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DPLA
DIGITAL PLATFORM FOR LEAKAGE ANALYTICS

# Simplifying Gas and Water

## Emerging Technologies Quarterly Review: May – July 2024

**Lead Organisations**

Cadent Your Gas Network

Guidehouse outwit complexity

**SIF Project Partners**

SGN Your gas. Our network.

WALES&WEST UTILITIES

Northern Gas Networks

national gas transmission

# Agenda

1. Executive Summary
2. Network Operations
3. Network Monitoring
4. Network Modelling
5. Current state of digitalisation
6. Opportunities for cross-sectoral collaboration
7. Conclusion
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# 1.
# Executive summary

# Executive summary

There is lots of overlap between the water and gas distribution industry in terms of network properties, dynamics, materials and leakage causes.

There are differences between how the industries operate and calculate leakage primarily due to the circular nature of the water system and the different properties of water and gas.


There are numerous opportunities for the industries to collaborate and share learnings to advance digitalisation, leak detection and monitoring.

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# 2.
# Network Operations

# Water and gas distribution systems are both pipe networks that transport fluids but present some operational differences

| | Gas distribution | Water distribution |
|---|---|---|
| **Conditions** | 30mbar - >7bar dependent on pressure tier, 0-20˚C | Minimum 0.7bar, 5-25˚C |
| **Materials** | Steel, Cast iron, Spun iron, Ductile iron, PVC | Steel, Cast iron, Spun iron, Ductile iron, PVC, Copper (in homes) |
| **Properties** | 0.65 kg/m$^3$ | 997 kg/m$^3$ |
| **Circularity** | One way from the transmission network to the customer. | Circular as clean drinking water is supplied to customers and wastewater is then transported away. |
| **Layout** | The UK is split into 13 regional networks overseen by 4 GDN companies. | In England and Wales there are 10 regional water and sewerage companies and 13 water only companies. |
| **Regulator** | Ofgem | Ofwat |

# Leakage is a problem in both utilities from a cost and environmental perspective

### Leakage causes

Common causes for leaks are the same across both industries:

- **Aging pipes** wearing out leading to fractures, joint and valve failures.
- **Ground movement** impacting the integrity of the pipes.
- **Accidental damage** from construction or tree roots.

### Impacts of leakage

Leaks from gas and water distribution networks lead to **increased costs to the customer** as valuable assets are lost before reaching the end user.

In the case of gas, leaks cause **increased emissions** of harmful greenhouse gases. Whereas leaks in water supply can lead to **contamination** of the water and leaks from wastewater are **hazardous** to people and the environment.

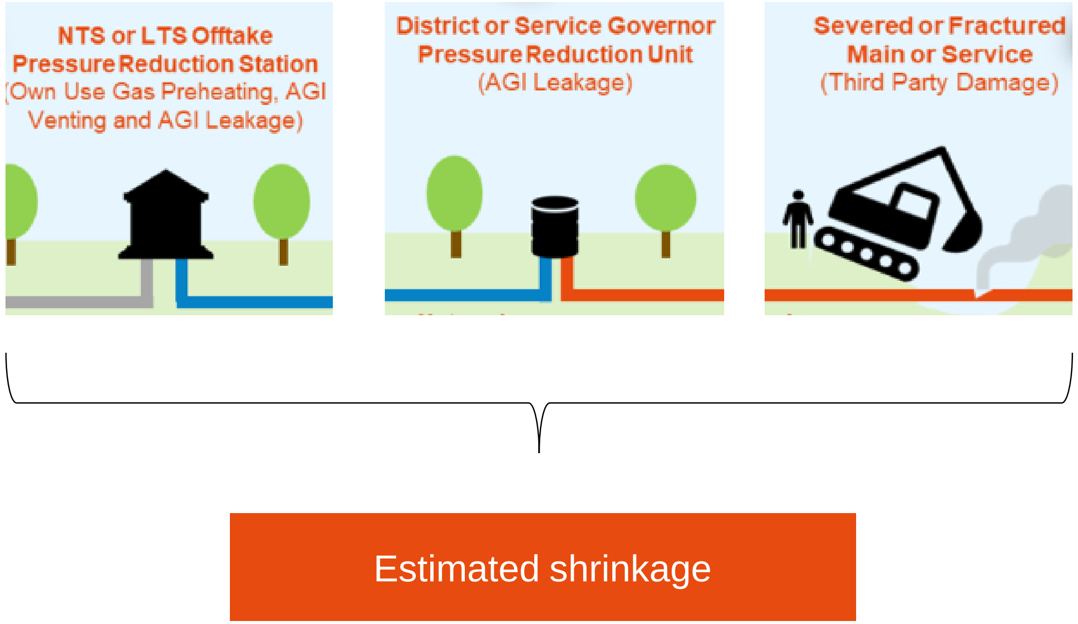
### How leakage is currently addressed

Leaks are predominantly **reported** to the utilities **by the public**, either when they smell gas, have water pipes leaking in their homes or when there is an abnormal pool of water on the ground. But more advanced leak detection methods are being researched.

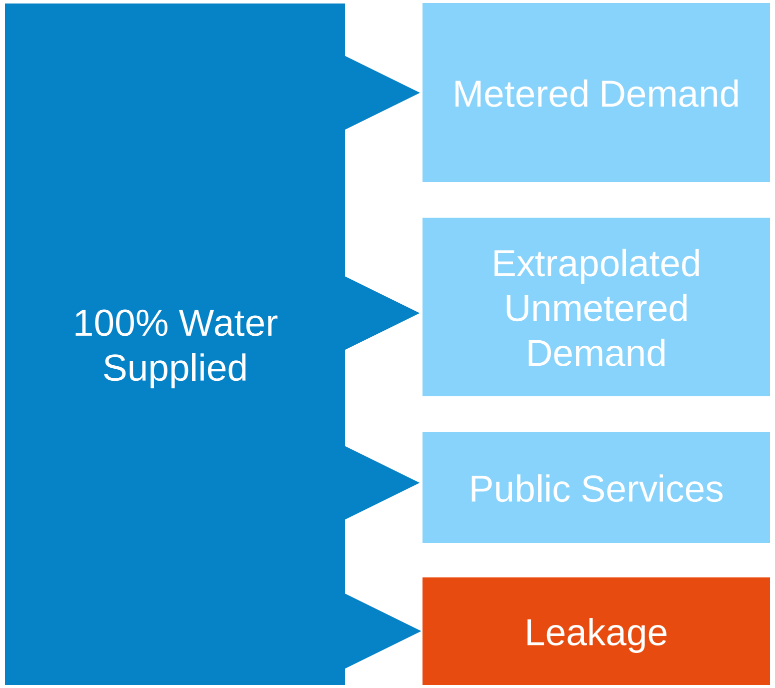
To date the primary method for **reducing leakage** has been **mains replacement programs** where old metal pipes are replaced with new plastic ones that are less prone to leaks.

# Currently in both cases leakage is predominantly assessed from an end-to-end perspective not on an individual leak basis

**Gas:** the Shrinkage Leakage Model (SLM) was developed to estimate gas lost through leaking pipes, theft and accidental damage. It estimates the amount of gas lost from each asset type or pipe material and extrapolates this across the network to obtain an overall estimate of shrinkage.




**Water:** leakage in distribution networks is estimated by subtracting the measured demand from the measured supply. If properties are unmetered their demand is estimated using data from similar property types.



**A key goal of developing the DPLA platform is to transition leak detection in the gas distribution sector from reactive to proactive and update the current SLM.**

### New Technologies

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### Machine Learning and advanced Data Analytics

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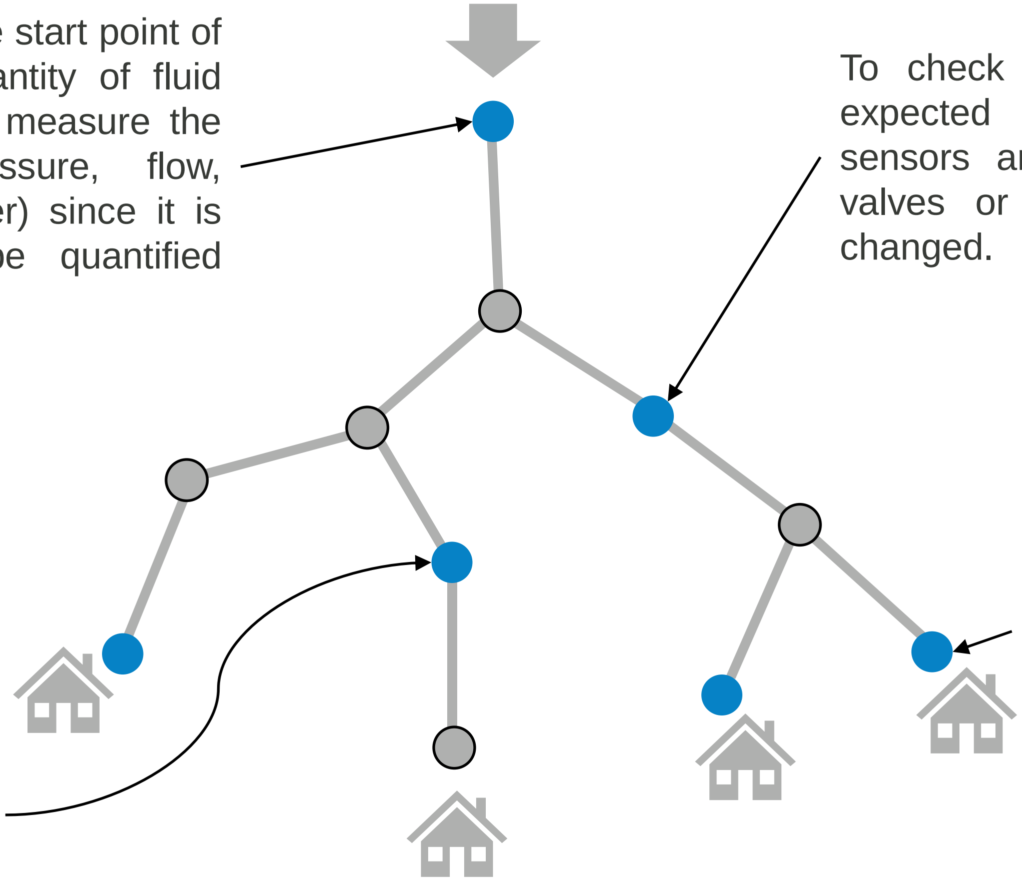
# 3.
# Network Monitoring

# Distribution networks contain sensors which are used to monitor and control the operational conditions but are not designed in function or placement to support leak detection.

Readings are carefully taken at the start point of the network to measure the quantity of fluid supplied. These sensors tend to measure the full range of variables (pressure, flow, temperature, and quality for water) since it is important for the supply to be quantified correctly.

To check that the network is operating as expected and can be remotely controlled, sensors are installed at e.g. PRSs, pumps, valves or any points where conditions are changed.



The end points of the network where gas or water is supplied to people's homes should each have a meter to record the amount of fluid supplied. This isn't always the case, and this data is not readily available for gas distribution companies, making network modelling and leak detection more difficult.

Sensors to monitor operational conditions can also be placed at other strategic locations, such as low points for gas.

# A range of advanced methane leak detection sensor technologies are becoming available on the market. These vary by sensor type, mode and primary use case.

### Vehicle-mounted

Methane sensors can be mounted to **cars** which drive set-routes to **survey** and detect leaks across certain areas. These are particularly suited to surveying **urban areas** where pipelines are located near the roads.

As well as dedicated leak detection vehicles, **pilots** are being performed with modular sensors mounted on **municipal vehicles** to bring down operational costs and increase survey frequency.

### Fixed and handheld

A variety of sensor technologies are also available to survey AGIs through **continuous monitoring**. These sensors provide a real-time view of leakage at the monitored site using inverse modelling to estimate the size and location of leaks.

**Handheld devices** can also be used to survey sites or **pinpoint leaks** detected by other sensor types. The sensor technology in these devices ranges from traditional infrared cameras to ultrasound-based.

### Satellite and remote sensing

**Satellite-based** methane monitoring and analytics has significantly advanced in recent years with resolution and accuracy continually increasing.

Other forms of remote sensing, such as **drone or helicopter** mounted sensors, are also available for methane leak detection.

Satellites can survey larger areas in comparison to drones or helicopters.

# The market for leak detection in water networks is also growing, especially with the shift from metal to plastic pipes.

### Acoustic and Fibreoptics

Traditionally **acoustic** leak detection has been heavily relied upon in water networks. Sensors are inserted into pipes to measure **shock waves** travelling down the pipe walls which can be used to detect leaks. The industry is moving away from this technology as it is less effective for PVC pipes.

Innovation has developed **fibreoptic** technologies which measure **changes in temperature** along the length of a pipe that signify leaks. These technologies are effective but require high upfront and operating costs.

### In-pipe inspection

**Intrusive** technologies, such as PIGs (pipeline inspection gauge), directly enter the pipes to find leaks. Driving techniques, autonomy and sensor type can vary but rely on directly **measuring anomalous conditions** around leaks.

A leak detection **robot** has been developed by research institutions, e.g. MIT, which can distinguish between debris and leaks through the drag caused to its fin.

In-pipe inspection methods come with the potential to contaminate the water supply.

### Satellite and remote sensing

Remote sensing techniques are developing for detecting leaks in water networks. **Radar-based satellite** data can detect ground moisture which makes it very promising for water leak detection.

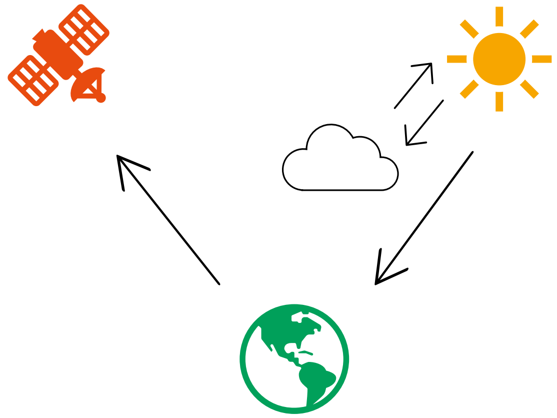
**Anglian water** are already employing this technology for leak detection and find leaks particularly in rural or remote areas.

**Infrared or thermal imaging** sensors mounted on drones can also be used to detect water leaks, but can struggle to distinguish between leaks and soil moisture

# Earth observation (satellite monitoring) has many advantages for leak detection and is being leveraged for leak detection in both water and natural gas networks.

**Optical satellite imagery** works by detecting the sunlight that reflects off certain objects on the Earth's surface, like a standard camera. Methane is visible in specific bands (short-wave infrared) of imagery collected by optical imaging satellites. Algorithms can then be applied to this imagery to detect and localise methane leaks occurring on the gas distribution network.

Developing and commercialising this technology is the aim of companies such as Satelytics.



An alternative satellite technology **(SAR imaging)** works in the same way as optical imaging but uses its own 'light source' to emit waves which are reflected from the Earth and detected by the satellite. Water can be easily detected in this imagery including different compositions or levels of ground moisture. This allows algorithms to explicitly detect 'drinking water mixed with soil' from SAR imagery making it very useful for leak detection from water distribution networks.

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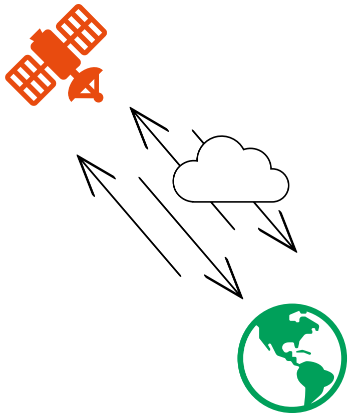

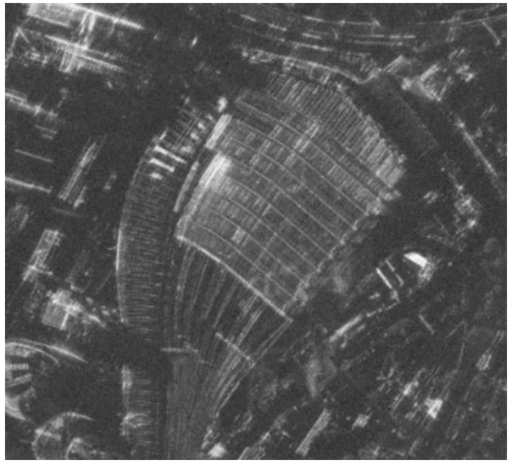

# After surveying the market, a selection of advanced methane leak detection sensor technologies were chosen for trial in the DPLA.

**Methane Leak Detection Technology Providers:**

- SENSIRION
- QUBE
- Satelytics
- Bohr
- DISTRAN SWITZERLAND

**Water Leak Detection Technology Providers:**

- xylem
- iota
- suez
- GUTERMANN — Gubelstrasse 15, 6300 Zug, Switzerland

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# 4.
# Network Modelling

# Hydraulic modelling is a traditional method to represent the dynamics of fluids. It is used in both industries to simulate operational network conditions for planning, monitoring and control purposes.

**Network Model:**

A virtual representation of the network being modelled, its assets, structure and properties.

**Hydraulic Equations:**

The mathematical equations which dictate the fluid dynamics. These can be configured for different fluids and purposes.

**Hydraulic Network Model:**

The network data and hydraulic equations are combined to simulate operational network states and leak detection.

# There are different classes of leak detection model that can be developed for any network dependent on the available data and target requirements

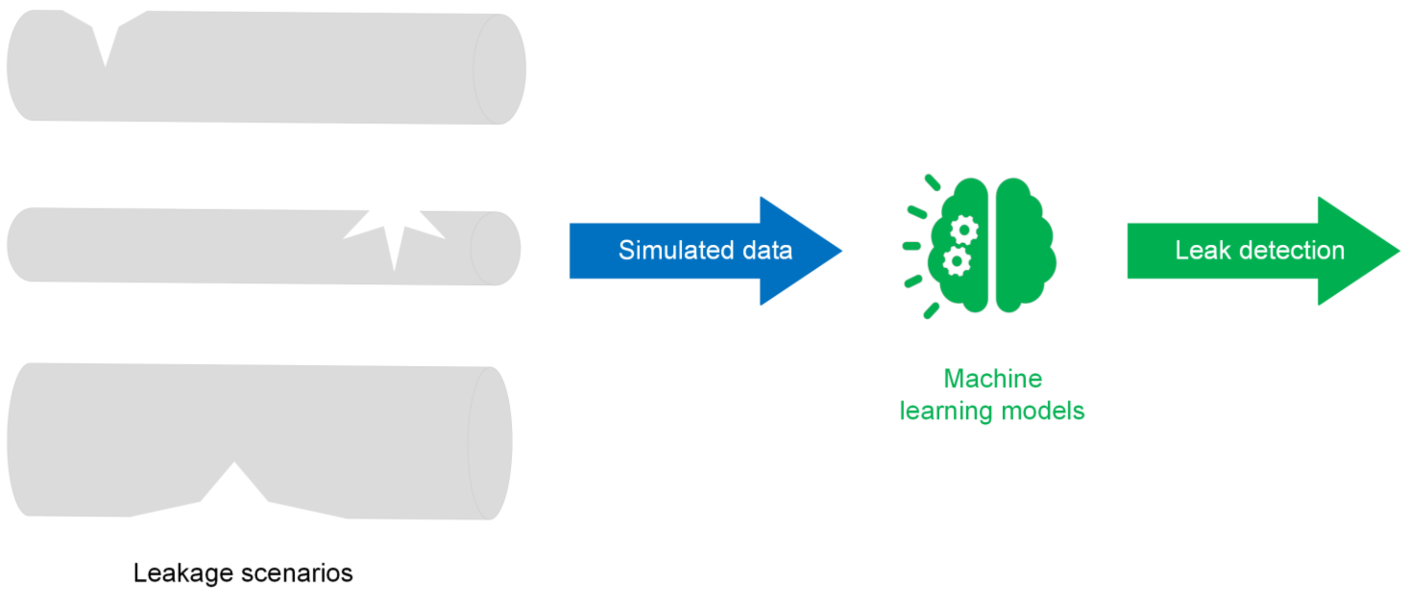
**Model-based:**

Model-based leak detection methodologies are those that are **directly built from,** and therefore highly dependent on, **network hydraulic models.** There are different methodologies, but they tend to work by comparing actual data to simulated data.

Where there is sufficient data available, the hydraulic model can be solved directly to accurately detect leaks through inverse modelling.

Where the data is insufficient, the hydraulic model can be used to produce representative data to train a machine learning algorithm for leak detection.

The properties of both the pipe and the leak are specified in simulations used to generate training data for machine learning models to learn to detect and locate leaks.



# There are different classes of leak detection model that can be developed for any network dependent on the available data and target requirements

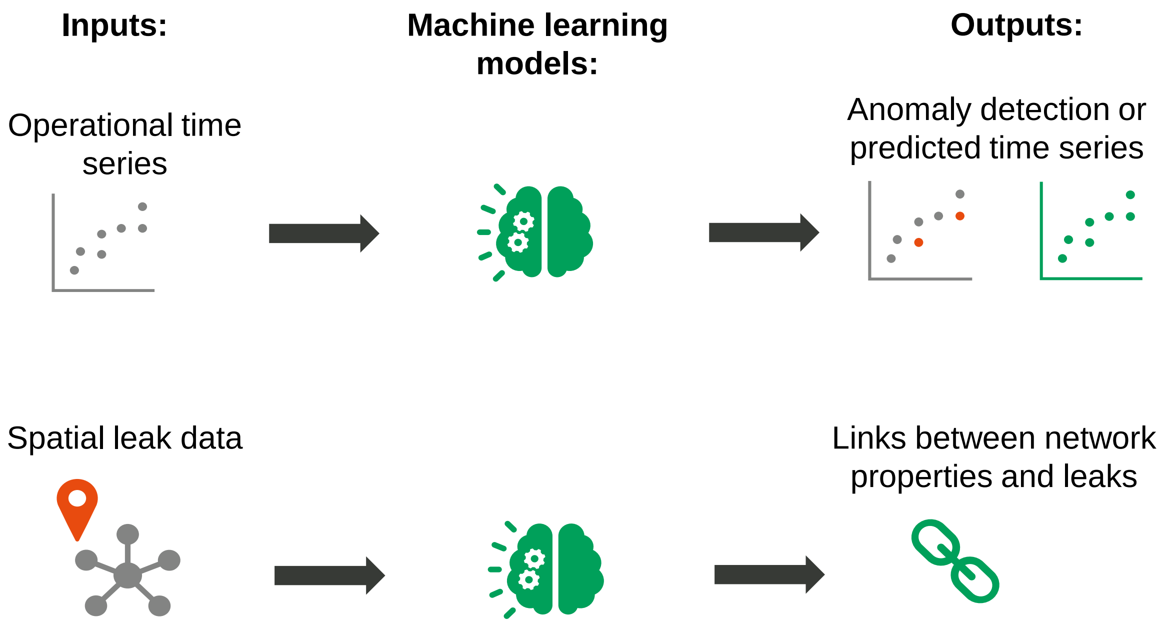
**Data Driven:**

Data driven models are **statistical or machine learning** models that attempt to solve the leak detection or localisation problem by detecting anomalies in the available **data**.

These models reduce the reliance on hydraulic models which can be difficult to accurately calibrate to the real network. However, they are **fully reliant on real data** and impacted by faulty sensors or lack of data.

A large amount of data pre-processing is also required which can introduce bias.

Various data sources can be used to train machine learning models to perform leak detection.



# There are different classes of leak detection model that can be developed for any network dependent on the available data and target requirements

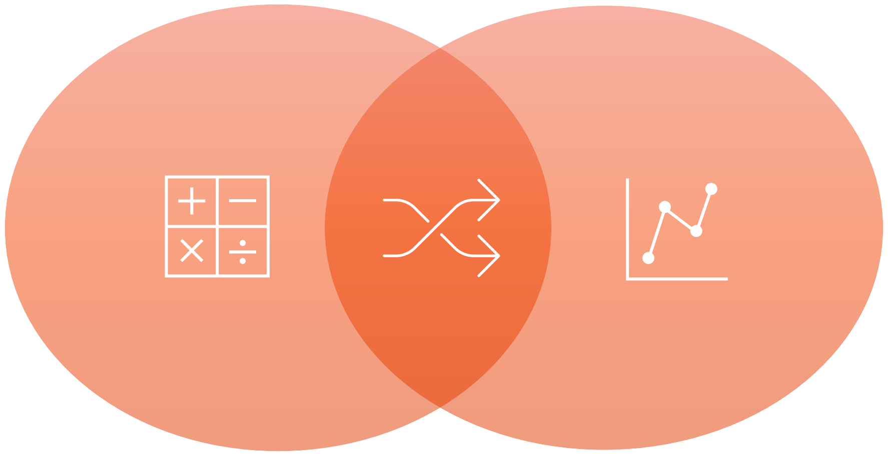
**Mixed:**

Mixed models attempt to **minimise** the **disadvantages** of both other model types by drawing on both.

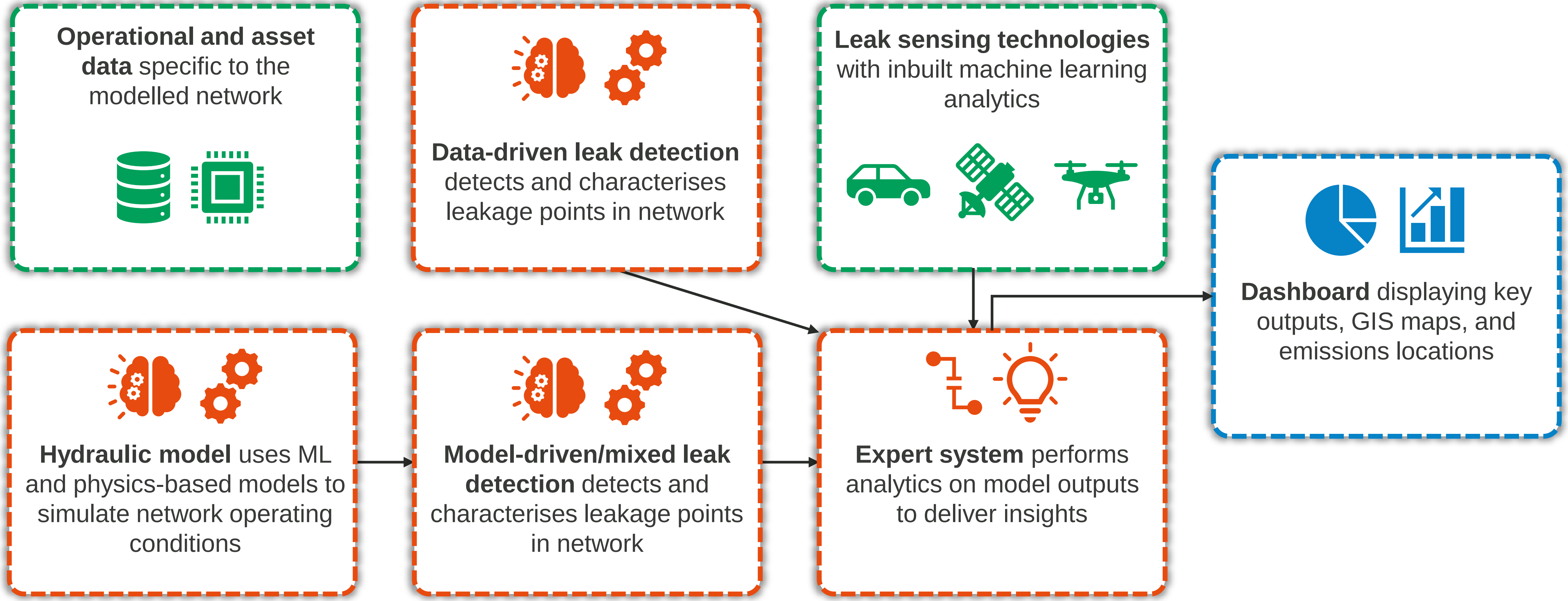
They can be developed to correct the outputs of **hydraulic models** using **machine learning**. Or mathematical theory can be used to constrain the predictions of data-driven models to improve results.

A variety of different architectures have been developed and tested in the academic field for the water application.

Mixed models aim to combine the theory of model-driven methods with the power of data-driven models to benefit from the advantages of each method, while minimising the drawbacks.



# The DPLA framework is designed to be technology agnostic with the ability to take in results from different models and data from advanced leak detection technologies to give an updated view of network emissions.



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# 5.

# Current state of digitalisation

# Recent technological developments have started a shift in both sectors towards digitalisation but there is further progress to be made.

**Sensorisation and intelligent control**

Over the proceeding decades both gas and water have increased their network sensorisation and moved to **Supervisory Control and Data Acquisition** (SCADA) systems which allow monitoring data to be collected and transmitted to a central server in **real time**. These systems also allow for operational conditions to be **controlled remotely**. Innovation work in projects such as Intelligent Gas Grid in the GDN industry is aiming to extend this control to work more intelligently.

**Digital Twins and Smart Networks**

Efforts are being made in both sectors to shift to **smart networks** through investment in new hardware technologies for sensorisation and monitoring as well as advanced software to improve network modelling and create **digital twins**. For emissions monitoring **the DPLA** is being developed for the UK and the Methane Emissions Monitoring Platform (MEMP) for the US. In the water sector, **Yorkshire water** have piloted a smart network in a section of Sheffield which is being extended to the rest of their network.

**Future Outlook**

Over recent years there has been a push to digitalise distribution networks with lots of **innovation** in the area, there is still work to do to develop and operationalise solutions. To support real-time monitoring and accurate network modelling, further **investment in network sensorisation** is needed. As digital solutions, such as the DPLA, develop they should be **made interoperable and technology agnostic** to maximise insights and ensure the latest developments in software and hardware can be integrated.

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# 6.

# Opportunities for cross-sectoral collaboration

# Since there is overlap in many areas of advanced leak detection between gas and water, there are multiple opportunities for collaboration

## Framework

There are many **commonalities** across the gas and water distribution sectors.

The **DPLA framework** has been designed to be **technology agnostic** and therefore **generalisable** for any hydraulic network.

## Sensor analysis

Effectively monitoring networks requires sensors to measure operational conditions. Although different networks may choose different suppliers of sensors, their **optimal placement** to support model development will be the same. Therefore, sensor optimisation **methodologies could be shared.**

## Modelling

Hydraulic and leak detection models are very **similar** for gas and water requiring **minimal adjustments** for different fluid dynamics. Therefore, there are lots of **potential shared learnings** to be gained through knowledge sharing, particularly from the wealth of academic research available for water leak detection.

## Data Sharing

With so much potential overlap, increasing **cross-sectoral collaboration, data and knowledge sharing** will provide mutual benefit.

For example, sharing learnings from the Yorkshire pilot could provide useful insights for the DPLA.

## Satellite data

Although most leak detection technologies will be different across the sectors there is potential for overlap. Both industries can leverage leak detection insights **from satellite data.** Although the data requirements are different there is the immediate potential for collaboration around integrating satellite data into **workflows.**.

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# 7.
# Conclusion

# Key takeaways

**Commonalities exist between gas and water distribution.**

**Effective leak detection and maintenance is needed.**

**Innovation in leak detection in both industries.**

**Leak detection frameworks (e.g. the DPLA) can be applied to any network.**

**Increased collaboration and data sharing would provide mutual benefits across sectors.**

# SME Q&A