



# EuroTube and the requirements of the hyperloop network

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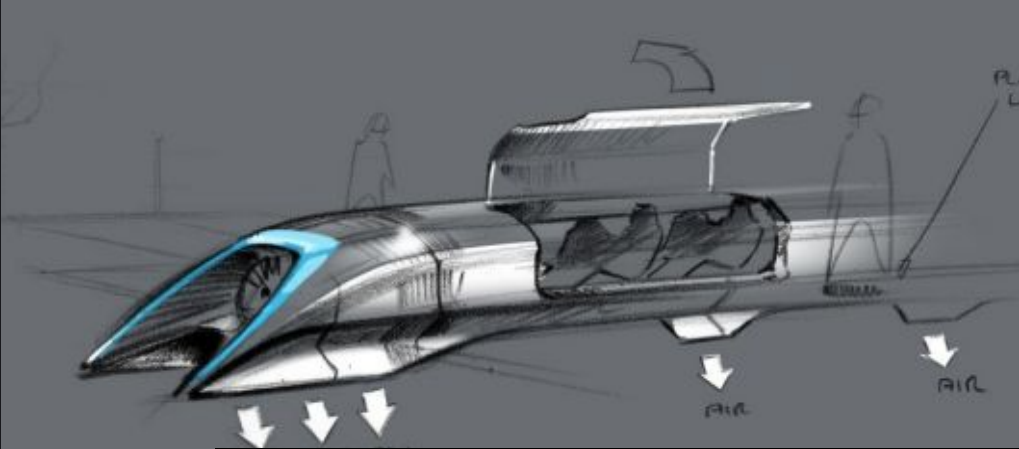


# Why hyperloop?

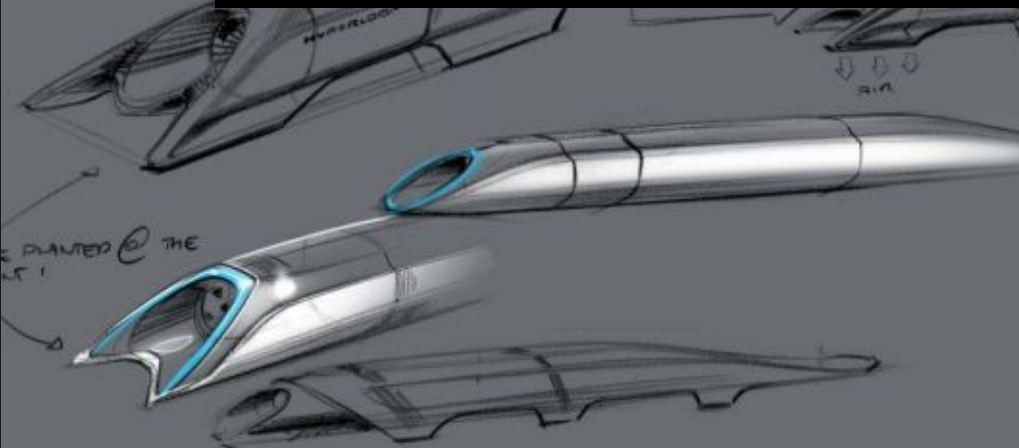


A 1980's Swiss idea?





2013's dream vs. today's reality



# Our vision

 a new means of long-distance transport

- Ultra-high-speed mobility - safer, more cost-efficient and more reliable
- Technologies that drastically reduce the negative impact on the environment

## Tube Infrastructure

A tube with ~Ø 5 m can be built over- or under-ground

## Partial Vacuum

Reduced air resistance enables high speeds of up to 1000 km/h (> 100 km routes)

## Vehicle

Offers space for 70 -200 passengers and can depart every few minutes

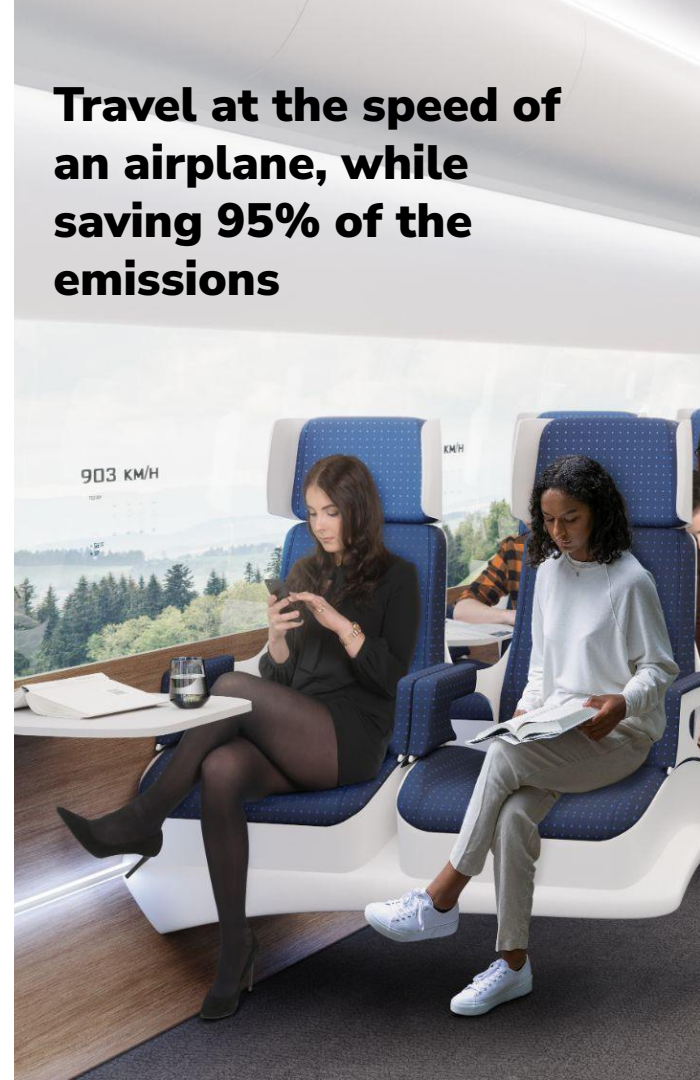
## Maglev

Low-wear high-efficiency maglev technologies allow for a smooth ride

**Commute with the convenience  
of public transport**



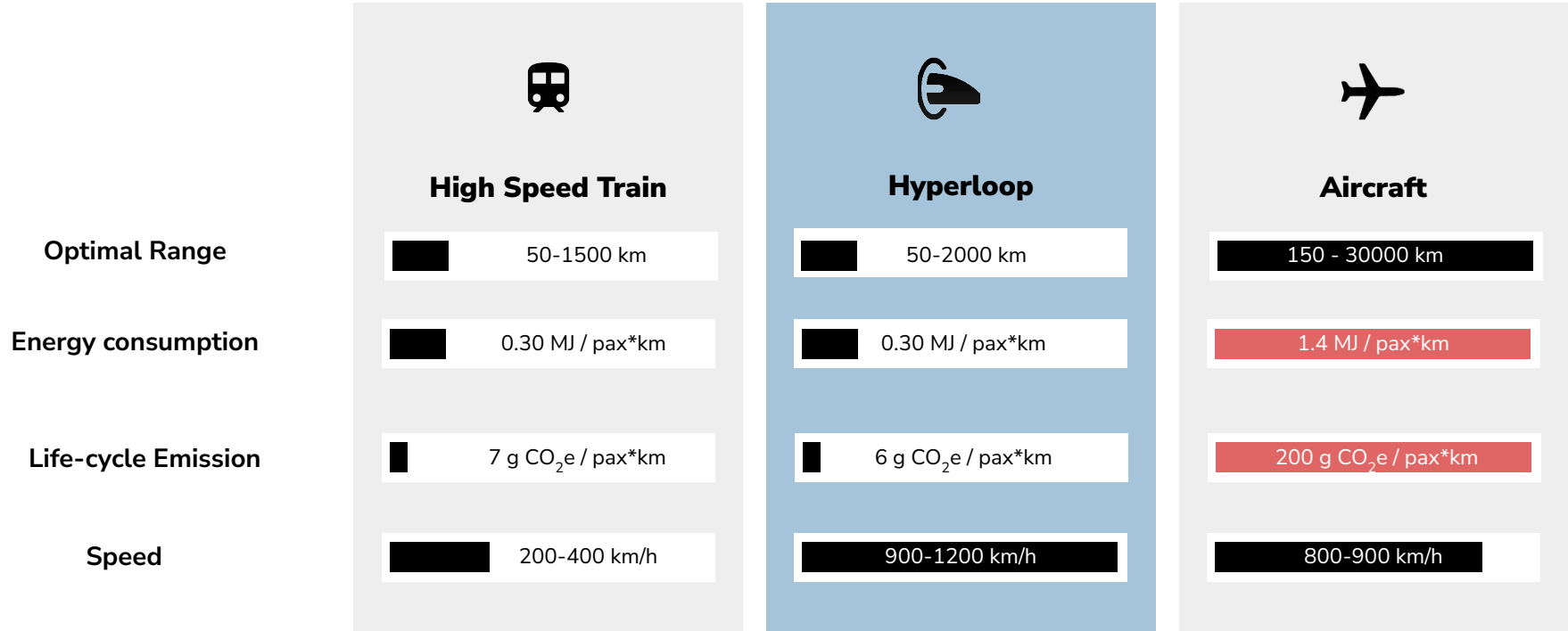
**Travel at the speed of  
an airplane, while  
saving 95% of the  
emissions**







# Between an airplane and a high-speed train - the hyperloop forte



# The EuroTube Foundation

# Development of Hyperloop



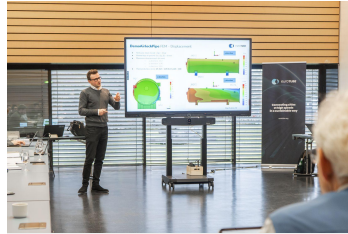
2017

**EuroTube Foundation** founded at ETHZ and EPFL and supported by SBB and the canton of Valais.



2020

**Recognition by the Confederation** as a research institution of national importance. Start-up funding of CHF 6 million for the ERI period 2021-2024.



2022

**DemoTube Project**  
>50 industrial partners for components. Technical design finalised .

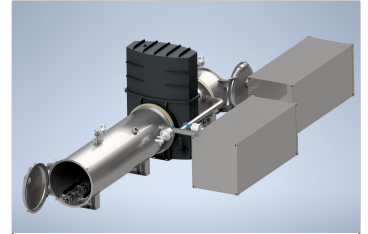
**TwinTube launch**  
First two digital modeling studies with authorities on hyperloop



2023

**DemoTube construction permit** issued for two possible building plots in Dübendorf.

**Completion of FOT-study**  
Third study finalised by the end of Q3 2023

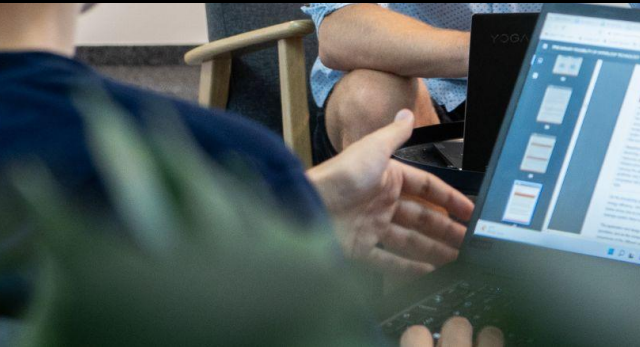


2024

**DemoTube**  
Construction and inauguration



# Research and Development





# Industry collaborations



A perspective view of a long, empty tunnel. The tunnel has a corrugated metal or concrete lining. In the center, there are two sets of tracks with overhead power lines. The lighting is dim, with some bright spots on the right side. A small white sign with the number '254' is visible on the left wall.

# Building infrastructure

# DemoTube Complete platform for hyperloop



- Half scale, 2.5 m diameter, 120 m length
- Direct development and testing of new technologies and processes
- Modular construction system
- Structural optimization (steel, concrete)
- Proof of concept, validation of components to demonstrate scalability for AlphaTube.



## DemoTube Facts

Location: Dübendorf, ZH Switzerland  
Length: 120 m

# AlphaTube Research centre and high-speed test track

## Launch Hub

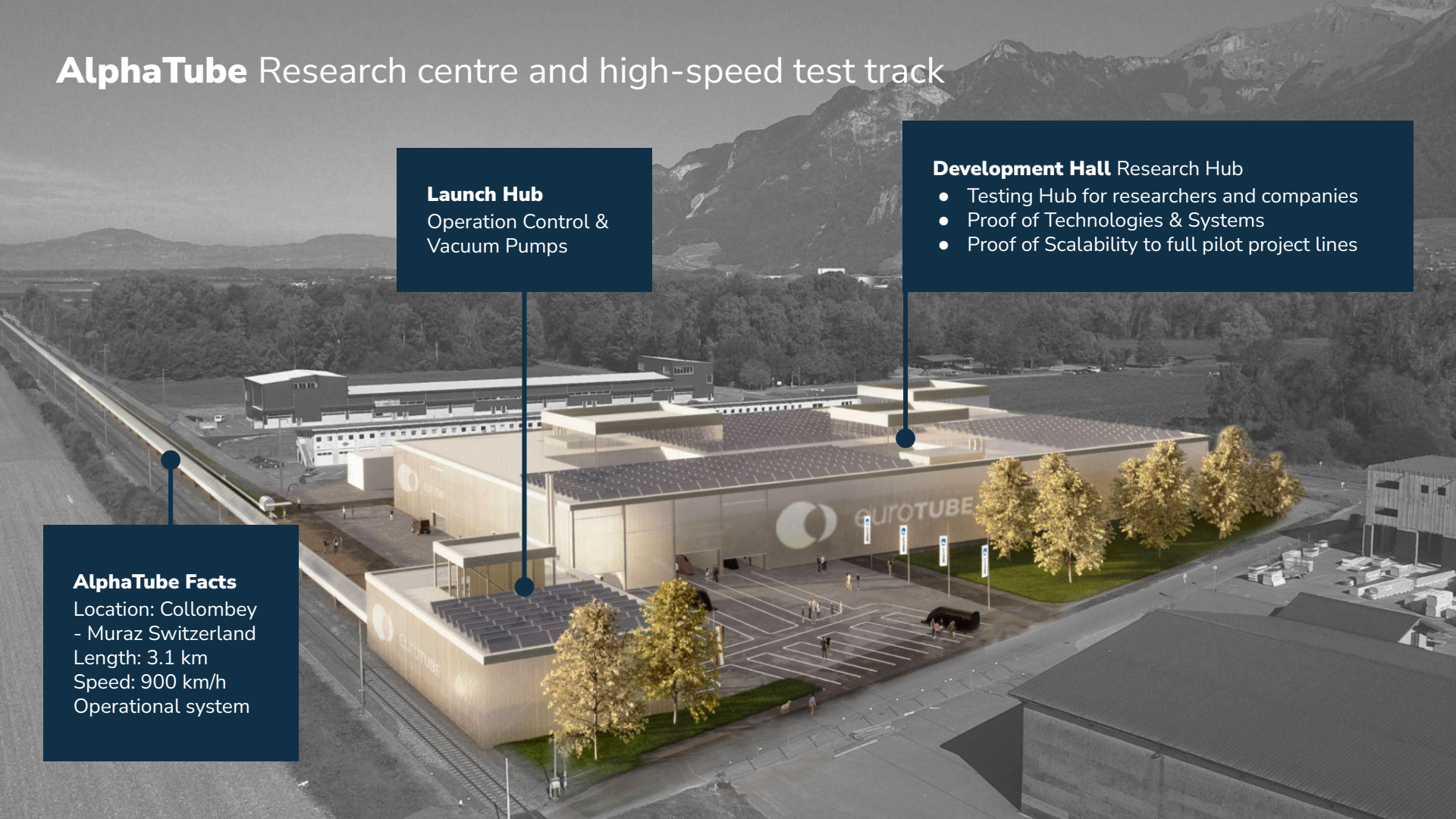
Operation Control &  
Vacuum Pumps

## Development Hall Research Hub

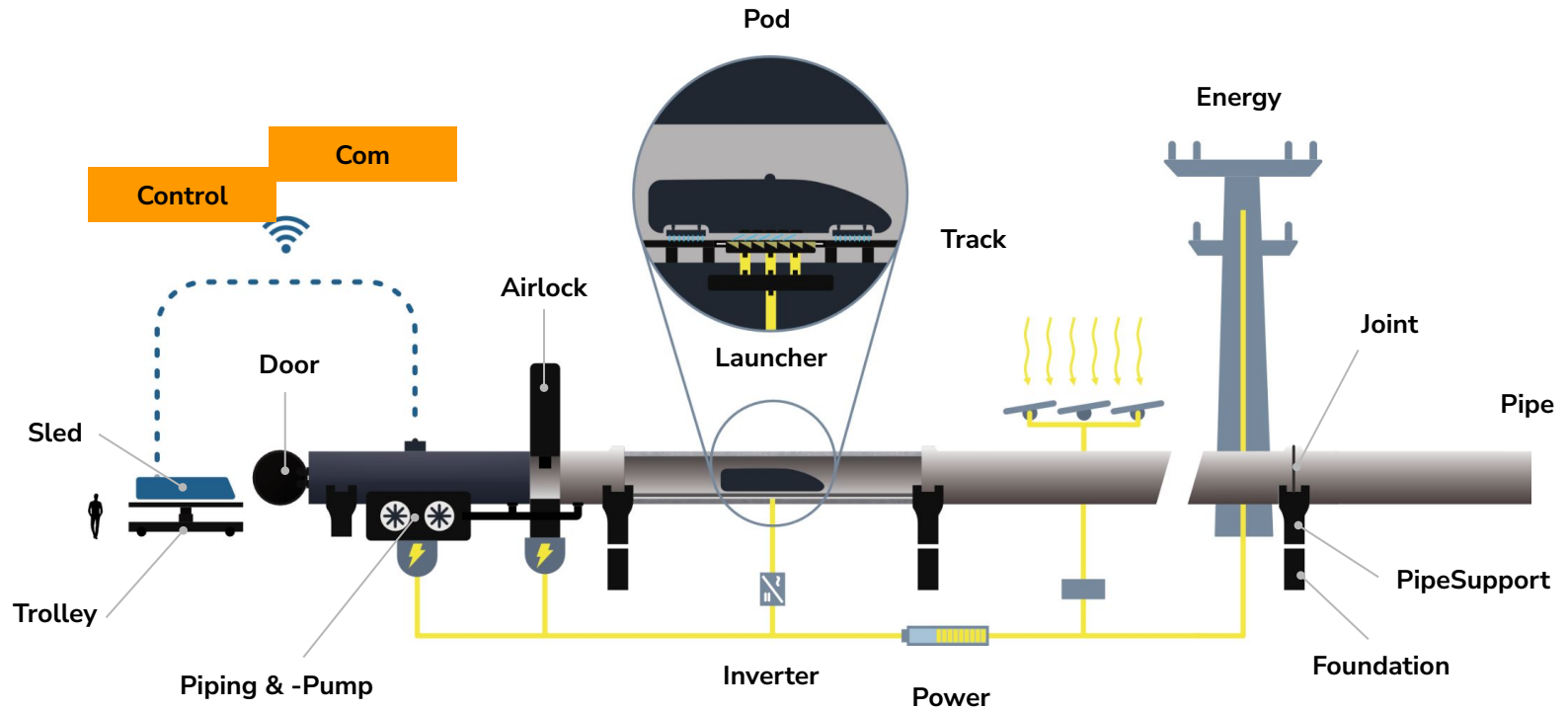
- Testing Hub for researchers and companies
- Proof of Technologies & Systems
- Proof of Scalability to full pilot project lines

## AlphaTube Facts

Location: Collombey  
- Muraz Switzerland  
Length: 3.1 km  
Speed: 900 km/h  
Operational system







# Infrastructure investment put into perspective

## 2050 European budget



<sup>(1)</sup>G20 Current forecasted infrastructure investments and needs (<https://outlook.gihub.org/>)

<sup>(2)</sup>Hyperloop Development Program (2021) joint study of all major European Hyperloop players





Jungfrauoch Railway - 1896  
Highest railway in Europe (3500 m), mostly tunnels

# 120 years apart, same challenges



St. Gotthard Base Tunnel - 2016  
Longest and deepest tunnel in the world (57 km, 2.5 km)

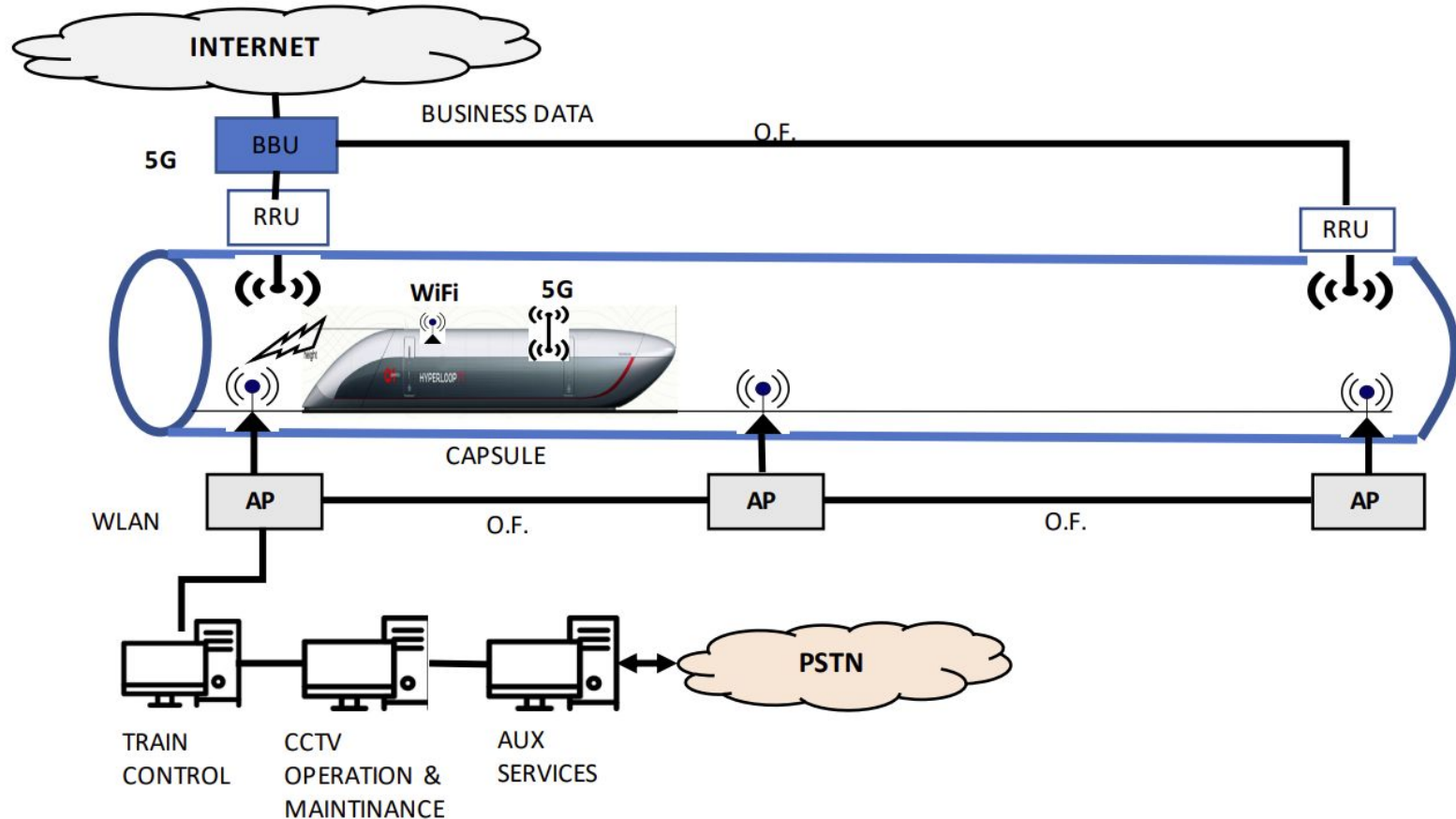
## Control centers

Key:  
do not lose any key  
information “at any time”

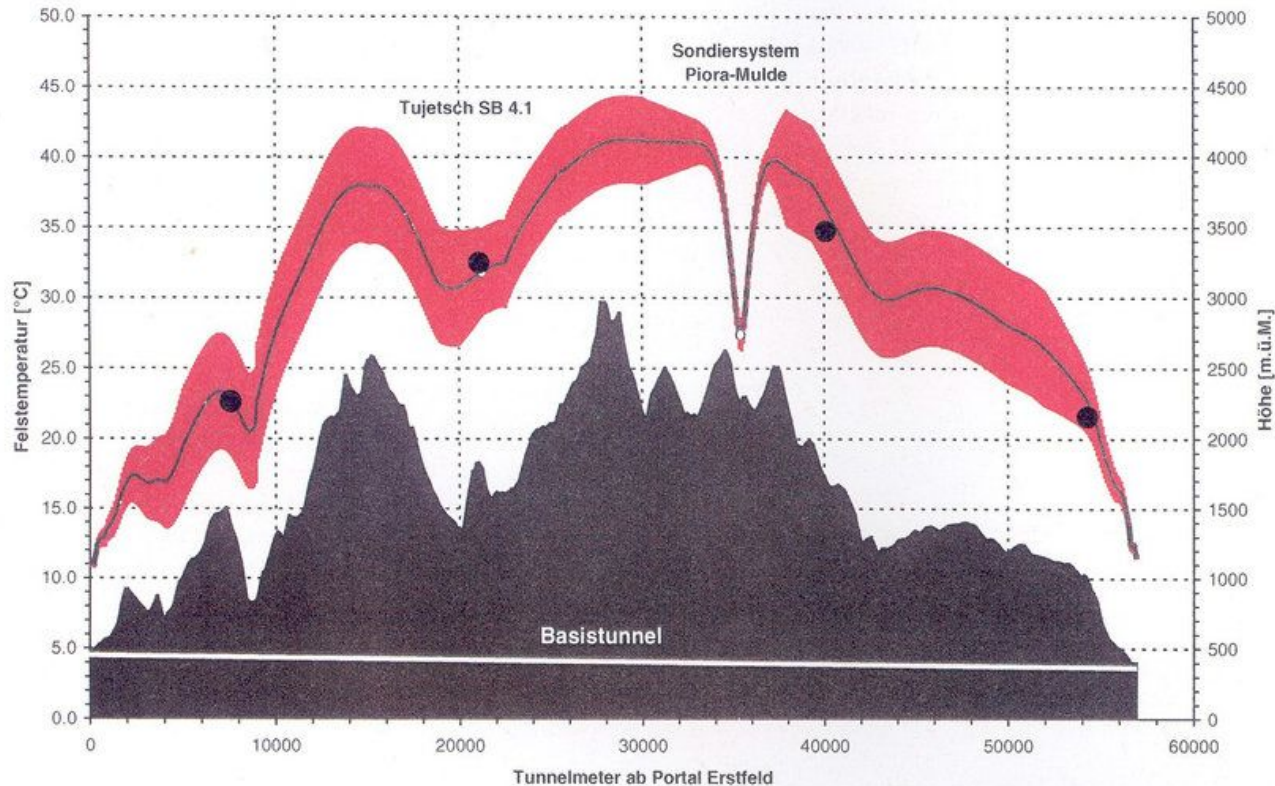


# Communication Challenges

# Distributed antenna systems (DAS) for communication in hyperloop



**Harsh conditions:** dust, heavy machinery, hot/cold and very humid, difficult to characterize



**Vacuum conditions:** not accessible (remote monitoring) and dedicated cooling solutions





Ensure reliability: 1 mishap = 100+ million €



## 2040 Bandwidth Requirement: ~500 MB/h/user -> 100 - 200 Mbps per vehicle

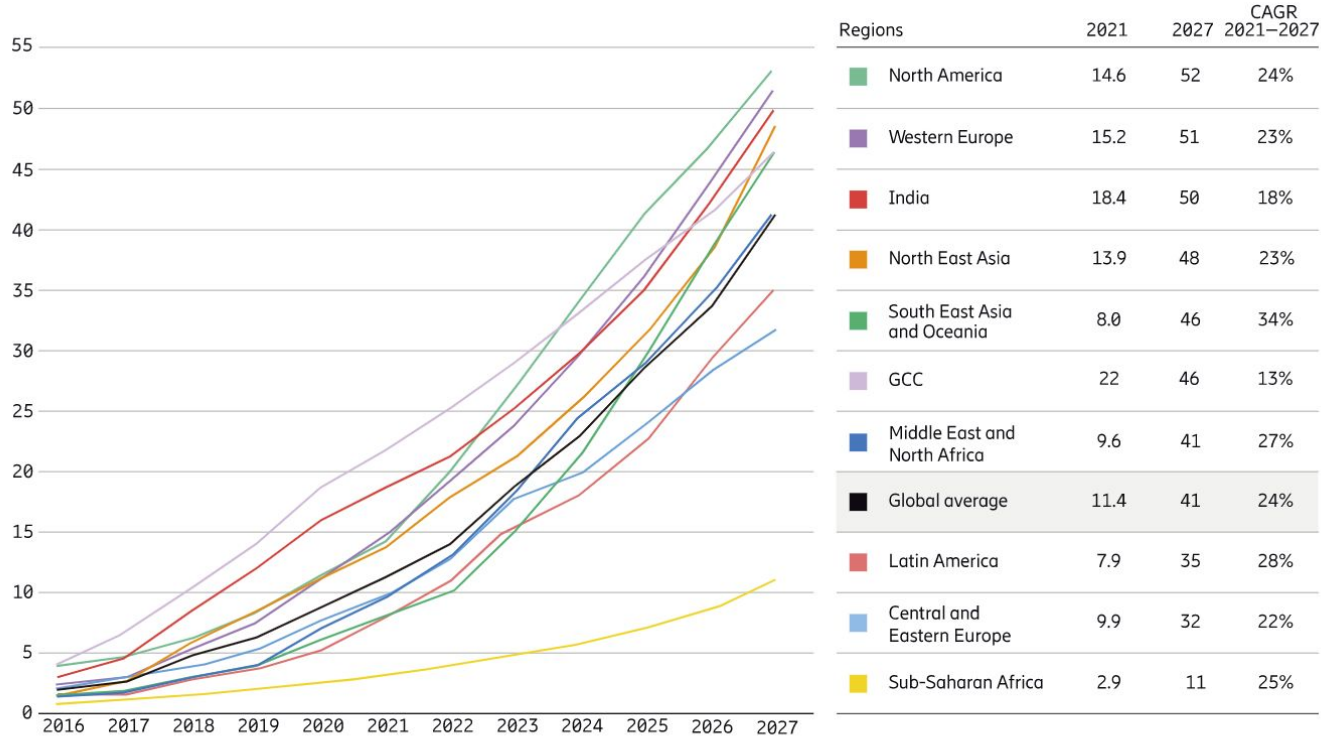
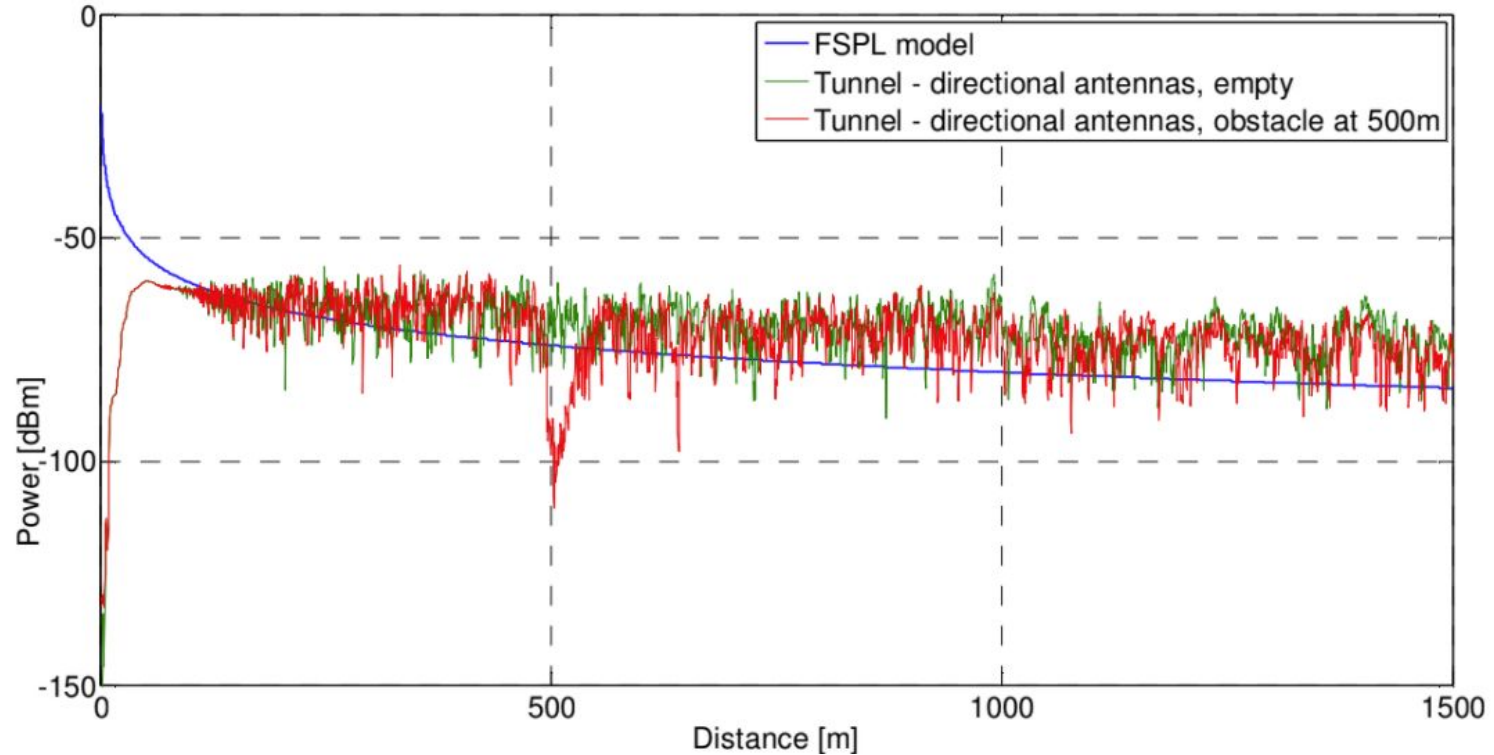


Figure 19: Mobile data traffic per smartphone (GB per month)

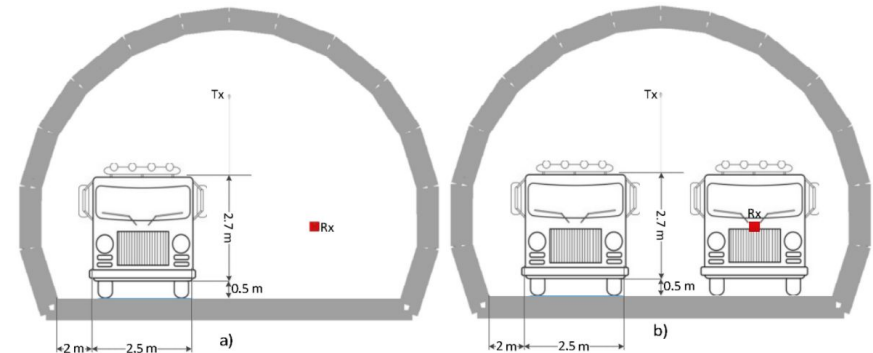
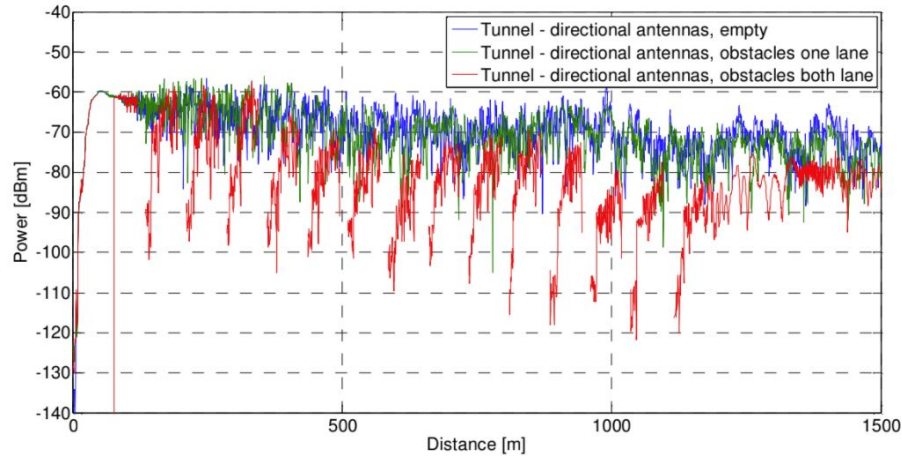
Source: Ericsson Mobility Report

## Attenuation of signal in tunnel: near zone vs. far zone



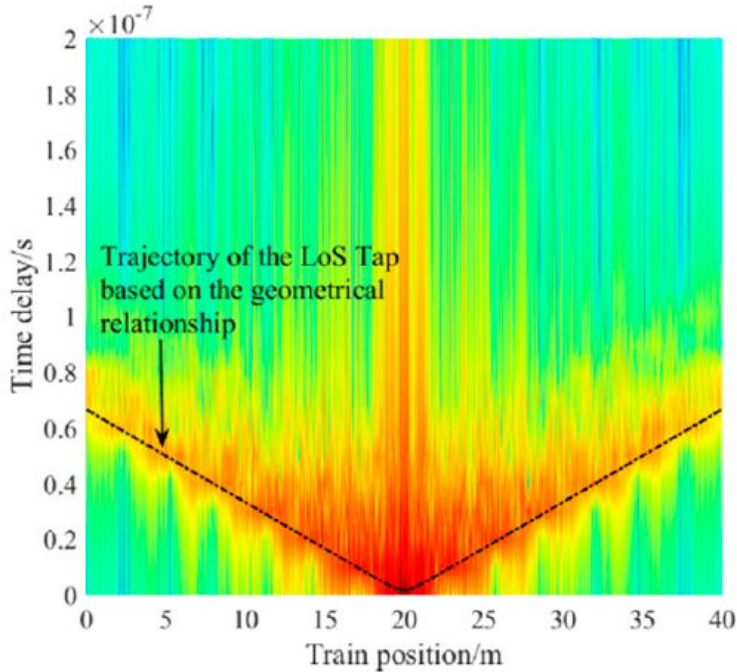
## Small tunnels: vehicle blocking line of sight

Important also for maintaining communication alive between access points and emergency vehicles

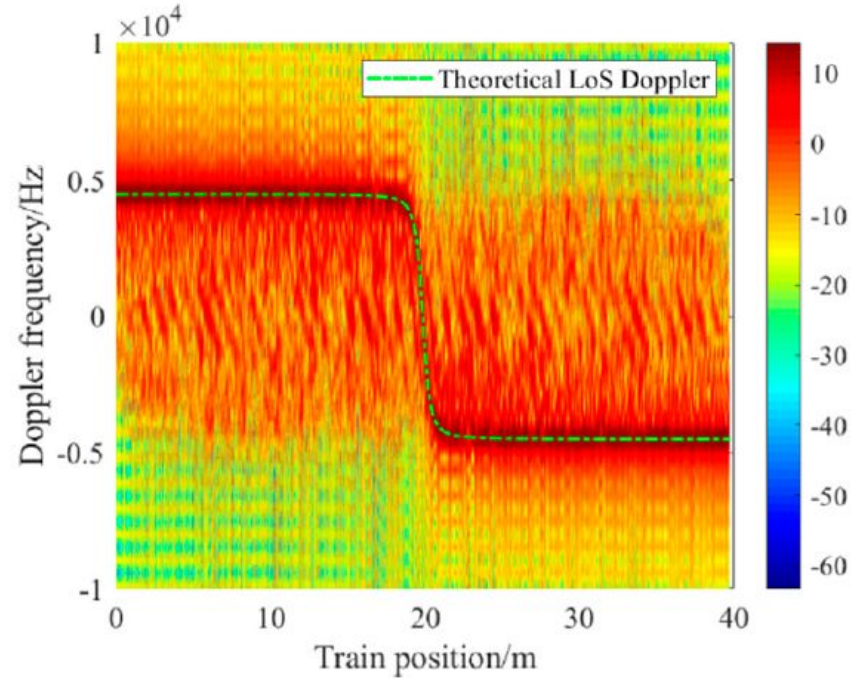


## Doppler shift

Images from: J. Zhang et al. (2020) Concepts on Train-to-Ground Wireless Communication System for Hyperloop



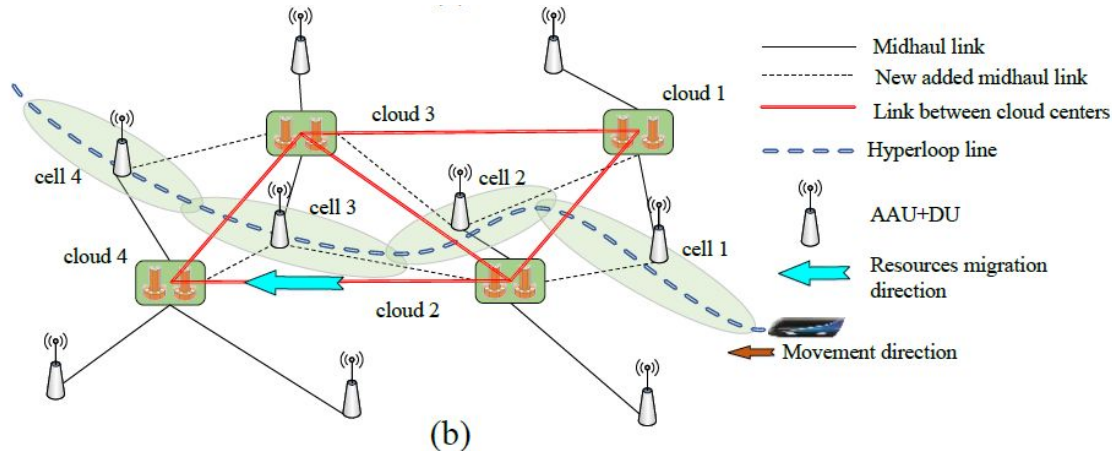
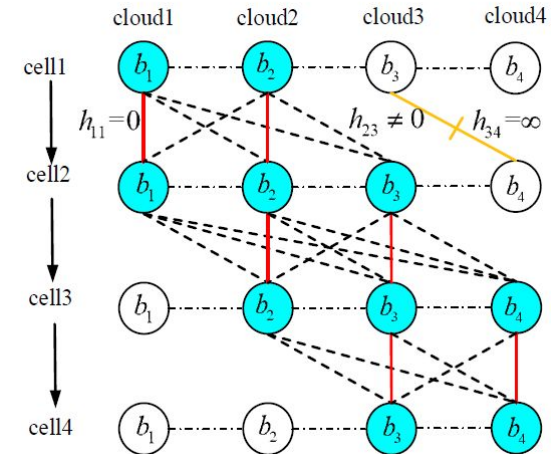
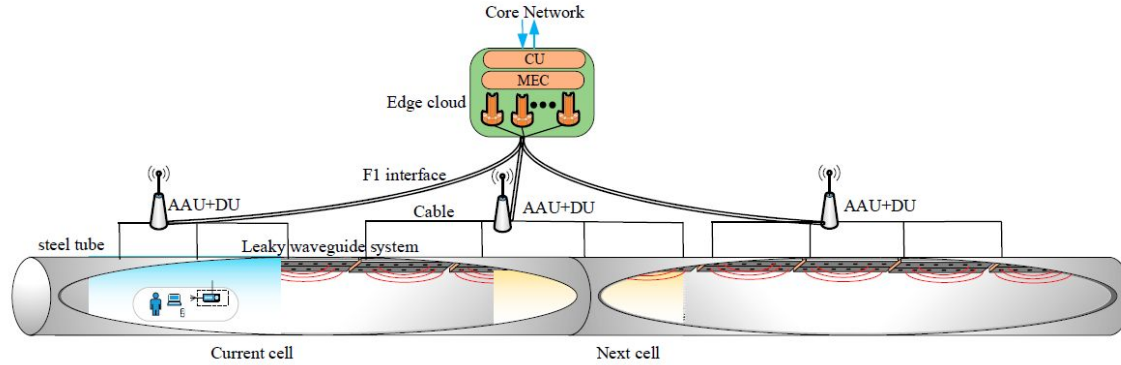
(a)



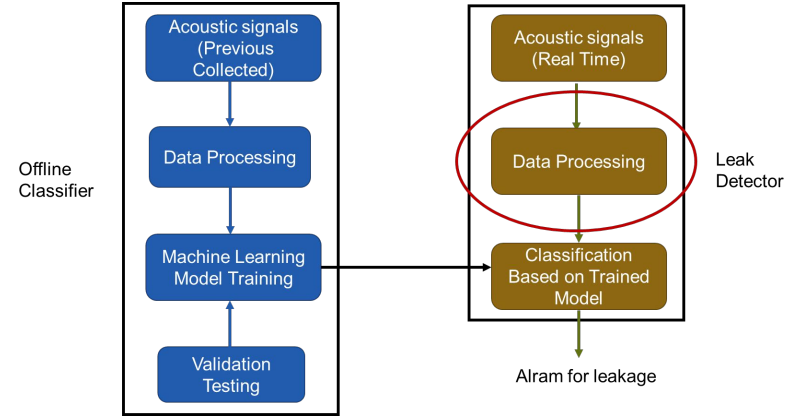
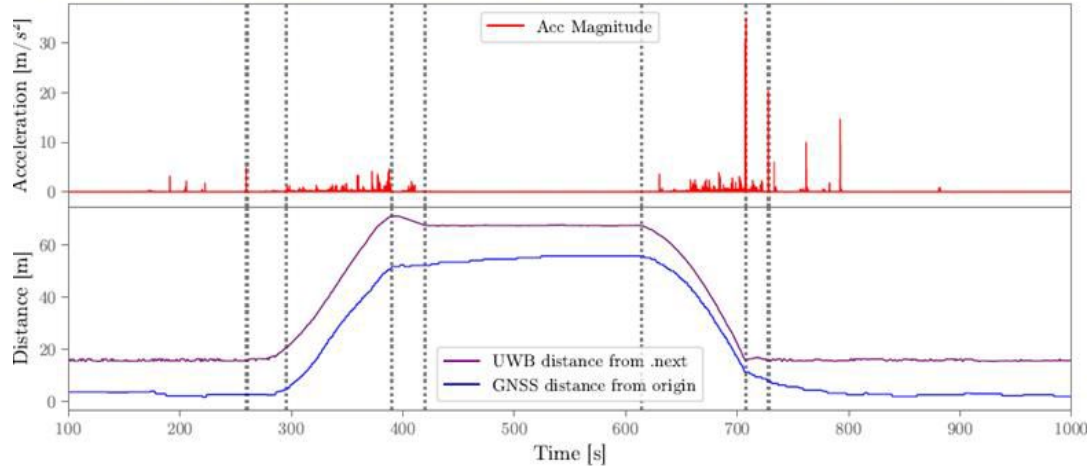
(b)

**Figure 2.** Wireless channel analysis results of the DAS: (a) the normalized CIR; (b) the Doppler power spectrums at different positions.

# Solutions: Handovers and graph optimization for uRLLC

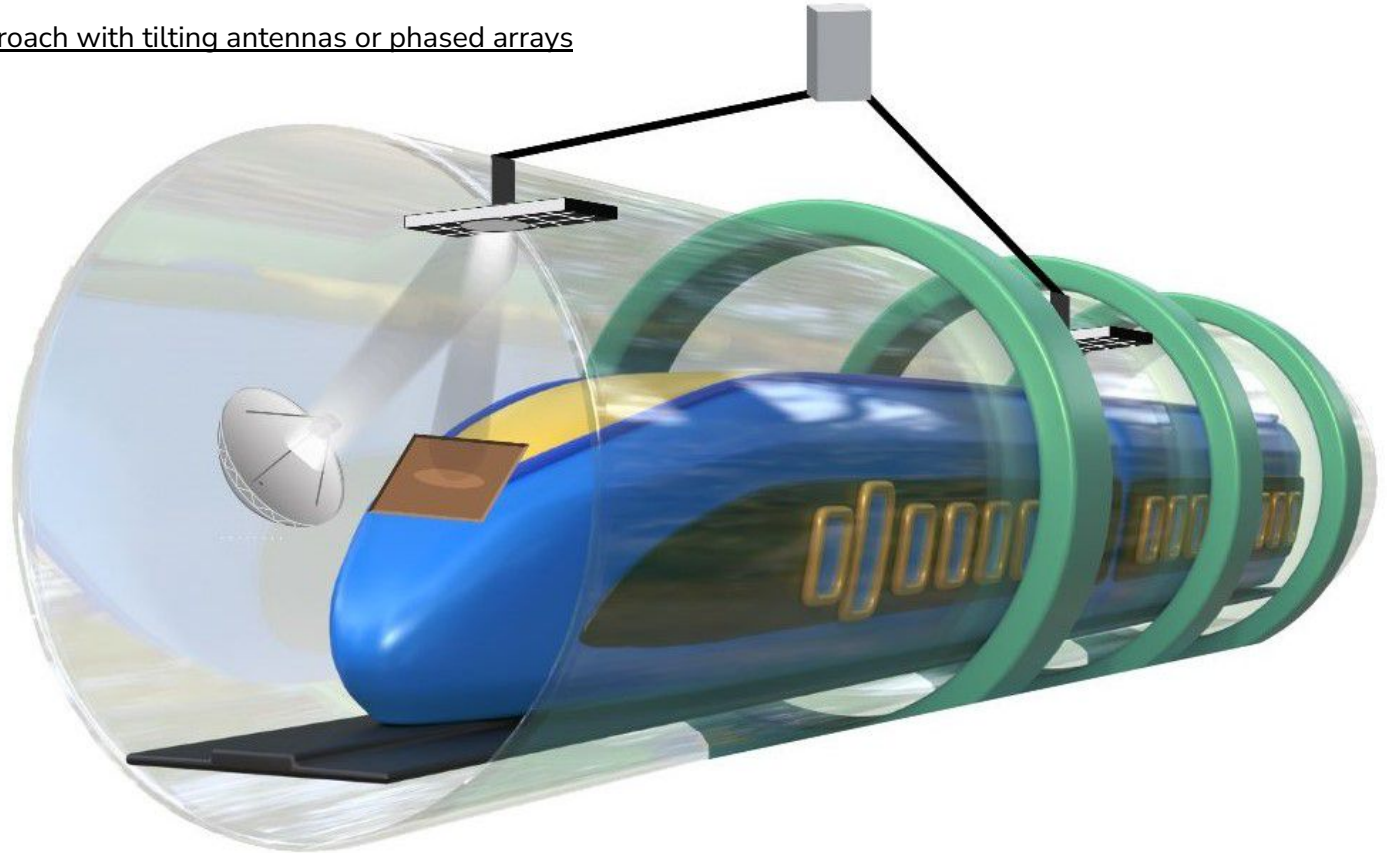


# Solutions: ML and edge computing on IIoT



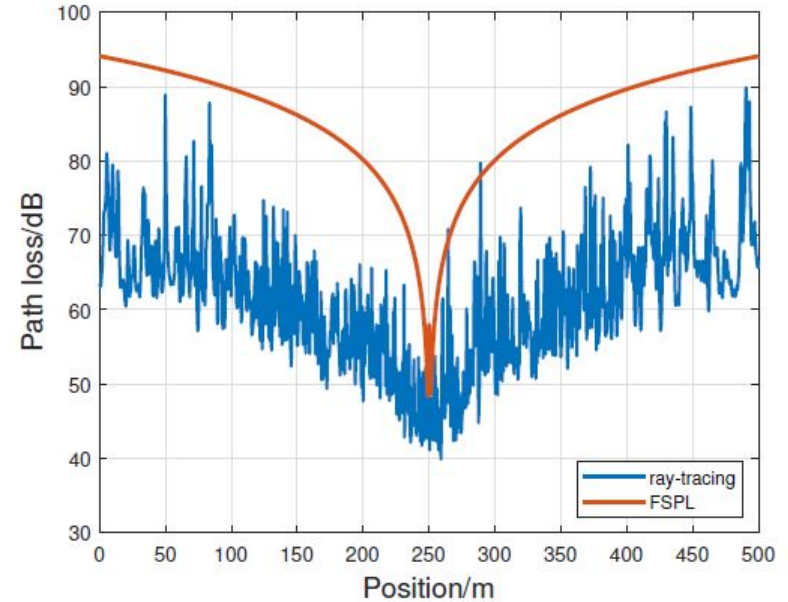
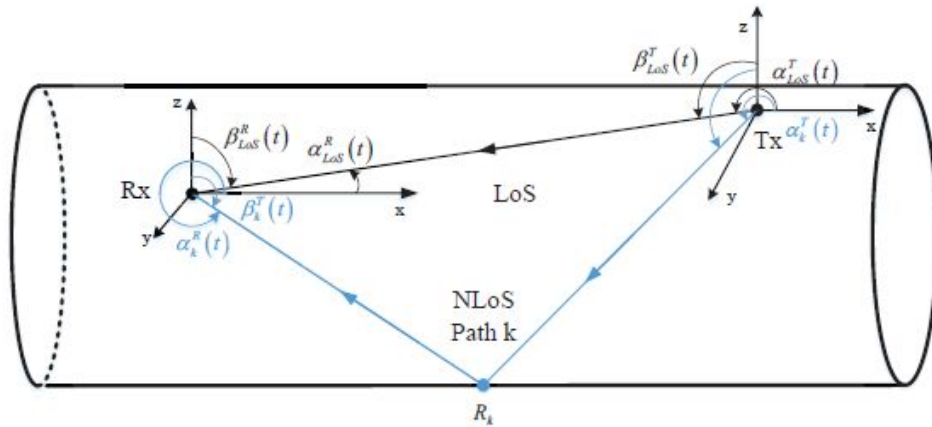
## Reconfigurable Intelligent Surfaces (RIS) Improve directional communication

Important: Simplify the approach with tilting antennas or phased arrays





# Ray tracing to reduce path losses and improve multipath issues



1. Hyperloop communication system is peculiar to its speed and its environment  
→ it cannot be 100% derived from the previous ones
2. The communication system is key for safety and real time control  
→ we need a “smarter” infrastructure
3. New wifi protocols as well as 6G or innovative communication systems are really needed  
→ throughput, quality of service and reliability are crucial
4. Discussions, ideas and collaboration initiatives are welcome! There is still so much to do!

Our research group thanks you for your attention & interest



EuroTube: connecting cities at high-speeds in a sustainable way