Flow4Link - The flow in the hand

Instrumentation & Automation Team

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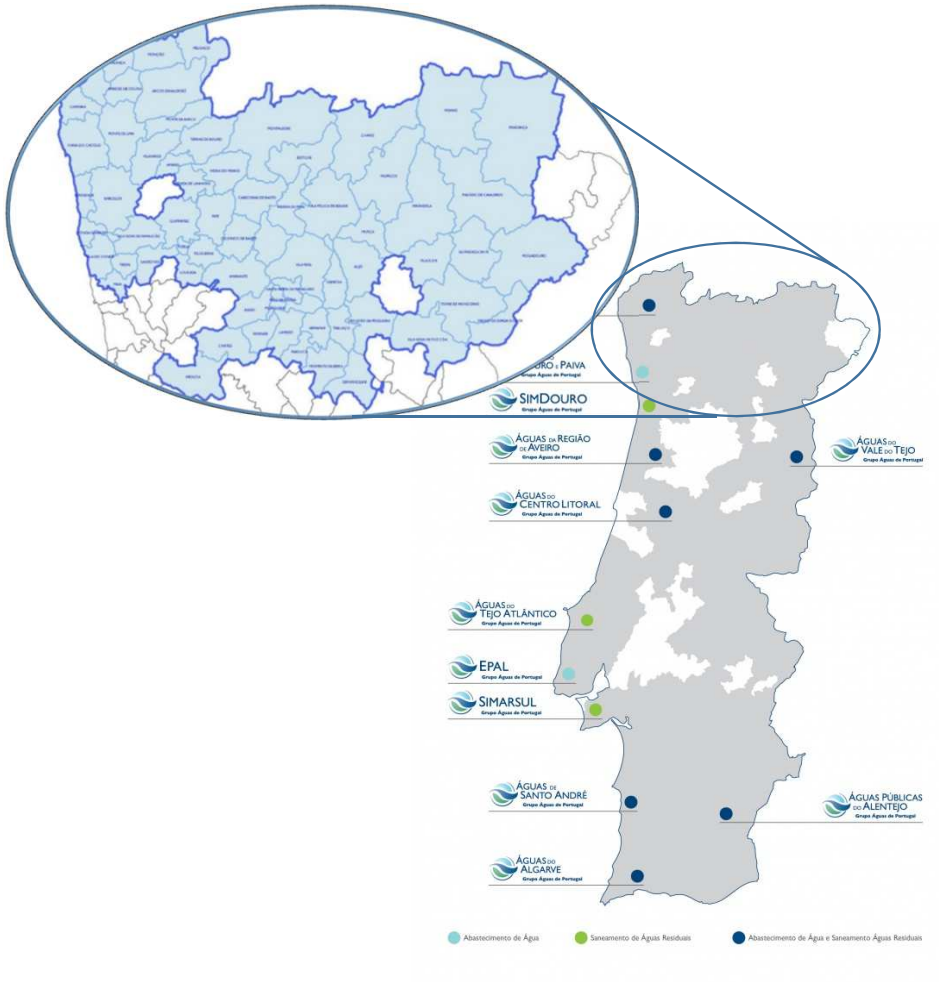
Águas do Norte SA

- Created in June of 2015

  Managing entity of :

- Multimunicipality system of water supply and waste water of northern of Portugal
  - ↘ Billed Volumes (2018):
    - Water Supply: 70 million m^3;
    - Wastewater: 77 million m^3;
  - ↘ Population served:
    - Water Supply: 801.000 inhabitants;
    - Wastewater : 815.000 inhabitants (eq.);

- Municipality water supply and waste water system of the northwest Region
  - ↘ Billed Volumes - 8 Municipalities (2018):
    - Water Supply: 3,1 million m^3;
    - Wastewater: 4,7 million m^3;



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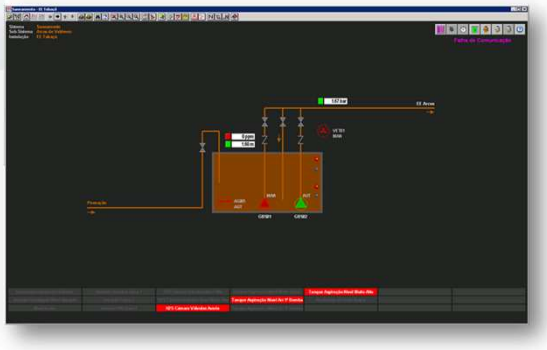
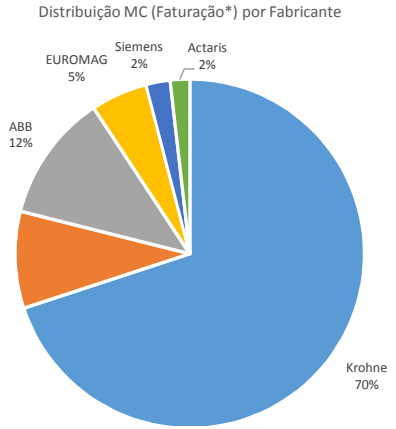
- The Instrumentation and Automation team:
  - Started in 2017;
  - Composed by 6 technicians;
  - Transversal to the 9 Exploration Centers;
  - Support to municipal operation teams;

- Manages about:
  - 950 Flowmeters;
  - 1.400 PLCs;
  - 100 SCADA Systems;
  - Others measurement instruments (Pressure, level, gas,…





Flow4Link - The beginning

- Project Flow**4**Link started in Oct / 2018, due to an internal competition

DEXpert

- Aims of the Flow**4**Link project:
  - Collection of data from billing equipment;
  - Calculation the operating point of the flow meter;
  - Calculation of global measurement error of a water supply subsystem;
  - Instantaneous water balance;
  - Operational management, configuration and remote diagnosis of instrumentation equipment;
  - Proactive management of flowmeter problems;
  - Reduction of costs in the travel of technical staff (municipal counts combined) and maintenance technicians.

- Main issues of operation where:

What is the measurement error?

The water balance gave very large values of losses!

The flow meter is in error. It's counting ok?

Flow4Link - The flow in the hand

- Set the course of the project:
  - In 2003, International Water Association (IWA) has developed a tool that has become the basis of all the analysis that is carried out around this theme - the water balance

System Input Volume	Authorized Consumption	Billed Authorized Consumption	Billed Metered Consumption	Revenue Water
			Billed Unmetered Consumption	
		Unbilled Authorized Consumption	Unbilled Metered Consumption	Non-Revenue Water
			Unbilled Unmetered Consumption	
	Water Losses	Apparent Losses	Unauthorized Consumption	
			Metering inaccuracies and Data Handling Errors	
		Real Losses	Leakage on Transmission and/or Distribution Mains	
			Leakage and Overflows at Utility's Storage Tanks	
			Leakage on Service Connections up to Point of Customer Metering	

- In 2018, overall losses reached an aggregate volume of 1.732.000m³ of water losses, corresponding to 2,37% of the water value entered into the system;
- But some subsystems have water losses of:
  - 540.675m³ in S. Jorge subsystem (4,95%);
  - 93.060m³ in Alvão subsystem (6,95%);
  - 87.571m³ in Penereiro subsystem (11,31%);
- In Municipalities we have water losses of:
  - Amarante: 1.722.668m³ (50,5%);
  - Baião: 99.911m³ (18,0%);
- The Apparent Losses are difficult to quantify

Flow4Link - Implementation

- Following phases:
  1) Installation of communications interface between flowmeters and Control Center;
  2) Development of functionalities intended for:
     - Telemetry and water balance
     - Current operating point and estimated error of each flow meter
     - Calculation of the overall error per subsystem;
  3) Development of functionalities intended for predictive maintenance and remote diagnostics of a flowmeter;
  4) Link to the manufacturer's cloud for equipment park management, spares and documentation.

1) Implementation of the method for data communication

- Some 950 flowmeters were identified and the ages can reach 20 years of operation
- The three most widespread communications protocols where:
  - ↘ HART- Highway Addressable Remote Transducer;
  - ↘ Profibus DP;
  - ↘ Modbus RTU;

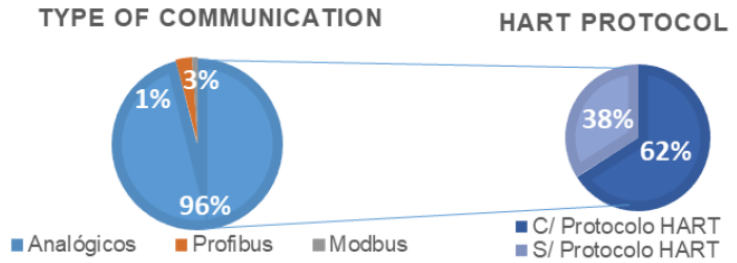


Figure 1: Communications protocols available in Águas do Norte flowmeters

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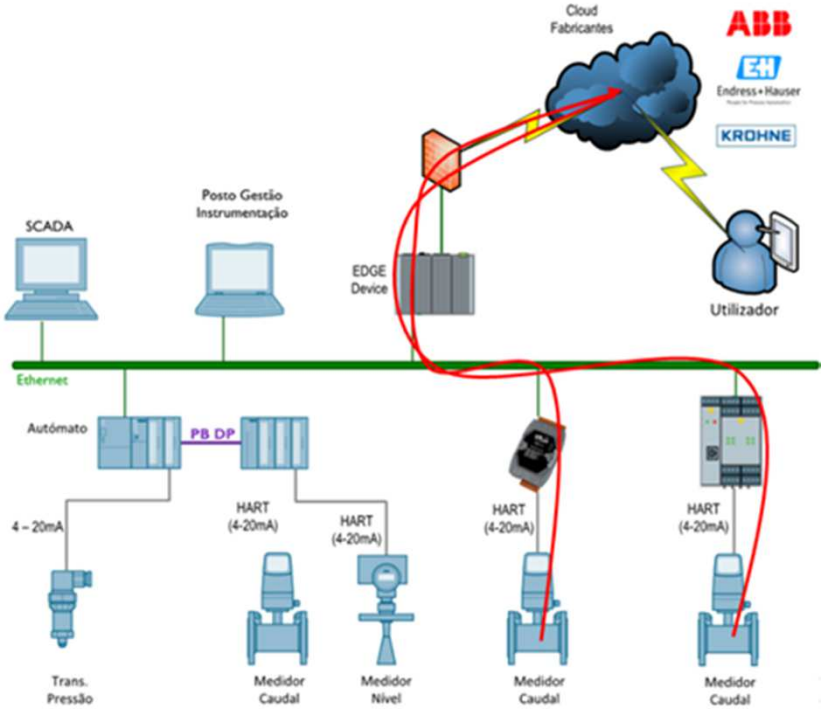

Figure 2: Diagram of data connection between flow and platform meters

- Exact digital data taken from the flowmeter;
- Allow for greater accuracy in the information;
- No add of uncertainty or external disturbances in the transmission/measurement chain;

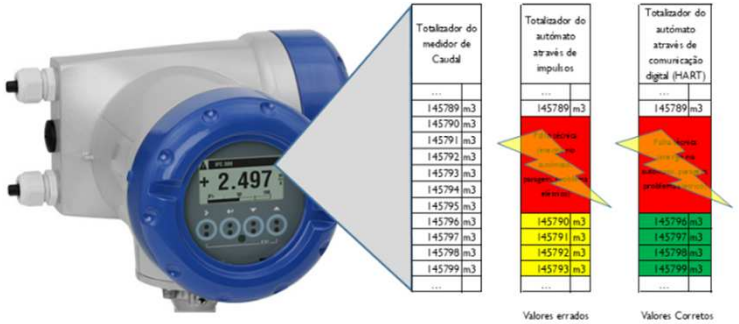

Figure 3: Example of data failure due to power failure

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2) Development of functionalities intended for telemetry and water balance

- An example: a flowmeter from a reservoir:
  - ↘ instantaneous flow and volume data were obtained over a period of 30 days;
  - ↘ Minute-to-minute sampling;

	Cavado.RME_FT001
Minimum flow (m3/h)	0,034
Mean flow (m3/h)	3,352
Maximum flow (m3/h)	28,306
Num. samples	42.938
Calculation. Classes	16
Standard deviation (SD)	2,243
Increment	1,767
Mean + 2xSD	7,837
Mean - 2xDP	-1,134
Mode	0,955
Median	2,879

Table 2: Statistical indicators of flow measurements

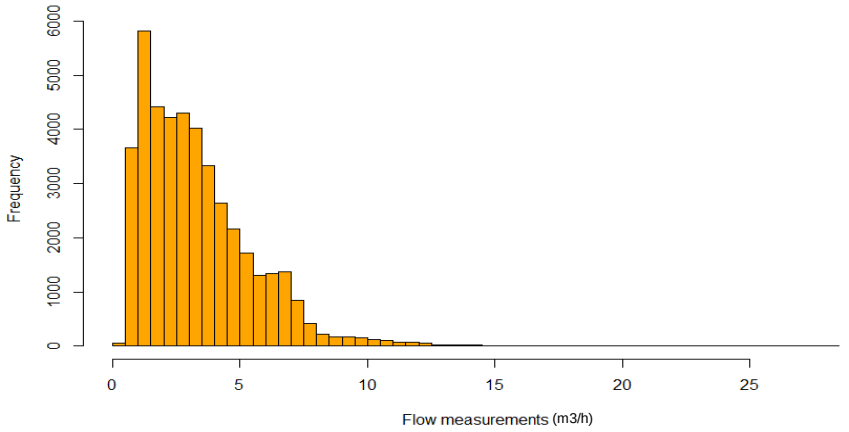

Figure 4: Histogram of flow measurements

- Applying the central limit theorem, we considered 20,000 random samples of size 50
- we can infer that 95% of the sample means will be between 2,735m³/h and 3,967m³/h
- average flow measurement converges to 3,352m³/h.

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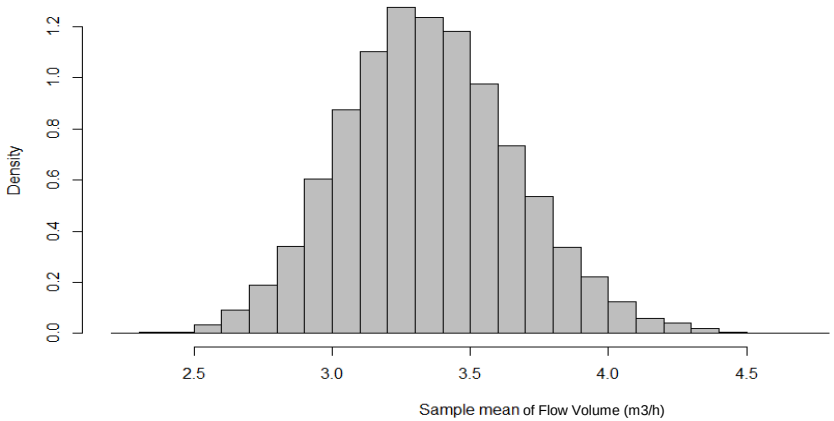

Figure 5: Histogram of sample means from 20 000 random samples of size 50

$$\mu = 3{,}352\ \mathrm{m}^3/\mathrm{h} \pm 0{,}615$$

↘ In the practical case, corresponding to a flowmeter of diameter 90mm, the values of minimum, average and maximum velocity of the flows where calculated.

Flowmeter Nominal Diameter = 90mm	
Minimum Flow Speed (m/s)	0,002
Average Flow Speed (m/s)	0,146
Maximum Flow Speed (m/s)	0,342

Table 4: Calculated flow speed

- One of the components of the error that is fixed is the transmitter. In this example was considered of 0.2% taking into account the existing measurement.

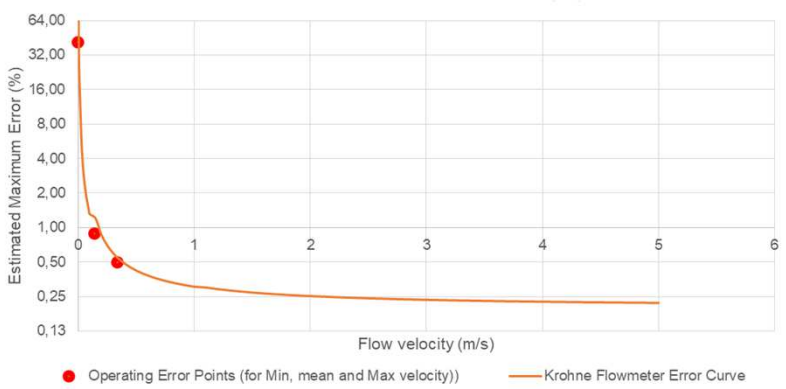

Figure 6: Operating Error Points for the Min, Mean and Max flow velocity

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- The maximum errors estimated for the above-mentioned flow values:

Flowmeter Nominal Diameter = 90mm	
Estimated Maximum Error (%)	±40,862
Estimated Average Error (%)	±0,883
Minimum Estimated Error (%)	±0,492

Table 5: Estimated errors for different flow speed

- **Estimated maximum operating error (%): ±1,404**

- With the goal of 1% tolerance error in the equipment, some of the measures to be implemented can be:
  - ↘ Resizing the meter;
  - ↘ Changing the mode of operation of infrastructure.

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- Resizing the new flowmeter: For example, for a diameter of 50mm, the estimated error values are:

Flowmeter Nominal Diameter = 50mm	
Estimated Maximum Error (%)	±20,772
Estimated Average Error (%)	±0,411
Minimum Estimated Error (%)	±0,290

- the result is about 50% below the previous value:

- **Estimated maximum operating error (%) ±0,571**

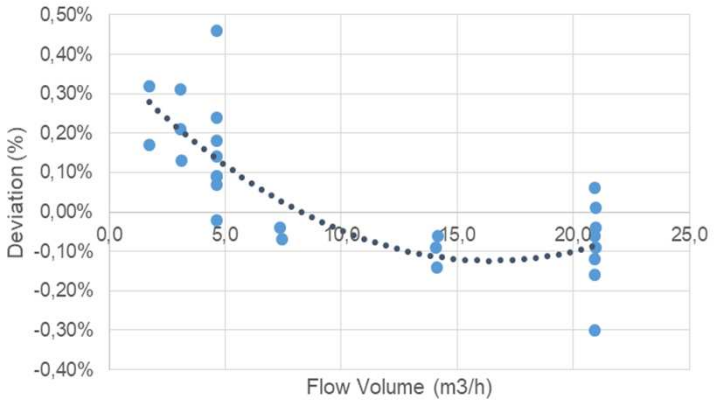


Figure 7: Deviation measurements for flowmeters with DN = 50mm

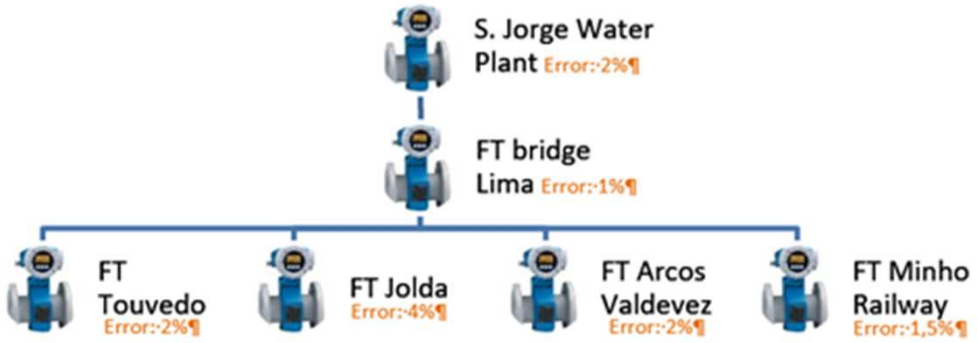
- We can minimize the errors of the meter in lower flow operating regimes, avoiding the exposure to readings with greater measurement error

Flow4Link – to be developed

1) **Calculation of the apparent losses of each subsystem** (to be developed)

- Depends of the global error resulting from the conjugation of several flow meters, in series or in parallel.
- The sum of the partial volumes of the billing flowmeters does not coincide with the system input values, subtracting the actual losses.

- The work will go through the individual analysis of the behavior of each flowmeter, so as to ensure that all have an estimated error value less than or equal to 1%.



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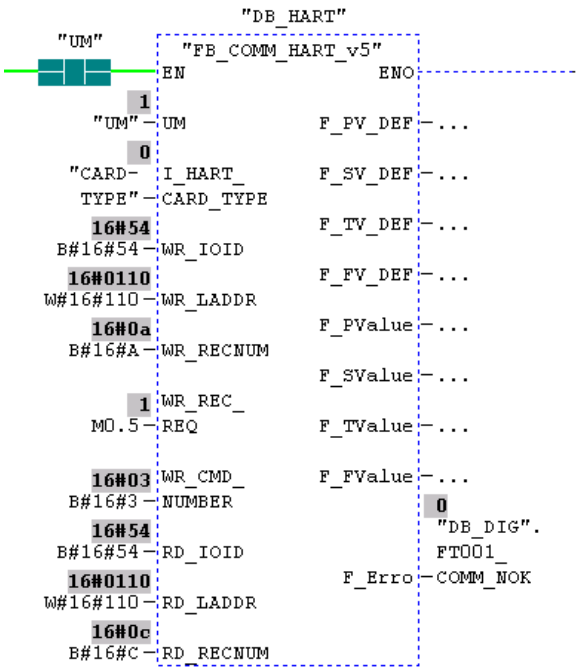
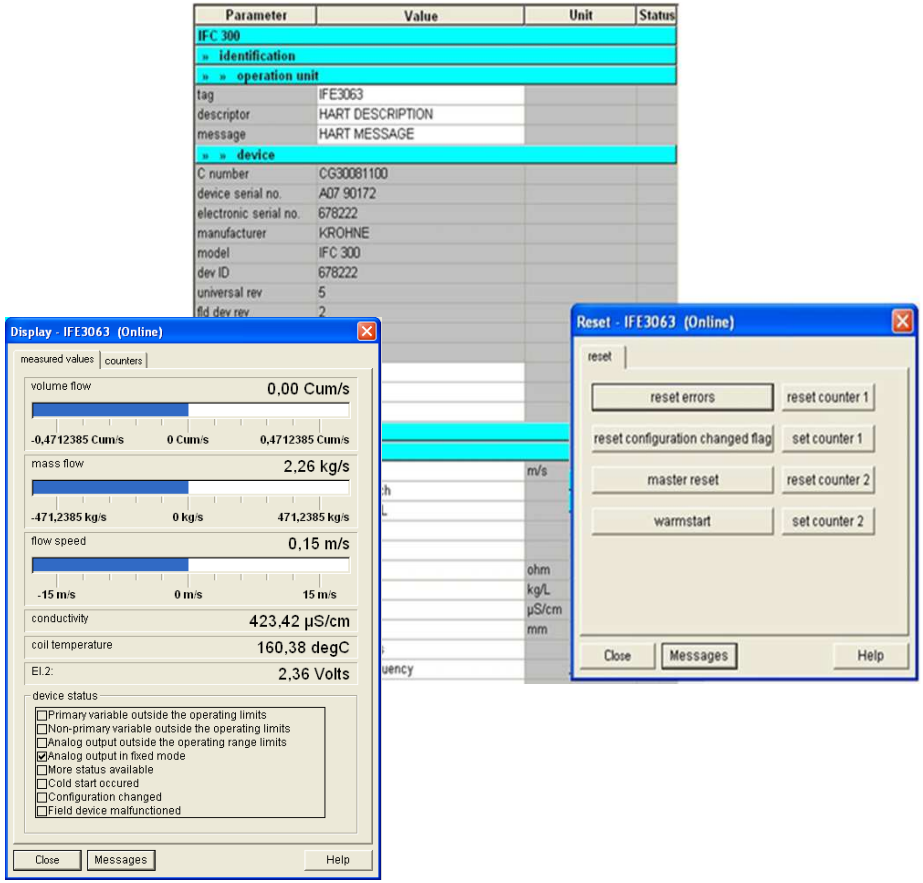
3) Development of functionalities intended for predictive maintenance and remote diagnostics of a flowmeter

- Flow Speed
- Volume Flow
- Conductivity
- Coil Temperature
- Counter 1
- Counter 2
- Counter 3
- Counter 4
- Diagnosis Value





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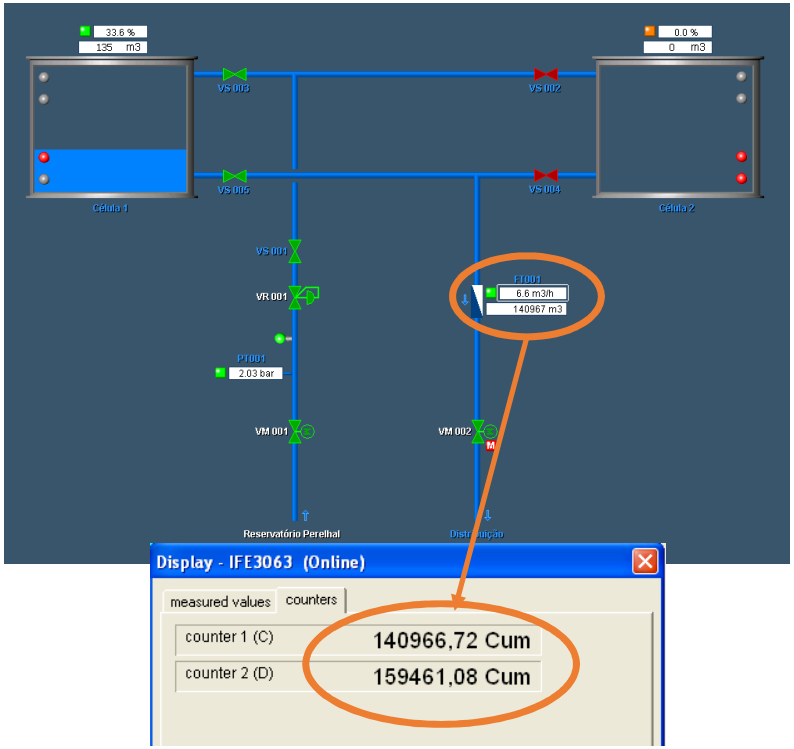
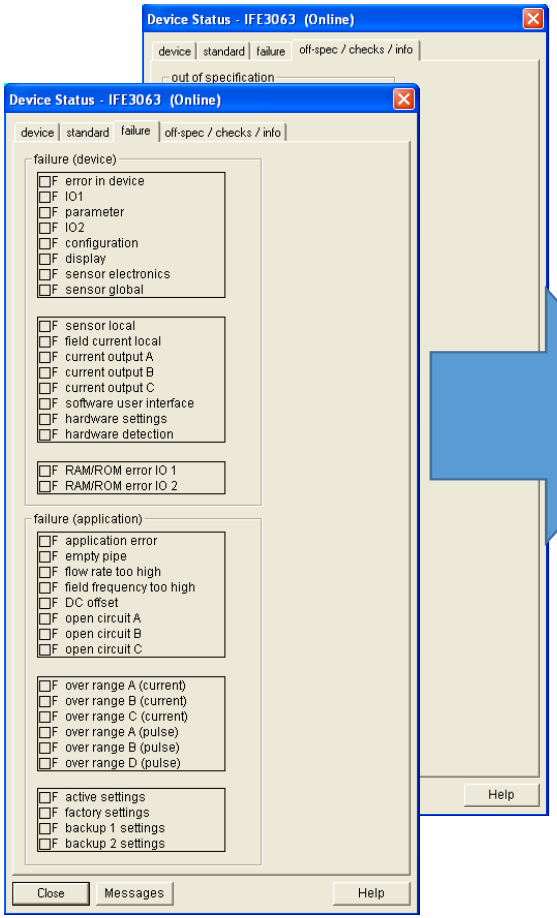
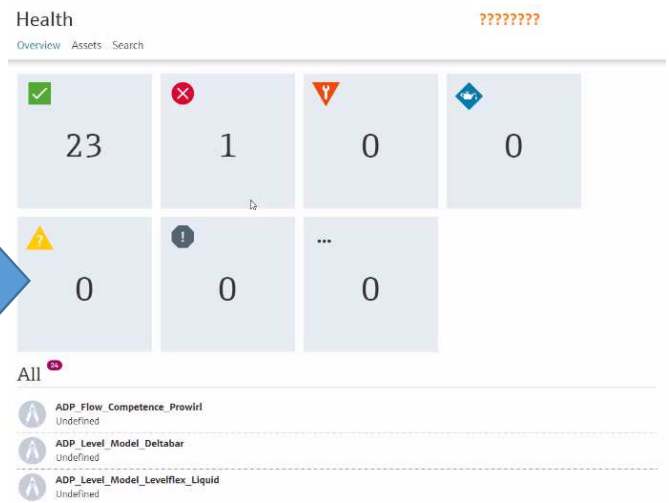
- From SCADA Systems to manufactures software the process values are the same





- The implementation of the Cloud with more appealing interface ...



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Conclusion

- The initial phase of the project has demonstrated practical and valuable results in obtaining data through digital communication:
  - Very reliable level of process data
  - Remote access to flowmeter status diagnostics;
  - Reduction of some of the tasks of field teams (e.g. monthly readings)
  - Anticipates some actions on the field, but to obtain them, manual verification routines are necessary.
  - Determination of the operating point of a flow meter
  - Identify some flowmeters that do not operate in the best operating zone;

Next Steps

- To evolve the project:
  - Apply and scale the implementation of communication modules (minor cost);
  - Check the most appropriate statistical methods that support operation point;
  - Get a mathematical model for the calculation of the global error of a water supply system;
  - Implementation of cloud services for automatic verification routines and connection to several manufactures clouds;

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Questions and answers…

Thank you for your attention