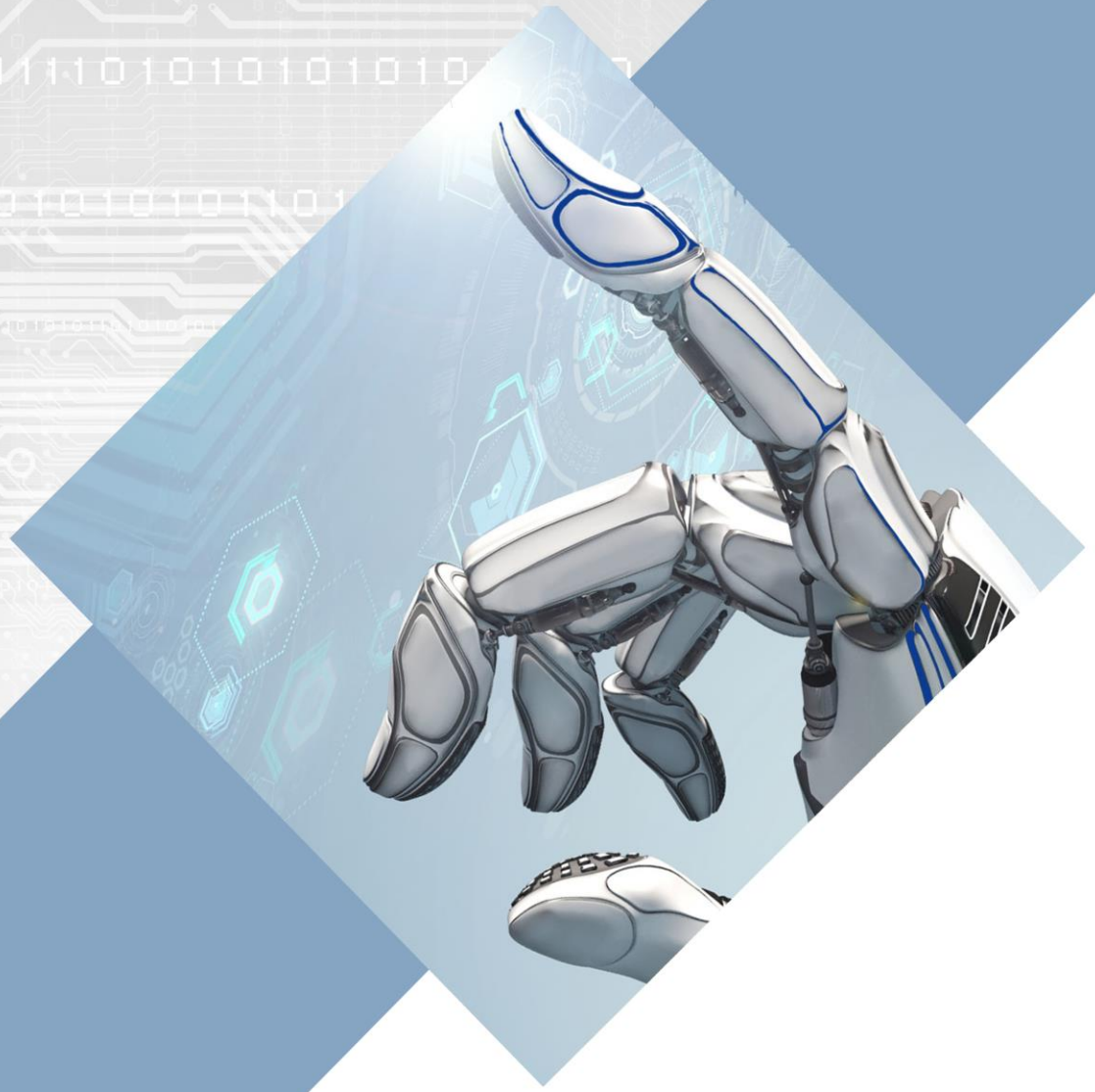
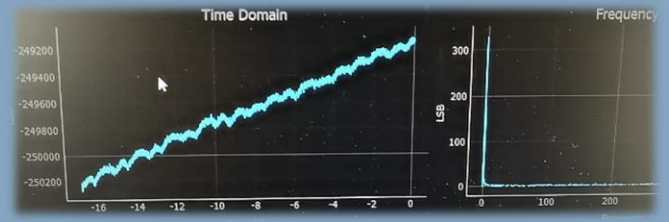
PIPE SENSOR

PRINCIPLE AND TECHNICAL DATA



Oil & gas



Revolutionary, fully external pressure sensor. 1 mbar resolution on 76 mm schedule 10 pipes at 100 bar full scale pressure

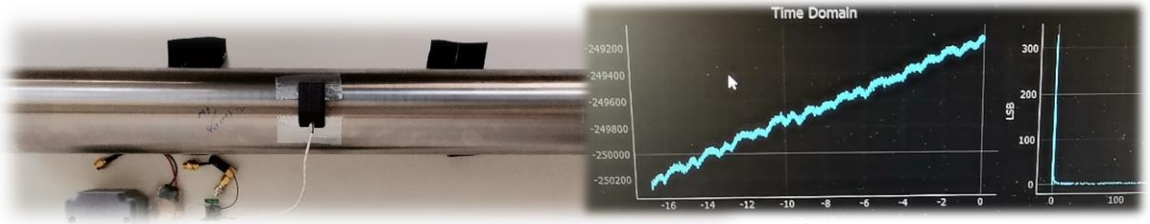
Detects anything: leaks, shocks, drifts, terrain setting, theft, etc.

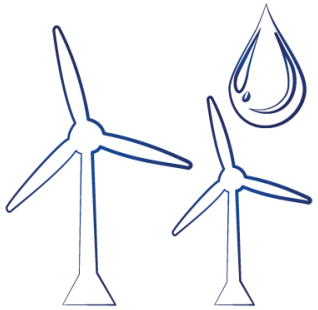
Long range communication

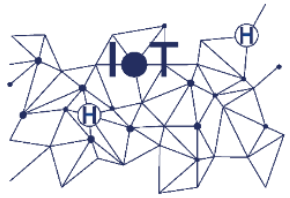
Condition-based monitoring of pipeline pressure with external devices

- Internal fluid pressure sensing **without pressure sensor**
- Superior semiconductor gauge technology enables an **external device** to transmit wireless **internal fluid** pressure and temperature data
- No hole through the pipe, no seal, intrinsic zero leakage
- No line interruption during the quick installation
- Reconfigurable sensing points during service life
- Continuous pressure monitoring anywhere on the line

Oil & gas







HAPTICA

Working principle

The sensor measures with high resolution the diameter increase of the pipe, by measuring the hoop strain.

For an infinitely long pipe:

$$\in_{\vartheta\vartheta} = \frac{\Delta C}{C_{ref}} = \frac{2\pi\Delta D}{2\pi D_{ref}} \approx \frac{1}{E}\frac{p \cdot D_{ref}}{2t}$$

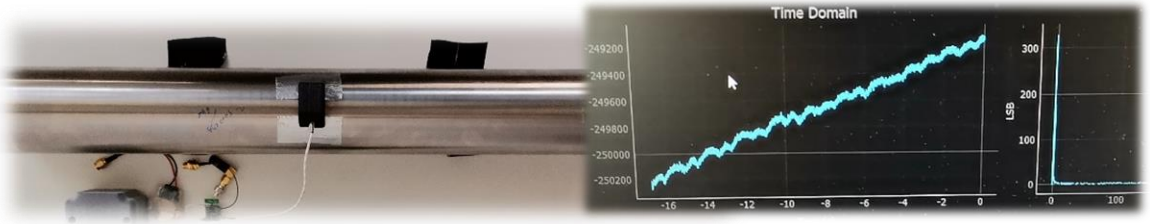
With C, pipe section circumference, D diameter, t pipe thickness, p pressure, and E elastic modulus of the pipe material.

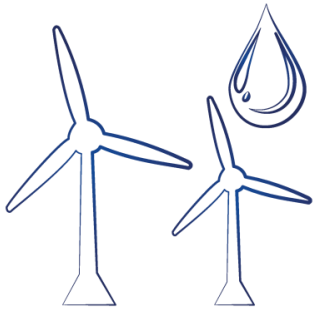
The signal is as usual for a full bridge sensor: $\frac{\Delta V_s}{V} = kG \in_{\vartheta\vartheta}$, with

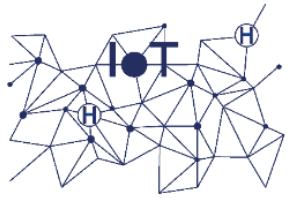
ΔV_s signal voltage, V input voltage (about 2.5 V to the bridge, and any typical voltage for the entire sensor)

G is the gauge factor of the strain gauges (~170) and k is a geometrical amplification factor of the sensing element

Oil & gas







HAPTICA

Technical features: signal resolution

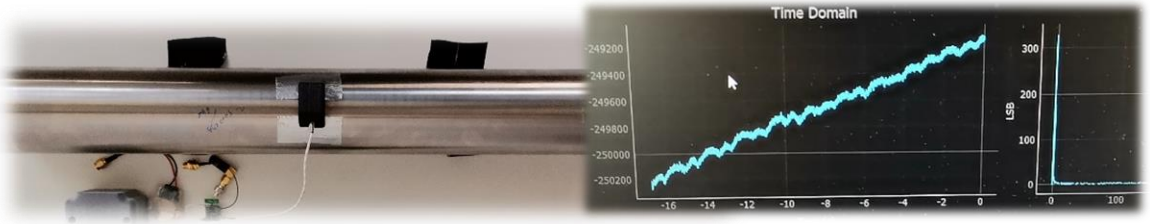
Current resolution, R, obtained with adhesive tape (can only improve with structural adhesive, micro-TIG welding or spot welding, etc)

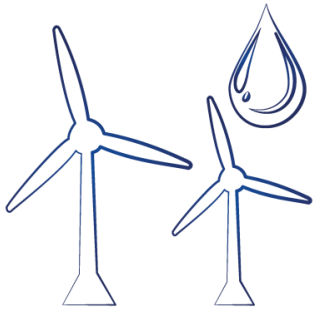
R ≈ 1 LSB / mbar (about + 5000 LSB for +5 bar, using our 24 bit ADC) on a schedule 10, 76 mm steel pipe, i.e. about 0.3 µV / mbar.

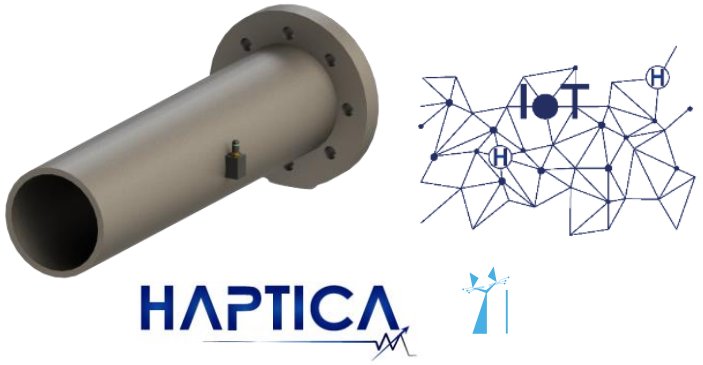
Resolution depends on the diameter vs thickness ratio (D/2t, here 12.6). Resolution can be scaled accordingly for larger and thicker pipes. For the TAP pipeline, D = 1200, t = 34 mm: 17.65; the resolution would be 1.4 times higher.

It really works on any pipe, as pipes thickness and diameter are always matched!

Oil & gas







HAPTICA

Technical features: installation & configuration

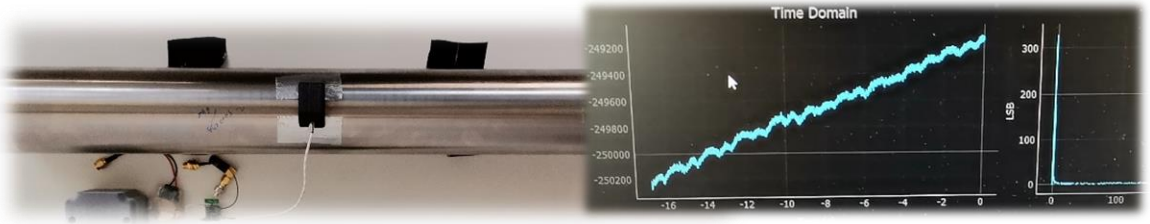
Installation requires applying the sensing element to the pipe exterior. This is simple and can be done in different ways, for example:

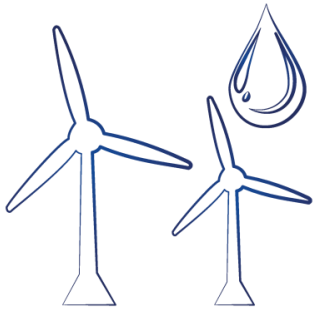
- Using a structural adhesive (Epoxy or similar).
- Using micro-TIG welding, spot welding/tacking and similar. These techniques do not necessarily require line interruption if the environment is checked and monitored with a detector.

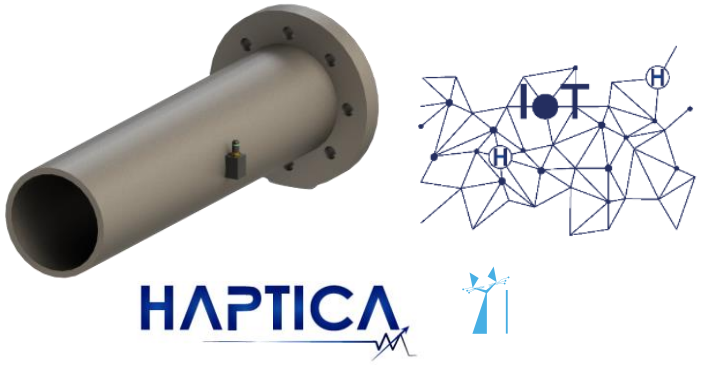
Next, the sensing element is protected with a small, thermally insulated housing. Thermal protection is important to signal drift stability.

Finally, power supply and connectivity are taken care of, depending on the adopted solution (antenna or data cable; battery, line power, local solar panel, etc.)

Oil & gas







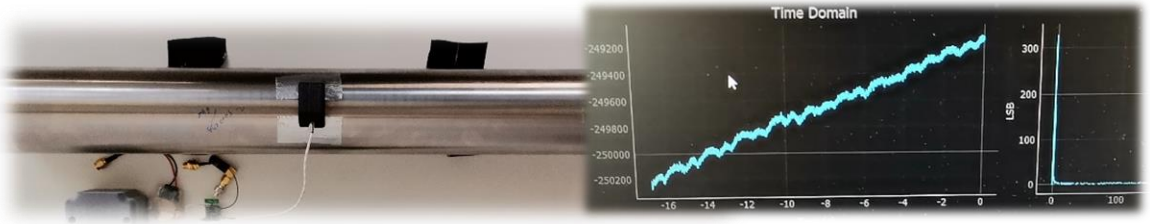
HAPTICA

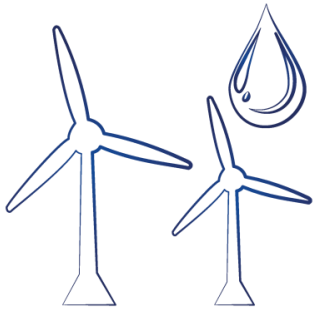
Technical features: power supply

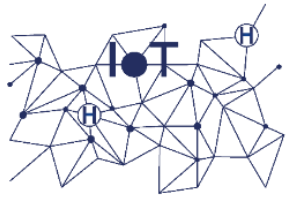
Power supply can be by battery, by line power, or attaching a local primary source unit.

- Line power: 9-32 VdC, or any other with additional transformation.
- Battery: primary, Li-Ion or higher Voltage, sized for the required maintenance-free autonomy.
- Local source: external solar power with secondary Li-Ion battery. Energy harvesting material is currently under investigation for systems that are not exposed to irradiation.

Oil & gas







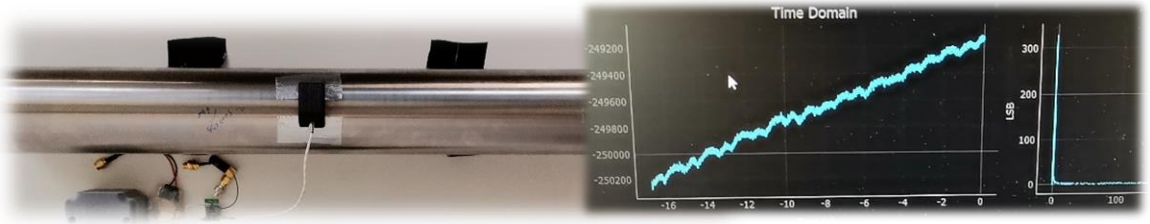
HAPTICA

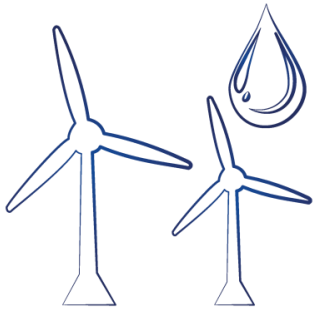
Technical features: data and connectivity

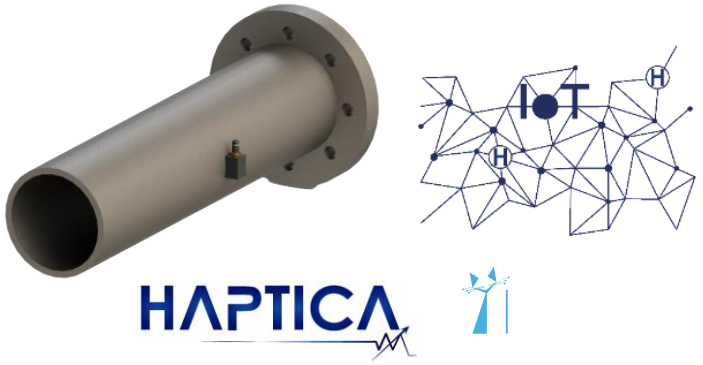
The system is modular and flexible.

- The sensor can be connected locally to a PC or small, single board computer (e.g. a Raspberry Pi) to deliver time data and automated FFT (frequency analysis).
- Data is locally digitized for maximum performance. 4-20 mA is possible, but requires a local acquisition channel and is not recommended.
- Data harvesting can be wired (standard coaxial cable, non proprietary) or wireless on 2.4 GHz.
- Long Range data connectivity can be through a LPWAN (e.g. LoRa, SigFox, etc.). This is a long range network delivering data and information in small packages, a few times a day, over large distance, using low power.
- Long Range connectivity can also be by satellite, if needed.

Oil & gas







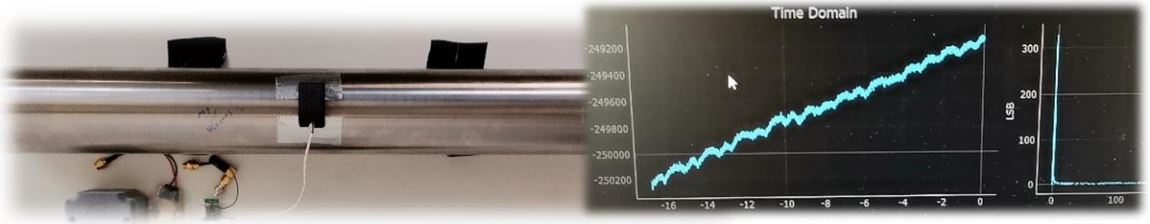
HAPTICA

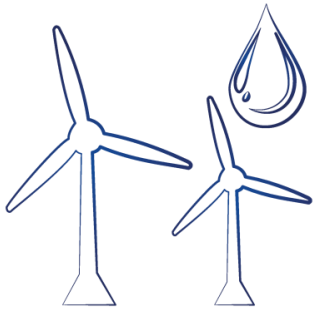
Technical features: data and connectivity

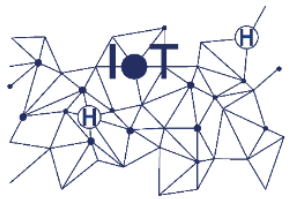
Through time, sensor data was interfaced in many ways: PC, PLC, SBC to PLC, PLC via wireless network, long-range to a data centre, etc.

- Data can be acquired as time-stamp / value, or just value (time-stamped by a local processor when available and suitable). Protocols are UDP and TCP/IP or CAN, via serial ports. Formatting is simple (basic, or JASON).
- IoT protocols have been implemented (server to client or client to server): OPC UA and MQTT are used in this case.
- Osisoft OPC UA was implemented with VPN internet connectivity from remote to critical infrastructure having sensors, using a local SBC with PI connector interface. Data streamed was the time signal, FFT, and stats (average, standard deviation, or any other)

Oil & gas

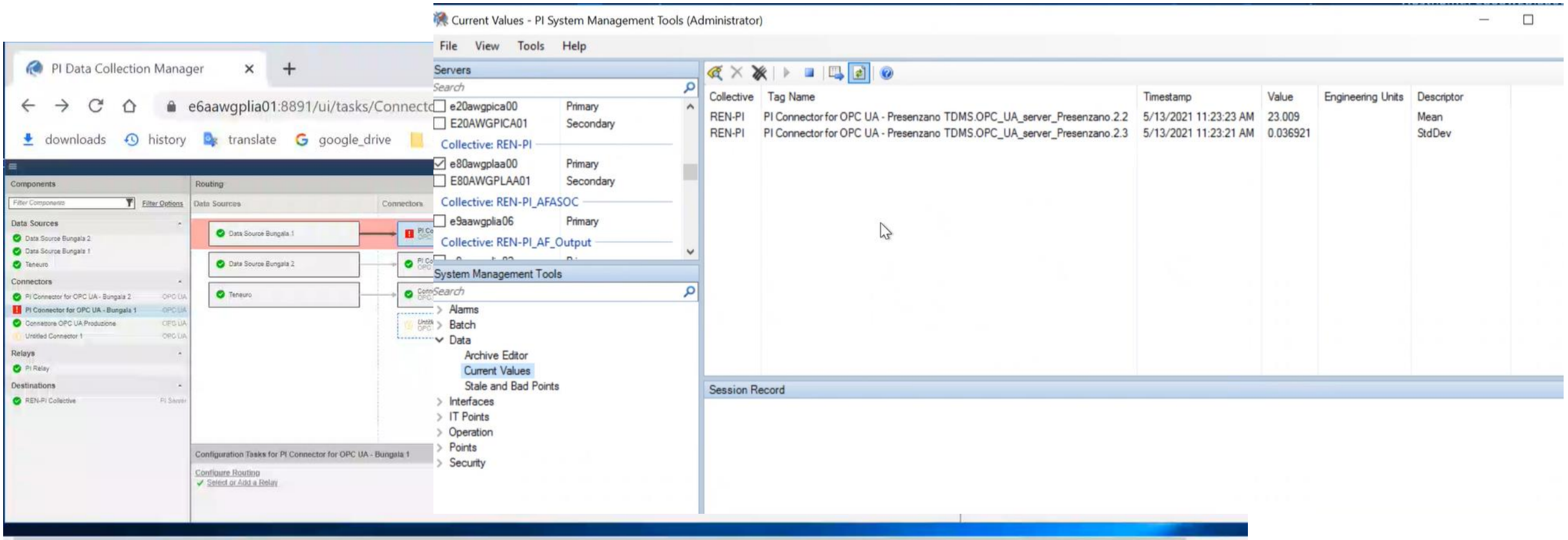




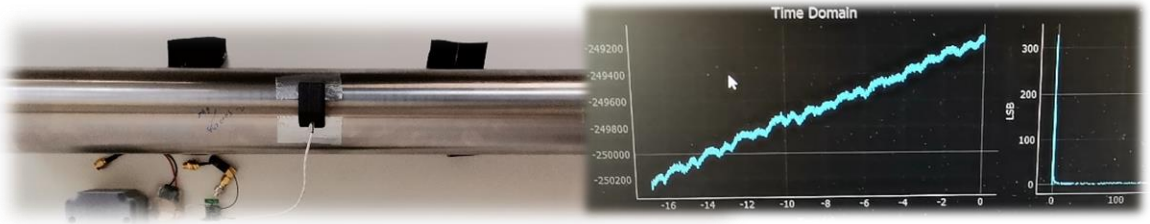


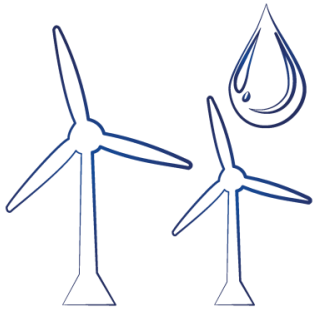
HAPTICA

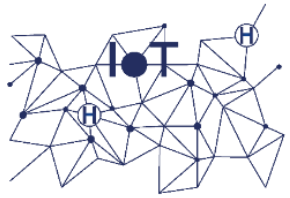
OPC UA data connectivity via VPN



Oil & gas







HAPTICA

Technical features: data analysis

The sensor is very sensitive and will respond to any source of strain in the metal tube.

Shock and vibration strain will be picked up over a large distance. This is an opportunity to observe events, carry out time-domain reflectometry, frequency analysis, but can be a nuisance. The sensor will notice local impacts if the strain is transmitted, for example sombebody walking near the tube, touches, etc.

Thermal strain on the pipe will be picked up also. Thermal strain can be: day-night cycles, or due hyperstatic constraints (complex pipe sections in a facility, expanding and contracting depending on operating conditions)

Compensation and filtering out of disturbances can be performed in some measure automatically (electrically: adding a temperature element with the sensor package, adding a longitudinal strain sensor; by analysis, using low pass and high pass filtering)

Good performance is achieved through a pilot, after a learning phase, also using soft-computing techniques (machine learning, data fusion, etc.)