EDF activities in IIOT

Energifosrk – Industrial IoT in nuclear

EDF R&D - Eric Perrier de La Bâthie

November 18th, 2021

DEPLOYMENT OF PRIVATE NETWORKS IN OUR NPP SITES

2019

Private 4G

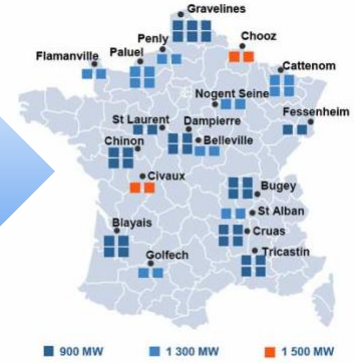
Regulation decisions
Band 38
Band 28

2020-21

Blayais 4G Pilot
4G network roll-out decision

2022-27

National roll-out : outdoor / indoor



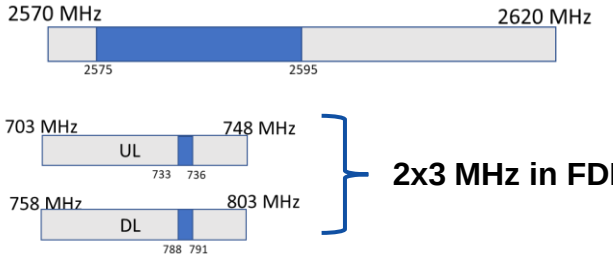
5G **2022-2024**
5G integration studies

IOT (since 2015)

LoRaWAN / WirelessHART **2021-2022**
Collect layer: IOT Platforms & Network servers
National roll-out (limited to SL5 applications)

National deployment of IOT networks within our NPPs is still not acted

Security levels (SL):
SL 5: e-monitoring
SL 4: control assistance
SL 3: integration to I&C



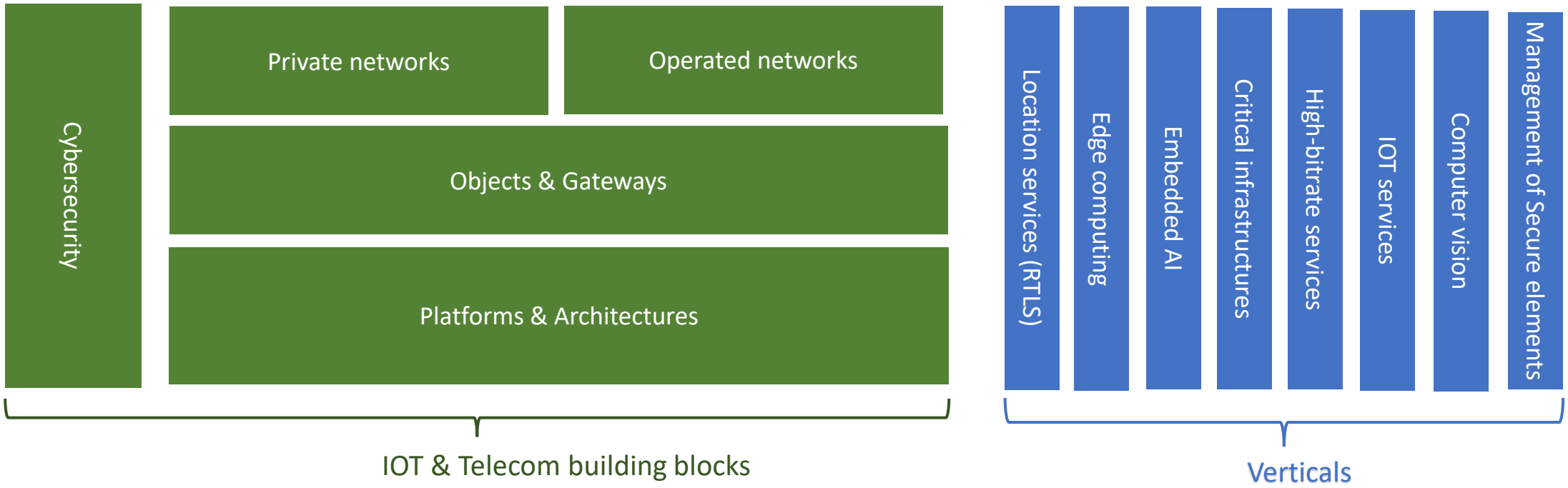
=> 20MHz in TDD Band 38 => no IOT

2x3 MHz in FDD Band 28 => NB-IoT **targeted**

Things → Networks → Collect platforms → Applications

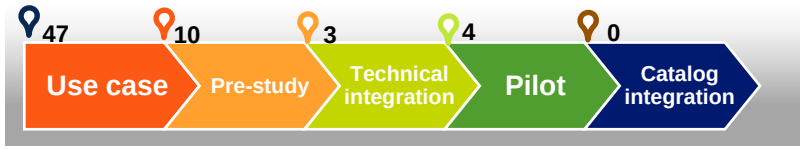
EDF

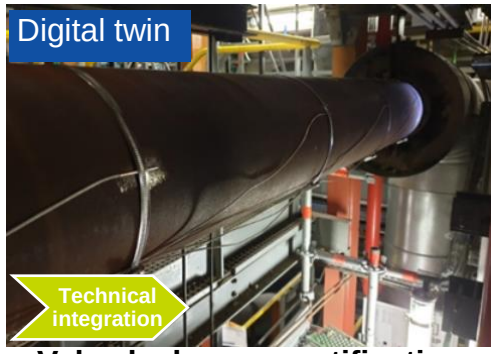
IIoT & Telecom integration: our segmentation



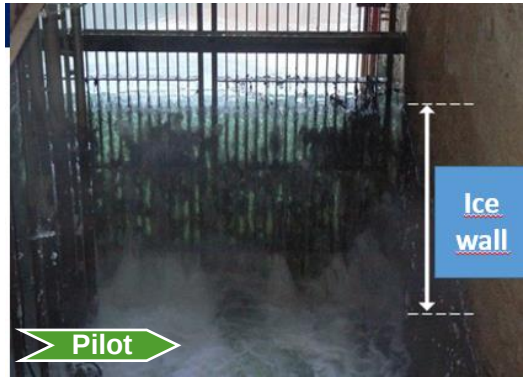
- Our IIOT infrastructure deployment strategy is to be linked with our strategies on the different verticals, in particular: Telecom & RTLS infrastructures, integration for control assistance (SL 4).

NUCLEAR IIOT: SOME USE CASES

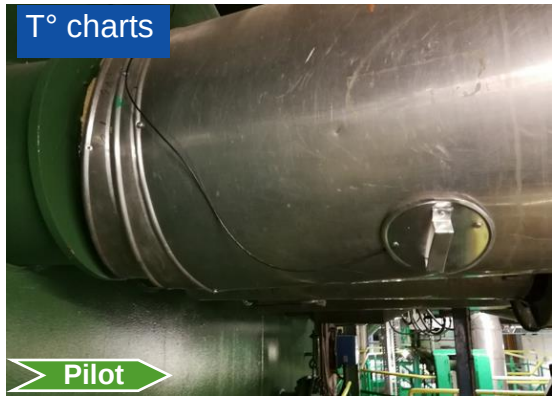




Valve leakage quantification



Frazil protection removal



Valve leakage detection

Thermic monitoring of transformers

Air quality monitoring

Max Time of Exposure in the machines hall

Transfo T° monitoring

Valves leakage detection

Use case | Pre-study | Technical integration | **Pilot** | Catalog integration

Needs:

Analyze the temperature evolution of important valves of the secondary circuit to :

- Locate yield-losses
- Optimize unit shudown maintenance by targeting the right valves

How:

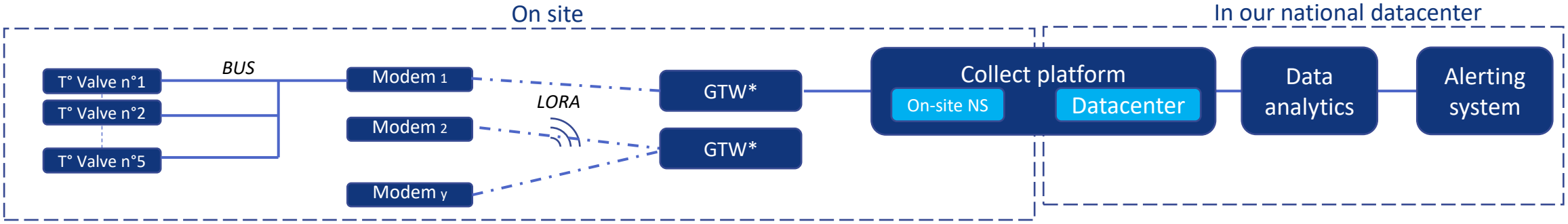
- Install 1 to 3 temperature sensor on different parts of the valve.
- Detect an asymptomatic evolution of an internal leakage by tracking anormal temperature evolutions.
- Use charts / operational guidelines for detecting leakage signatures, e.g. :

Average T° recommendation on RE valves	> 225,5°C (expected = 227°C)
RE 601 & 602 efficiency ratio: R = (TsFf-TeFf)/ (TeFc-TeFf)	>88% (expected 90%)
RE 601 & 602 efficiency ratio: R = (TsFf-TeFf)/ (TeFc-TeFf)	>86% (expected 90%)

Gains :

Yield losses optimization

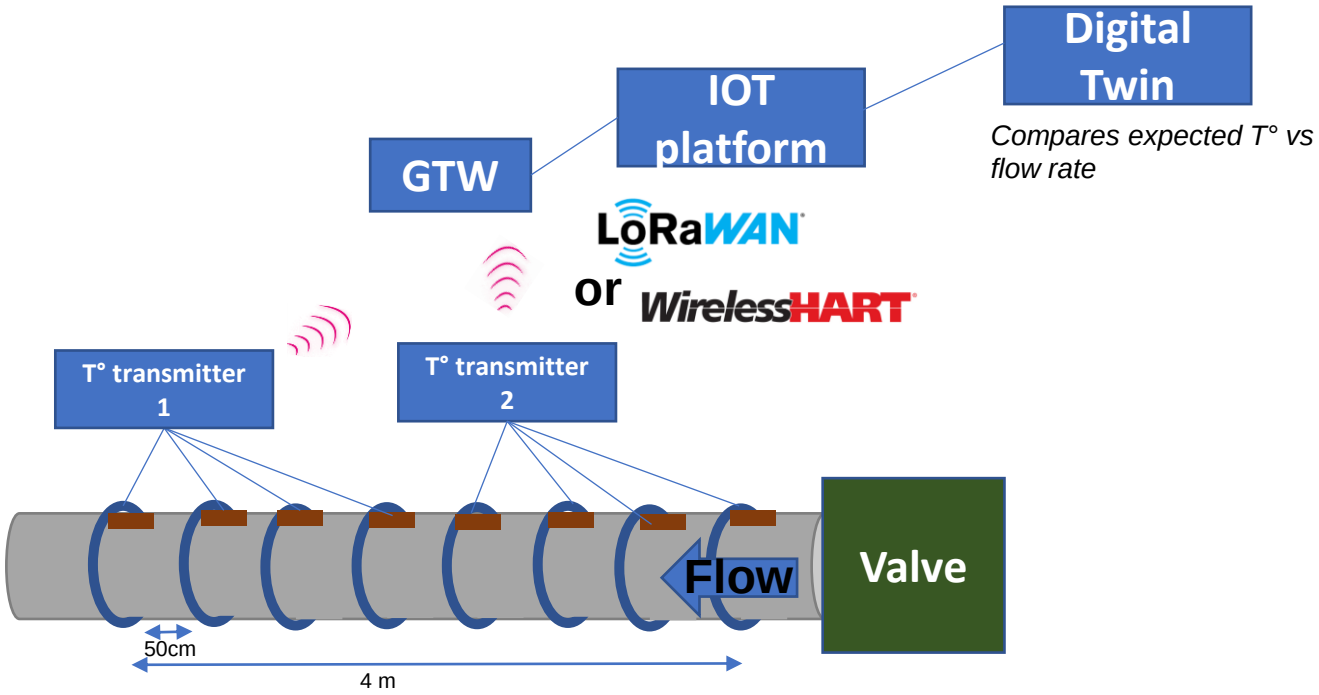
1MWh over 1 year is 350k€ at the ARENH regulated rate



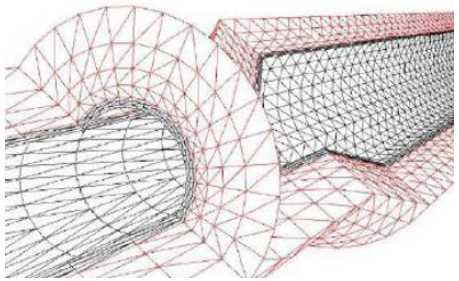
By-pass condensor valves leakage quantification

Use case | Pre-study | Technical integration | Pilot | Catalog integration

- Leakage detection is not enough to decide adequate maintenance of the internal parts of these valves.
- Leakage quantification is necessary to determine the right actions, at the right period.
- Average yield-losses due to these valves is estimated 1MW - 2MW per nuclear unit
- **Gains: minimize global yield losses by anticipating the right maintenance program / period**



Compares expected T° vs flow rate

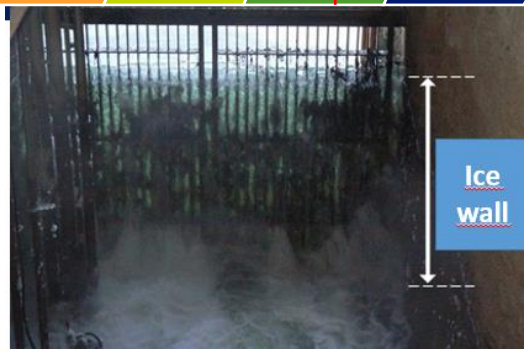


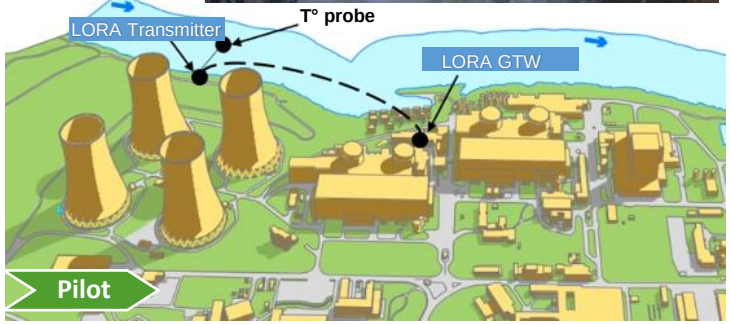
Digital twin: steel and insulating layers CFD model

Frazil protection removal assistance

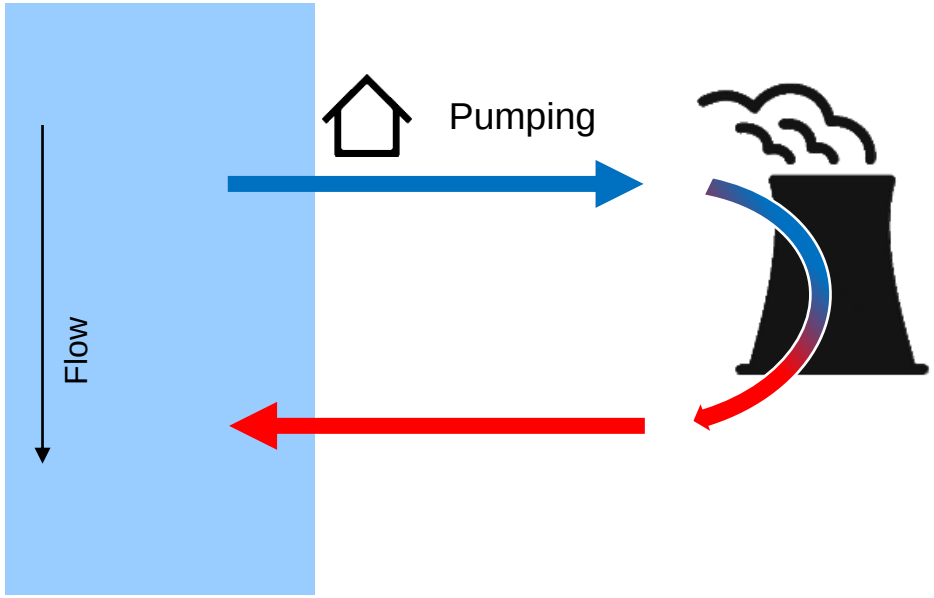
Pumping station freeze-up → Inefficient water suction to cool the secondary circuit → Core metdown

➔ **Frazil protection is required**

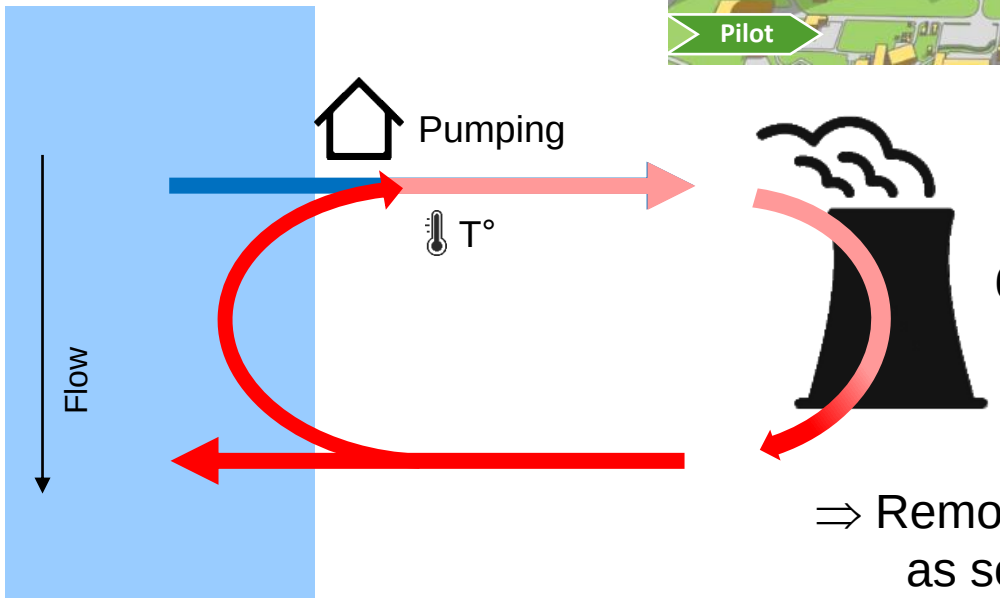




Normal operations:



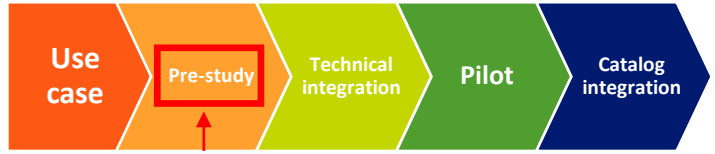
With Frazil protection:



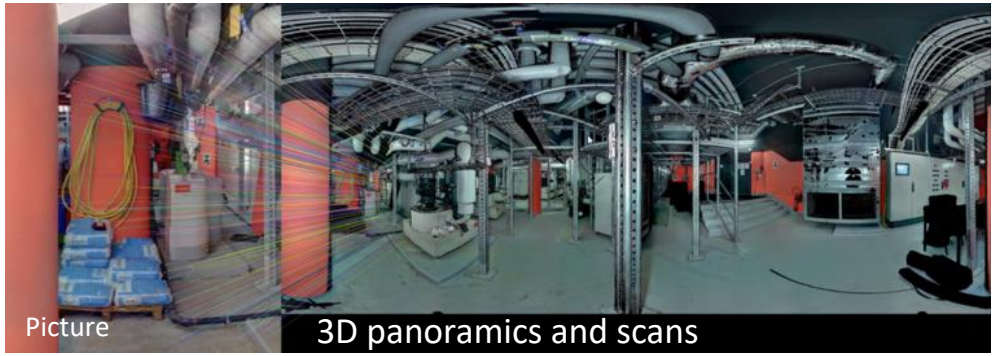
60% Reactor Power required

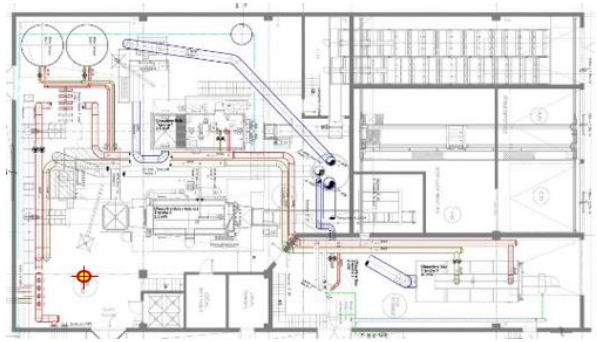
⇒ Remove the protection as soon as possible

Visual Positioning



- Radio protection (georeferencing dose & dose rate measurements) and logistics (track objects / deliveries, etc…) are key applications for RTLS systems in NPPs.
- RTLS infrastructures are expansive to deploy
- In the medium term, our 4G infrastructure is not able to provide location services for IOT objects
- EDF has scanned most of its nuclear industrial buildings
- Our investigation: using our 3D scans & panoramics to enable localization services

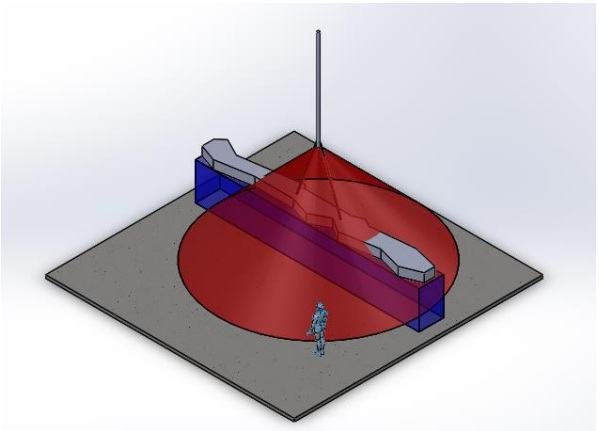


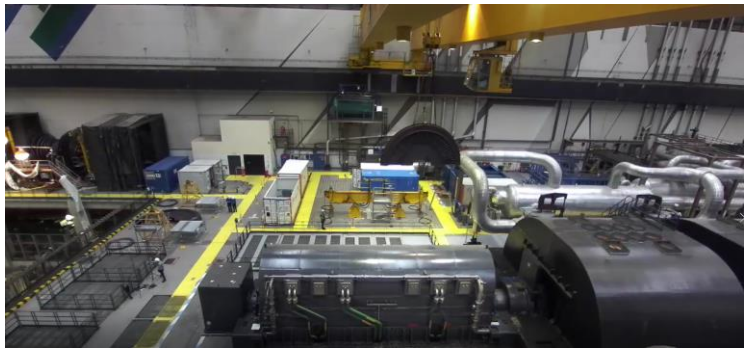


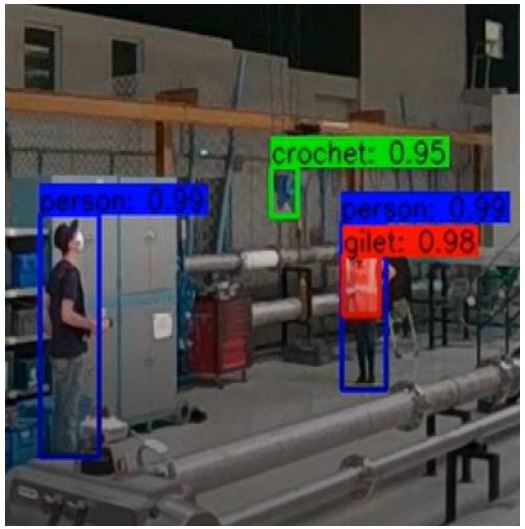
- Static service: take a picture with your smartphone and get the geo-reference in the edge
- Dynamic service: location tracking thanks to a camera on the helmet.

Alerting workers of lifting dangers

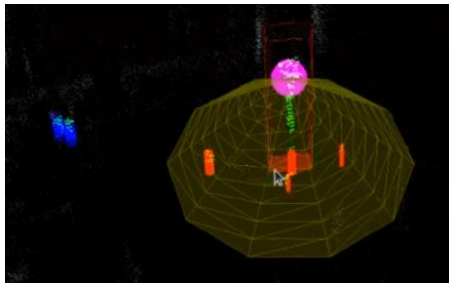
- Need: Alert workers of lifting dangers thanks to dynamic geofencing
- Two zones:
  - Red zone is forbidden to unauthorized workers
    - Radius (r) of the red zone is determined by the elevation (d) of the hook: r=d.
  - Blue zone is the ground footpring of the load: strictly forbidden to any worker.
- Workers are not supposed to wear any specific active tag.
- 4 tracking functions are necessary:
  - hook elevation
  - Ground footprint load
  - Authorized workers (wearing yellow jackets)
  - Unauthorized workers







Stereoscopic edge



Lidar edge

Our challenges & R&D investigations in IIoT

Private cellular network

eSIM : objects bootstrap / eSIM server integration cost, IOT safe applications
Multi-sites roaming
Objects localization
Open infrastructure (OpenRAN, multi-RAT), low-cost cabling

Embedded AI / edge

Multi-targets / frugal learning / trusted AI
Orchestrators of µ-services, standards for edge
Low-cost / low power computer vision

Cybersecurity

Minimize our certification work of IOT devices :

- Adopt / develop standards and guidelines (ex: BLE / NFC integration rules)
- Follow recommandations / European certifications (ex: ENISA SCCG)

Power impact of cyber protocols on cellular IOT devices: TLS/DTLS, ligthweight tunnels, etc…

Territorial IOT

Coverage / regulation: QOS IOT, 450MHz, satellite

Massive IIoT & standardization

Plug & Play provisioning (QR Code based)
Secure local device access for

- *Object configuration & sensor calibration*
- *Offline updates of the objects*

Standardized integration of cellular IoT
Need for an alliance!

Standardizing offline secure device access: