New trends in high frequency water demand monitorization and analysis:

Experiences and challenges

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HIGH FREQUENCY MONITORING

What is it?

- What can be defined as high frequency monitorization?

    - 1 min, 30 sec, 10 sec, 1 sec, …?

- What for?

    - Network operation

    - Water meter management

    - Water demand characterization

    - WATER END-USE ANALYSIS

WATER END-USE ANALYSIS

What is it?

Split water consumption into its fundamental components

Legend:
- Leaks
- Showers
- Toilets
- Washers
- Dishwashers
- Faucets
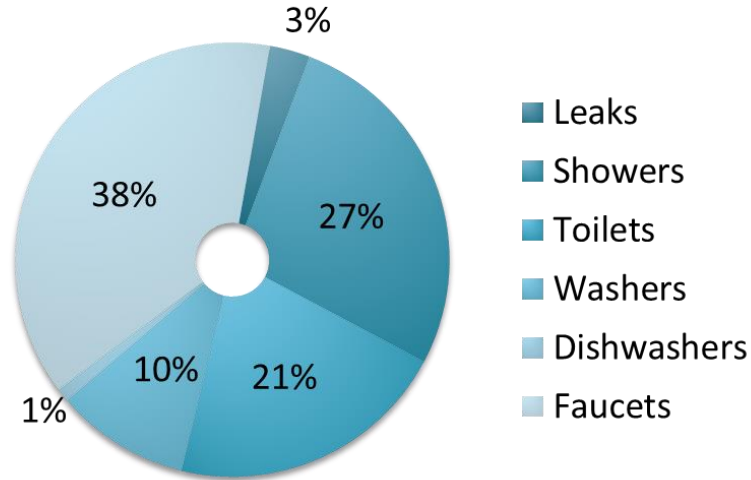
RESIDENTIAL WATER END-USE ANALYSIS

What for?

Improves network operation

    — Water demand modelling and forecasting

    — Network leakage management

    — Reduction of commercial losses

Enhances water conservation strategies through:

    — Behavioural understanding of water uses

    — Improved design of water devices

    — More efficient plumbing schemes

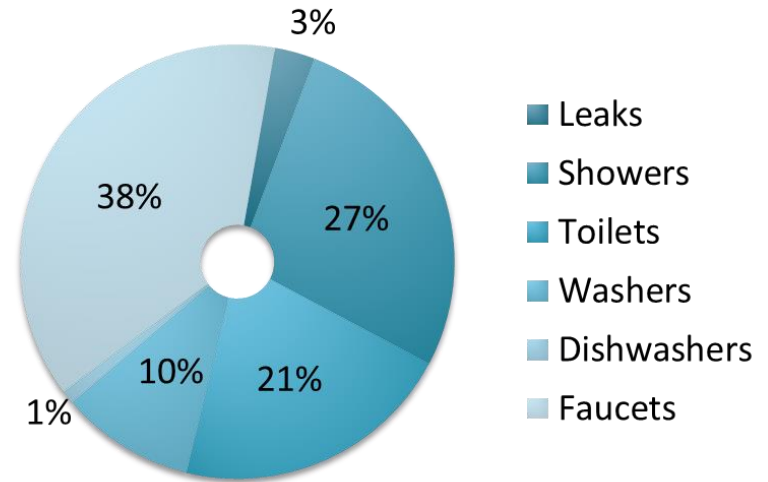**New trends in HF water demand monitorization and analysis**
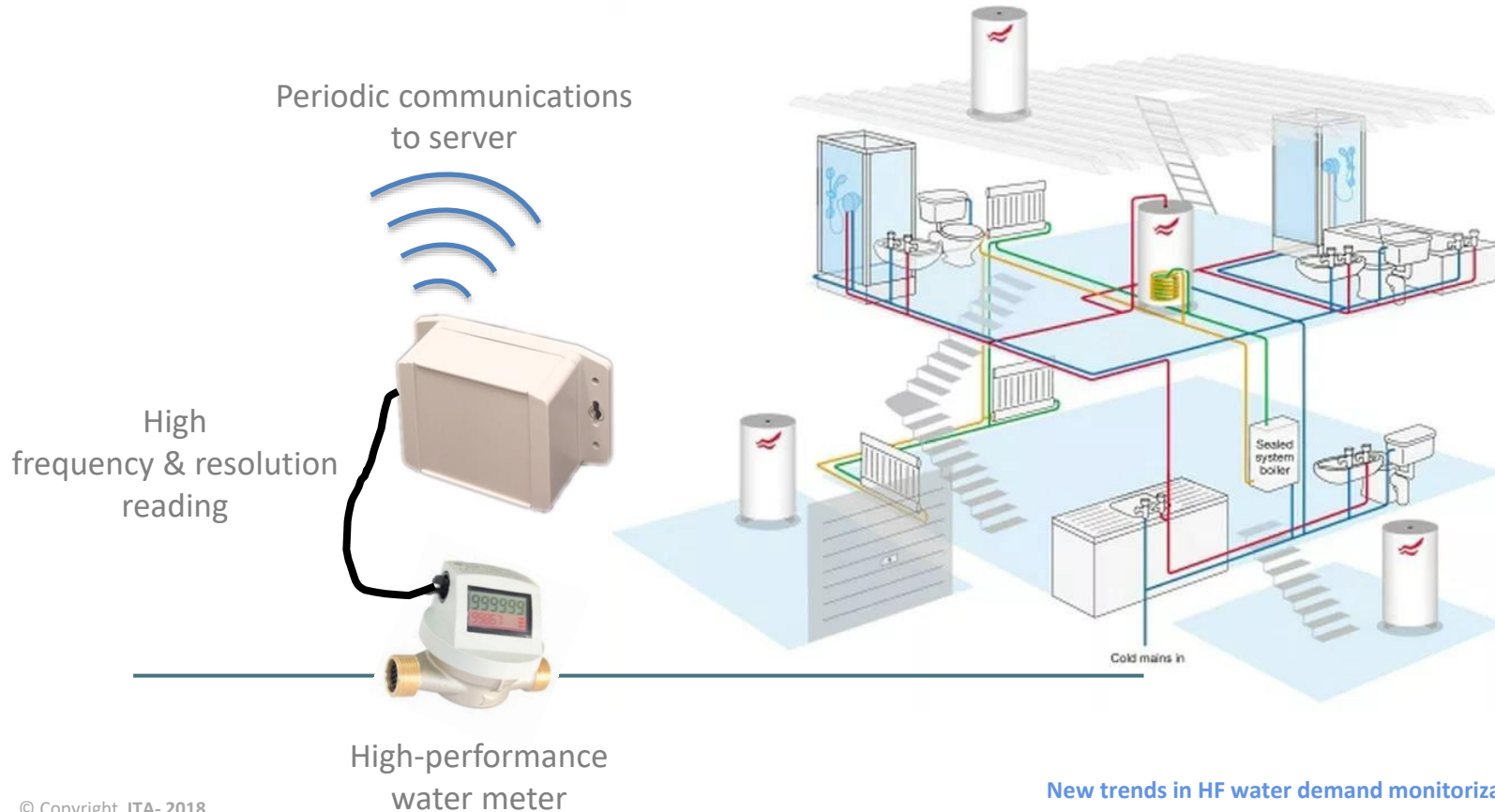
END-USE ANALYSIS

Main approaches

Traditional

— Flow trace analysis

Alternative

— Pressure monitoring

— Noise analysis

— Flow switches
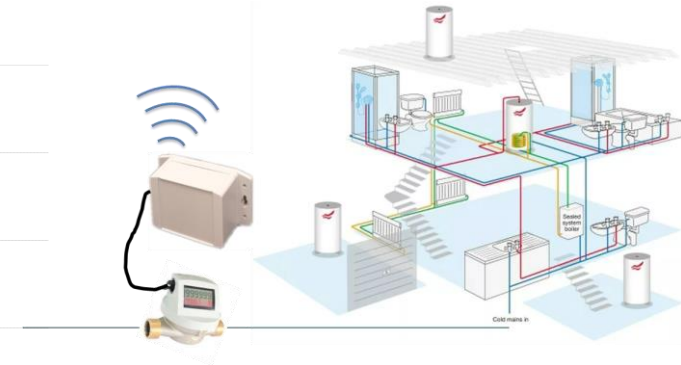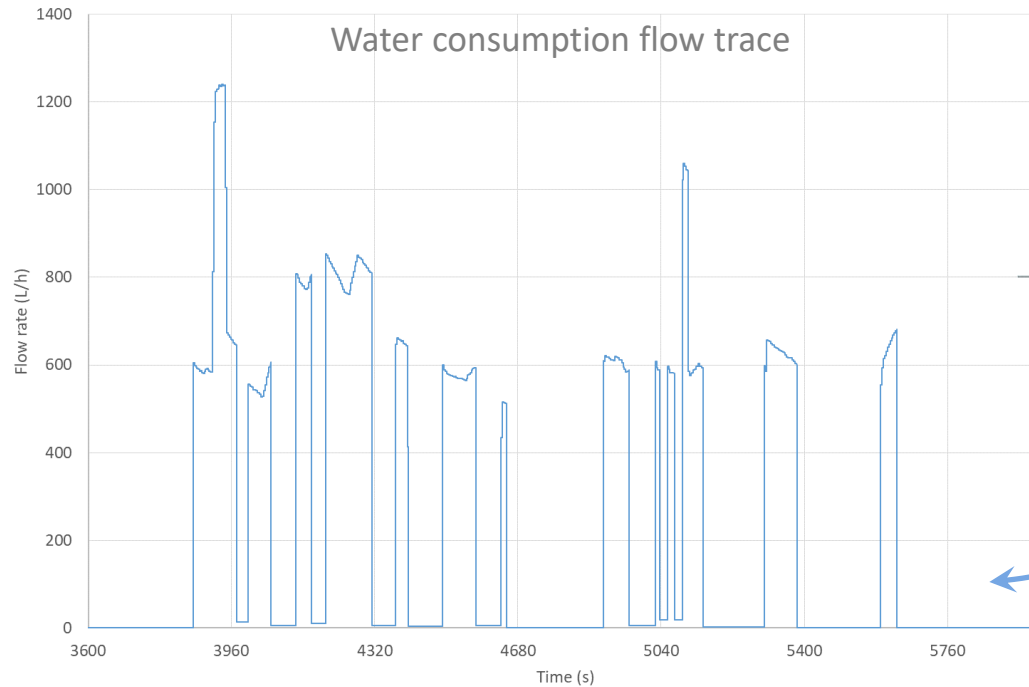
— AI + Machine learning techniques

— And ….. Marketing

- Leaks
- Showers
- Toilets
- Washers
- Dishwashers
- Faucets

3% 38% 27% 21% 10% 1%

New trends in HF water demand monitorization and analysis

BASIC PRINCIPLES OF FLOW TRACE ANALYSIS

Periodic communications to server

High frequency & resolution reading

High-performance water meter

Sealed system boiler

Cold mains in

New trends in HF water demand monitorization and analysis

BASIC PRINCIPLES OF FLOW TRACE ANALYSIS

What is used for analysis?

Water consumption flow trace

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BASIC PRINCIPLES OF FLOW TRACE ANALYSIS

Accuracy of the analysis

Meter measuring capabilities	Meter to logger communication	Logger recording and analysis capabilities	Software capabilities

New trends in HF water demand monitorization and analysis
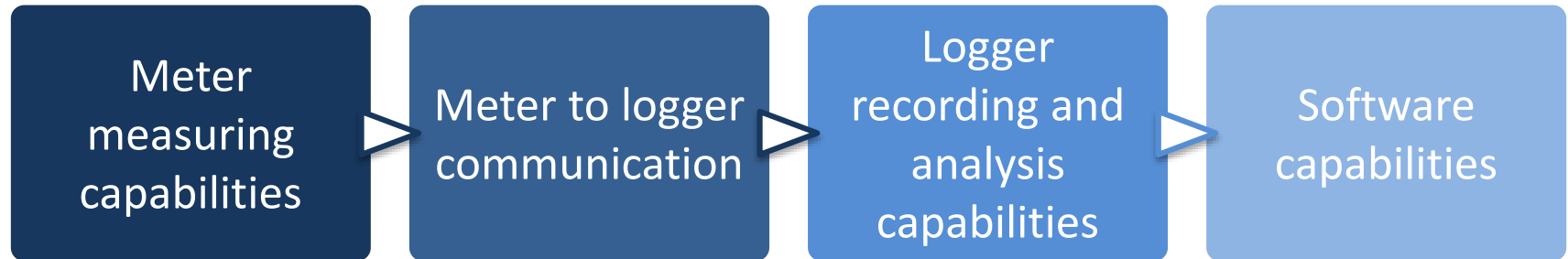
WE WILL ANALYSE WHAT WE SEE...

... or what we think we see

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ARE THE SQUARES HORIZONTALLY ALIGNED?
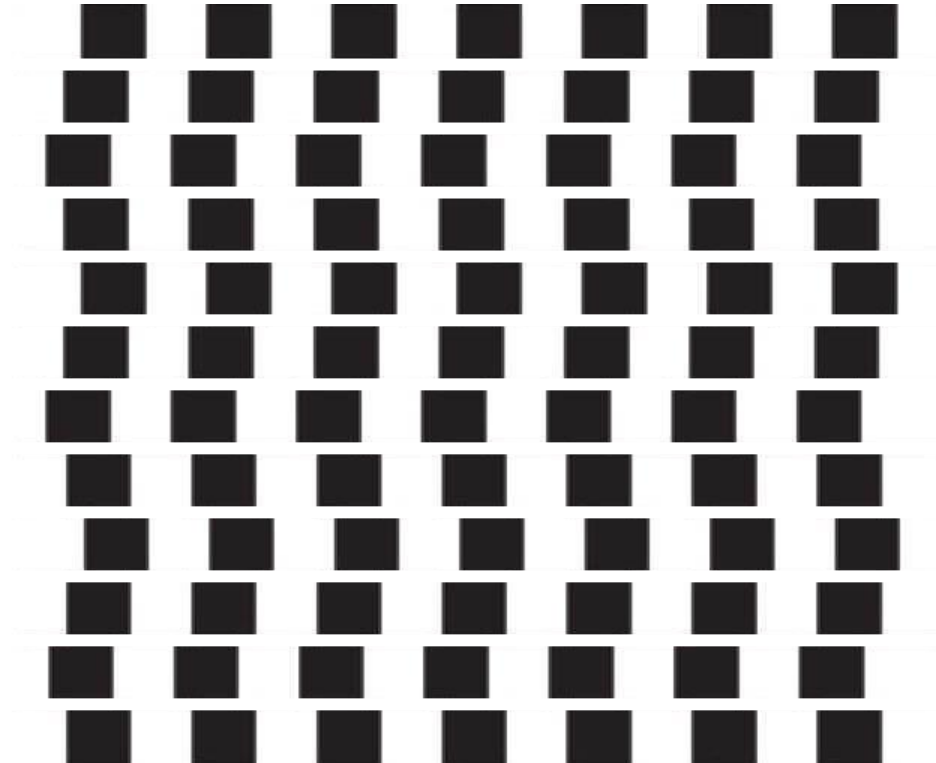
METER MEASURING CAPABILITIES

What do we see?

Flow trace analysis depends on the quality of the original flow trace:
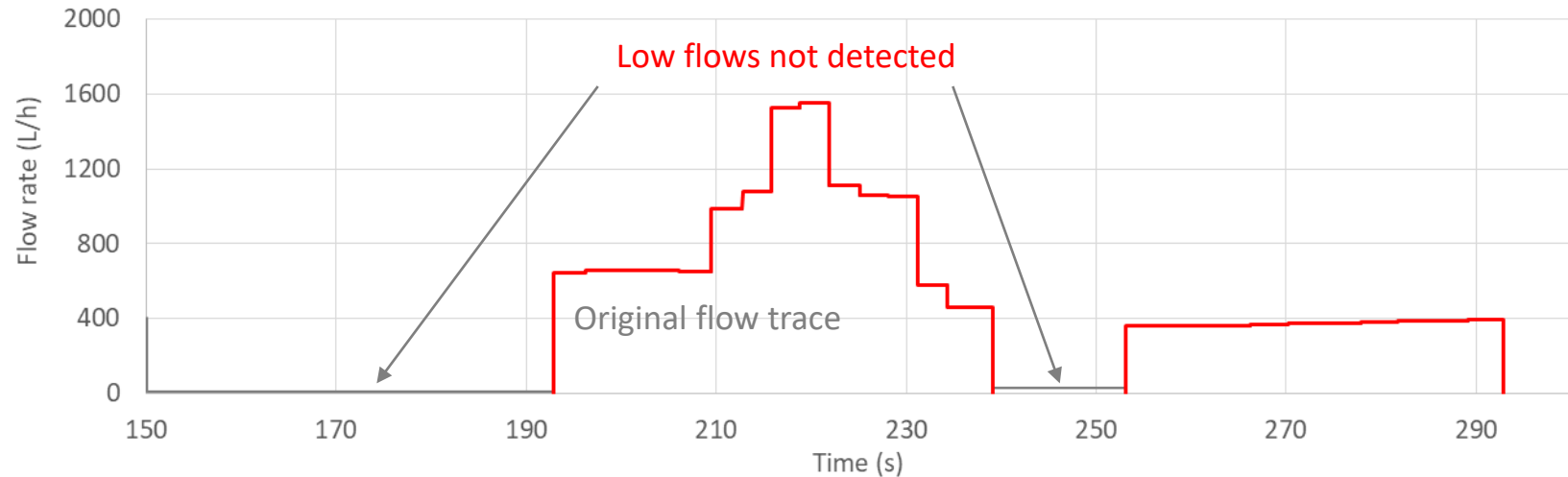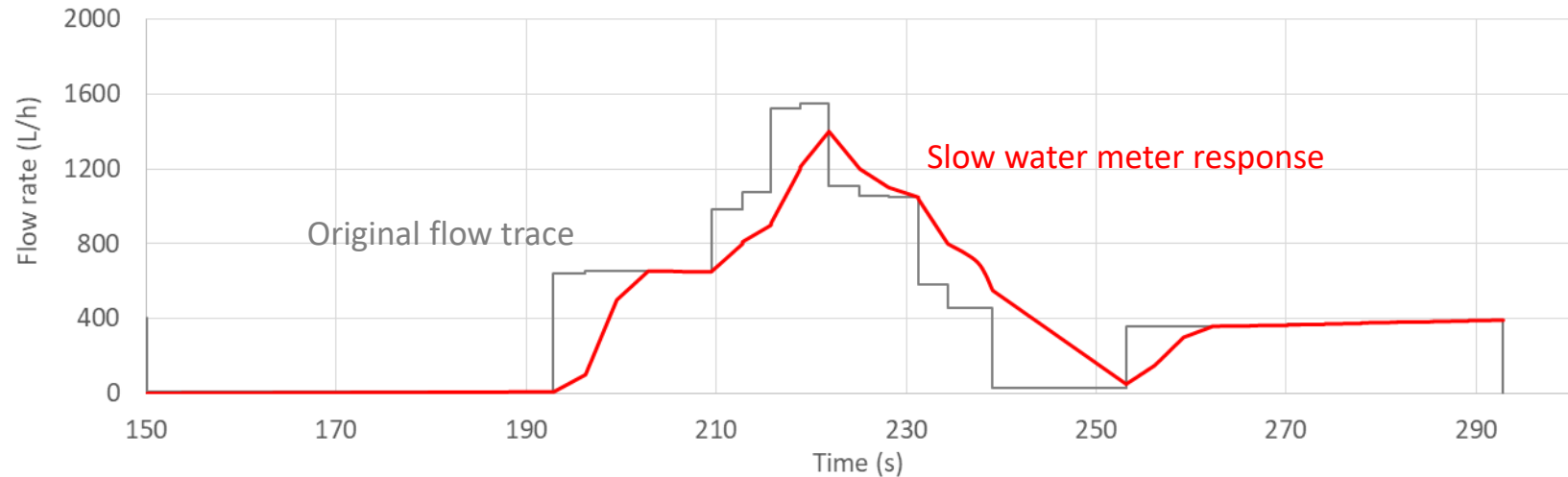
    —   Accuracy of the meter
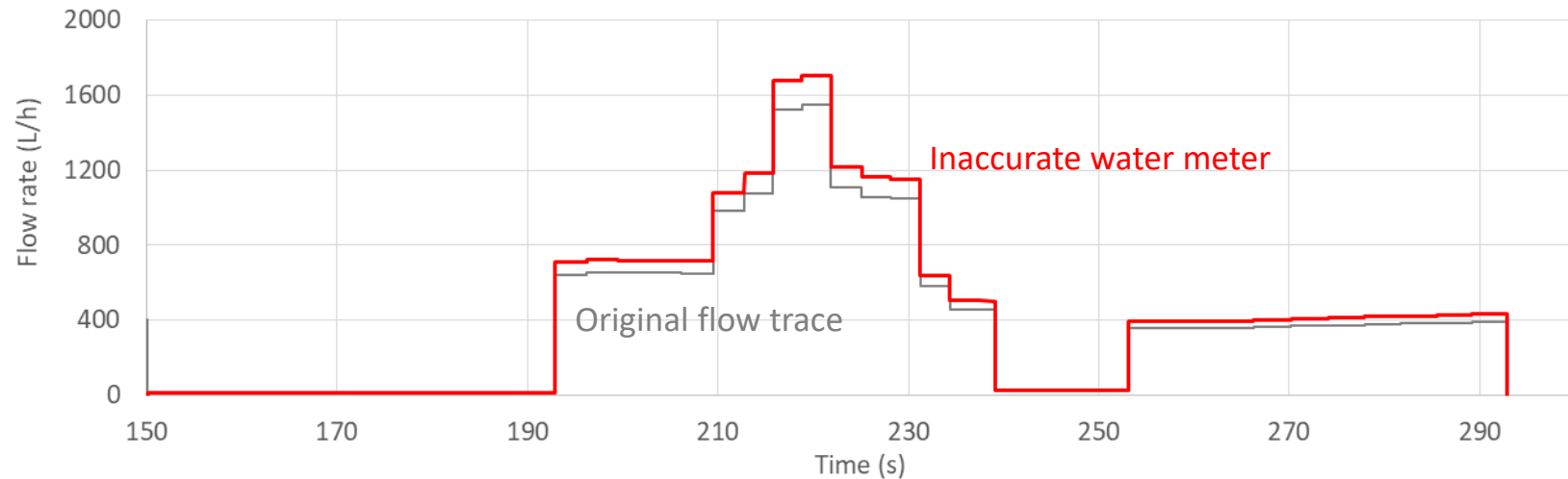
METER MEASURING CAPABILITIES

What do we see?

Flow trace analysis depends on the quality of the original flow trace:

– Sensitivity of the meter at low flows

METER MEASURING CAPABILITIES

What do we see?

Flow trace analysis depends on the quality of the original flow trace:

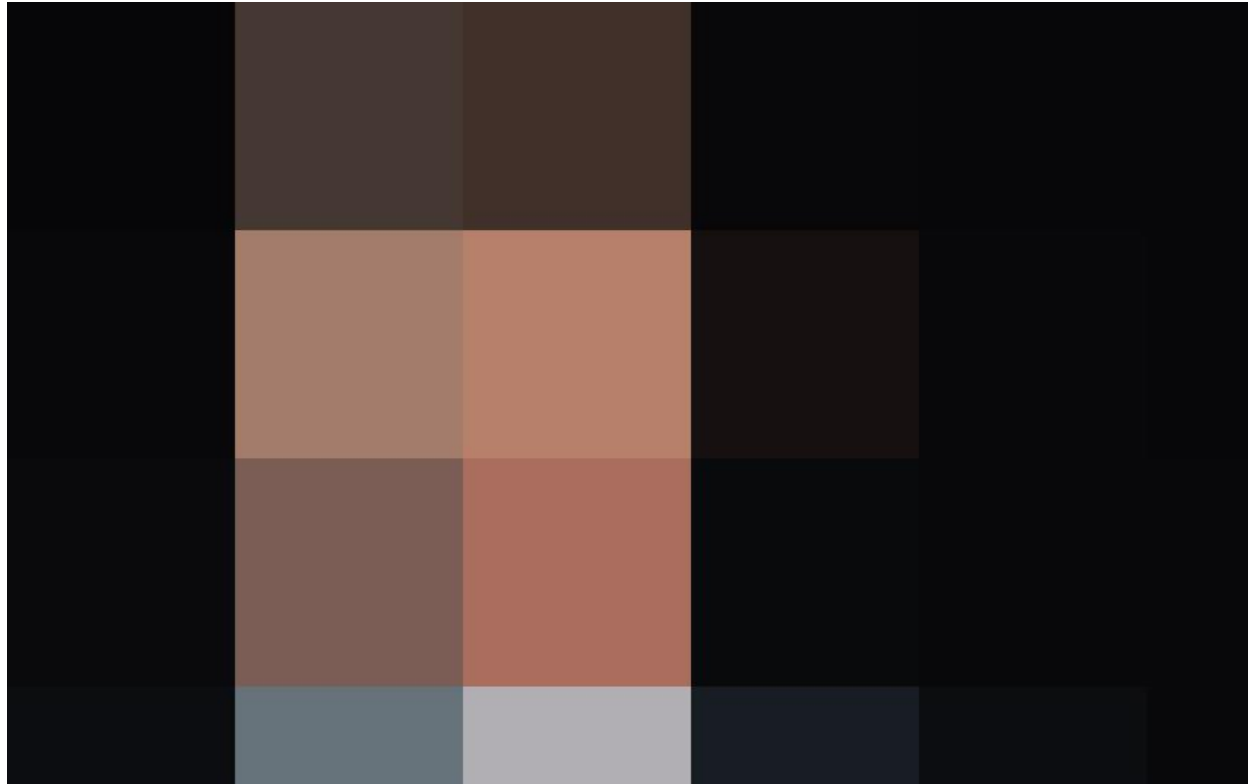– Frequency response (meter + communications) against flow changes

Slow water meter response

Original flow trace
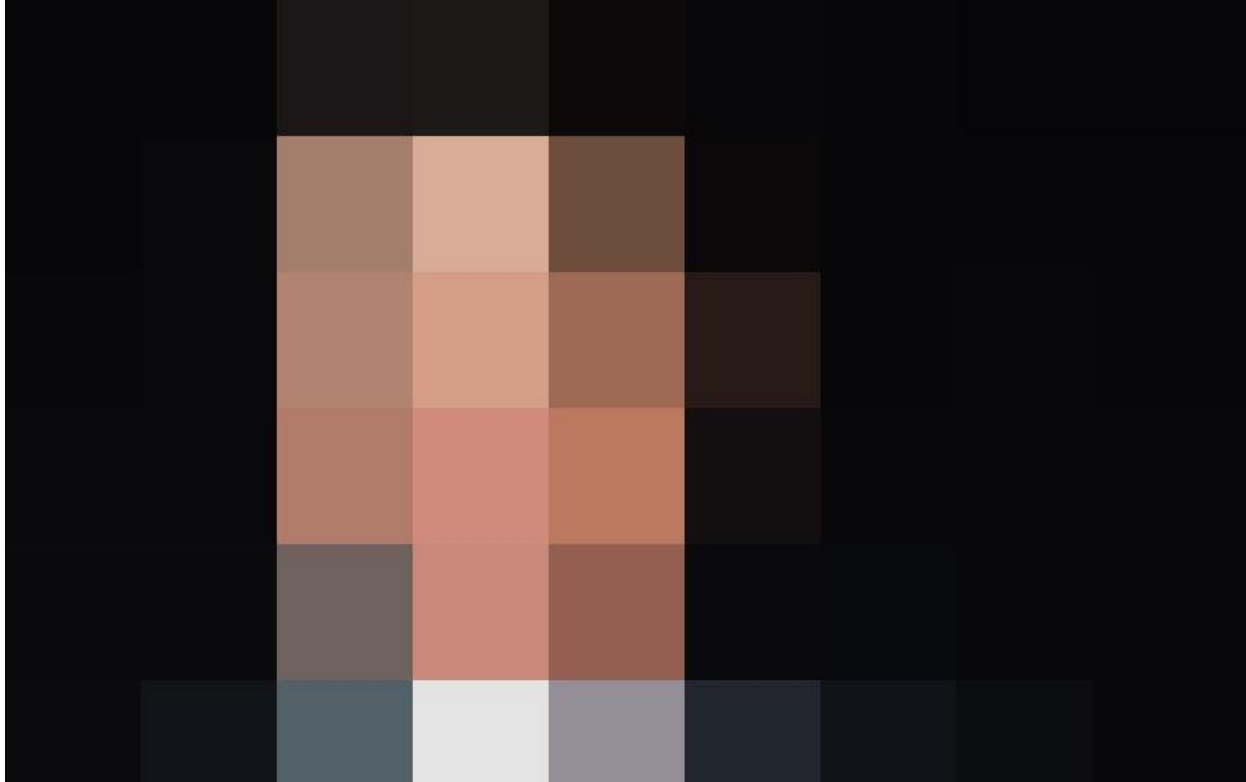
METER MEASURING CAPABILITIES

What do we see?

Flow trace analysis depends on the quality of the original flow trace:

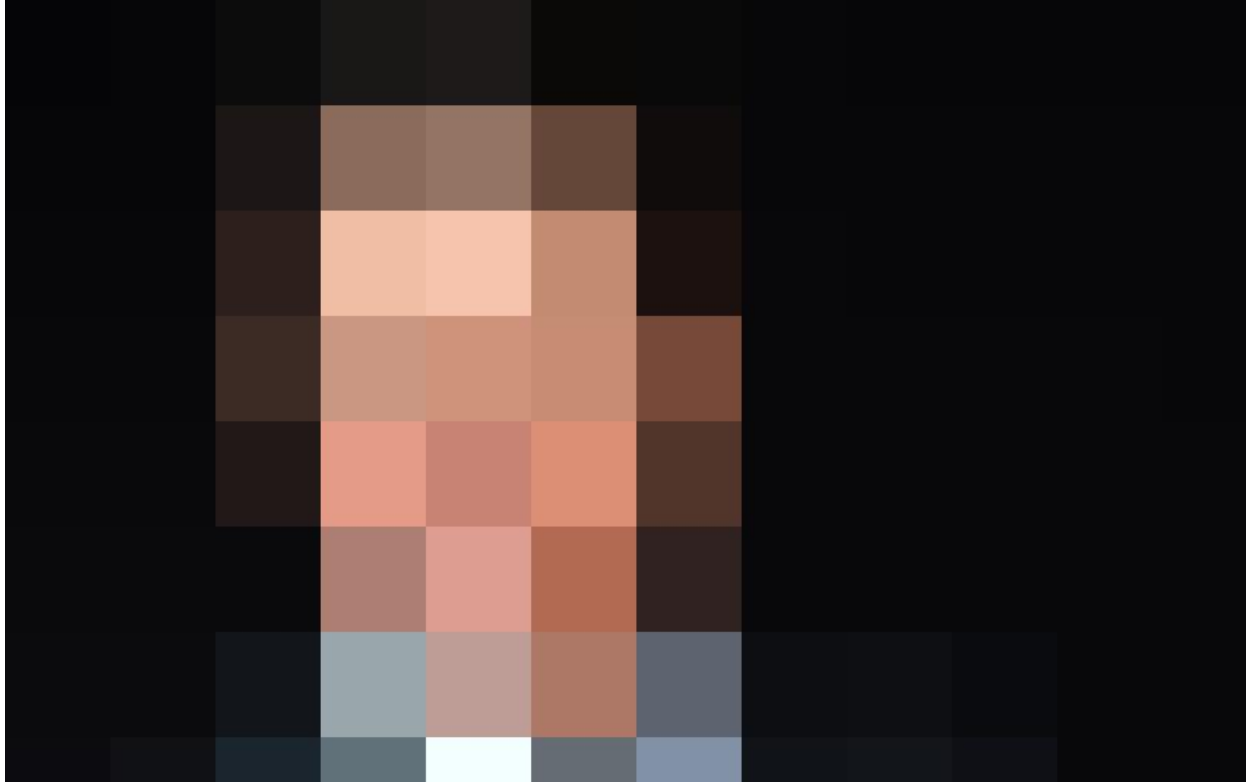– Volume reading resolution of the meter
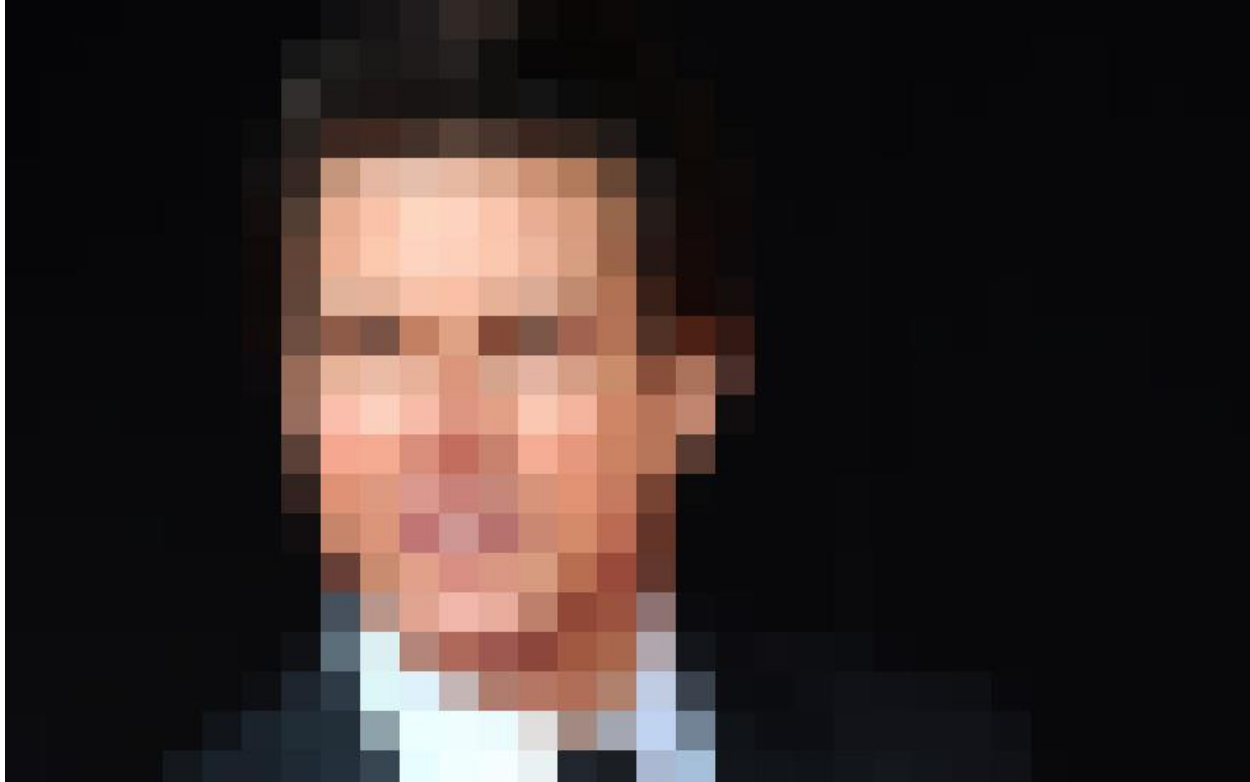
WHAT IS THIS?

WHAT IS THIS?

WHAT IS THIS?

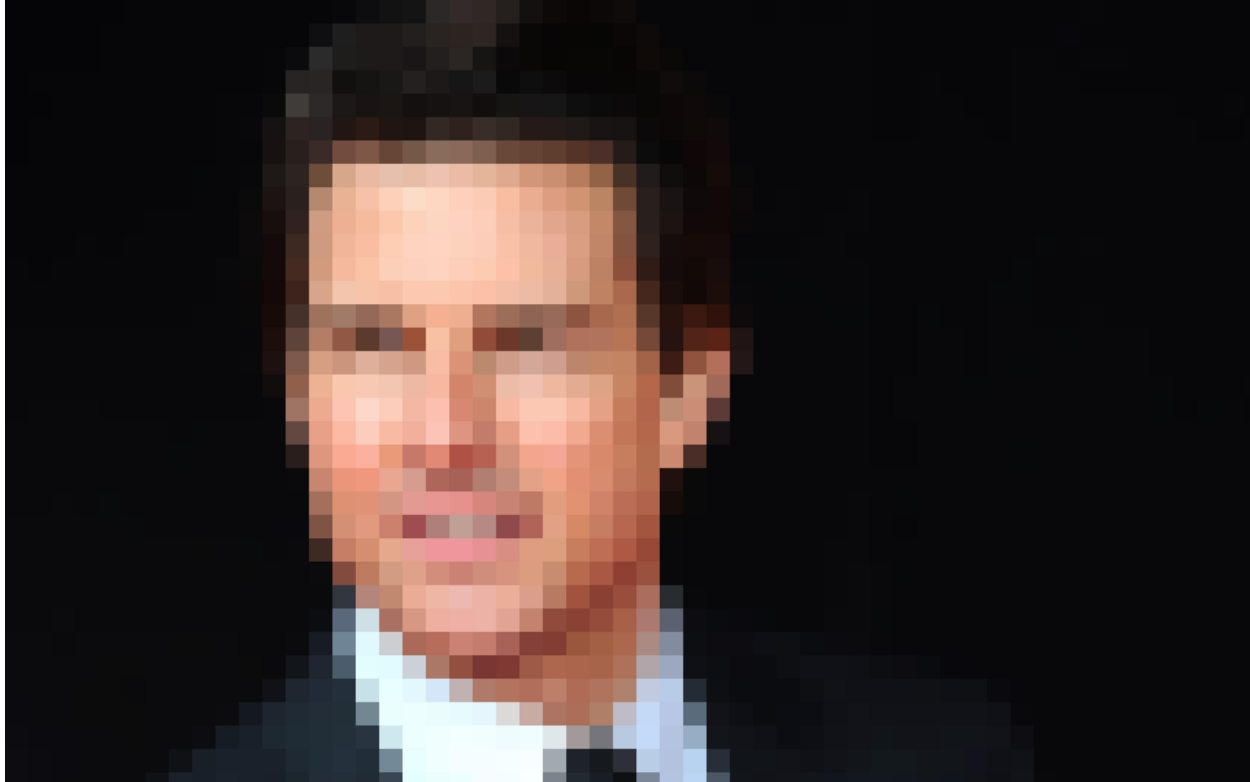New trends in HF water demand monitorization and analysis

WHAT IS THIS?

New trends in HF water demand monitorization and analysis

WHO IS HIM/HER?

WHO IS HIM?

WHO IS HIM?

WHO IS HIM?

WHO IS HIM?

New trends in HF water demand monitorization and analysis
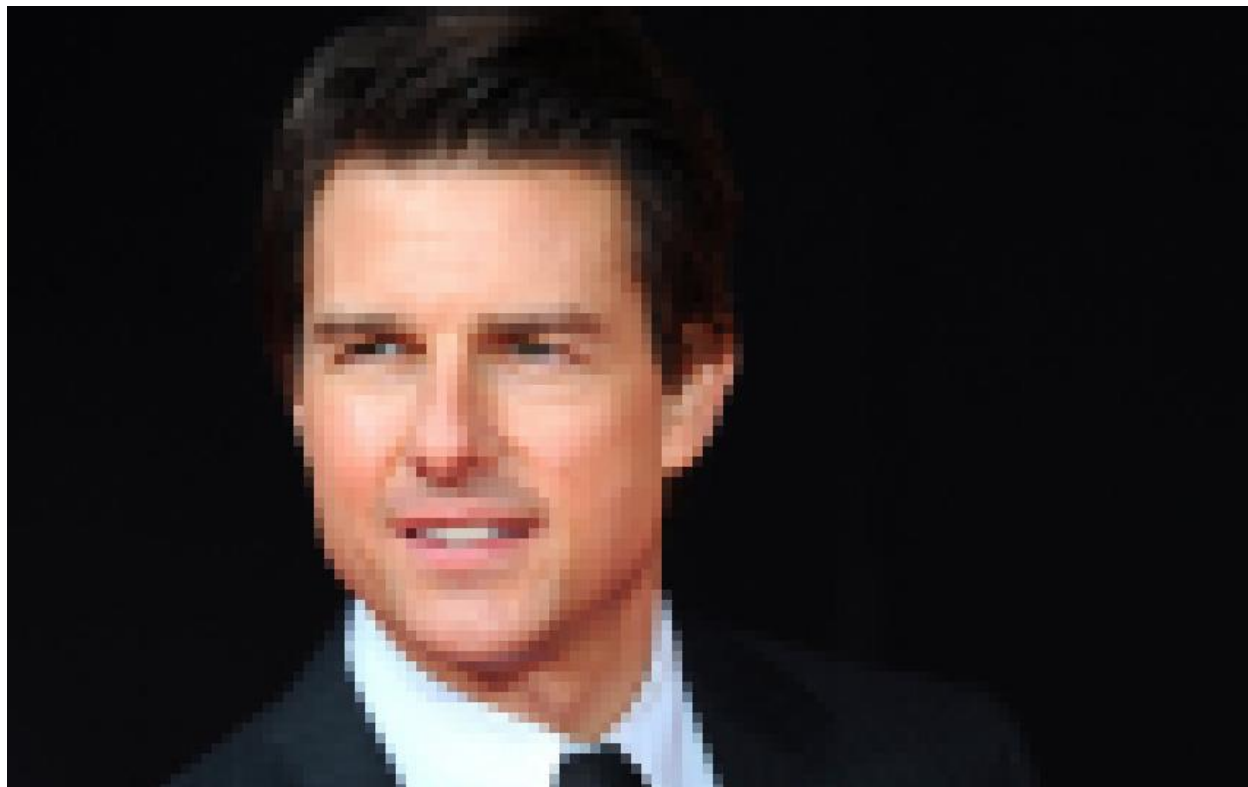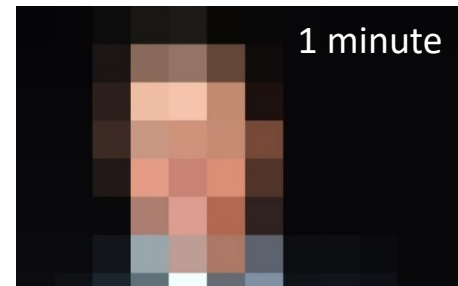
WHAT QUESTION DO WE WANT TO ANSWER?

What?

1 hour

Is it a who?

1 minute

He/She?

10 seconds

Name?

1 second

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IS IT POSSIBLE….?

New trends in HF water demand monitorization and analysis

IS IT POSSIBLE....?

6 min

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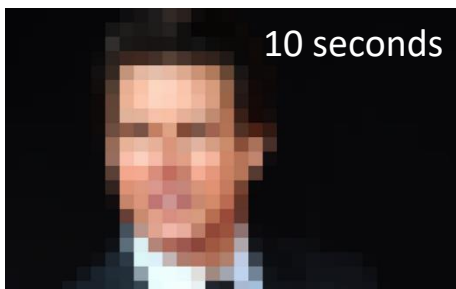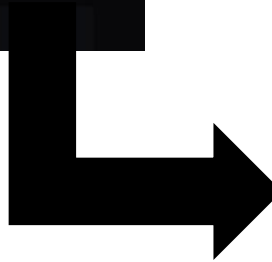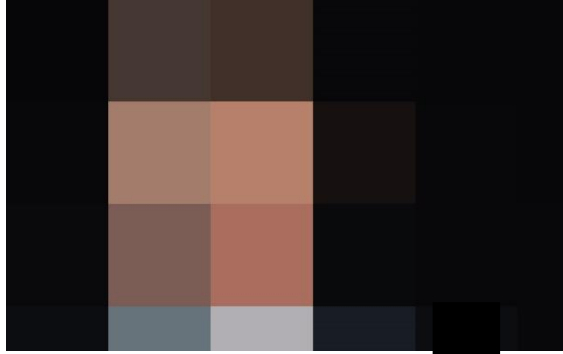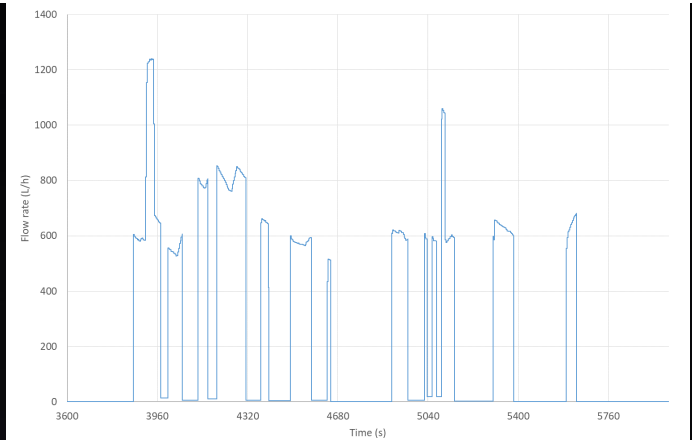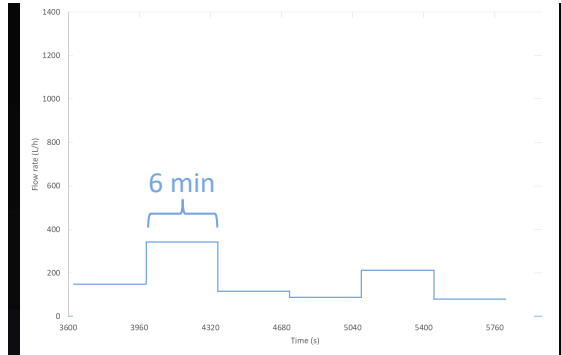
METER MEASURING CAPABILITIES

What we see?

Flow trace analysis depends on the quality of the original flow trace:

- Accuracy of the meter

- Sensitivity at low flows

- Frequency response against flow changes

- Volume reading resolution

- Flow rate sampling rate

METERING TECHNOLOGIES AVAILABLE

For flow trace analysis

Working principle of the meter

    — Mechanical: Velocity – Positive displacement

> Continuous flow measurement

   — Non-Mechanical: Ultrasonic – Electromagnetic

> Flow signal is sampled to save battery

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BASIC PRINCIPLES OF FLOW TRACE ANALYSIS

Accuracy of the analysis

How do we extract data from the meter?

Meter measuring capabilities	Meter to logger communication	Logger recording and analysis capabilities	Software capabilities
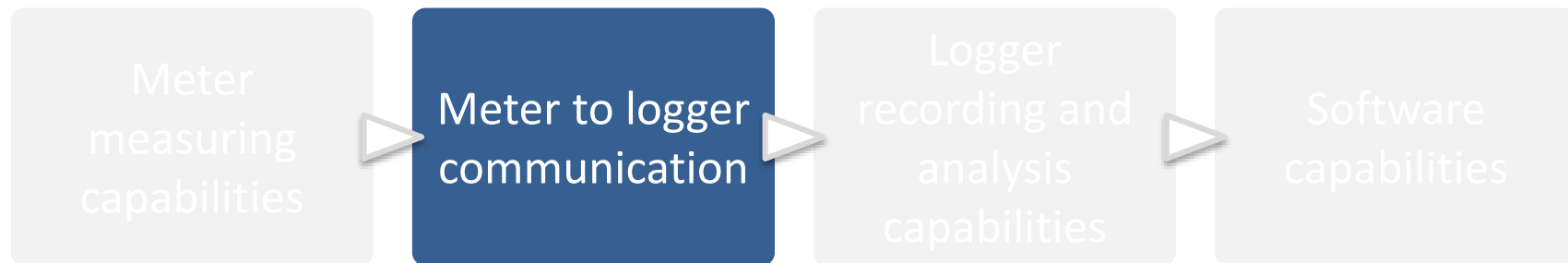
BASIC PRINCIPLES OF FLOW TRACE ANALYSIS

How do we extract data from the meter?

By type

- Pulse output
  - Mechanical (Reed switch)
  - Non-mechanical (Hall effect)
- Communication protocol
  - M-BUS
  - Other protocols
- Analogue output

By medium of communication

- Wired

- Wireless

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METER TO READING COMMUNICATION

	Advantages	Disadvantages
Pulse output	Low cost	Reliability
	Volume reading resolution	Limited amount information
	Availability & flexibility	Backward flow
Protocol comm.	Absolute readings	Slow communications
	Additional information	Poor volume reading resolution
		Battery consumption

FINAL DECISION ON EQUIPMENT

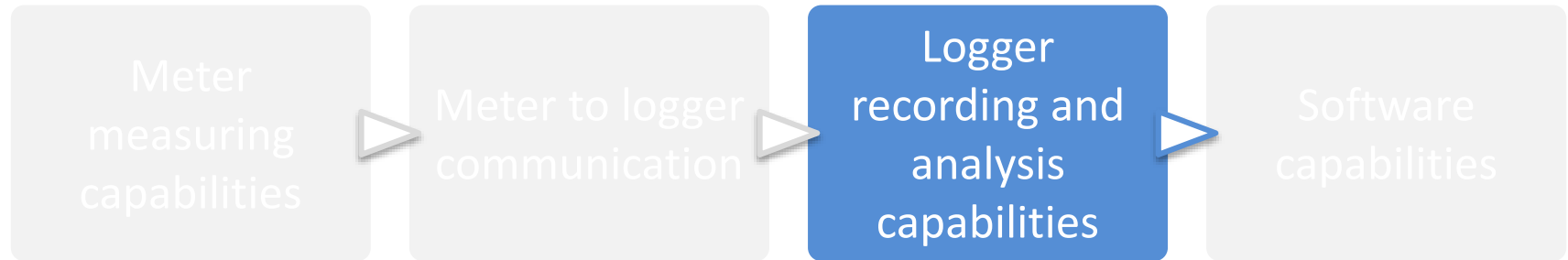**Which configuration is best?**

From our experience, what works best is:

- Mechanical meter – Positive displacement
  - Instantaneous response
  - Very good low flow sensitivity
  - Excellent accuracy
  - Highly repetitive instruments

- Inductive pulse output
  - Reliable
  - Good frequency response

- Wired connection to logger

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BASIC PRINCIPLES OF FLOW TRACE ANALYSIS

Accuracy of the analysis

Meter measuring capabilities ▷ Meter to logger communication ▷ Logger recording and analysis capabilities ▷ Software capabilities

LOGGER RECORDING, TRANSMISSION AND ANALYSIS CAPABILITIES

Memory capacity

How consumption data is stored in the logger

- At fix intervals of time

- Recording the time of occurrence of the pulses

Battery duration

- Lithium batteries

- Rechargeable batteries + solar panel

3G/GPRS communication

- More data –higher transmission costs and battery consumption

Remote configuration capabilities – 2-way comm.

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BASIC PRINCIPLES OF FLOW TRACE ANALYSIS

Accuracy of the analysis

| Meter measuring capabilities | ▷ | Meter to logger communication | ▷ | Logger recording and analysis capabilities | ▷ | Software capabilities |
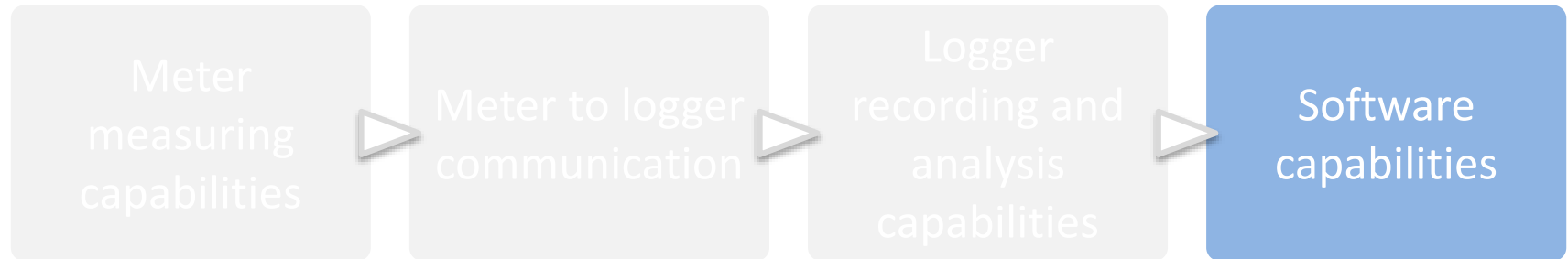
SOFTWARE

Need for advanced software tools

Pilot study	Extended study
Limited number of users	Large number of users
Limited duration of monitoring period	Unlimited duration of monitoring period
Manual data downloading	Automatic data transmission
Manual processing	Automatic processing
High unitary cost	Low unitary cost

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SOFTWARE

Ideal features

Web based software

- – Software does not have to be installed in a specific computer

- – It can be used with any web browser

Data is stored in the "cloud" in a secured server

Advanced overlapped consumptions processing

Automatic end-use classification

Powerful querying tools

Data-base exporting features

Project management capabilities

FLOW TRACE ANALYSIS – SOFTWARE

Software. New web-based application
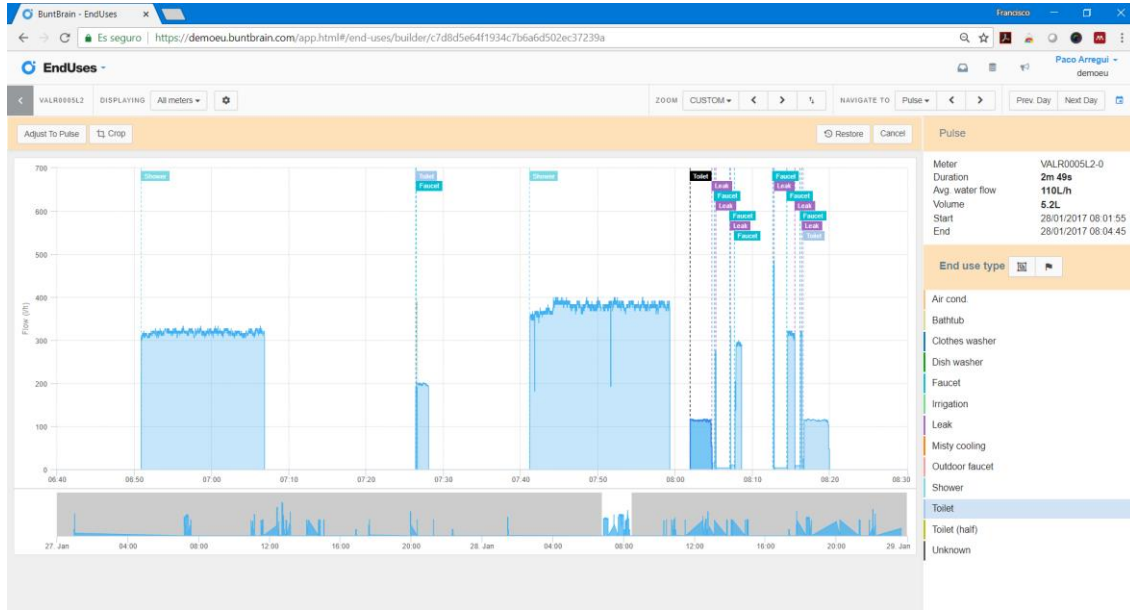
It can be run through web browser

The latest version is always available

Secure data-repository

Multi-user capabilities

FLOW TRACE ANALYSIS – SOFTWARE

Software. New web-based application

"Extended" capabilities

Wider range of end-uses

Configurable uses

FLOW TRACE ANALYSIS – SOFTWARE

Software. New web-based application
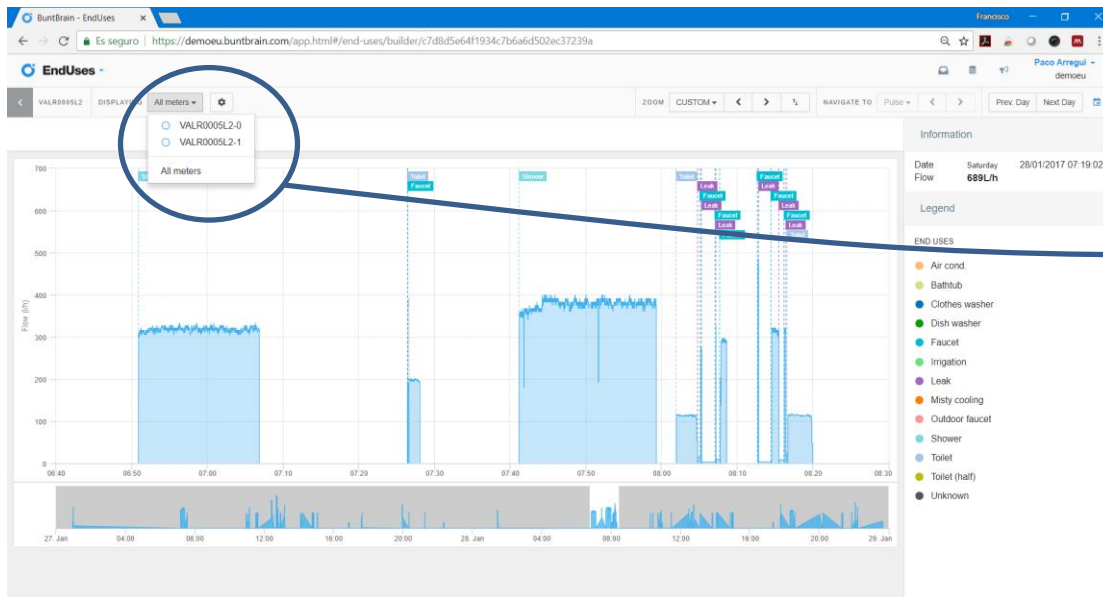
"Extended" capabilities

Up-to 4 meters for one user

FLOW TRACE ANALYSIS – SOFTWARE
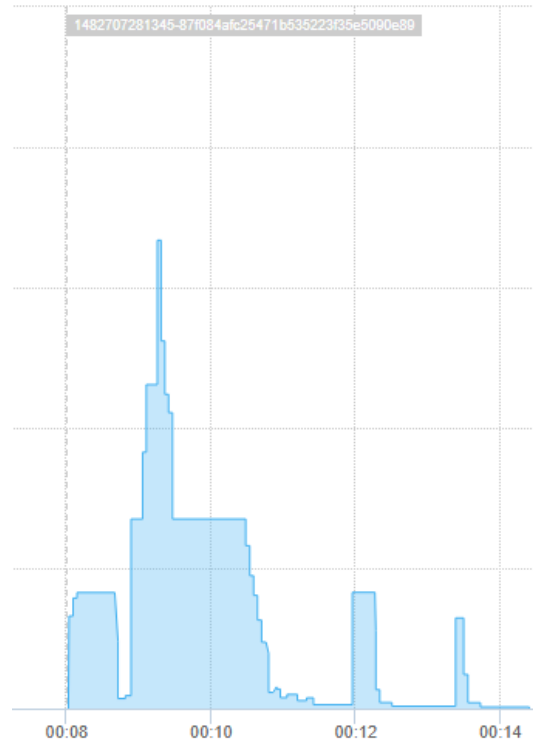
Software – designed for water demand research

"Extended" capabilities

Manual cropping of overlapped uses

FLOW TRACE ANALYSIS – SOFTWARE

Software – designed for water demand research
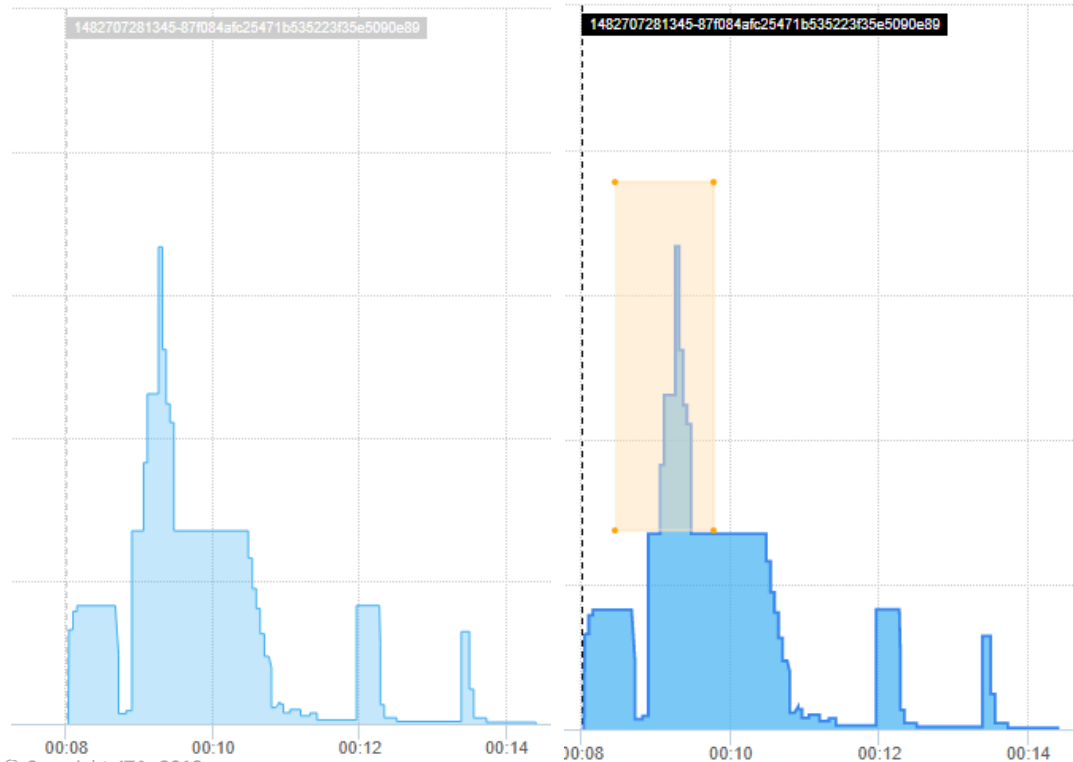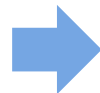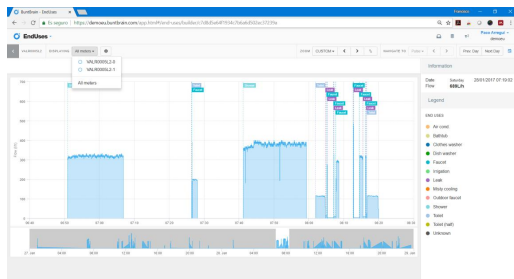

"Extended" capabilities

Manual cropping of overlapped uses

FLOW TRACE ANALYSIS – SOFTWARE

Software – designed for water demand research
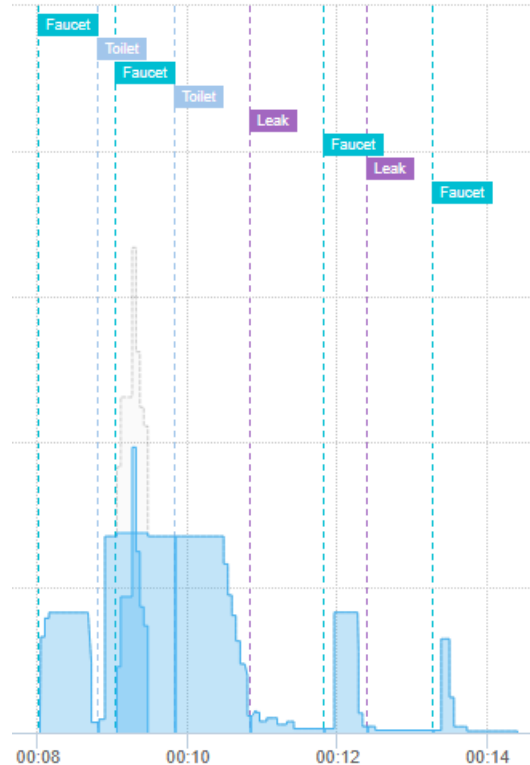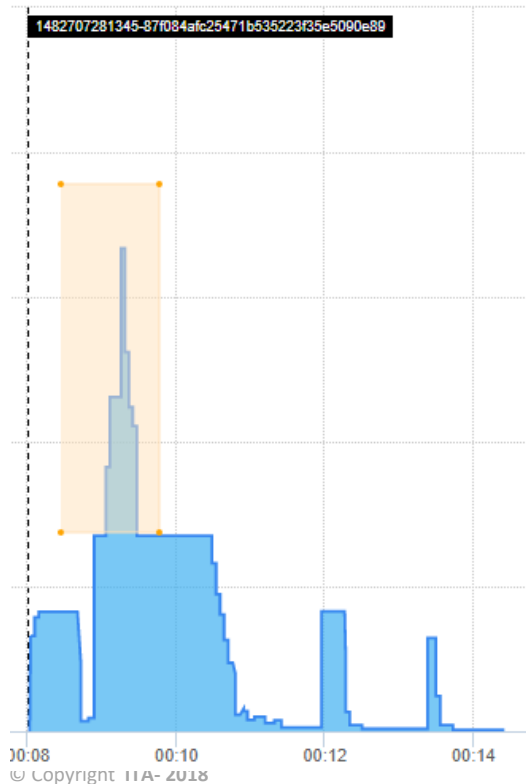
"Extended" capabilities

Manual cropping of overlapped uses

FLOW TRACE ANALYSIS – SOFTWARE

Software – designed for water demand research
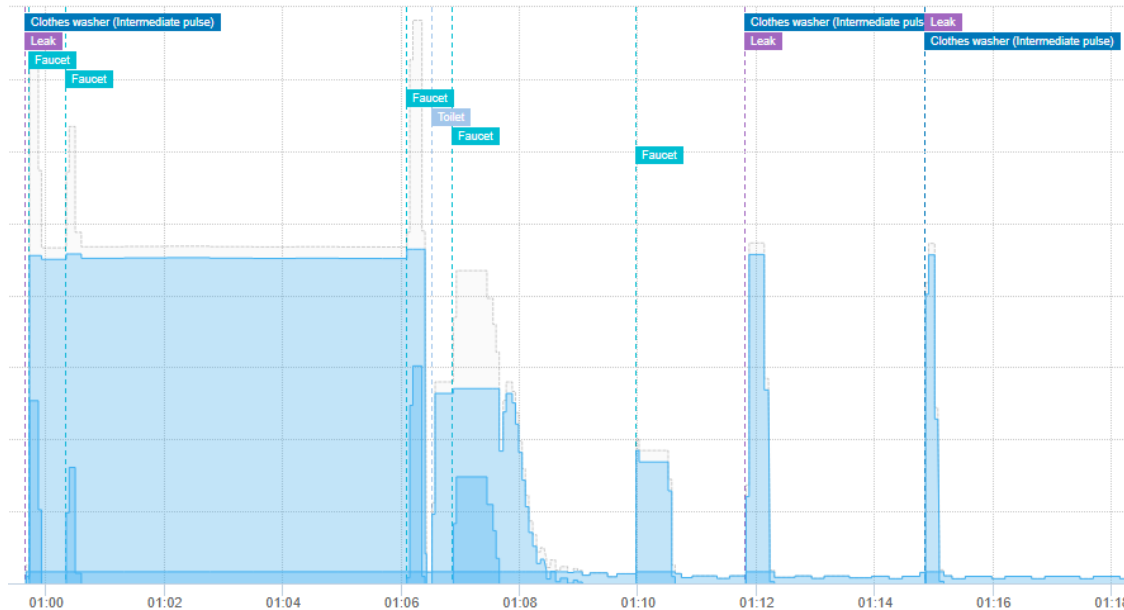
"Extended" capabilities

Leak management

FLOW TRACE ANALYSIS – SOFTWARE

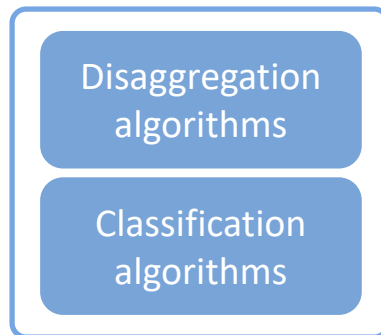## Software – designed for water demand research

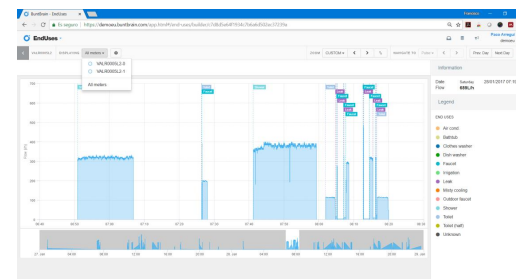New trends in HF water demand monitorization and analysis

FLOW TRACE ANALYSIS – SOFTWARE

New trends in HF water demand monitorization and analysis
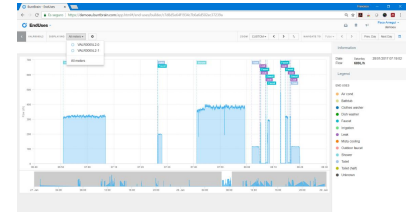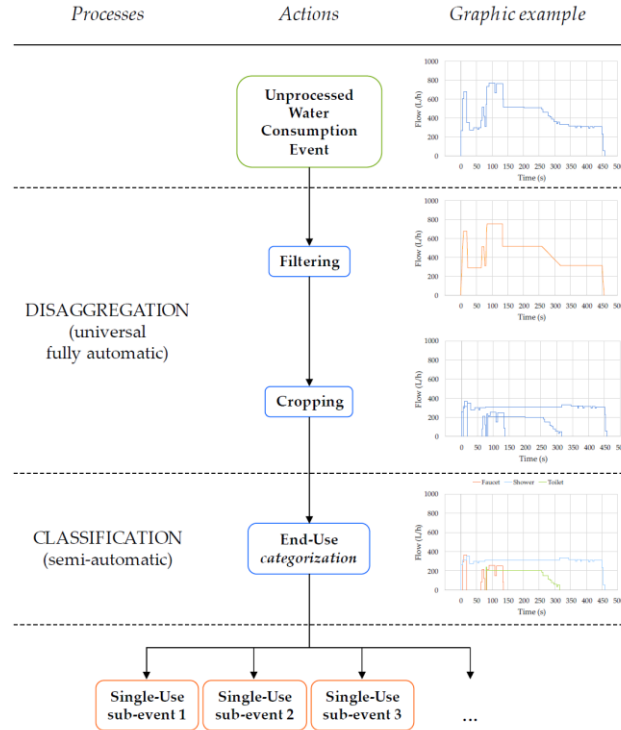
FLOW TRACE ANALYSIS – EXAMPLE

New trends in HF water demand monitorization and analysis
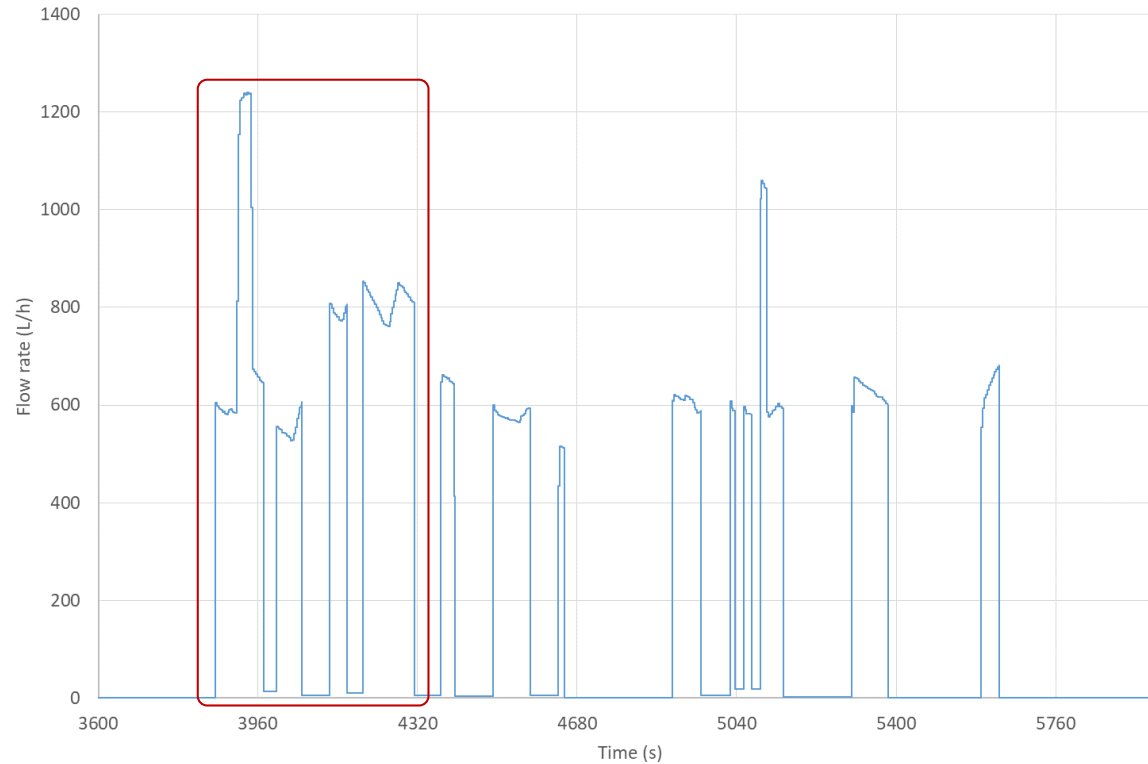
FLOW TRACE ANALYSIS – FILTERING

Simple overlapped uses

Off   On   Off
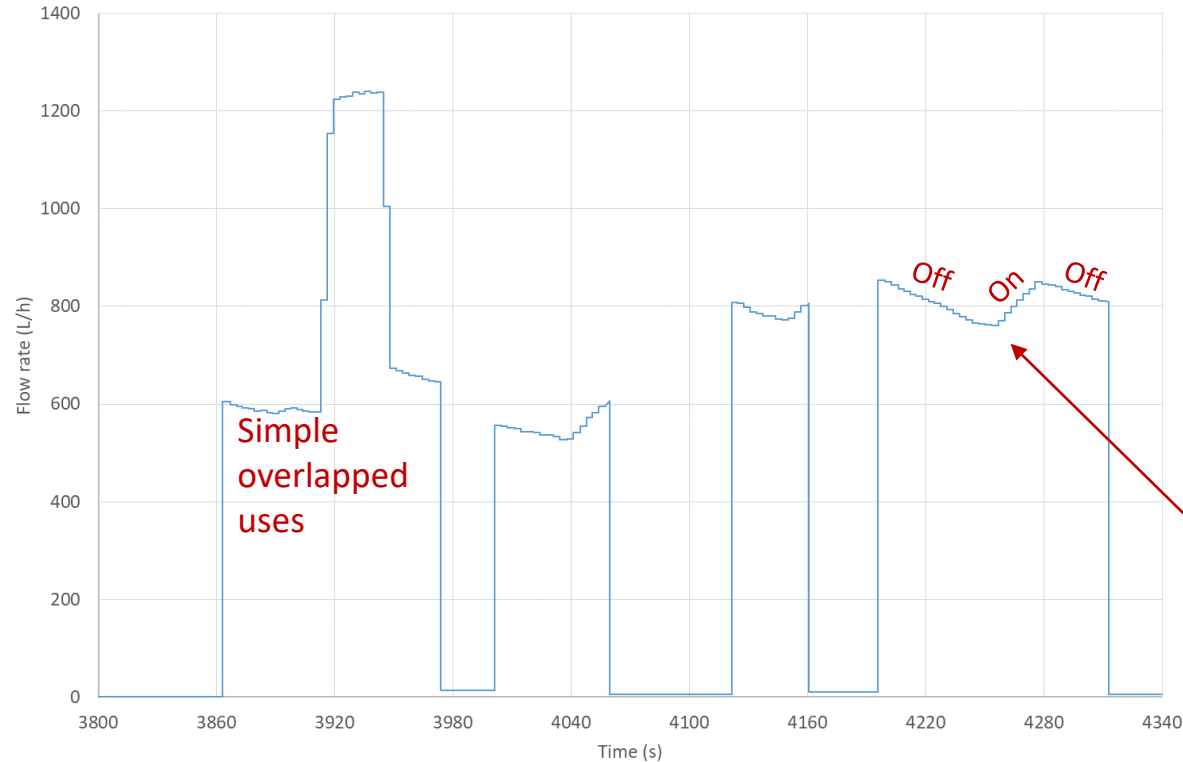
Flow fluctuations due to pump operation in the building changes consumption flow rates

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FLOW TRACE ANALYSIS – DISAGGREGATION

Original flow trace

Complex overlapped uses

FLOW TRACE ANALYSIS – DISAGGREGATION

Complex overlapped uses

New trends in HF water demand monitorization and analysis
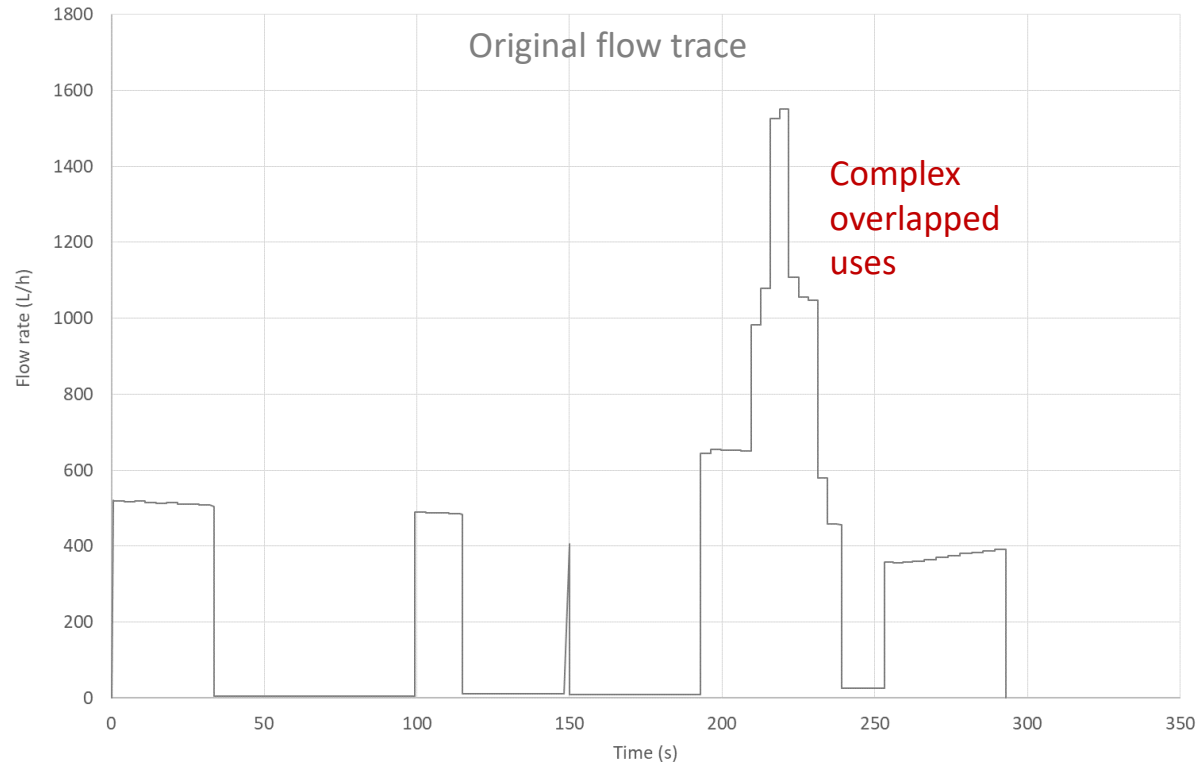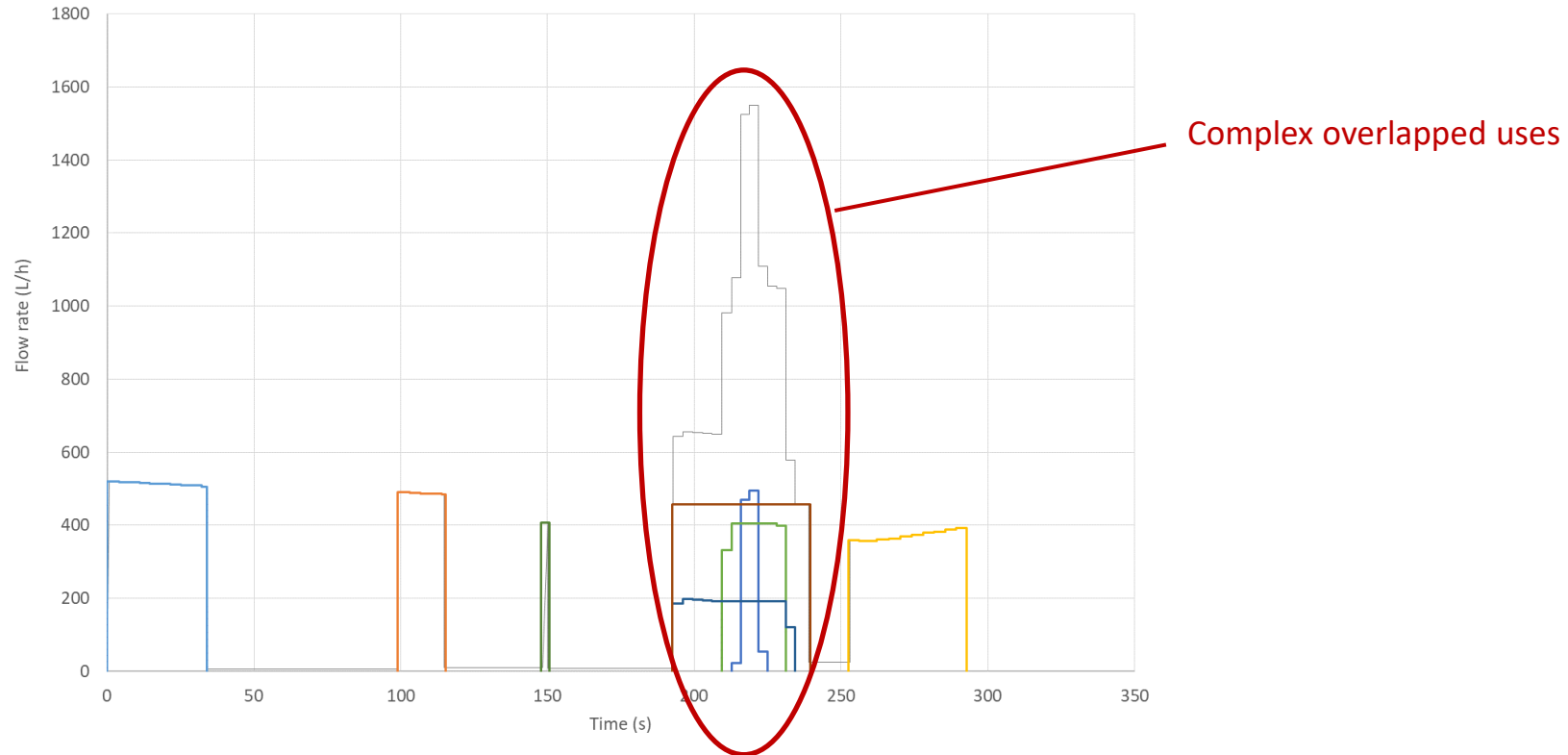
FLOW TRACE ANALYSIS – DISAGGREGATION
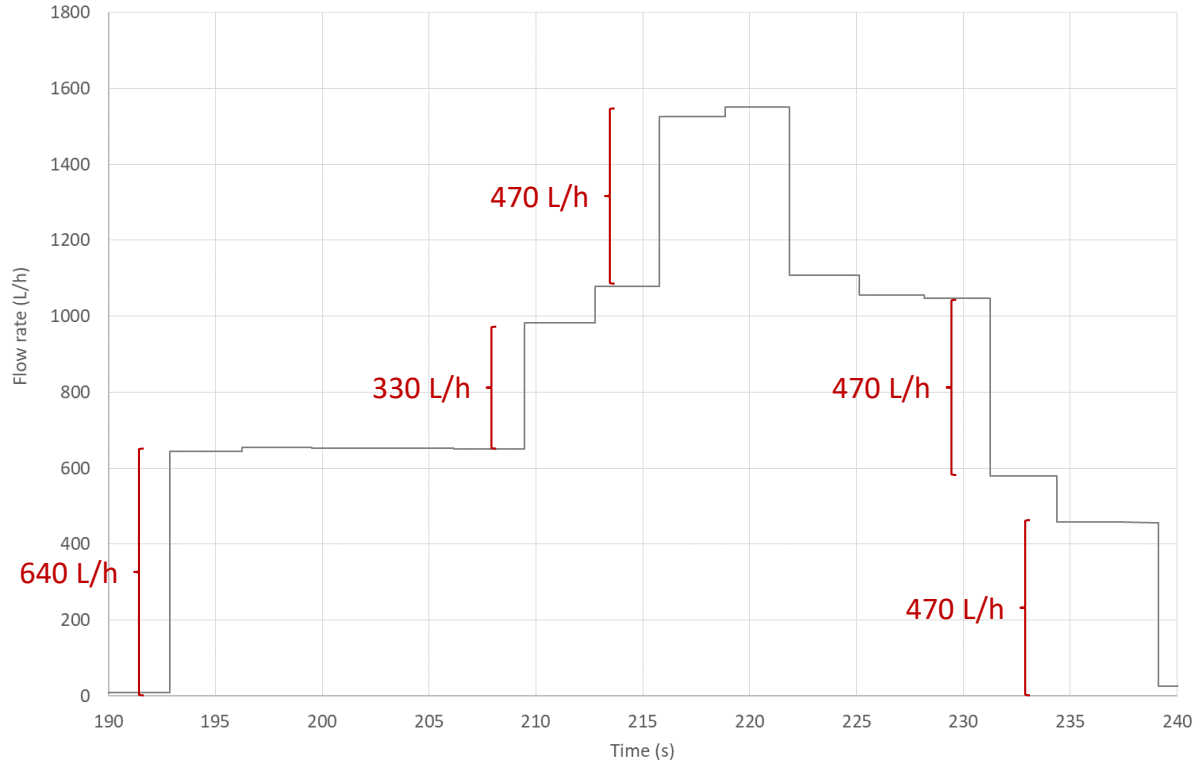
How many uses do we have?

When do they start and finish?

COMSUMPTION FLOW RATES

Individual flow rates

Q = 600 L/h   Q = 400 L/h   Q = 500 L/h
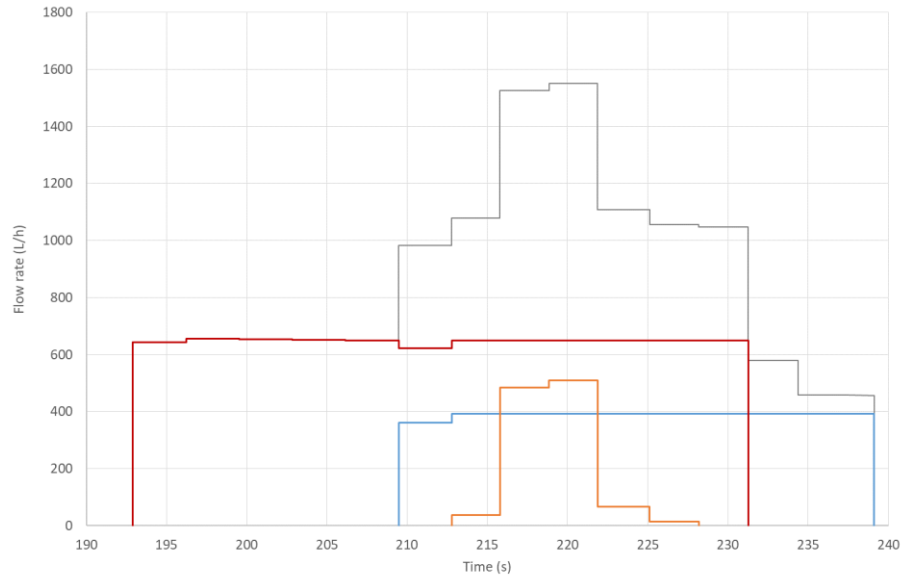
Combined flow rates

+   +   ✗   600 L/h + 400 L/h + 500 L/h

Because of
head losses in
the plumbing

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Disaggregation of complex pulses is a problem that cannot be easily solved without additional information

Option 1

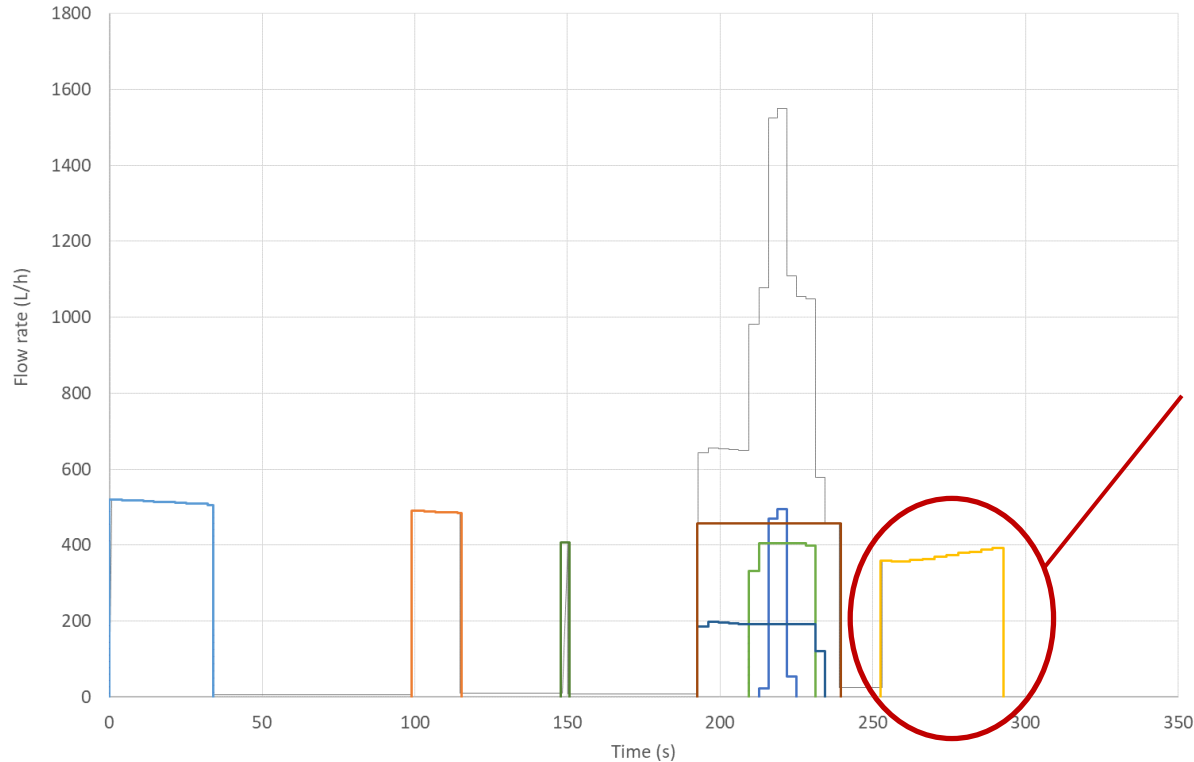## Option 2

New trends in HF water demand monitorization and analysis
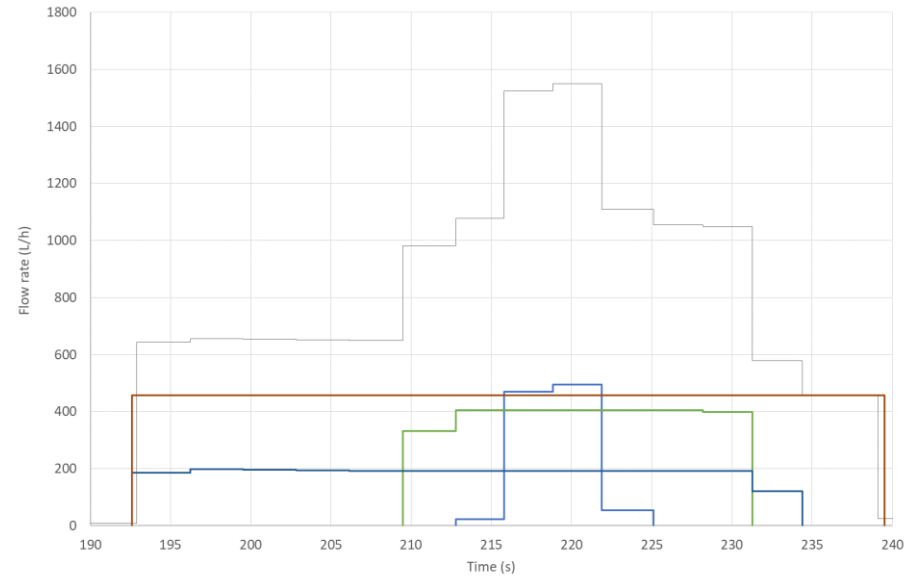
FLOW TRACE ANALYSIS – END-USE CLASSIFICATION

Based on:
- Flow rates
- Volume
- Shape of the flow trace
- Hour of the day
- Previous-late end uses

New trends in HF water demand monitorization and analysis

COMMERCIAL SOLUTIONS – SINGLE FLOW SIGNAL

http://www.fluidwatermeter.com/

COMMERCIAL SOLUTIONS – SINGLE FLOW SIGNAL

TAKE CONTROL OF YOUR WATER CONSUMPTION WITH DRIPVIEW

DripView from Aqubiq helps you save water and prevent water damages in your home. The smart water sensor gives you the full overview of your water consumption. To help your household save 15% water, and to warn you in case of leakages in your house. So you can live a greener and safer life.

http://aqubiq.com/en/home/

COMMERCIAL SOLUTIONS – SINGLE FLOW SIGNAL

New trends in HF water demand monitorization and analysis
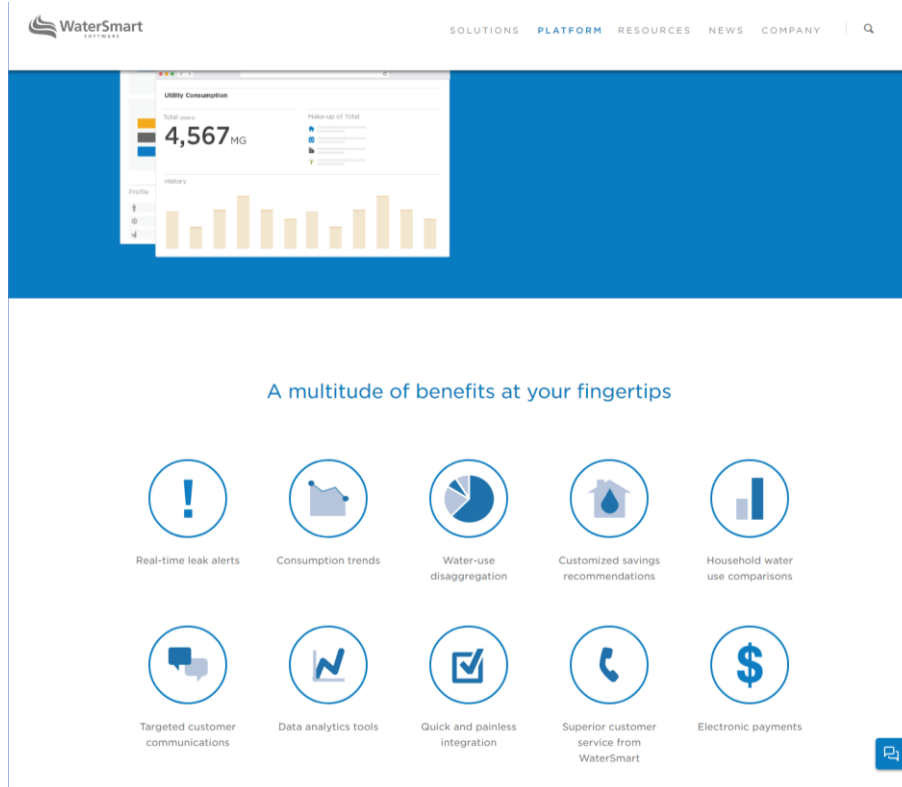
WATER END-USE ANALYSIS

Conclusions

- The use of a single flow trace has been the traditional approach

- It has clear limitations related to the amount of information that can be analysed

- Flow traces are always distorted and classification is difficult

- Some uses produce the same exact flow trace

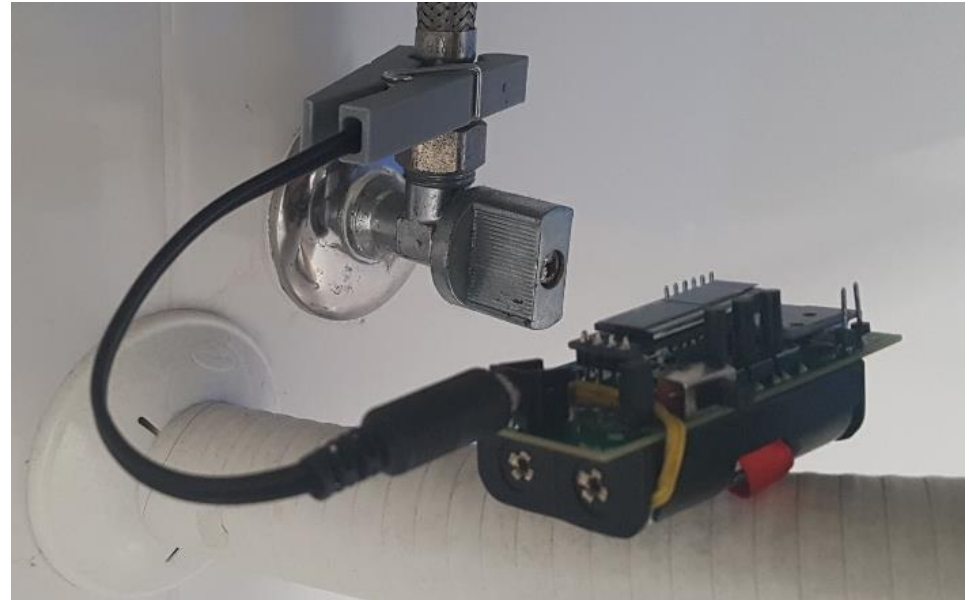- Overlapped uses make the analysis more complex

More accurate/relaible analysis requires additional

New trends in HF water demand monitorization and analysis
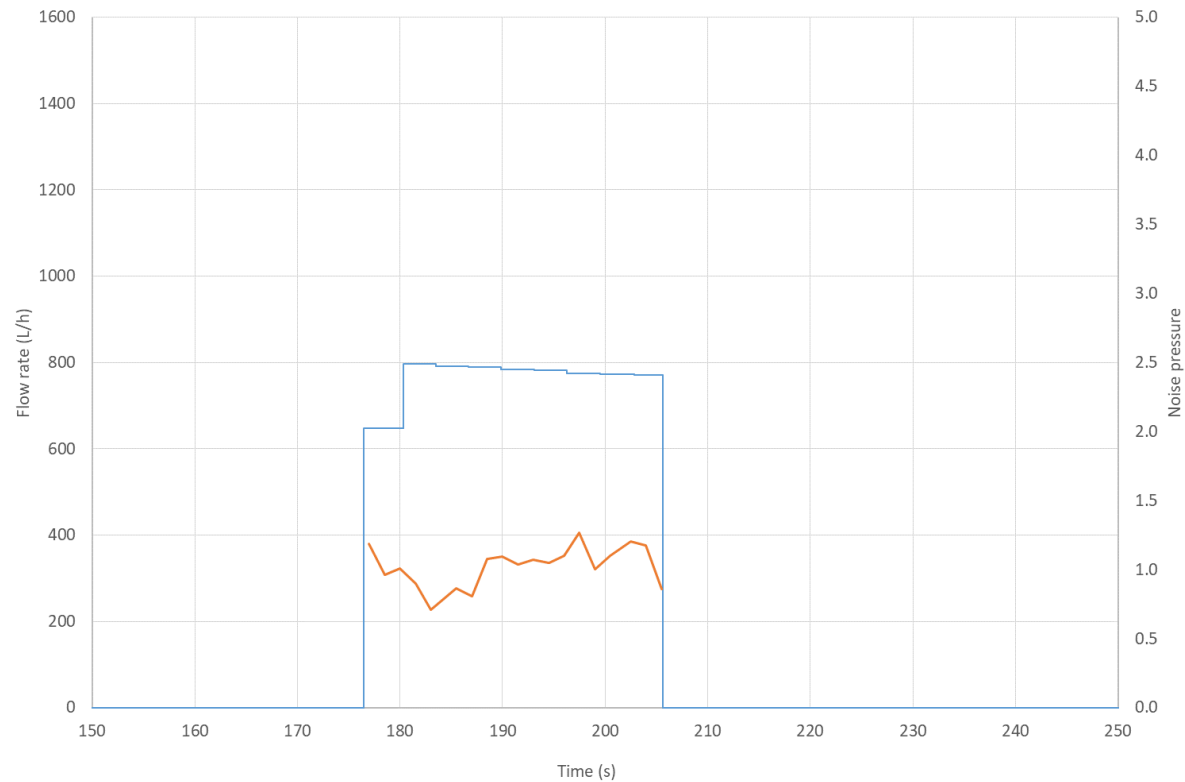
ADDITIONAL SIGNALS TO HELP - NOISE

Advanced end-use analysis

Noise level

Frequency spectrum

Bath tub cold water

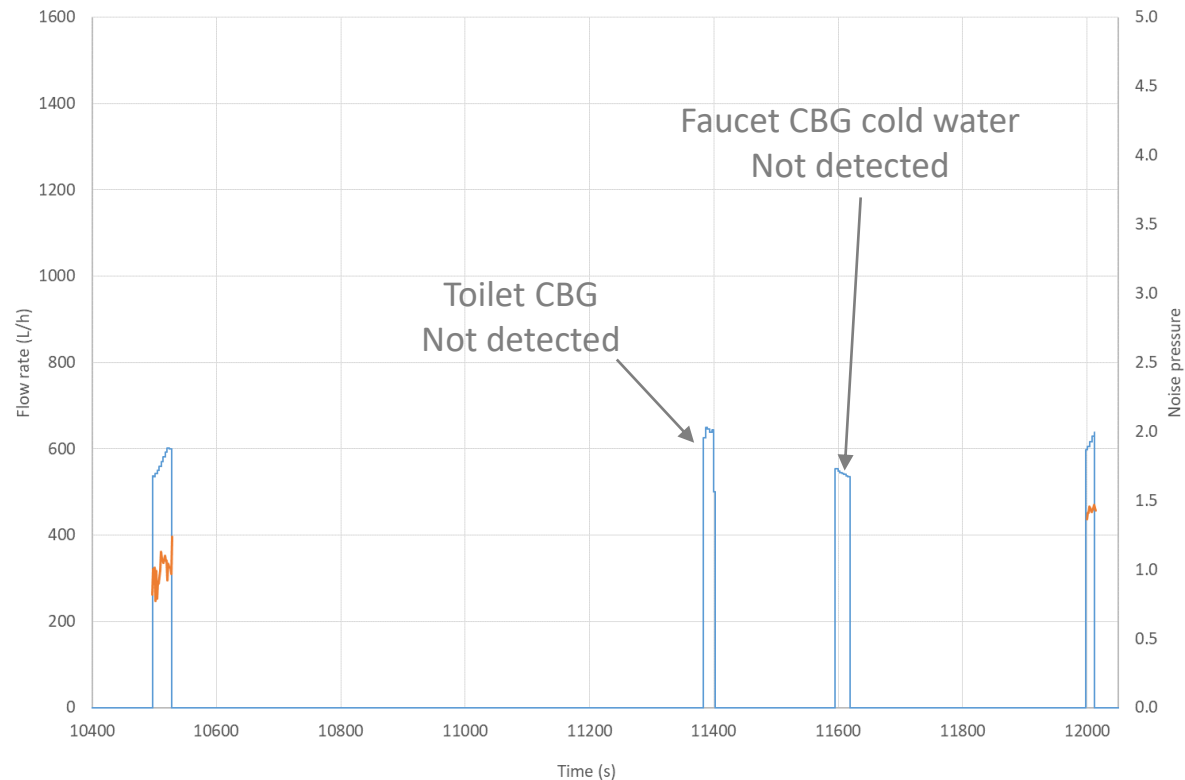New trends in HF water demand monitorization and analysis

Sink faucet CBP – cold water fully open

New trends in HF water demand monitorization and analysis

Toilet CBP

New trends in HF water demand monitorization and analysis
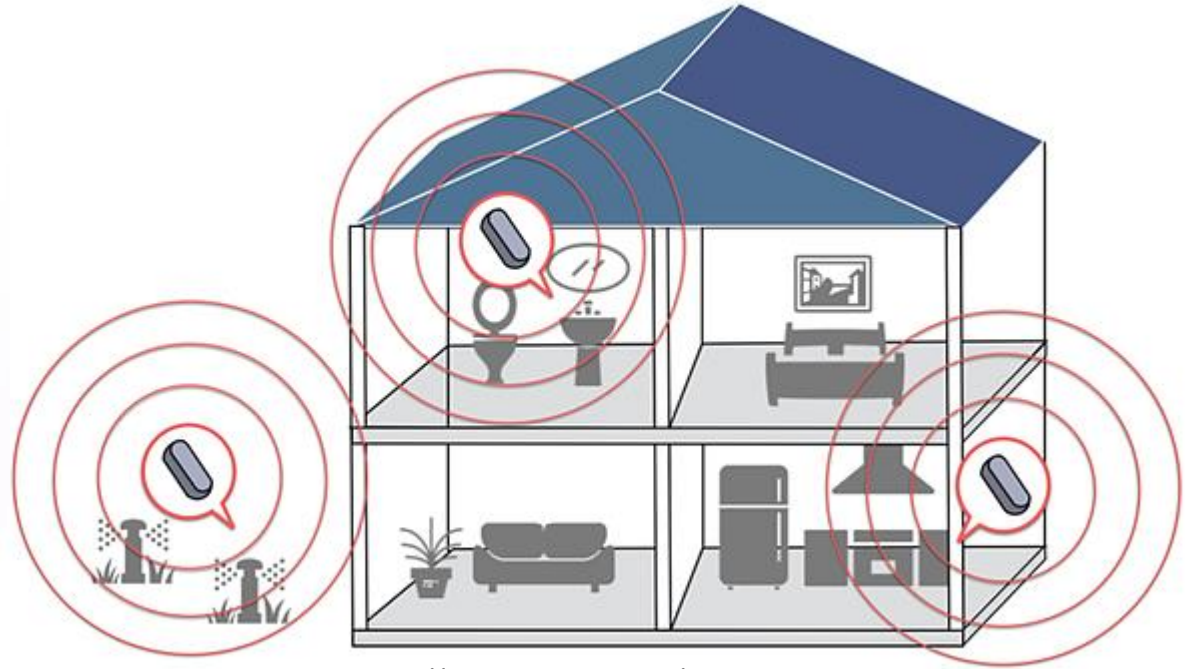
New trends in HF water demand monitorization and analysis
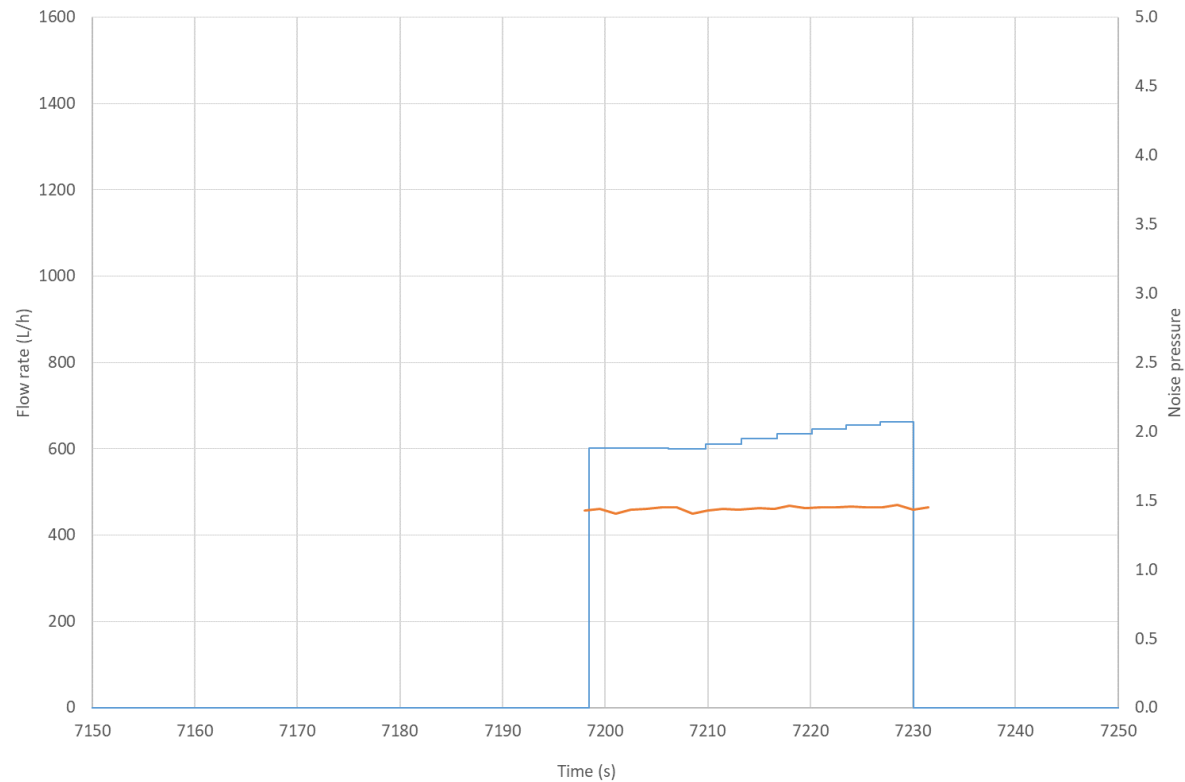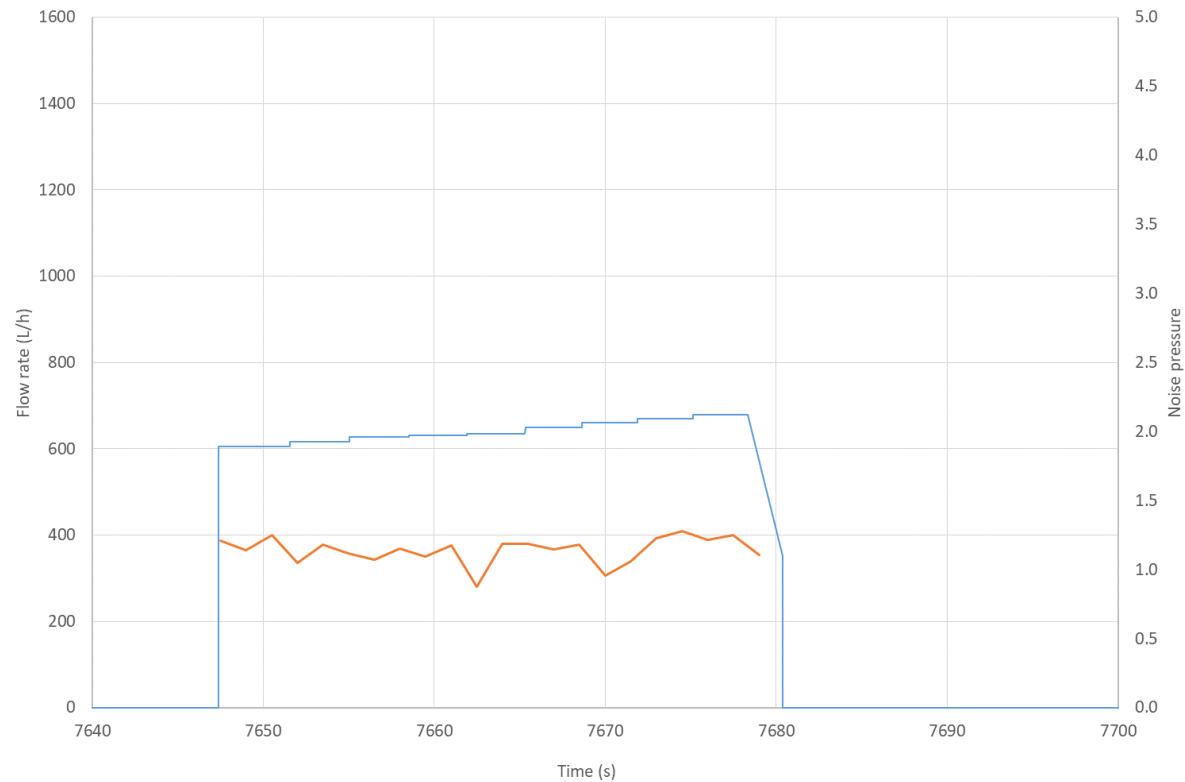
ADDITIONAL SIGNALS TO HELP – PRESENCE SENSORS

How intrusive this is?

ADDITIONAL SIGNALS TO HELP – flow switches

https://www.watersen.net/

New trends in HF water demand monitorization and analysis

ADDITIONAL SIGNALS TO HELP - PRESSURE

http://aqubiq.com/en/home/
https://www.phyn.com/
http://www.fluidwatermeter.com/

https://www.phyn.com/

ADDITIONAL SIGNALS TO HELP - ENERGY
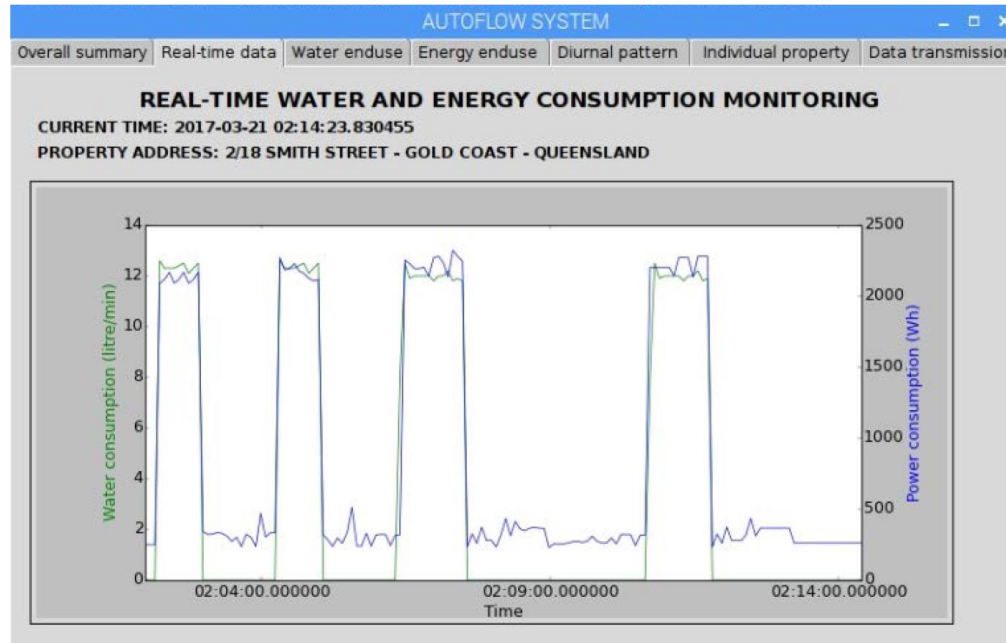
NEW TRENDS IN HF WATER DEMAND MONITORIZATION AND ANALYSIS

CONCLUSIONS

- High quality HF consumption monitoring is already here

- Its main application is to use it for water End-Use analysis through the flow trace)

- However, flow trace analysis still has a long way to go and many issues have to be solved

- This analysis to be fully accurate requires additional variables:

    - Energy

    - Sound

    - Pressure…

Thank you !!

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