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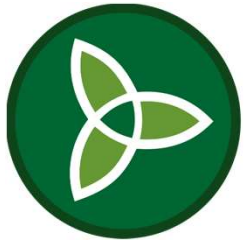
Supplement of

Embedded sensors system to monitor cemented waste drums

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PREDIS

WP7 Innovations in cemented waste handling and pre-disposal storage

Embedded Monitoring System

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SafeND, September 13th 2023



This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 945098.

Introduction

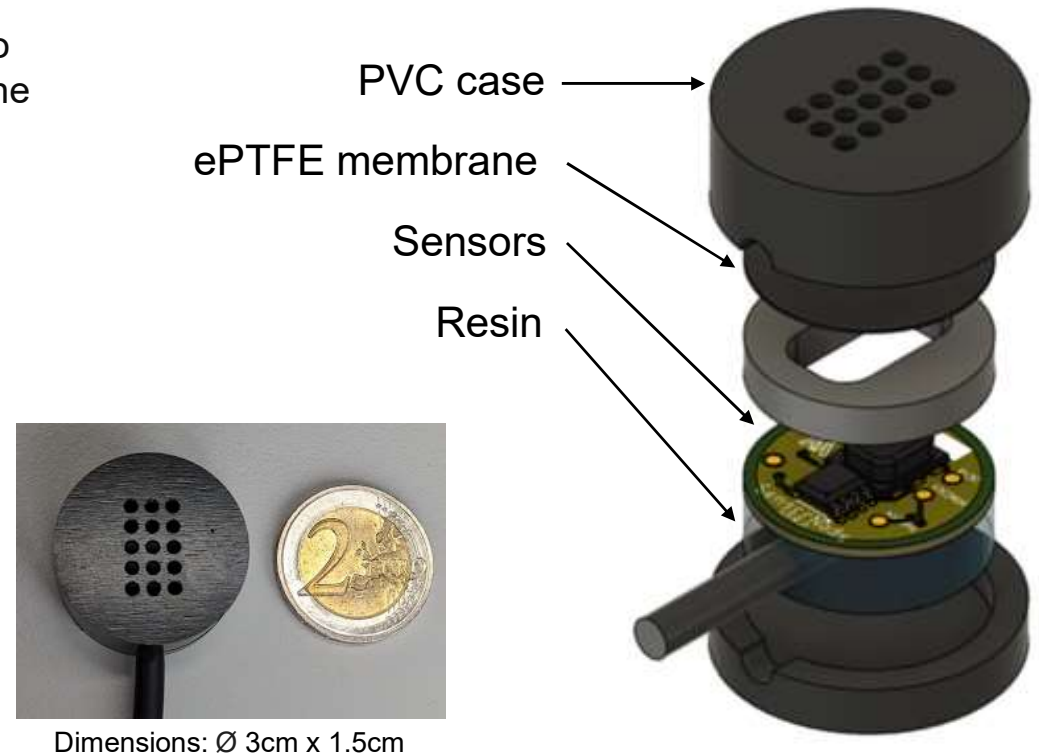
- The aim is to long-term monitor by embedded batteryless sensors the process of hardening and the evolution of the concrete itself over time, to indirectly identify potential defects such as corrosion or cracking of metallic waste drums.
- It is necessary to develop a technology able to transmit power and communicate through the metal layer of the sealed drum, as well as develop low-power sensors able to work embedded in concrete.

These two main tasks have been carried out by BAM and VTT:

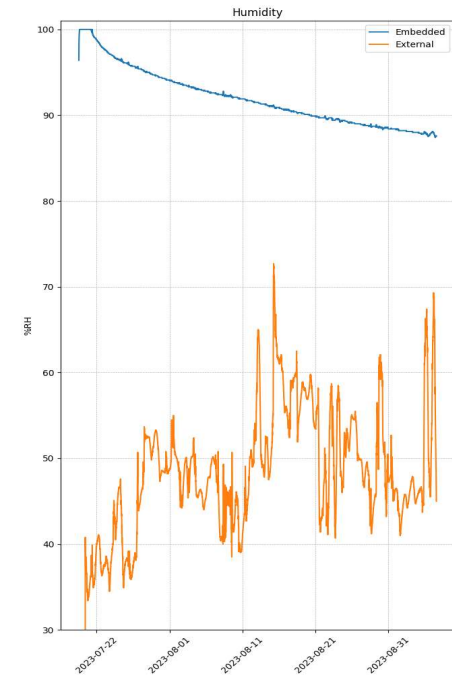
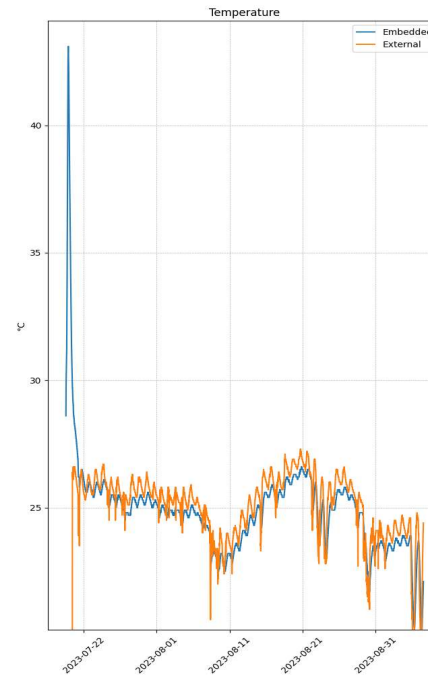
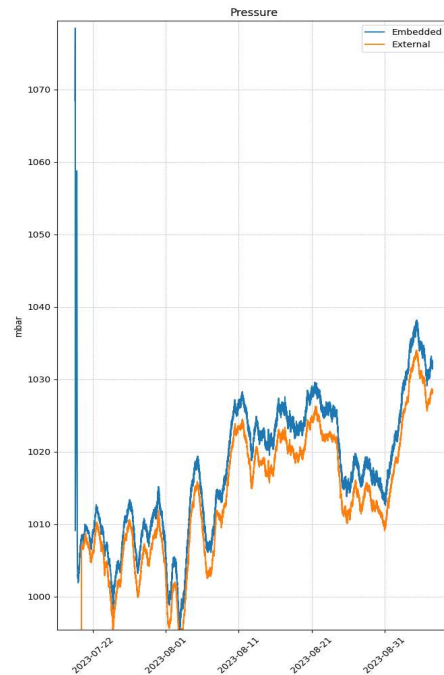
- BAM: development of a net of custom low-power measurement units (*SensorNode*) that allow the onboard sensors to measure the state of the concrete without being in direct contact with it.
- VTT: development of a customized RFID solution to power sensors and transfer data through solid metal structures.

SensorNode: embedded instrumentation (BAM)

- The membrane's pores allow water and gas particles to pass through and let the enclosed air equilibrate with the external environment.
- One measurement cycle for each node requires about 0.4mAs (20mW x 60ms).
- Onboard sensors:
 - Absolute Pressure (0 to 400kPa)
 - Relative Humidity (0%RH to 100%RH)
 - Temperature (-40 °C to 125 °C)
- Limitations:
 - Max 64 nodes on the same bus (Unique ID limit)
 - Max 6m water depth (Membrane's permeability limit)
 - Max 10m cable length (Communication protocol limit)



SensorNode: Small Scale Test

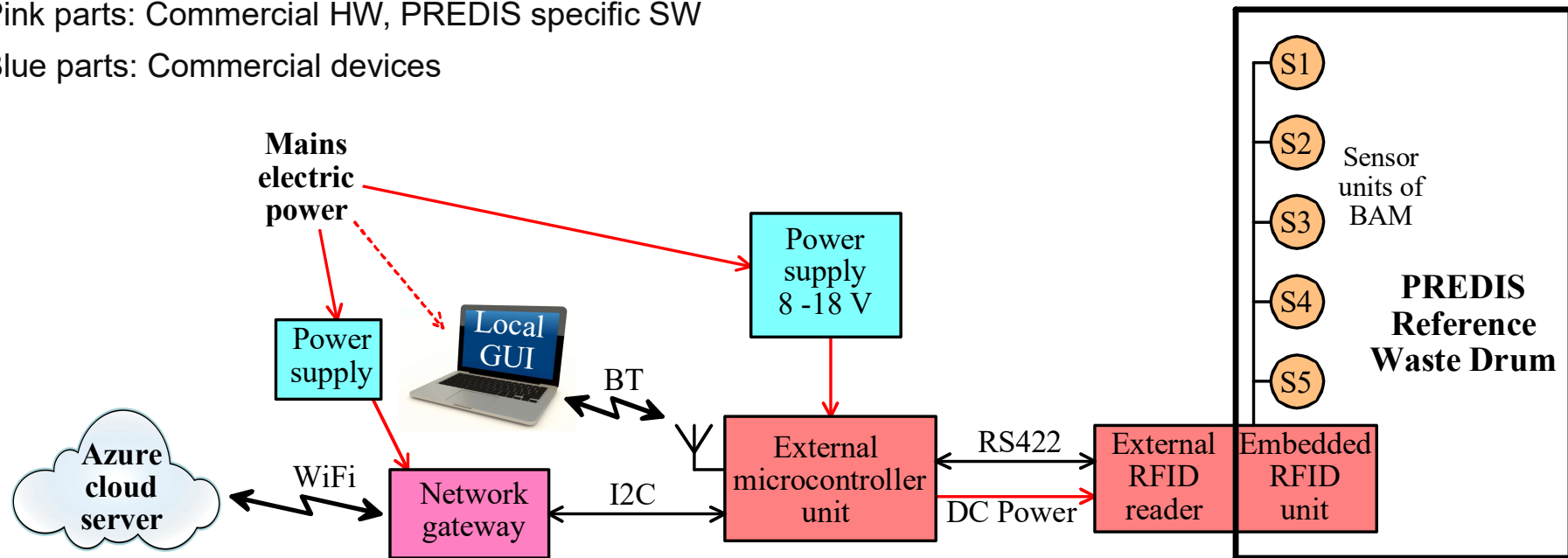


One SensorNode (blue) has been embedded at the bottom of a 40cm-height pipe and one (orange) is outside to monitor the external environment.



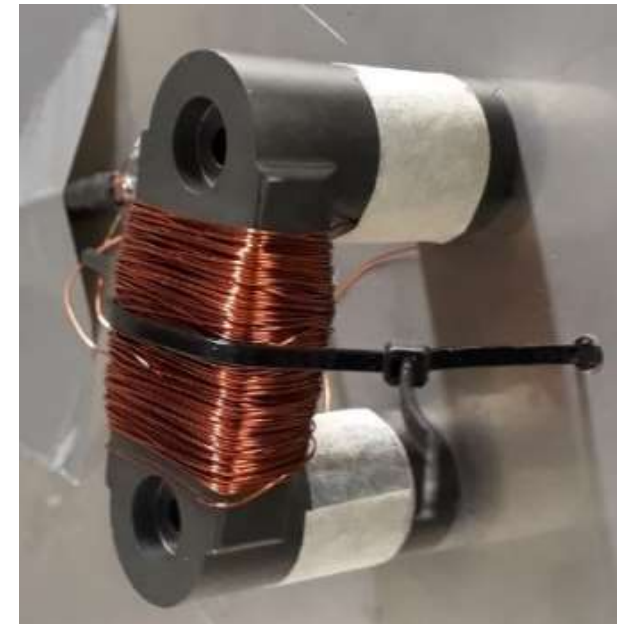
Sensor data acquisition system (VTT)

- Red parts: PREDIS specific HW and SW
- Pink parts: Commercial HW, PREDIS specific SW
- Blue parts: Commercial devices



Customized RFID (VTT)

- The contactless powering and data uplink of the sensors in the drum is based on a couple of UR ferrite core antennas, symmetrically placed on the inner and outer surface of the drum.
- The PREDIS mock-up is a 1.4 mm thick steel drum, with a total gap between the antenna cores of about 2 mm. The maximum power transfer (about 1%) is achieved by superlow frequency carrier (100 Hz). With a similar non-magnetic stainless steel drum, the power efficiency would be much higher.
- The required time to transmit enough energy to control up to 5 *SensorNodes* is about 30sec.

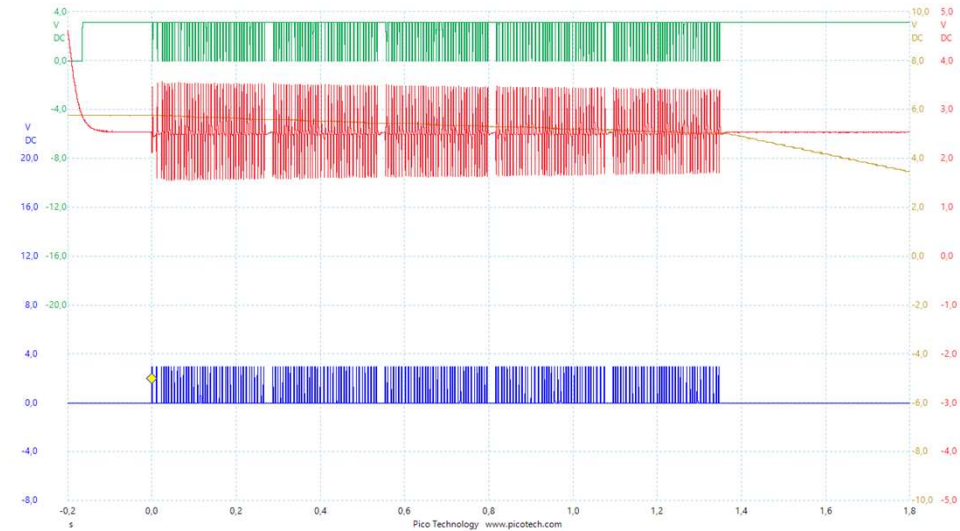
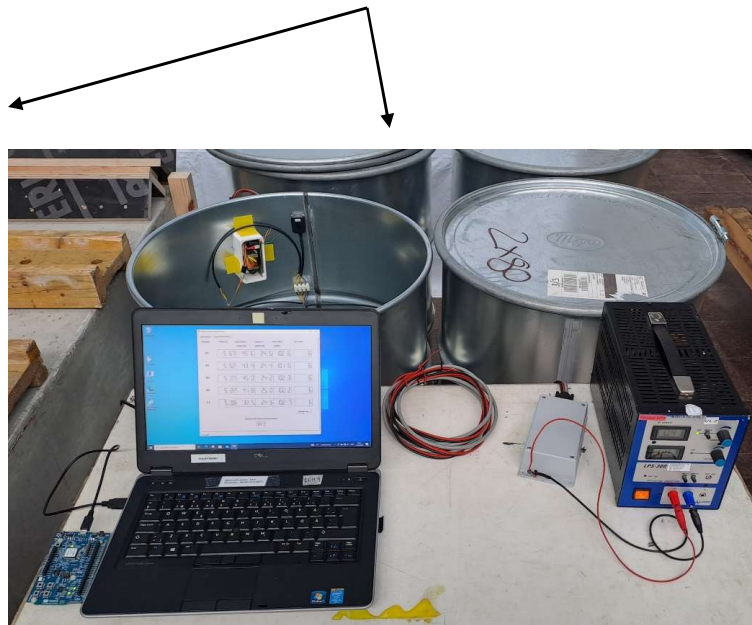


View of a UR ferrite core with wrapped coil

First drum integration at BAM 9-12/05/2023



Drum Instrumentation



Measured data uplink signals of five sensors:

- Blue: *Embedded RFID unit transmitted data*
- Red: *External RFID unit received data*
- Green: *Regenerated data in the External μC unit*
- Yellow: *Embedded RFID energy storage voltage*



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Further activities in PREDIS Task 7.3

- September 2023: Start experiment with Mockup 1.1 @BAM
- October 2023: PREDIS demonstration of Mockup 1.2 @UJV (same setup as Mockup 1.1 with cloud database integration)
- End 2023: Demonstration by VTT @TVO

