownership of this data and the transparency and interoperability of the tools used in this transformation process?**

We are in a data-driven economy. Anything that is not measures cannot be improved, so we first should be able to collect the data, refine, store, decipher and transform it into knowledge that leads to suitable decisions, which are data based, therefore objective. Furthermore, taking into account this type of infrastructure and the amount of data that can be generated in real time in a medium-sized municipality, it is important to have data exploitation platforms based on non-SQL technologies or big data distributions such as Cloudera, Graphenus and others that can help a lot in data processing.

*"Municipalities mission is to provide services to their citizens in the most efficient and transparent way possible"*

On the other hand, it is increasingly necessary for this data to be interoperable with Smart Cities platforms, such as Fiware, Elliot Cloud, Onesait or Telefónica, as these platforms make it possible to correlate the collected data with other city verticals such as energy, the environment or irrigation, which is so closely related to water, avoiding peaks in installed power, saving water and optimizing municipalities resources.

**In this sense, how does the Administration view the creation of data lakes or shared data spaces for the water sector and other sectors that affect cities management?**

As long as they have a practical application and a measurable return on investment, they are welcome. Municipalities mission is to provide services to their citizens in the most efficient and transparent way possible.

Pilots projects that are not initially cost-effective can also be set up, but when these projects are city implemented on a large scale, ROI is an important parameter to consider.

For example, it does not make sense to install a large network of smart meters with a state-of-the-art communications system to measure consumption in real time if this system operating cost is much higher than sending operators by car to check meter by meter.

**Technology is ready for the creation of these shared data spaces as there are innovative solutions in the sector that offer advantages over traditional ones. Do you think that the Public Administration and its technicians are aware of these innovative solutions and the potential of shared data spaces?**

Not usually. That is to say, it is necessary to raise awareness among municipal technicians so that they are informed of the different possibilities and make decisions for their implementation, always taking into account the cost/benefit ratio.

As for the potential of data spaces, we are still beginning to see their benefits and there is still not a large scale one that provides the theoretical results, so it is still a work in progress. The main hurdle we have to overcome is to convince companies to share their information in these data spaces and be able to exploit this information to generate value enhanced products. The contribution of cities to these data spaces will not be a problem, however, the issue will be that all stakeholders perceive the added value of such infrastructures.

**Digital twins are being promoted and there is growing interest in them. Can you define them and describe how they are used in integrated urban water management?**

The digital twin is a virtual infrastructure that simulates a real infrastructure and its operation, so that it represents, on a computer platform, everything that is happening in a real system, for example,

water, in all its stages: intake, treatment, storage, distribution, sanitation and recycle.

Vertical smart city platforms typically allow to view an monitor infrastructure status, established indicators and generated information to aid the decision-making process. But a digital twin does not stop there alone. The most advanced ones allow the operation of the infrastructure, or are even supported by intelligent systems based on artificial intelligence or advanced neural networks; they make it possible to simulate operations before they are performed to see the behaviour of the system before they are made, thus avoiding costly mistakes and favouring semi-automatic monitoring and operation in an ideal state.

*"There needs to be a smart city platform that allows different services to aggregate, operate and interoperate with each other in a way that makes everything more efficient"*

**So, could we say that digital twins will change the future of water management?**

Of course, digital twins will change the way we operate our infrastructures, they will allow us to simulate unforeseen situations, and they will introduce artificial intelligence in municipalities, lightening the management of large infrastructures.

**And finally, in relation to smart city management, is RECI in favour of integrating the different verticals, such as urban water cycle management and shared data spaces, into horizontal smart city platforms?**

Yes, from the Spanish Smart Cities Network we promote the use of technology in municipalities management, and given the atomization on technology adoption in the different municipal departments, it is necessary for there to have a smart city platform that allows the different services to be aggregated and operated.

Furthermore, they should interoperate with each other, and synergies should be established, so that everything becomes more efficient and simpler in terms of city horizontal management.

# Energy Efficiency in Water Supply Systems

PAULA JUNQUEIRA, PROJECT MANAGER OF SANITATION 4.0 AT ELLIOT CLOUD BRAZIL

**Globally, electricity prices are becoming increasingly high, which makes it necessary to promote the responsible and efficient use of resources. In this regard, energy conservation policy and good practices are of global importance with the Sustainable Development Goals (SDGs) associated with the 2030 Agenda. Some of them aim to achieve 'Sustainable Cities and Communities', 'Affordable and Clean Energy' and 'Industry, Innovation and Infrastructure'.**

Globally, electricity prices are becoming increasingly high, which makes it necessary to promote the responsible and efficient use of resources. In this regard, energy conservation policy and good practices are of global importance with the Sustainable Development Goals (SDGs) associated with the 2030 Agenda. Some of them aim to achieve 'Sustainable Cities and Communities', 'Affordable and Clean Energy' and 'Industry, Innovation and Infrastructure'.

Electricity consumption is indispensable in water supply and sewerage systems management and operation and generates considerable operational expenditure. Indeed, so energy expenditure is the second or third most important item in sanitation companies' budget.

For Sabesp, the fourth largest sanitation company in the world, according to Milton Tomoyuki Tsutiya, administrative facilities account for only 2% of the total electricity cost and operational water and sewerage facilities account for 98%. It is estimated that at least 90% of the cost is due to water pumping stations.

In this respect, initiatives that promote optimization and electricity consumption efficiency become a priority in basic sanitation utilities; programs using innovation and technology are in line with these initiatives.

In this context and to address these challenges, work began in 2021 on Sabesp to develop innovative ideas using the 'Design Thinking' method as the basis of the process. The objective of this project was to arrive at a prototype that contemplated all the innovation attributes, providing quantitative indicators and the certainty of the project's exponential growth potential. Thus, was born the energy efficiency project in water supply systems pumping equipment management.

## Evolution towards sanitation 4.0

The 'Innovative' project has used the concept of sanitation 4.0 and Elliot Cloud has contributed to achieving the objectives and constant improvement within this initiative.

The aim of the project has been to manage the activation of the pumps supplying the tanks in order to save electricity costs. According to previous estimates, up to 54% energy savings could be achieved at the time when the energy tariff was at its highest.

The project has been divided into three phases:

1. Prediction of the optimal water tank level when pumps are off.
2. Prediction of the optimal level in the period when the pumps should be switched off, in this case from 18:00 to 21:00 hours. In other words, the amount of water stored at reservoir in the selected period should be sufficient to guarantee water availability for the population.
3. Prediction of the optimal pump flow to ensure that the reservoir is at an adequate level.

In this sense, the ideal characteristics of the water supply system for implementation and telemetry data from the equipment are: the level of the reservoir; the pumps supplying the reservoir (status on/off); the inflow from the reservoir and the outflow from the reservoir.

*"According to previous estimates, the 'Innovative' project could achieve up to 54% energy savings"*

The platform allows the user to observe the tank level in meters and its variation over the selected period (figure 1). The selected point displays the information on the optimum level that the reservoir should have at 18:00 hours. This prediction will ensure enough population water supply without further replenishment into the reservoir from 18:00 to 21:00 hours.

## Level forecast

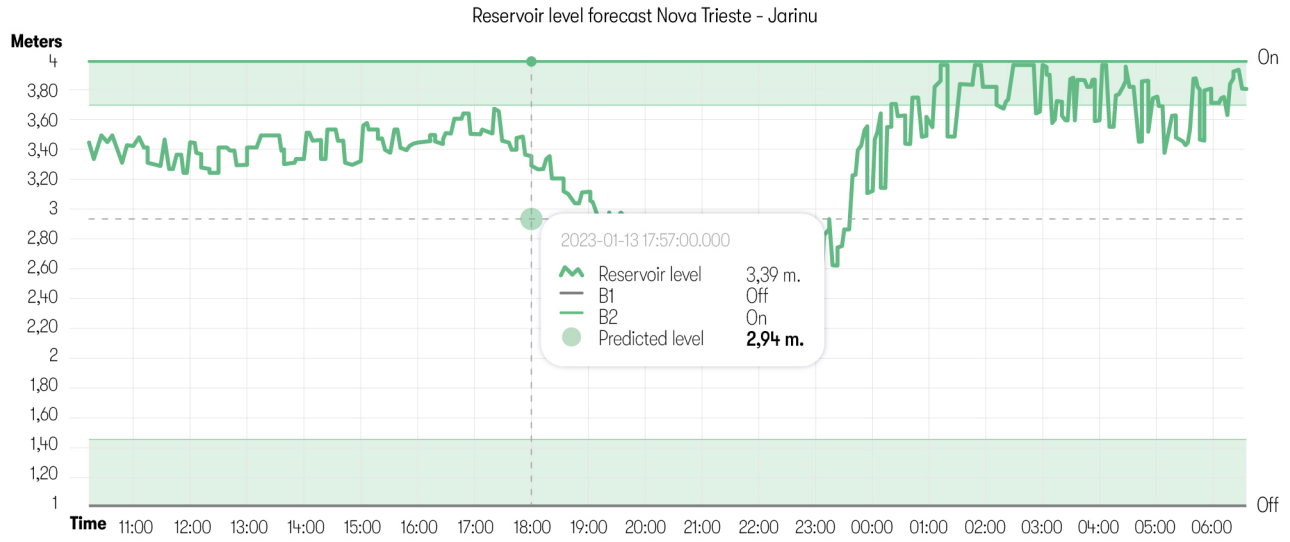



Figure 1.

In addition, the reservoir inflow (light green), the reservoir outflow (dark green) and the real-time reservoir inflow forecast (dotted line) can be observed. The reservoir inflow forecast aims to ensure the appropriate reservoir level (figure 2) at the time when energy costs the most, in this case from 18:00 to 21:00. The thick vertical line indicates an alert with data problems.

## Inlet flow rate

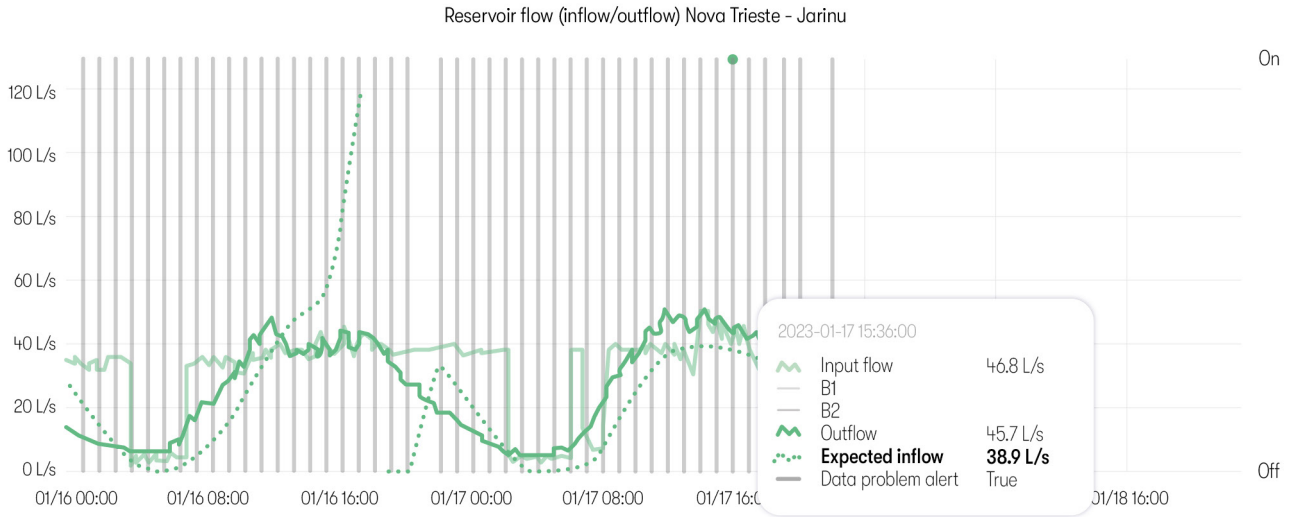



Figure 2.

An alert is also displayed when the artificial intelligence mechanisms indicate that pumping will not be able to reach the expected level (Figure 3).

## Insufficient capacity alarm


Figure 3.

Once demand forecasting, artificial intelligence and the functional resources available in the Elliot Cloud platform for water supply systems have been realised, it is possible to develop asset management. This allows optimisation of energy use in water supply systems, generating cost savings and thus increasing the availability of financial resources for other investments.

All this information can be managed and analysed through a solution called Elliot Water. However, it should be noted that the evolution of these initiatives is constant and runs in parallel with the improvements that are made in the energy efficiency process on a daily basis.

# Enrique Cabrera

**SENIOR VICE-PRESIDENT OF THE INTERNATIONAL WATER ASSOCIATION (IWA)**

IWA the international water association

*"Programmes such as PERTE of Digitisation of the Water Cycle serves to activate the sector, either by the sector, either as an opportunity to attract resources or to improve"*

Enrique Cabrera has been a member of the International Water Association (IWA) since 2002, has been a council member from 2012 to 2022, vice-president of this association for four years (2018-2022) and chairman of the board of IWA Publishing since 2013.

In addition, he has been a Professor at the Universitat Politécnica de Valencia since 1999 and has held the Chair of Fluid Mechanics since 2017. He combines this work with consultancy work on numerous national and international projects in the efficient management and operation of urban water systems.

The International Water Association (IWA) is an open but orderly platform where both innovators and adopters of new technologies and approaches can generate creative friction. It is a place of dissemination, benchmarking and

evidence. Its programmes develop research and projects focused on water and wastewater management solutions, organising world-class events that bring the latest science, technology and best practice to the water sector at large, and working to put water on the global political agenda and influence best practice in regulation and policy making through IWA's global membership.

# INTERVIEW

**First of all, could you tell us what motivated you to join IWA?**

It seemed to me that IWA was a good place to be in contact with water professionals and it has always been. In fact, I started to take on responsibilities very early on, which has given me access to many working groups and ground-breaking research.

**And how do you think the digitalisation process in the water management sector has been since you started your professional life until now?**

I think it has been progressive, there have been several lines of work that have been converging, and, together with the maturity of the sector, they have I think it has been progressive, there have been several lines of work that have been converging and, together with the maturity of the sector, have led to this moment in which the climate is very suitable for progress and improvement in this sense. For example, operators have been digitising for more than 25 years with the first GIS and SCADA. Simultaneously and gradually, the use of the first mathematical models became popular, as well as greater and better advances in computer processing capacity, the possibility of cloud computing, etc. If we add to this the right marketing, we are at the ideal moment to maintain lines of work for continuous digital improvement in the field of water networks.

**Do you think that the term digital has suddenly arrived to refer to something already known, but which was previously referred to by another name, such as smart?**

Actually, it is not the same, because people do not perceive it in the same way, but they are very similar concepts. It has changed for example in that we now have new data aggregator platforms; these tools collect a lot of data, arrange it in an attractive way, so that it can be used for something useful and eye-catching. They generally run in the cloud and make it easy and affordable for almost anyone to use.

On the other hand, models used to be a complicated technology, distant for almost all users; now they can almost be built without much prior knowledge or experience. Data is now used for many things; it used to be collected, but used sparingly, for very marginal applications, and is gradually being applied to many more processes and tools. However, I think that artificial intelligence processes, at least applied to water networks, have not reached full maturity and still have some way to go.

**What do you think about replacing mathematical models with sets of data series that are related to each other and obtain new forecasts?**

Well, in reality these are also models, it's the same thing. But instead of a physical model, it's a statistical model, a black box. Because the

equations of physics are not perfect, but I know how they work and they are always the same; whereas in models where statistics are applied, the results will depend on the ability of the model builders to find relationships between variables, the significance of those relationships and the quality of the data used.

**Do you think it is worth spending the time and resources to build a model in great detail?**

In my opinion it is sometimes putting the cart before the horse, because you should first ask yourself what you want to do with the model or what you need to solve. The problem with water network models is that they are representations of systems that are very difficult to know in detail as they are difficult to know in detail as they are buried underground.

Nowadays you can build a model with much less effort with the tools we have at our disposal, it is possible to have it in an hour, but then you have to check how good that model is and if it fits properly or helps to solve the problem you have to tackle. But you always have to do a cost-benefit analysis. In general, depending on the level of maturity of the operator, it is usually a worthwhile investment, as it will improve the quality of service.

**In your opinion, do studies to find the optimal point of information and detail needed to get a good enough model make sense?**

I am not aware of any such public studies, but I am convinced that private companies are already carrying them out. In particular, the software companies have the most capacity to do it, because they have all the data from their users, but it will be research of a public nature. but it will be internal research, to better understand the application of their products, and they are not going to publish it externally.

Regarding the level of detail that can be expected from a model, it is clear that incorporating remote reading data for all meters in the network can lead to a very reliable characterisation of the network behaviour. What is less clear is whether such accuracy is really necessary.

The needs will depend on the level of service to be offered and the price of the service. If the service provided to customers is positioned as premium, it will be very important to use the latest technology available and to take advantage of all the options it offers. But from a purely engineering point of view, sometimes such detailed knowledge is not necessary to operate the network optimally.

**Do you think there are external factors that have encouraged digitalisation, such as the increase in energy prices?**

No, in the case of Spain and in the last year, which is when energy prices have shot up, I think that what has encouraged it most has been the injection of public money. And, on the other hand, digitalisation in itself has also helped to make the operation of the networks more efficient, feeding back into their autonomous development.

**In your opinion, is it advisable for the administration to collaborate with these natural incentives? Who do you think benefits the most?**

It is very beneficial for the government to support digitalisation. In Spain there is no central regulator, so the competences are atomised in the city councils, making it more difficult to force global change. When we find ourselves in a natural monopoly like this, where there are no incentives for continuous improvement, programmes such as the PERTE Water Cycle Digitalisation Programme serve to activate the sector, either as an opportunity to capture resources or to improve.

This benefit will depend a lot on how the projects are awarded. I am concerned that it will end up being a typical fund that is spent without a clear technical guideline, without a strategic vision, and I am concerned about the haste to execute this expenditure. If it is used for projects such as having 100% smart meters, which in places where there is no clear technical guideline, where there is no strategic vision, I am worried about smart meters, which in places where they are very behind in digitisation is surely not the optimal way to approach digitisation focused on solving problems, this risk is run. It is true that it will move money in the sector, but it will not have the full impact it could have had. Each project should be associated with a strategic digitalisation plan that includes objectives and an investment plan, requesting a timetable of actions to carry it out. This would be the ideal theoretical approach.

**Do you consider that we have always been in a position of digital leadership in water in Spain? Why?**

Spain has always been well positioned in water management, and right now we are leaders in the digitalisation of water, due to the existing concentration of companies and projects. We have always had leading systems with technology and operation on a par with the best examples in other emblematic places in the world.

However, there is also the other side of the coin, we are more than 8,800 municipalities, with very fragmented management, in which it is not possible for all the technology to reach us. If we are compared to other countries such as the United Kingdom, where water management is grouped in only 10 companies, it is difficult to achieve the same development in all water supplies.

We cannot compare, for example, Canal de Isabel II with a small town of 100 inhabitants, for economy of scale. The latter will always be less advanced.

*"Digitisation has helped to make the operation of networks more efficient, feeding back into their autonomous development"*

In Spain, globalisation has been good for us, because Spanish companies that had the know-how found it difficult to go abroad, simply because of communication difficulties, because we were perceived as a less advanced country just because we had a different accent when it came to speaking English. But as the digital revolution is very digital, applications are often screens that can be easily translated, users do not look so much at the origin, which is less visible, as at the usefulness and capacity of the solution.

It has always been the case that the Anglo-Saxon has had a tinge of greater prestige, just for being native speakers of the language, even within research groups, with equal capacities, but in recent years this difference has been diluted.

We must bear in mind that Spain is also a country that does not sell itself very well abroad. There are countries that, globally, are trying to position themselves as leaders in the water, which is not our case, but the quality of our professionals speaks for itself, and we will see if PERTE can give that definitive push.

*"We are living on borrowed time, for example, in the exploitation of aquifers, which we are reaching almost 1,000 metres deep in some of them"*

**What do you think of digitalisation in irrigation, which accounts for 70% of water expenditure?**

Digitalisation is positive in all areas, but the problem we have in Spain is more one of quantity of resources than of technology. In this sense, it is not so much a problem of irrigation, but of governance. A great deal of emphasis has been placed on the modernisation of irrigation. Before, irrigation was done by drip irrigation and now it is all drip irrigation and, incidentally, this process may not be optimal from an energy point of view. Spanish irrigation is more efficient than in many other parts of the world.

With climate change there is going to be little water available and we have to learn to prioritise uses, all uses, which is a political problem. Just as there is not enough money to spend as much as we would like on education or health, there is not going to be enough water for everything. We are living on borrowed time, for example, in the exploitation of aquifers, which we are reaching a depth of almost 1,000 metres in some of them. The only thing that can be done, apart from being more efficient, is to prioritise uses and we have to accept this. On the coast there will be expensive water based on desalination, but in the interior there is not enough water for everything and we have to plan, we cannot have, in addition to irrigation, huge urban developments, recreational uses, growth in all sectors and everything that is proposed, saying yes to every project.

**Do you think digitalisation can help to decide which water uses are most necessary, as well as to optimise processes?**

Well, it can help us to hide in the data, to justify a decision, but I think in the end it has to be a decision made by people. We can support it with data, but it will always be an ultimate political decision and one for which we should start educating citizens, because it is not going to be easy.

**Right now, those who decide on the use and allocation of water are the Confederations, right?**

Yes, they use models for allocating the resource, distributing it among those who have the right to use it, not prioritising some uses over others in a clear and strategic way.

In the future, there should be clear mechanisms to be able to deny water to certain projects or change the allocation already granted to certain uses. This is a very complicated issue, especially taking into account the relationship of our citizens with water throughout history.

We have historical rights that have played a very important role and that until now have been immovable. We are a country with a long tradition in this sense, and, for example, in Valencia there is the Tribunal de las Aguas, with more than 1,000 years of history (the oldest in the world in operation), which is an example of how important it is to have a water tribunal.

Is an example of how important water is for us. But precisely because of that importance we have to start thinking that we will not be able to maintain the current status quo and that we will have to re-imagine how to manage a resource that is going to become much scarcer.

We will have to start thinking outside the box, because what we have used so far is no longer useful to us.

# Data is the key to keeping the water flowing

JOSÉ MANUEL BRUZOS, GRAPHENUS CEO

**Integral water cycle management presents important challenges, derived from aspects such as climate change, demand increase due to economic development, regulatory framework and the ever-increasing demand for transparency and efficiency from all stakeholders (customers, citizens, suppliers, etc.).**

These challenges require new approaches in the integrated management of the water cycle: advanced metering infrastructures implementation, digital twins creation, geographic information systems adoption and artificial intelligence are becoming increasingly common in water lifecycle upgrade and will certainly become essential in the future.

These new tools share a common problem: the need to retrieve and manage a large volume of data originating from totally heterogeneous systems and environments.

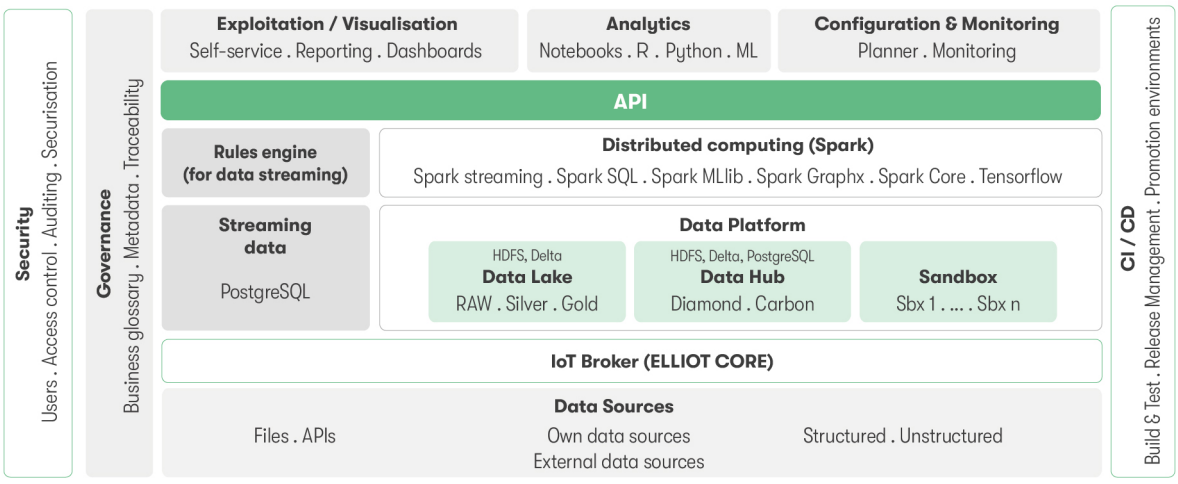
Until now, each of these tools was in charge of autonomously data managing, creating numerous information silos and making it impossible to obtain the maximum value from the data.

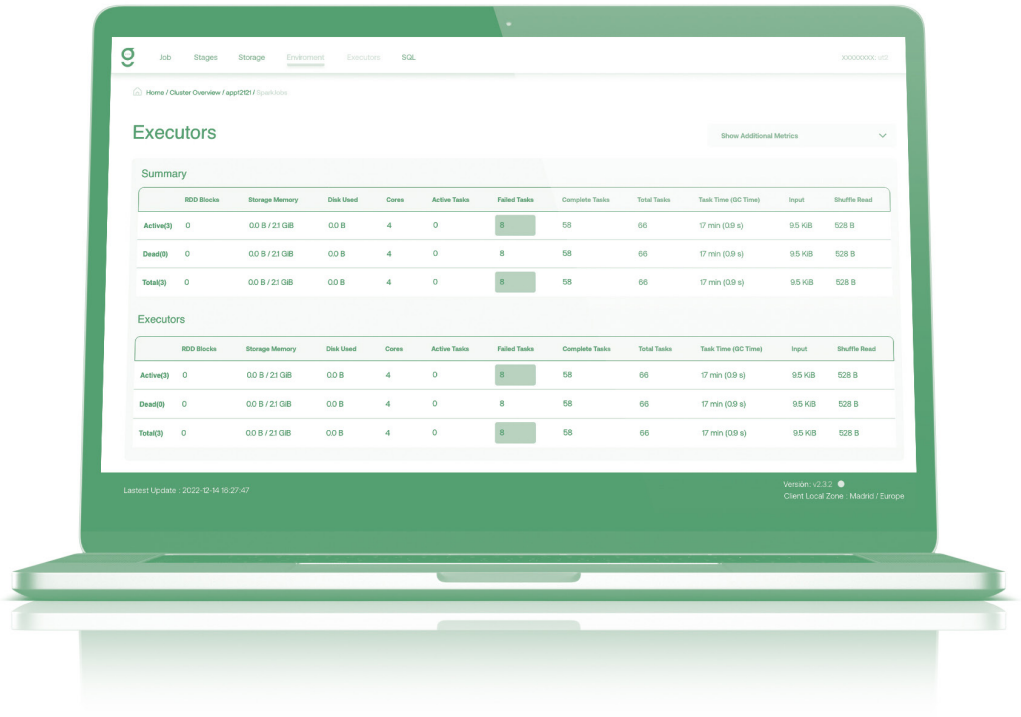
Graphenus was created to solve this problem, providing a platform that unifies all these tools data needs, defining data spaces that facilitate governance and ensure total interoperability and scalability:

1. Graphenus allows the discovery and incorporation of information from any source: measurement systems, APIs, databases, etc.
2. Data hosted in Graphenus can scale infinitely: there is no need to delete historical measurement data, which can be easily used in the creation of analytical and artificial intelligence-based models.
3. Distributed processing capabilities are available to meet both real-time and batch needs.
4. It incorporates end-to-end governance capabilities, allowing the definition of security and quality policies at the minimum level of detail.
5. Graphenus allows the integrated creation of machine learning models on the data hosted in the system, facilitating their training, publication and updating.
6. Graphenus is fully interoperable with other systems, thanks to GAIA-X compatibility. Graphenus allows data to be shared with private companies or public entities in a totally secure and scalable way.

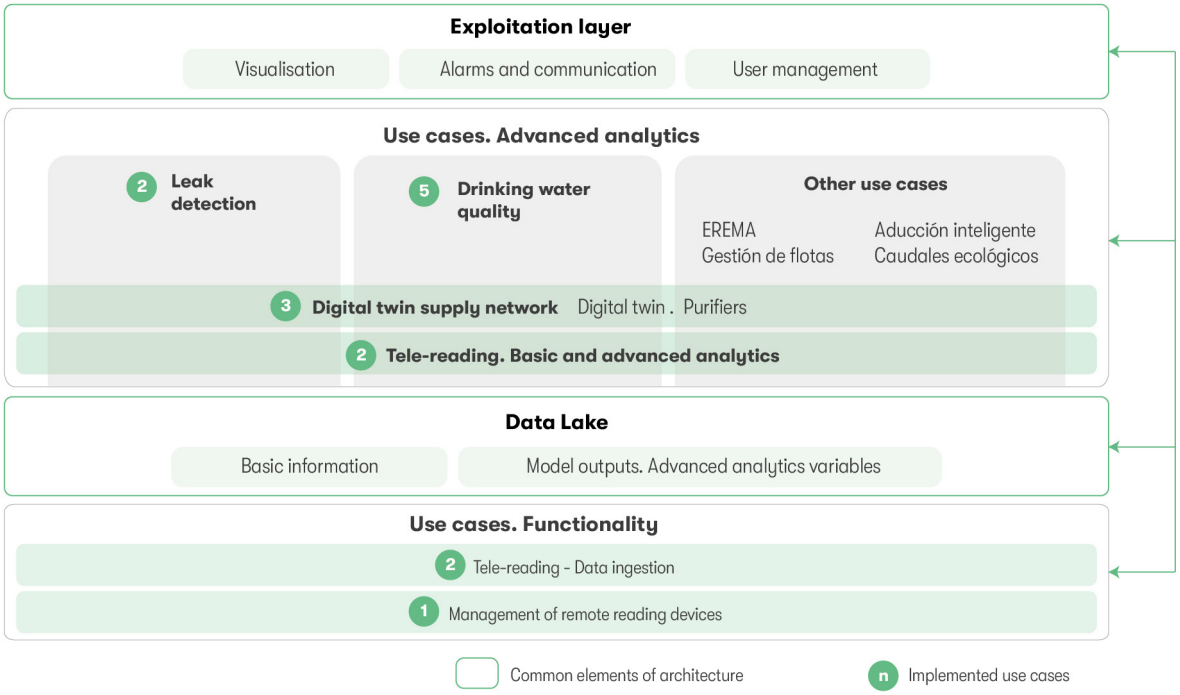
In addition, thanks to native integration with Elliot Cloud and its Smart Water solution, it allows exponentially increasing the speed of development of advanced use cases for water management, allowing leak and fraud detection, and digital twins development for supply networks, treatment plants, valves, etc. It also facilitates drinking water quality proactive management for fleets and maintenance services integrated into our distribution network; it enables environmental impact assessments, as well as intelligent adduction.

## Graphenus system integrated into Elliot Cloud platform






## Example of functional structure of use cases and relationship with base architecture elements



# Graphenus: data at water resources service

Data plays a crucial role in water management. Having a platform such as Graphenus in place will allow companies and public bodies to completely transform current management processes, improving efficiency and facilitating decision making.

Graphenus provides a functional and technical architecture proposed to cover the needs specified by companies in the sector to create data lakes or shared data spaces at a very low cost, as it is not developed with licensed tools.

The Graphenus solution model includes a set of tools for capturing, storing, processing, exploiting and querying large volumes of data. Elliot Cloud integration allows ingesting data from different sources, storing them in

*"Graphenus provides a platform for defining data spaces that facilitates governance and ensures full interoperability and scalability"*

a reliable and fault-tolerant way, performing complex analytics, both in volume (batch processing) and streaming (real-time processing), ensuring the persistence of data structure through the creation of databases and tables, or developing predictive and classification models on them, i.e., creating databases and tables, or developing predictive and classification models, i.e. machine learning processes, for subsequent consultation and exploitation.

To meet these needs, the platform encompasses different services and/or tools that allow us to perform these tasks. Most of these tools have been built on containers (orchestrated with Docker Swarm) with the minimum components necessary for their operation, in such a way that tools have a modular architecture that is easily deployable, scalable and changeable, as well as being tolerant to failures or crashes of the nodes on which they are deployed, thus providing a highly available environment.

All these tools used are open source and widely known in the Big Data field, most of them belonging to the Apache project (which has a large, very active and collaborative community), which have been configured, customized and adapted to work together and integrated in a container environment across different nodes.

# The importance of the data economy in the digital transformation processes

GUILLERMO PASCUAL GISBERT, DIRECTOR OF OPERATIONS AND DIGITAL TRANSFORMATION, AGBAR

**The effects of climate change are forcing the water sector to reinvent itself, to adapt, and this major challenge will be easier to overcome with the support of technology and digital tools. We are in a process of water transition that will have to be accompanied by an eco-digital transformation in water management, in which data management is a key element for success.**

Climate change effects are forcing the water sector to reinvent itself and adapt; this major challenge will be easier to overcome with the support of technology and digital tools. We are in a process of water transition that will have to be accompanied by an eco-digital transformation in water management, in which data management is a key element for success.

Thanks to public policies to promote data economy that boost the technological modernization of infrastructures and supply networks, the water sector has a clear opportunity to improve the services provided by the companies managing the urban water cycle.

At Agbar, we are focusing our efforts on developing highly resilient systems, capable of providing water in quality and quantity for the different needs: agriculture, industry and cities. And we are promoting this through Dinapsis, the network of digital transformation hubs for water management, environmental health, and the ecological transition of the territory.

From the Dinapsis centers, we develop new solutions by combining expert knowledge with new digital technologies, seeking to optimize environmental management. This combination is what we call operational intelligence, and

it is applied to various fields such as remote water consumption reading, treatment plants digital transformation, or contribution to 2030 Agenda objectives achievement, among others.

All of this, guaranteeing data security (availability, integrity and confidentiality) through prevention, cybersecurity, commitment to responsible data management and a governance model that safeguards data quality.

This strategy is part of Agbar's commitment to sustainable development and innovation, and of its ongoing commitment to digital transformation and the digitalization of processes to streamline management and continue moving towards circular growth models that are more respectful of the environment.

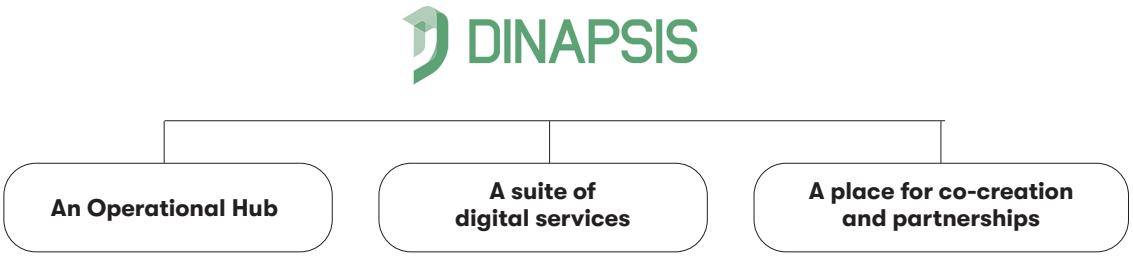
## The data economy in Agbar's digital transformation strategy

Climate change, the main challenge we face as a society, has a direct implication on water management. The increase in temperature alters rainfall patterns and increases the frequency of extreme meteorological phenomena, both in the form of torrential rains and episodes of drought. More and more territories - our country clearly among them - will be vulnerable to droughts and water scarcity.

For all these reasons, we in the water sector are focusing our efforts on developing highly resilient systems, capable of providing water in quality and quantity for different needs: agriculture, industry, and cities.

The application of technology to water management is essential to meet this challenge. At Agbar, we are committed to the incorporation of new technologies and to the data economy, which, together with advanced knowledge of the operation, allows us to completely transform the management of the water and environmental cycle, increasing efficiency in the provision of these services and improving all assets that form part of the infrastructures performance, with the aim of being able to guarantee supply in this context of growing water stress.

We are in a process of water transition that will have to be accompanied by an eco-digital transformation in water management, in which data management is a key element for its success.



## Dinapsis Digital Transformation Hubs in Spain


To this end, Agbar is promoting the creation of the Dinapsis digital transformation hubs, with 9 of them already in operation throughout Spain.

In addition, they are committed to co-creation and alliances to establish synergies, applying the knowledge acquired and collective creativity. The Dinapsis hubs allow us to scale and adapt digital solutions to real each territory needs, in terms of sustainable water management, environment and environmental health, facilitating optimal resource management.

From these centers we develop new solutions combining expert knowledge with new digital technologies, seeking to optimize environmental management. This combination is what we call we call operational intelligence.

*"The Dinapsis network deploys benchmark digital solutions for the digital transformation of water management and environmental health in the territories, promoting the development of smart, resilient and green cities"*

The Dinapsis hubs, both for the water cycle activity and for city or industry, draw on the diversity and volume of data stored for several decades, as well as Agbar's experience in processing them to calibrate each and every one of the artificial intelligence algorithms that we apply.

As an example, it is worth mentioning that in the water networks we manage we have a high sensitization level (there are more than 6,000,000 connected IoT objects), generating and managing some 15 terabytes of daily data.

Another relevant aspect to highlight is the contribution of Agbar's data

economy to the achievement of the 2030 Agenda, through Agbar's Dinapsis Environmental Indicators Platform: a tool to support the digitalization of the Spanish Urban Agenda in the municipalities that implement it. This platform, which is fed by satellite information processed with specific algorithms, facilitates decision-making and is a key tool for improving the environmental health and habitability of the territories.

Through digitalization, it is possible to measure and continuously monitor the positive or negative impacts generated by the different lines of action of the Urban Agendas of our cities and, therefore, to calibrate or redirect their objectives when the effect is not as expected. These digital Urban Agendas will facilitate a kind of benchmarking process between different cities with similar characteristics, contributing directly to sharing best practices and, therefore, to accelerating the processes of green and ecological transition towards a true scenario of sustainability.

More than 250 automated indicators allow the public manager to have the data always updated and on the same platform, facilitating a constant verification of compliance level with the Sustainable Development Goals and the 2030 Agenda, which allows planning and/or improving infrastructures; defining sustainability strategies (Smart City); designing the Spanish Urban Agenda for the municipality; improving access to Next Generation Funds; fulfilling the commitments to the Sustainable Development Goals and the 2030 Agenda; fulfil ecological commitments set by the European Union; and demonstrate good environmental management to citizens.

Another essential aspect is that of prevention. Digital data collection and processing systems with which we operate are essential to guarantee maximum action efficiency in the face of possible climate crises in cities. Thus, thanks to provided and processed in real time data, authorities have all the information they need to make the best decisions. The operational intelligence of Dinapsis' solutions is essential to create resilient cities, capable of withstanding crisis episodes.

In all its different aspects, Dinapsis is part of Agbar's commitment to sustainable development and innovation, and of its ongoing commitment to digital transformation and the digitalization of processes to streamline management and continue moving towards circular growth models that are more respectful of the environment.

## Secure, unified, accessible and open data

Ensuring data security is a key factor in building the Digital Economy. And data security is based on prevention: data is increasingly decentralized and security must always go hand in hand with data. Perimeter measures are no longer sufficient; cybersecurity must be based on identity and protection from the point of access to the data.

The development of the Data Economy implies major cybersecurity challenges requiring the protection of information processed, stored, and transported by systems, and the handling of threats.

Establishing mechanisms for securing storage and monitoring transition channels by means of controlled management of permissions and access codes are essential to prevent data loss, malicious access, unauthorized use and data corruption.

Agbar has protocols and a cybersecurity plan that guarantees data availability, integrity, and confidentiality. It is prepared to identify and respond to cyber-attacks.

When it comes to personal data, data protection is not a one-off action. It is an ongoing commitment of the organization to responsible data management, with compliance with standards constantly evolving towards the protection of individuals' privacy in the new context of data relationships.

The current regulatory framework at European level in the field of personal data protection, consisting of the European Data Protection Regulation and the National Organic Law on Data Protection, is based on a proactive or "risk-based approach" that is deployed in a preventive manner with a very precise purpose: to guarantee society data rights and freedom from the definition of a processing activity to its further development. And, to this end, an important principle to bear in mind: that of "Privacy by design and by default". Agbar has assimilated privacy and data protection principles as the default mode of operation within its business model and from their very conception in a clear commitment to its customers long-term trust .

Another of the key pieces of the data economy at Agbar is the governance model that regulates the processes, procedures, roles and responsibilities within the scope of data management.

Agbar's data management environment brings those responsible for each area closer to data operation and treatment with an active role in products and services creation through a datahub: a centralized repository that systematically allows the extraction, modelling, storage and processing and distribution of activity data, in which having continuously updated data in an analytical space enables integrated management of data independently of the operational systems that create them.

Data management involves the expansion of specialized roles and professions in the organization: the management of data ownership,

*"Agbar has protocols in place and has a cybersecurity plan which guarantees the availability cybersecurity plan that guarantees the availability, integrity and confidentiality of data"*

quality, privacy, as well as rethinking the data life cycle through of corporate processes. Among these, the functions of the data steward (guardian of the quality of the information) and the data owner (specialist reference in the process or field in question) should be highlighted.

In this process of Agbar's digital transformation, a firm commitment has been made to the implementation of AGILE methodologies in the creation of any organization service and process.

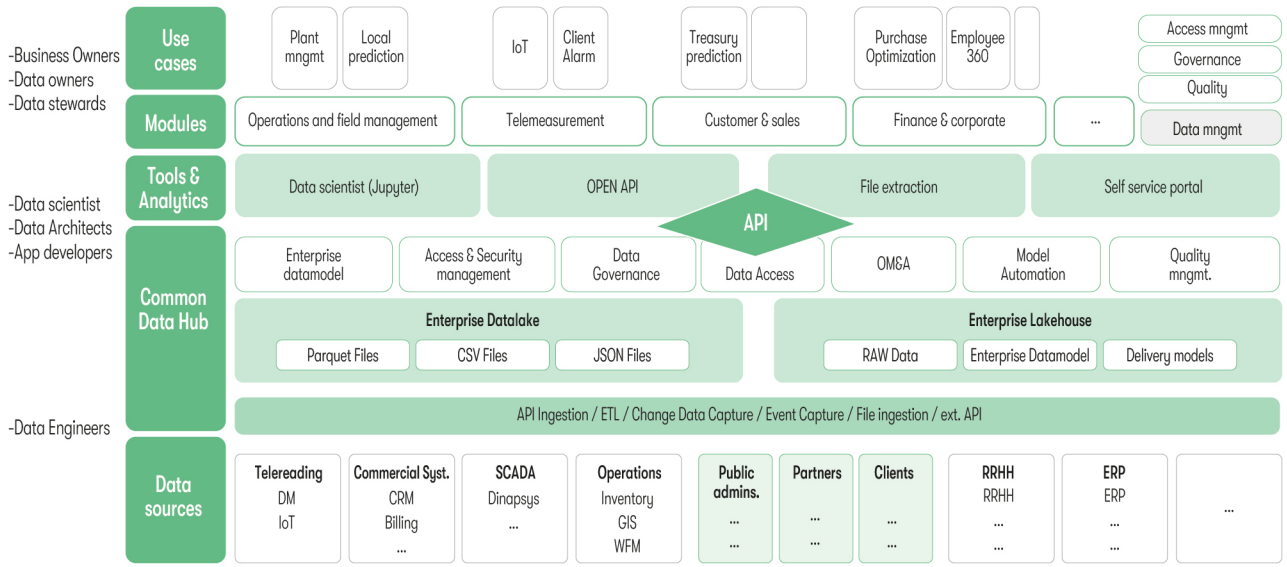
The participation of data user units in all phases of data design, development and exploitation together with technical teams (developers

and specialists such as Data Scientists or Data Architects) has enabled the implementation of new methodologies and much more efficient processes, also improving data quality and access and security policies.


This data governance and management model allows for a single, near real-time source of facts before they are processed from all internal and external systems and processes of the organization, facilitating the creation of dashboards, analytical models, artificial intelligence algorithms, digital twins and decision-support systems models from raw data.

Data scientists in turn have a simple system for quickly accessing data for research and building new models, training machine learning algorithms and building digital models.

## Data governance and management model




This approach to data management at Agbar enables the following:

- Single source of events disaggregated from operational processes and obtained on a continuous basis.
- A complete data model of the entire organization, relating data to each other with great granularity.
- A platform for development and delivery of data products and services accessible to internal and external users.
- An environment to audit and manage data quality, define usage policies, and have processes in place to ensure and improve data quality.
- The availability of frequently updated indicators for decision making of any organization and process.

Thus, Datahub becomes a source of data consumption with a transversal function to which all Agbar professionals have access to improve decision-making in their management area. And it is also a viewing window open to customer administrations. For this reason, each use case included in the platform has data and indicators that can be analyzed at different granularities that respond to the detail required level for each decision-making process. These visualization levels can be summarized as follows:

- **Visualization Level 1 - Operational:** At this level, the indicators necessary for a service manager and his team to facilitate the correct management of their installation or activity are visualized. At this level we can have the maximum granularity and temporality of data and indicators, for example, granularity of analysis by asset and with hourly or immediate analysis timeframes.

- **Visualization Level 2 - Tactical:** At this level, the indicators necessary for a manager of several installations are visualized with aggregated information on them. It allows an adequate on-line supervision of the operational status of each one of them.
- **Visualization Level 3 - Strategic:** This level visualizes the most relevant indicators that the management needs to know in order to monitor the good operational status of all the facilities. The detail is even less detailed than level 2, focusing on indicators that carry a higher management risk or cost.

This organization evolution to take charge of the data and its value contributes progressively to the optimization of processes and the obtaining of new values that have not been exploited until now.

Furthermore, all technological and process-level advances need to be accompanied by appropriate change management, given that people are an essential part of the company's transformation process. To this end, Agbar applies initiatives that promote a work philosophy in the teams based on the application of continuous improvement dynamics (lean management applied to operations), so that good visual and indicator-based management practices are naturally integrated into the daily routines of the teams. At the same time, they are a fundamental mechanism for involving all staff in the continuous improvement cycle, capitalizing on talent through the generation of ideas for improvement that are incorporated into the action plans, and from which feedback is given to the teams. In this way, the continuous improvement cycle is kept alive and active, while at the same time facilitating, organizing and optimizing the activity of the services provided.

# Conclusions

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# CONCLUSIONS

## Water management objectives and challenges

Today, there is an opportunity to drive the water sector digitalization process, as there is at the same time an arising need, coming from climate change, pollution and population growth, to ensure good water quality levels and to efficiently and equitably distribute this resource.

Therefore, the sector has several objectives: to have sufficient water, due to the frequency with which water crises occur, the increase in demand and quality; to make water distribution and purification more efficient with infrastructures modernization to minimize losses and thereby increase operations competitiveness and, finally, to achieve a social benefit through Sustainable Development Goals compliance, which seek to achieve a better future for all.

## The time for water digitalization is now

The water sector is going through a time of uncertainty with factors such as water deficit or desertification that show the vulnerabilities and challenges of the sector but which, at the same time, pose a moment of opportunity to make structural changes with which to adapt to the new times and carry out the integral water cycle digitalization.

A context in which to place Spain as an international benchmark in water resources management thanks to technification, not only of urban water, but also of agriculture, the main consumer of water resources. Thanks to the European Next Generation funds, the PERTE (Recovery, Transformation and Resilience Plan) and the Agri-food PERTE, a contribution will be made to avoid obsolescence in the sector and to adapt to the new challenges of the future.

## The value of data

Sustainable water management is not an option, it is a necessity. With this premise, data plays an essential role in the integral water cycle governance, increasing efficiency, optimizing and accelerating processes and saving expenditure and energy.

In order to develop sound water management, it is essential to have a data infrastructure that stores and manages, securely and efficiently, all the information generated in the water networks; that is capable of analyzing it and that helps to make better decisions. The sector must be committed to this open data management and sharing, transparency, data ownership and data sharing are key aspects for the administrations that manage these infrastructures.

In addition, monitoring and managing assets remotely will facilitate faster leaks detection or incidents in the systems; it will help to optimize networks performance, guarantee water in adequate quantity and quality, and contribute to raising awareness among citizens about the responsible consumption of this resource.

## Strengthen public-private partnerships

The digital transformation of the water sector is a common objective in which public and private entities must be aligned to overcome the existing barriers in the Spanish water sector.

The Ministry for Ecological Transition and the Demographic Challenge is promoting this through funds linked to plans, measures and programs for water management such as the 'Hydrological Plans', the PERTE for the Digitalization of the Water Cycle, the National Strategy for River Restoration and the Flood Risk Management Plans (PGRI).

In this context, it is interesting that public administrations rely on specialized companies for the development of technological projects that allow progress in sustainable water management, placing Spain in a position of international reference.

## Data spaces, key infrastructure for the development of the digital economy

The exploitation and extraction of value from data is a key aspect for the digitalization and competitiveness of economies. European and Spanish administrations are encouraging the participation of an increasing number of agents through initiatives such as the Digital Europe Program and the Digital Spain Plan 2026.

These initiatives encourage the development of shared data spaces and promote the interconnection of these to achieve data and information cross-exploitation that currently exists. A sector that is still in the development phase and in which there is a need to overcome the awareness barrier of administrations and companies to perceive the added value that is provided by information inclusion in these shared data spaces to generate relevant products, adapted to the water sector needs required.

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