



# High-Speed Mobile Communications in Hostile Environments

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Okinawa

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# Introduction

Increasing demand for indoor wireless networks



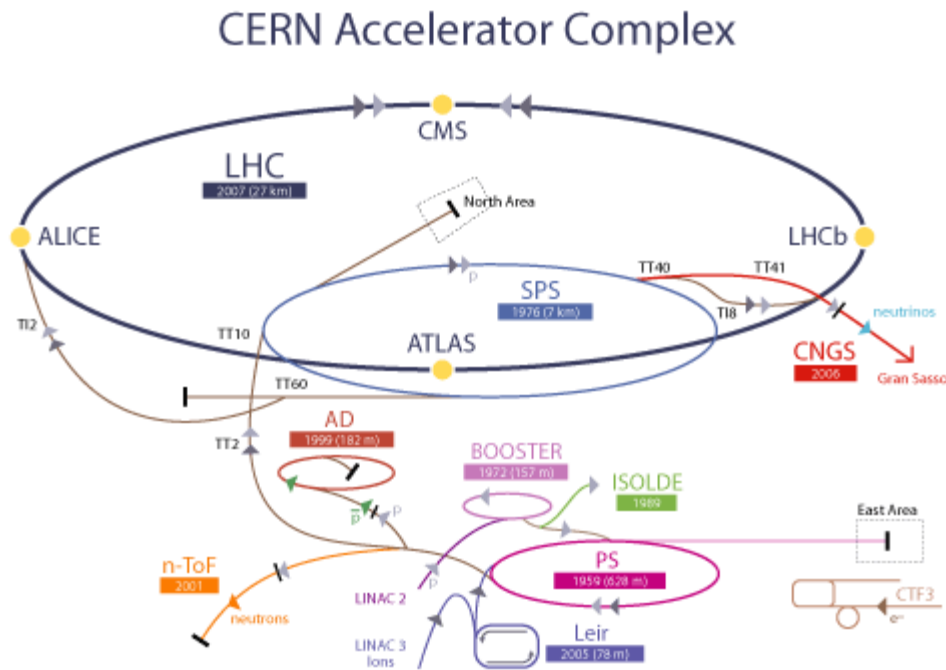
- Homes
- Offices
- Trains
- Meeting points

Hostile environments

- CERN underground

# CERN needs

## Target



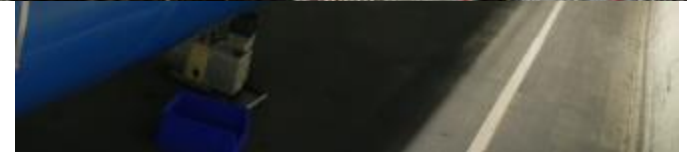
- Ionizing radiations
- Gas release risk
- Strict access constraints

# CERN needs

## Services

Voice and data for :

- Standard machines operation
- Train Inspection Monorail (Radio Protection surveys)
- Temperature and humidity sensors
- Remote experts consultancy



# WiFi technology



- Widely deployed in residential and office areas
- 802.11ac wave 2 offers 3.5 Gbps
- Access Points (AP) cover small areas (few meters)

# WiFi @CERN

- Adopted for offices
- Not suitable in the underground
  - Ionizing radiations
  - Tunnel lengths (27 Km for LHC, 7 Km for SPS)
  - Temporary VDSL during LongShutdown1  
10 Mbps, 275 APs in LHC tunnel

# LTE technology

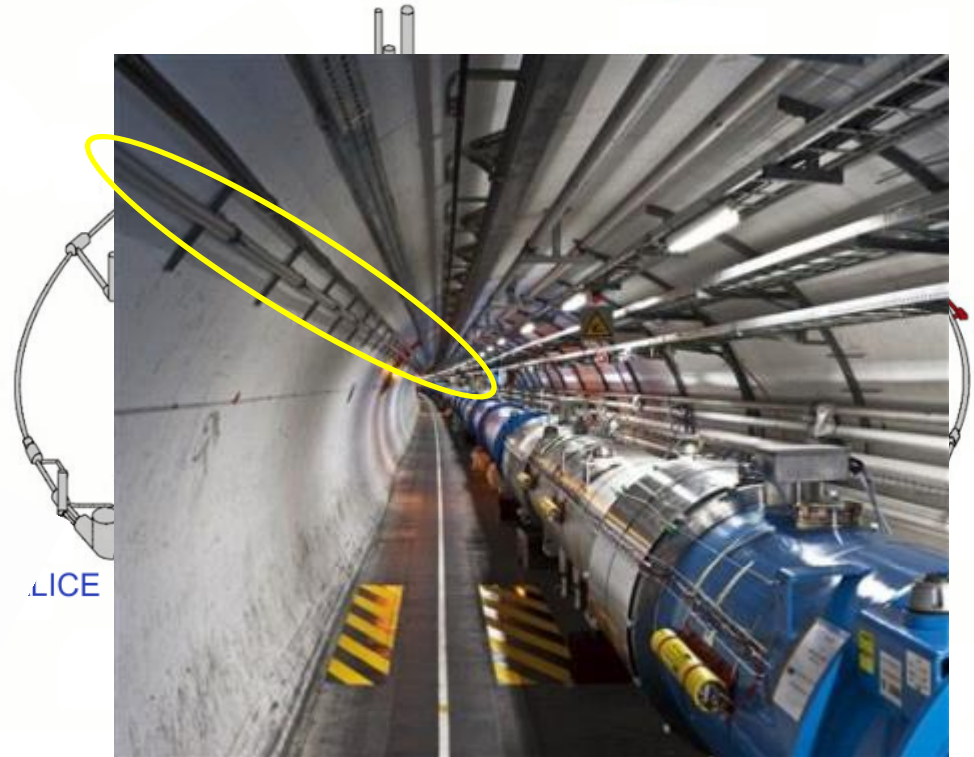


- 100% IP network
- High spectral efficiency
- MIMO (reliability and/or throughput enhancement)
- Round Trip Time <10 ms
- 1 Gbps download, 500 Mbps upload



# CERN tunnels mobile infrastructure

- Target: tunnels + LHC caverns
- Services: GSM, UMTS, TETRA, TETRAPOL
- Antenna cable  
resistant to radiations



# CERN tunnels mobile infrastructure

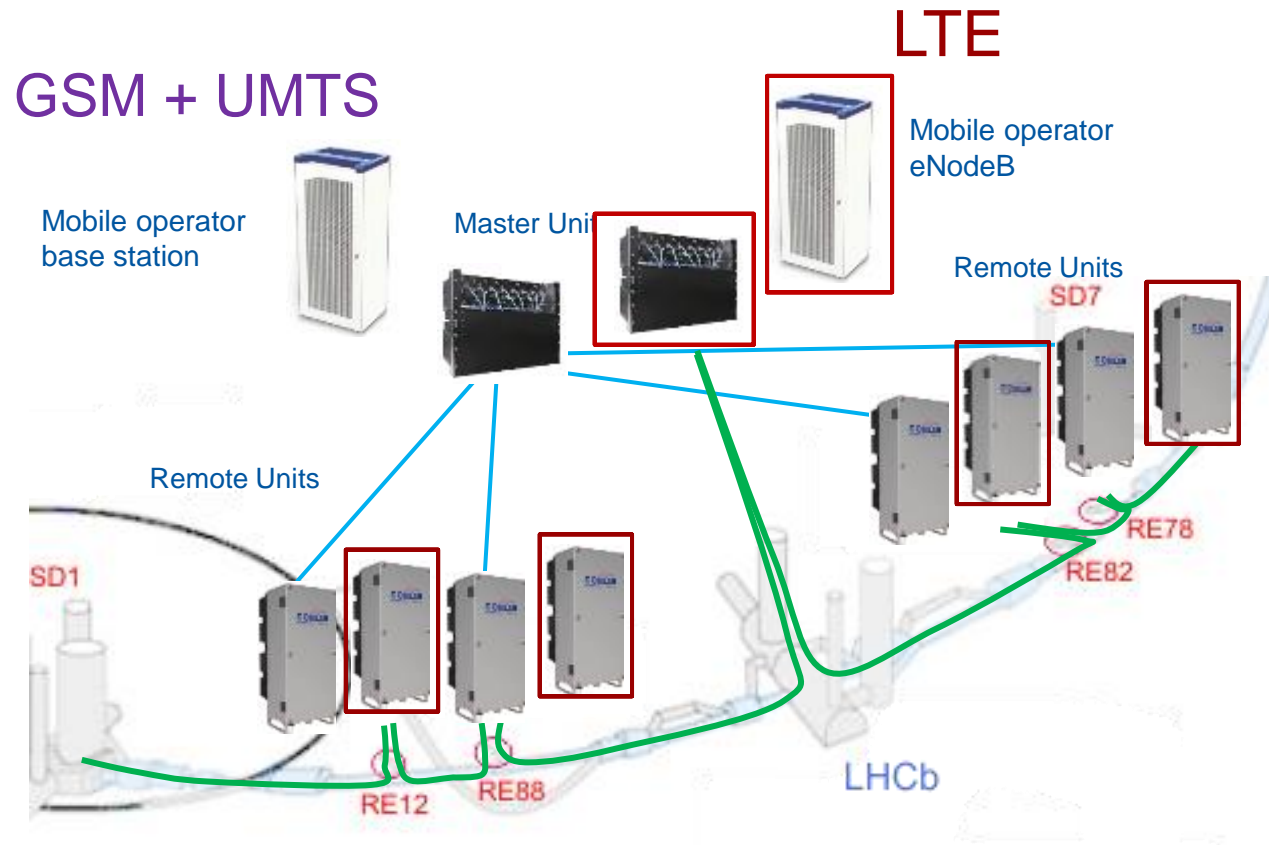
## Inter-technology compatibility

Passive Radio Frequency network optimized for bands:

- 400 MHz
- 800 MHz
- 900 MHz

# CERN tunnels mobile infrastructure

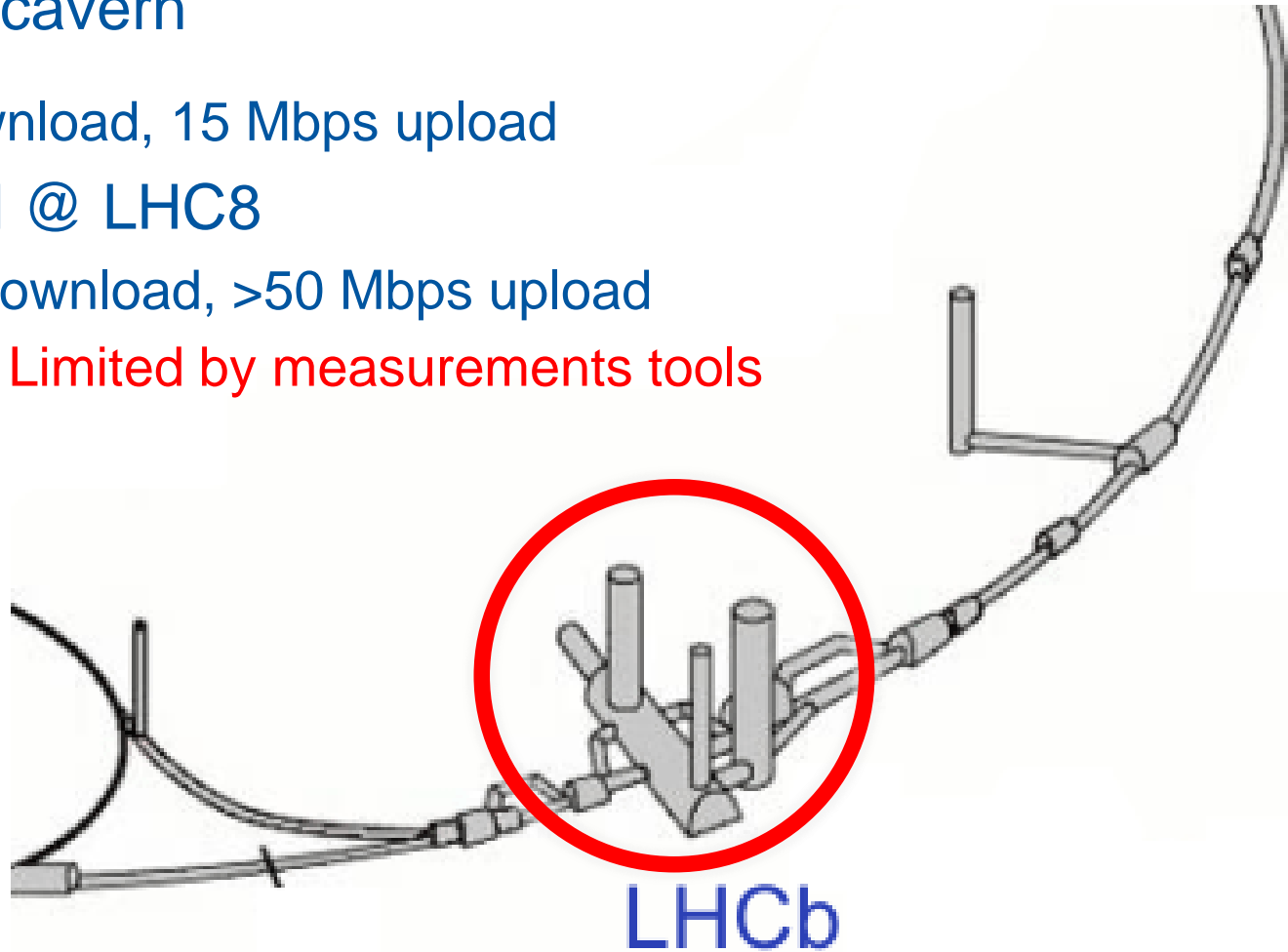
## LHC repeating system



# Measurements

- LTE @ LHCb cavern
  - 70 Mbps download, 15 Mbps upload
- LTE-Advanced @ LHC8
  - >100 Mbps download, >50 Mbps upload

Limited by measurements tools

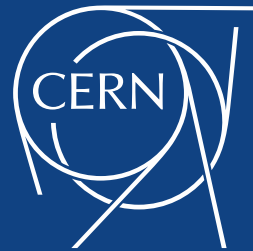


# Conclusions

- Voice + data services needs in CERN underground
- WiFi: good performance, problematic feasibility
- LTE: high throughputs in tunnels + caverns
- RF infrastructure upgrade for inter-technology compatibility

# Thank you!

# Questions?



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