

IoT in tunnels

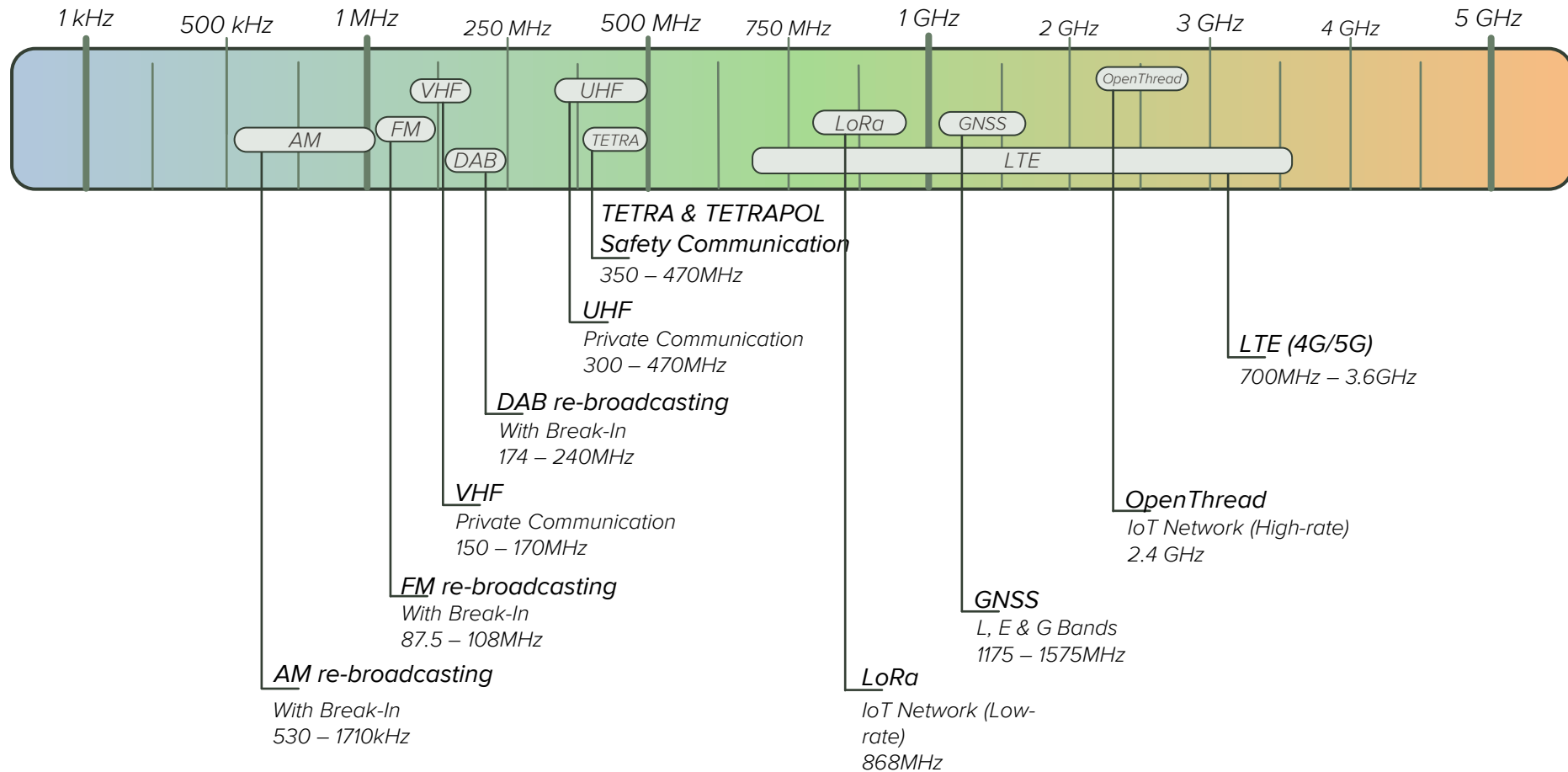
*State-of-the-art
& future vision*

smart tunnel in a smart world®

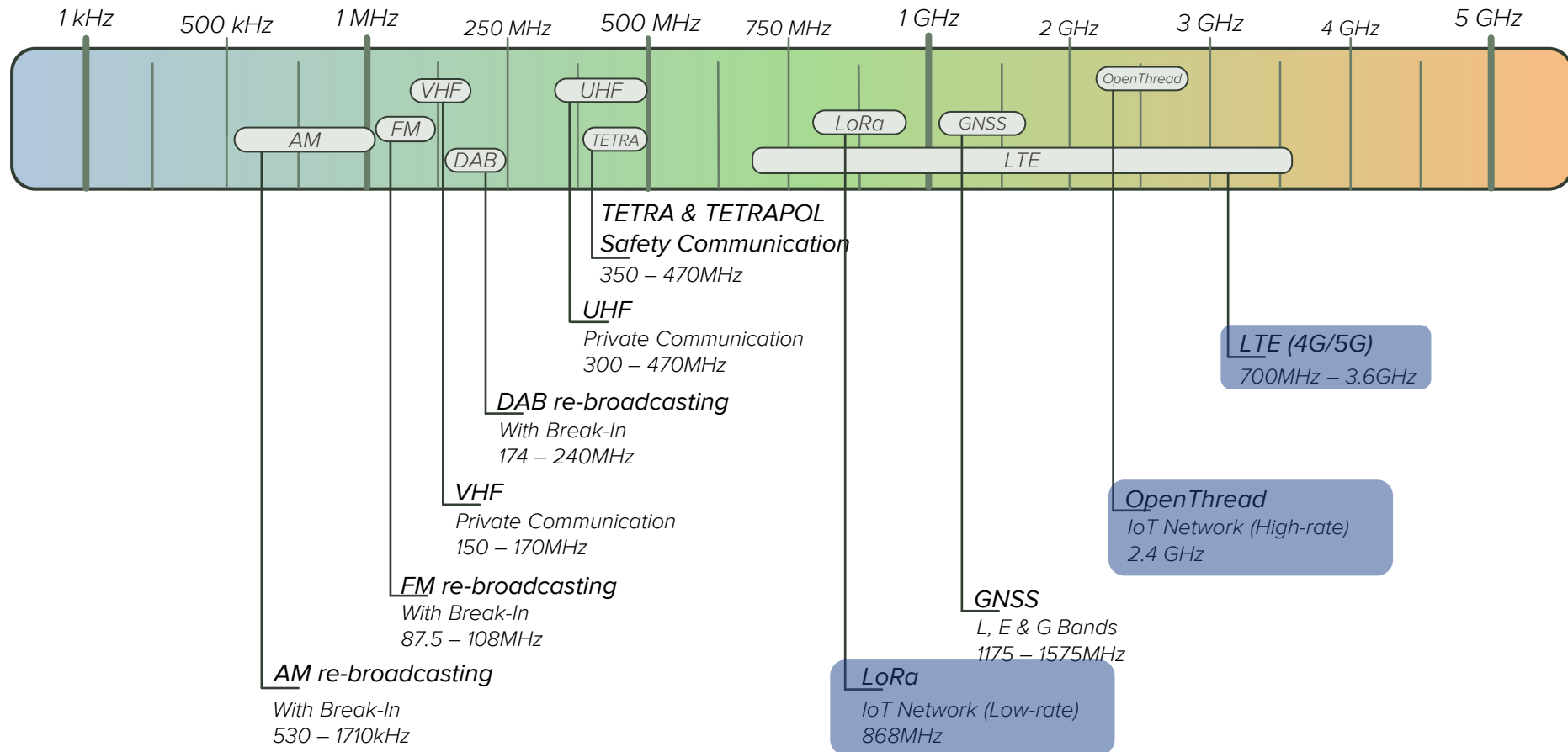
see
Telecom

Connecting to life

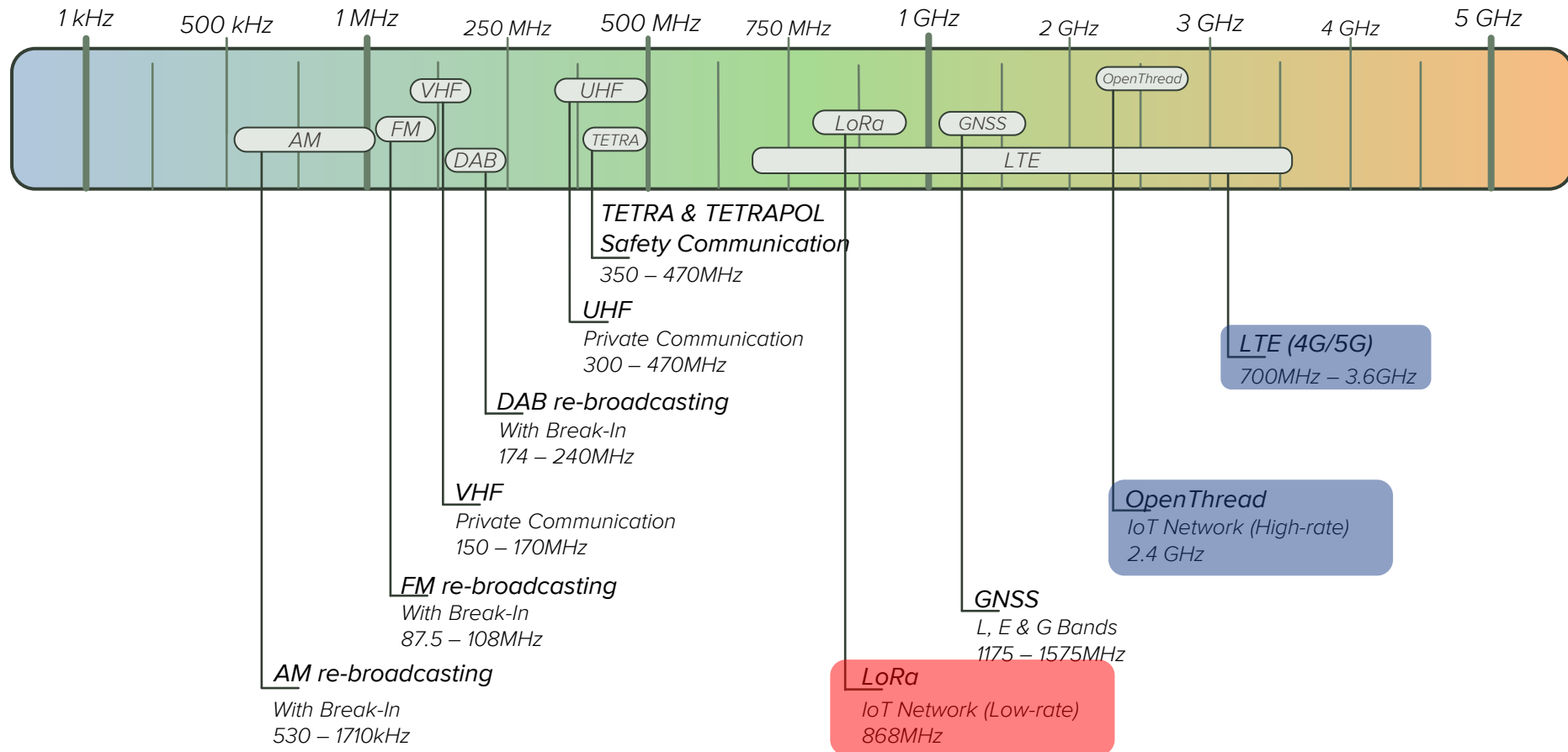
Frequency plan inside a tunnel



Frequency plan inside a tunnel



Frequency plan inside a tunnel



Wireless Infrastructure

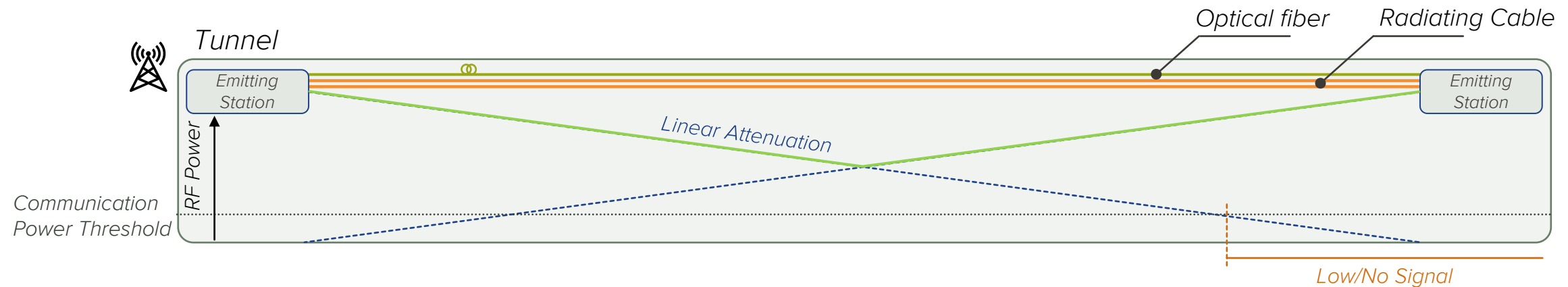
Radiating Cables delivers a wideband signal across their entire span.



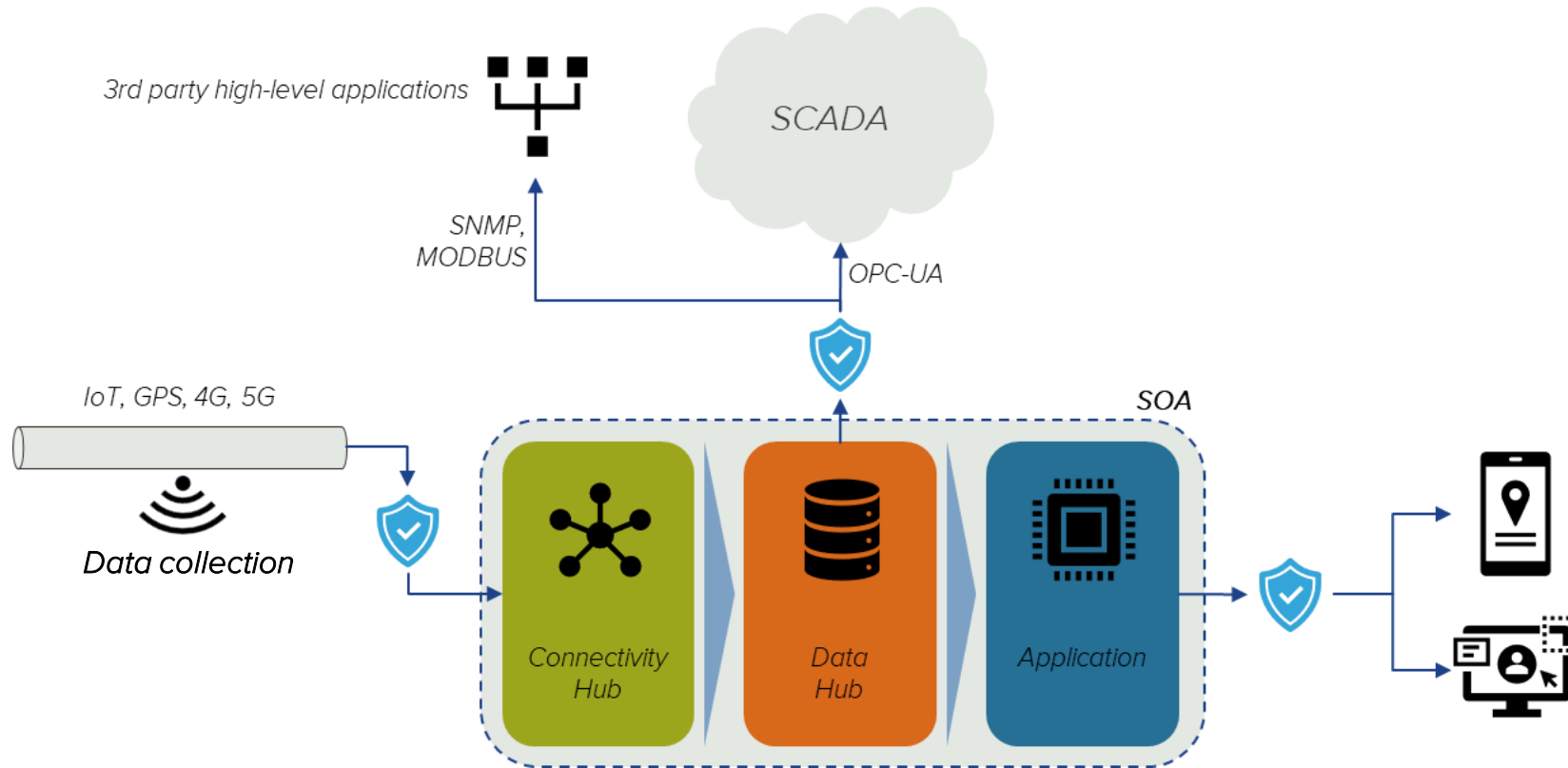
Characteristics

- Frequencies: 3kHz up to 3.5GHz depending on cable type
- Connectors: 50 Ω
- MIMO: 1x2 & 2x2

Propagation in Tunnel



Data collection



Cybersecurity EU Rules

Tunnels and metros are classified as *critical infrastructures*.

Their *economic and social functions* is such *essential* that they must be *protected* from disruption by *natural disasters* or *man-made threats* (e.g. *terrorism, cyberattacks, disinformation, hostile foreign control*).

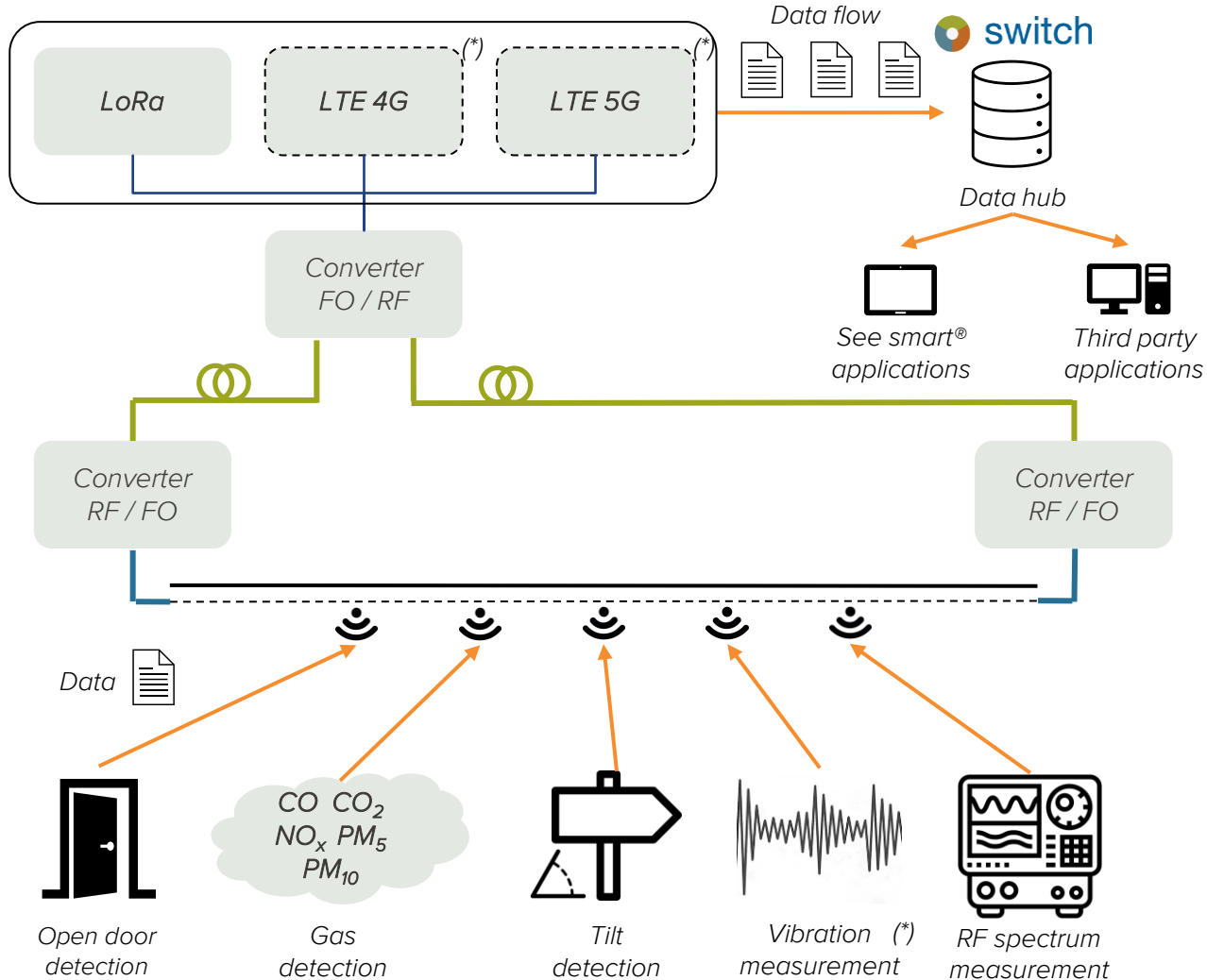
Mandatory compliancy with **the rules of the European Union** to guarantee **maximum security** in systems and software :

- RED - Radio Equipment Directive: ETSI EN 303 645 & EN IEC 62443-4-2
- NIS2 - Network Information Security
- CRA - Cyber Resilience Act
- CSA - Cyber Security Act



IOT IN TUNNELS

IoT introduces wireless data collection inside tunnels



Data for maintenance and safety

- Private digital radio network adapted for data are deployed inside the tunnel : LoRa for low-rate data, and LTE 4G/5G for high-rate data.
- Base stations are installed in the master stations, and RF signals are mixed with all other radio signals broadcasted in the tunnel and transported through optical fiber up to slave station and radiated by the leaky feeder in all the infrastructure.
- Wireless sensors are deployed in the tunnel, dedicated to specific use cases (see above).
- Collected data are stored in a generic semantic in our see smart® SWITCH
- Data are available in see smart® applications, or delivered to 3rd party applications
- Roadmap : processing data with AI and introducing predictive maintenance

Use cases

- Dry contact detector : open doors detection, extinguisher position, etc...
- Gas detector : CO, CO₂, NO_x, fine particles to monitor atmospheric conditions
- Tilt detector : detection of damaged safety elements (ex: bent panel)
- Vibration measurement : continuous control of jet fans (analysis made by fan manufacturer to detect defaults)
- RF spectrum measurement : control of RF inputs / outputs of the system
- And more to deploy with operators to solve their operational problems

(*) Available in 2023

Vibration Analysis

Predictive Maintenance of fans and pumps inside tunnels

– Benefits :

- Reduce health and safety incidents and prevention of unexpected failures for critical assets

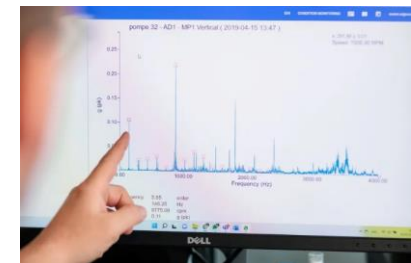
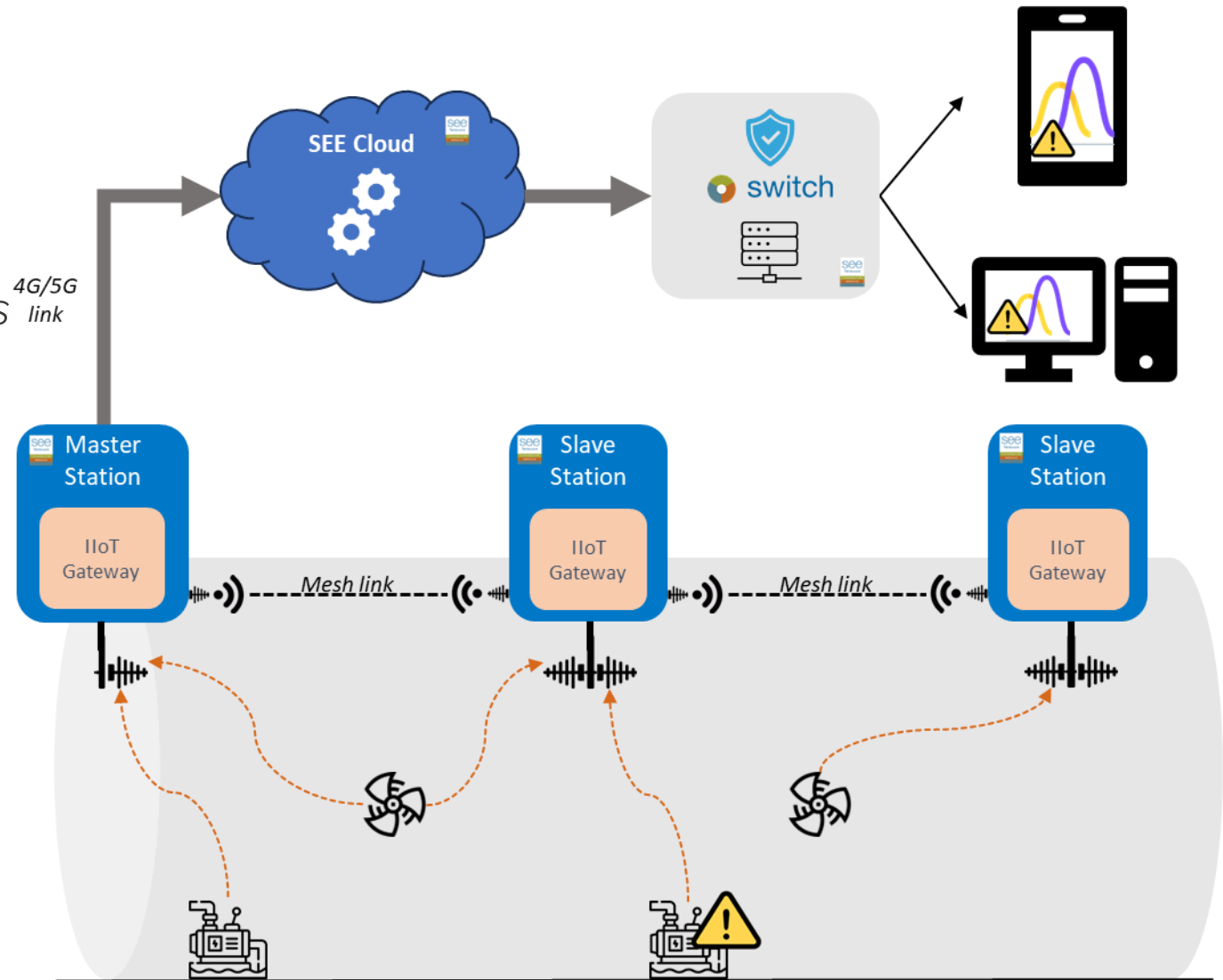
- Optimize maintenance operations

– Features :

- Improved asset health monitoring

- Vibration analysis to diagnose issues before failure

- IA for 80% of cases, and 20% of machine learning by human confirmation



Example of graphic measurement





Copenhagen Sydhavn Metro Project



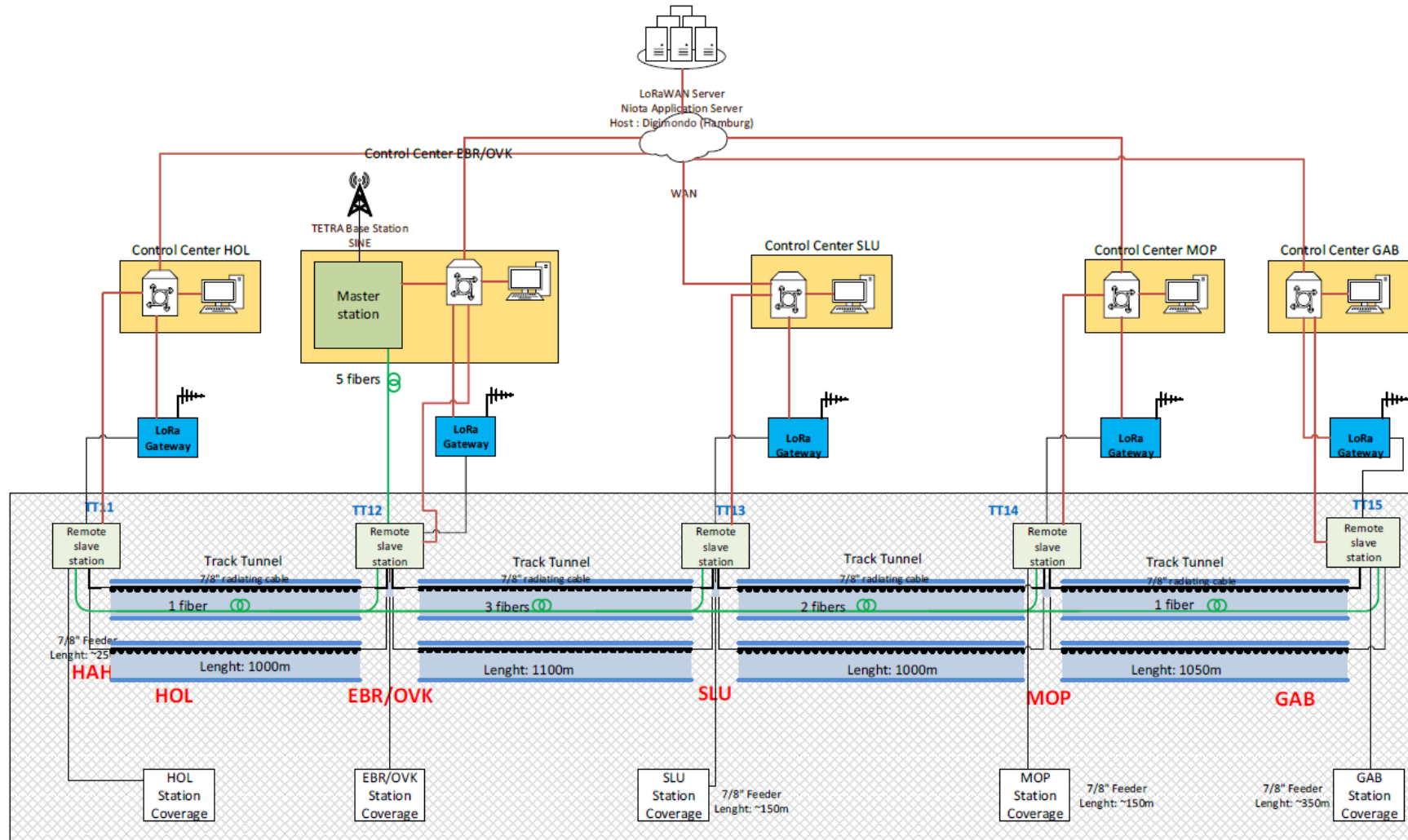
Tunnel Boring Environment

IoT Alertbox deployed for accidents and fire alerts

- *2 x 4.5 km length*
- *5 stations*
- *Danish national safety network TETRA SINE*
- *Private IoT network on LoRa protocol*
- *Single radio infrastructure*
- *Single web interface visible through dashboard on PC, tablet and smartphone to monitor in real time*

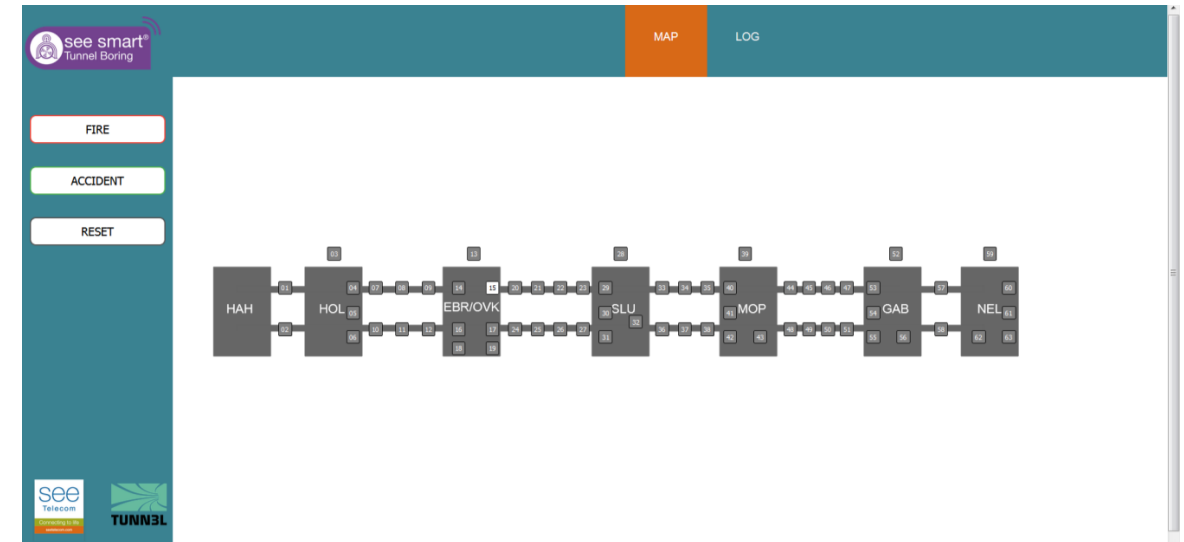
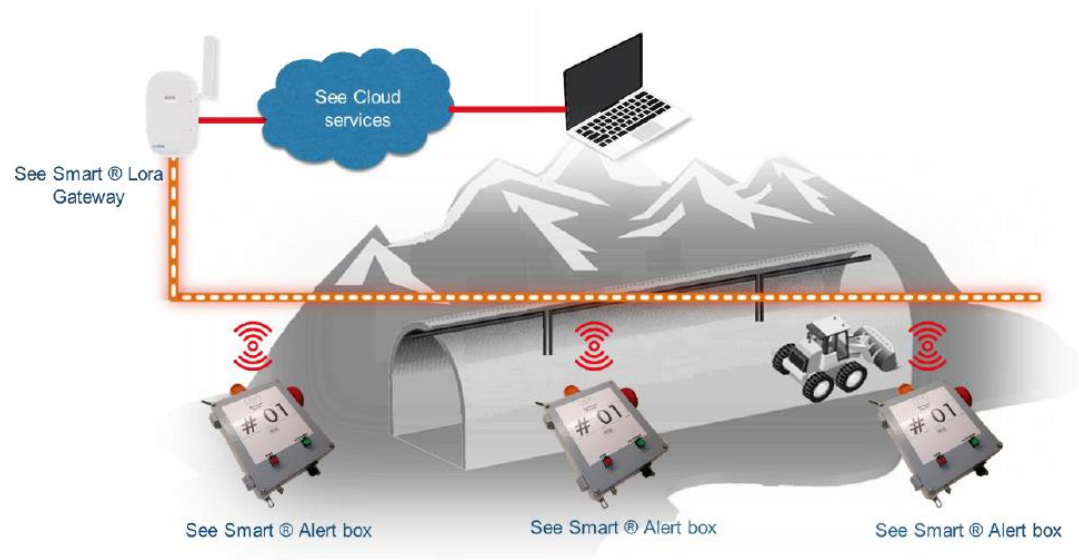


Sydhavn Metro Project - 1



Sydhavn Metro Project - 2

- Alert Boxes installed everywhere in the tunnel in construction
 - ➔ easy to install, to remove, just a plug needed
- One dashboard available on laptop, smartphone, tablet



TETRA (SINE) and IoT LoRa for Safety System

Future of IoT in tunnels

Femern tunnel



- *First project to request an IoT network*
- *Opening : 2029*

GEIE Mont-Blanc / Monte-Bianco



- *Project for IoT network expected in the next years*

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THANK YOU !

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