

Final Event

October 7th, 2026

Funded by the European Union

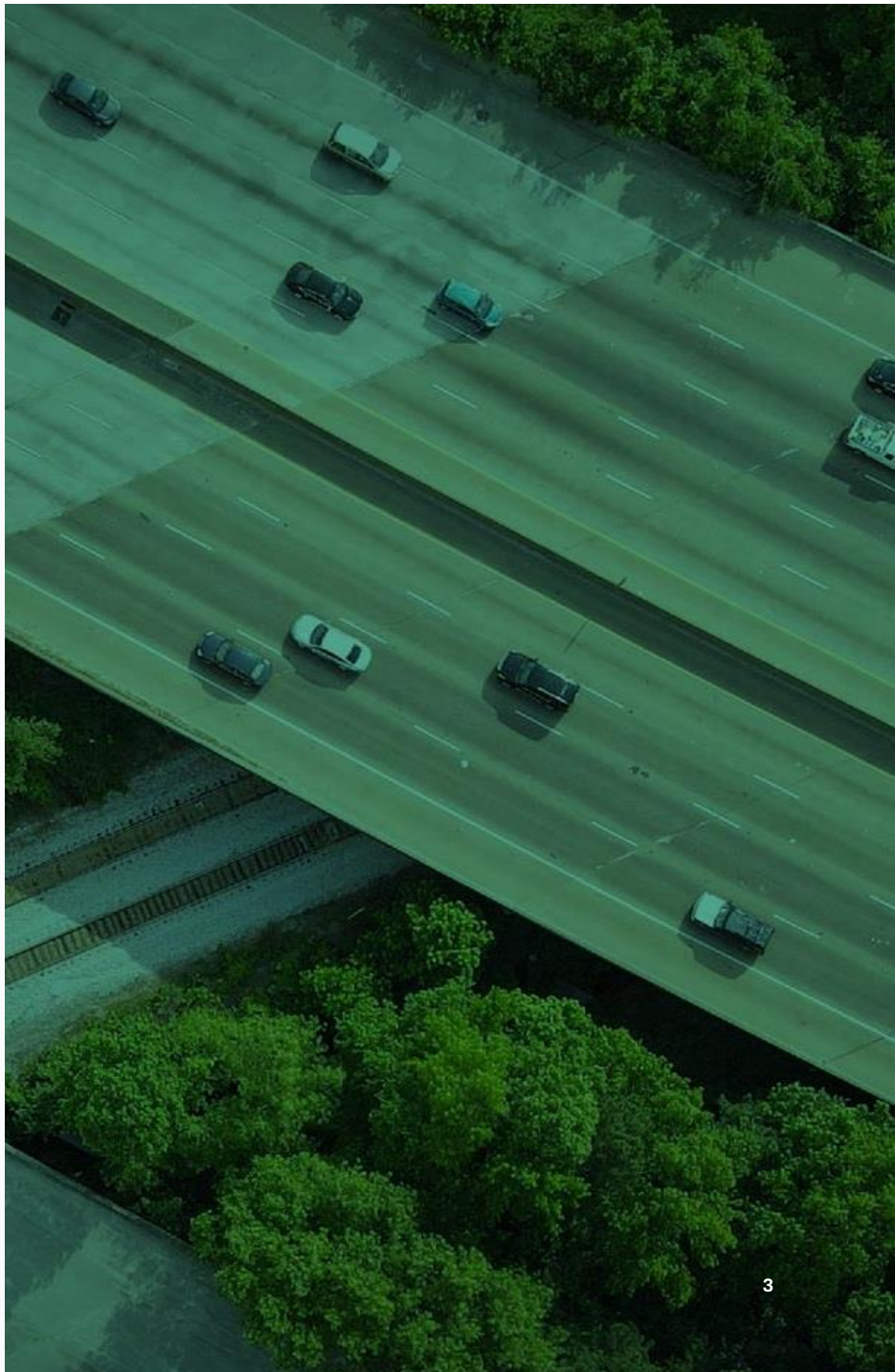


S5LECT
Data Acquisition’s

SNCF/CEIT/HITACHI

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Scenarios and Use Cases

Application and Services

- The S5LECT has undertaken the development of the three distinct types of the application to address a broad range of telecommunication requirements and a service to manage them. All these applications would establish a service that can effectively manage them through an **MCx Server**.
  - Voice Communication
  - Control and Command System(CCS) - ETCS2
  - Video Surveillance - CCTV

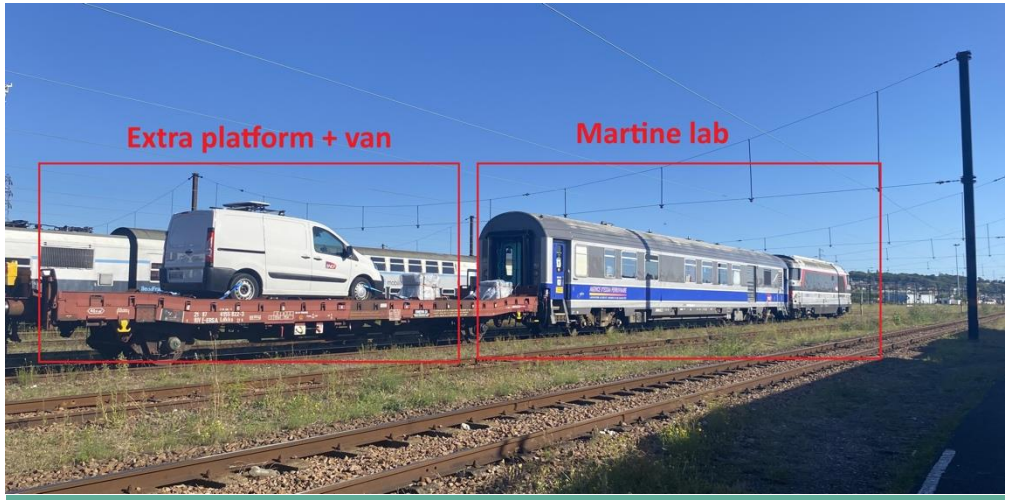
KPI Definitions

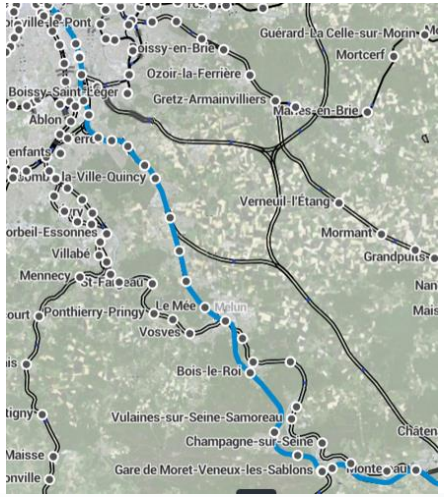
- KPIs for the validation of the S5LECT development was defined around the hybridization, radio technologies and seamless handover functionality.

Use case : Regional Line				
KPI #	1	2	3	4
	RTT(s)	Minimum Data Rate (kpbs)	Jitter (ms)	Packet Loss (%)
ETCS2(ERTMS)	3,5	4	N/A	{1;3}
Critical Voice	0,15	24	30	{0.1; 0.5}
Performance Video 1 cam - HEVC 640x480	0,3	Low Quality LQ 1320 High Quality HQ 5000	30	<1

Table 1 : The KPI Overview (S5LECT D2.2)

Field campaign and test bench







Villeneuve-Saint-Georges ↔ Montereau-Fault-Yonne, line 830000

- Three test days in September 2025
- Maximum speed: 100 km/h
- Approximately 51 minutes per one-way circulation
- Tunnel, forest, bridges, stations, rural and urban areas

On-board: LCT Agents, ACS, 5G modem and OneWeb terminal
Trackside: LCT Server and ACS at Hitachi premises in Vélizy

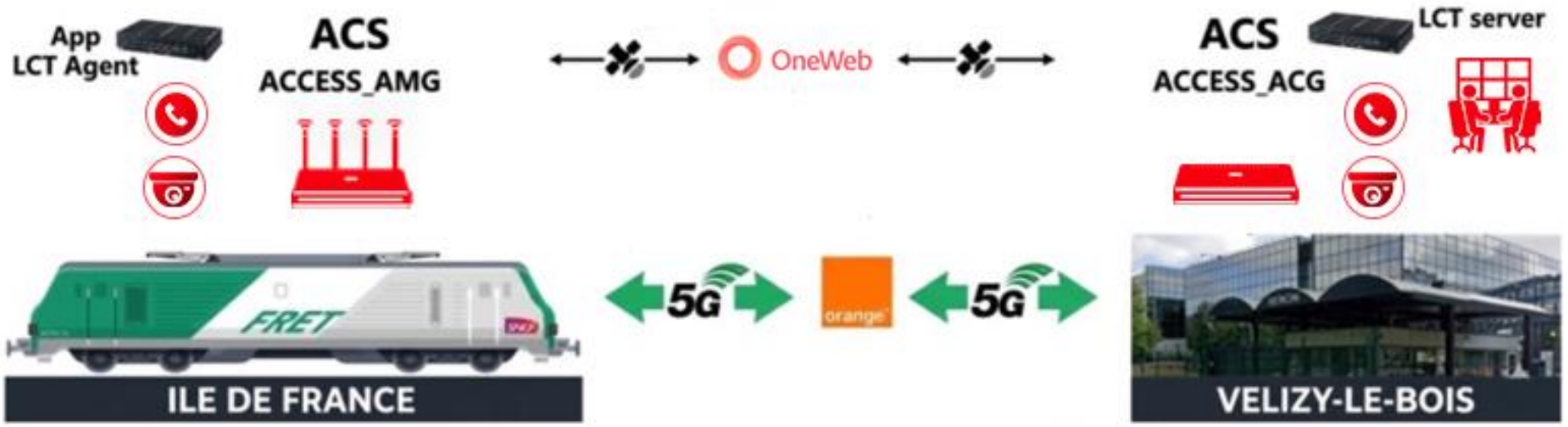
Circulation

Christophe

Circulation ID: # (1-9)	Test Date	Metric to Measure	Radio Technology	Direction	Weather Condition
Circulation # 1	10 June 2025	Validation of the System	Public 5G and SATCOM	Villeneuve to Montereau	
Circulation # 2	10 June 2025	RTT	Public 5G and SATCOM	Montereau to Villeneuve	
Circulation # 3	11 June 2025	yThrouhput Uplink	Public 5G and SATCOM	Montereau to Villeneuve	
Circulation # 4	16 September 2025	RTT	Public 5G and SATCOM	Villeneuve to Montereau	
Circulation # 5	16 September 2025	Throuhput Uplink	Public 5G and SATCOM	Montereau to Villeneuve	
Circulation # 6	17 September 2025	Throuhput Downlink	Public 5G and SATCOM	Villeneuve to Montereau	
Circulation # 7	17 September 2025	RTT with Limited Througput	Public 5G and SATCOM	Montereau to Villeneuve	
Circulation # 8	18 September 2025	Throuhput Uplink	Public 5G and SATCOM	Villeneuve to Montereau	
Circulation # 9	18 September 2025	RTT	Public 5G and SATCOM	Montereau to Villeneuve	

Table 2 : Overall Test Sequence

S5LECT - Measurement and connectivity



LCT

Measures IP and radio KPIs along the railway line and links every observation to train position.

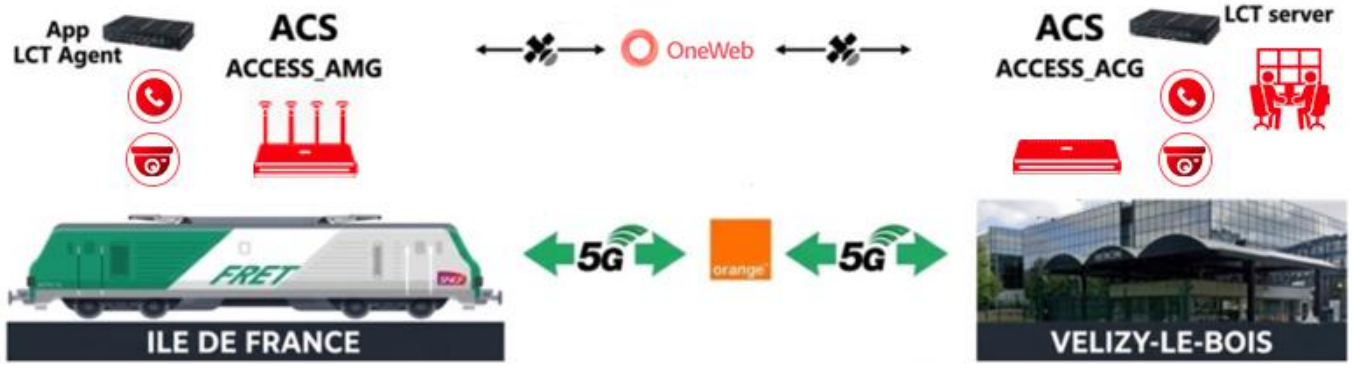
ACS

Provides secure multi-connectivity and enables dynamic switching between 5G and SATCOM.

Bearers

Orange public 5G and OneWeb LEO SATCOM were measured simultaneously.

Test Setup Overview – ACS (Adaptable Communication System)



The Hitachi's **ACS** has been designed to meet the growing complexity of railway communication networks. It addresses key challenges such as technological obsolescence, limited radio spectrum availability, and the integration of advanced digital railway applications, including radio-based signaling.

Key Functions of ACS:

- **Multi-Connectivity Platform**: ACS serves as a versatile communication platform, supporting multiple network technologies to ensure continuous and reliable connectivity for railway operations.
- **Secure Communications**: ACS provides secure connections ensuring data protection and system integrity.
- **Operational Continuity**: It guarantees that critical railway services remain functional across diverse network environments, minimizing disruptions.
- **Seamless Technology Handover**: ACS enables smooth transitions between different communication technologies, such as 5G and satellite communications (SATCOM), ensuring uninterrupted service.

Test Setup Overview – Radio Onboard equipments

OneWeb User Terminal Characteristics:

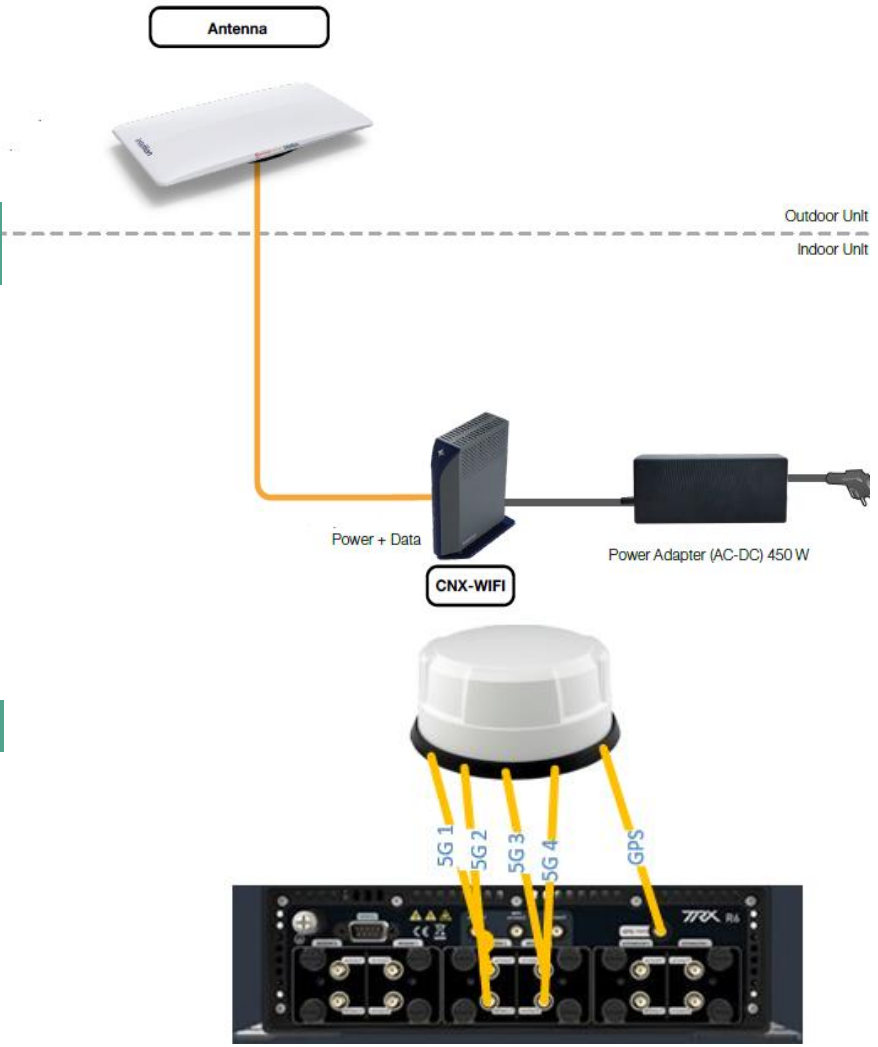
- **Intellian OW11FV**, is a flat panel user terminal for railway applications, providing low-latency, high speed and reliable connectivity for the S5LECT project during the data acquisition.
  - Maximum Downlink Throughput up to 195 Mbps.
  - Maximum Uplink Throughput up to 32 Mbps.
  - EIRP 36.6 dbW
  - G/T 10.7 db
- **CNX-WIFI Router**, is physical and network interface between the antenna and network.
  - QoS Management
  - Encryption
  - Monitoring

Data Subscription for field trial : cDL /10mbs /DL

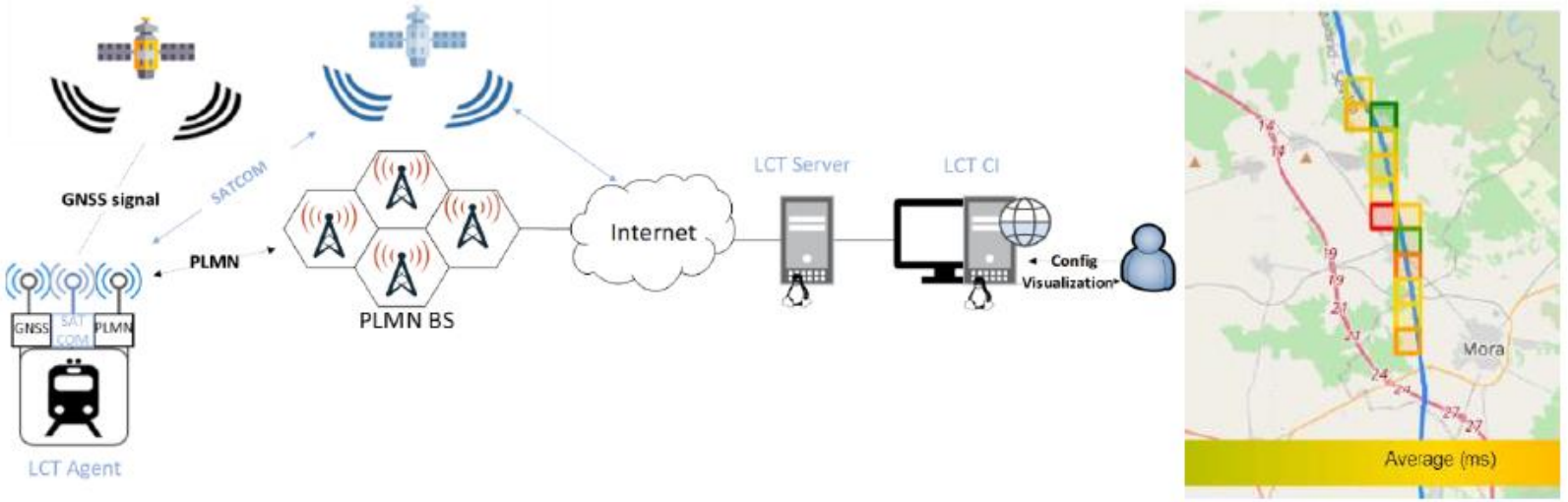
5G Modem Characteristics:

- **Quectel RM500:**
  - 3GPP Release 15 NSA/SA operation, Sub-6 GHz
  - Max data rate DL 2.1 Gbps; UL 900 Mbps in SA
  - DL: 4x4 MIMO and UL: 2x2 MIMO in 5G
- **5G antenna:**
  - 4G/5G Frequency range: 617-960 MHz and 1710-6000 MHz
  - GPS frequency range: 1562-1612 MHz
  - 4G/5G Gain: 4 to 9 dBi
  - GPS Gain: 26 dB

Orange 5G offer : 120 Go / month



Test Setup Overview – LCT (Link Characterization Tool)



The CEIT's LCT is a tool that characterizes the performance of different communication technologies in terms of IP and radio frequency parameters along a railway track. The LCT Agents were active on board and connected to the LCT Server via Hitachi ACS with two different radio technologies.

- **LCT Agent**: is the on-board part located in the train. It is the subsystem responsible for obtaining the train position and for monitoring the IP and RF parameters together with the LCT Server.
- **LCT Server**: is the subsystem located on the trackside. It is the subsystem responsible for monitoring the IP parameters of the different communication technologies together with the LCT Agent. It can be located on a server in the part of the infrastructure which is Hitachi Velizy or in the cloud which OVH Cloud for the S5LECT data acquisition.
- **LCT CI**: is the subsystem responsible for configuring and visualizing the results from the measurements. It can be placed both, on-board and trackside

Test Setup Overview – Collected Data

LCT metrics :

IP level:

- RTT
- Jitter
- Max. throughput downlink
- Max. throughput uplink
- Packet loss

RF metrics (given by ACS):

- RSRP
- SINR
- RSRQ
- RSSI

GPS (given by ACS)

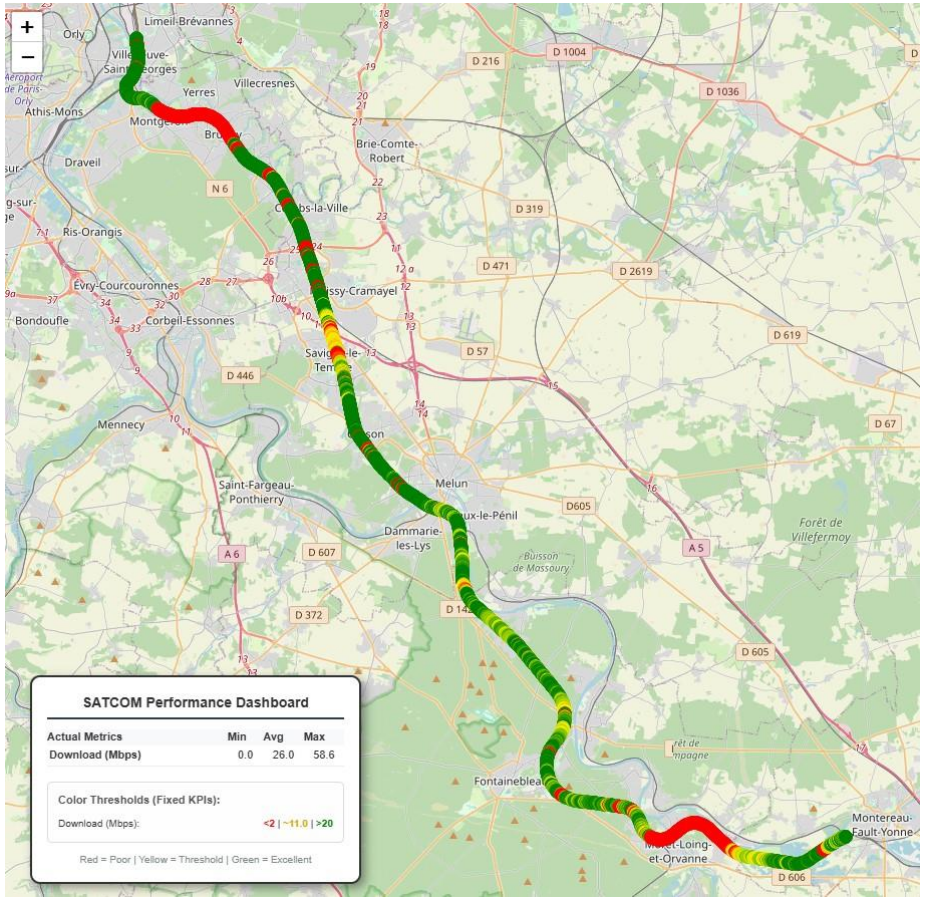
ACS metrics :

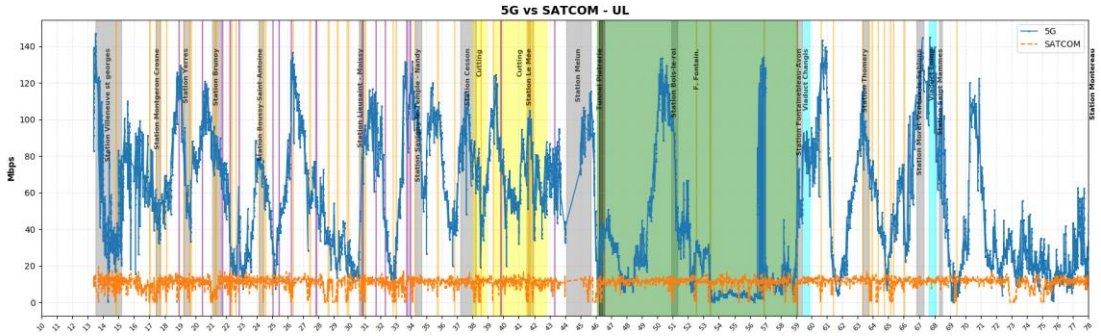
- **LCT metrics recorded**
- **Trafic data recorded (pcap files) to analyse impact on application level**
- **Environmement metrics**
  - Kilometer point
  - Weather (after field tests)
    - Temperature
    - Sky status (cloudy/rain)
- **Internal ACS metrics**
  - Bandwith for each bearer, for each tunnel
  - Temperature
  - RAM/CPU usage
- **Power Consomption**
  - ACS including 5G modem
  - Satcom system

External sensors :

- **Temperature sensors**
- **External video systems**
  - To analyse other events like train crossing

Public 5G results: high capacity with local degradations

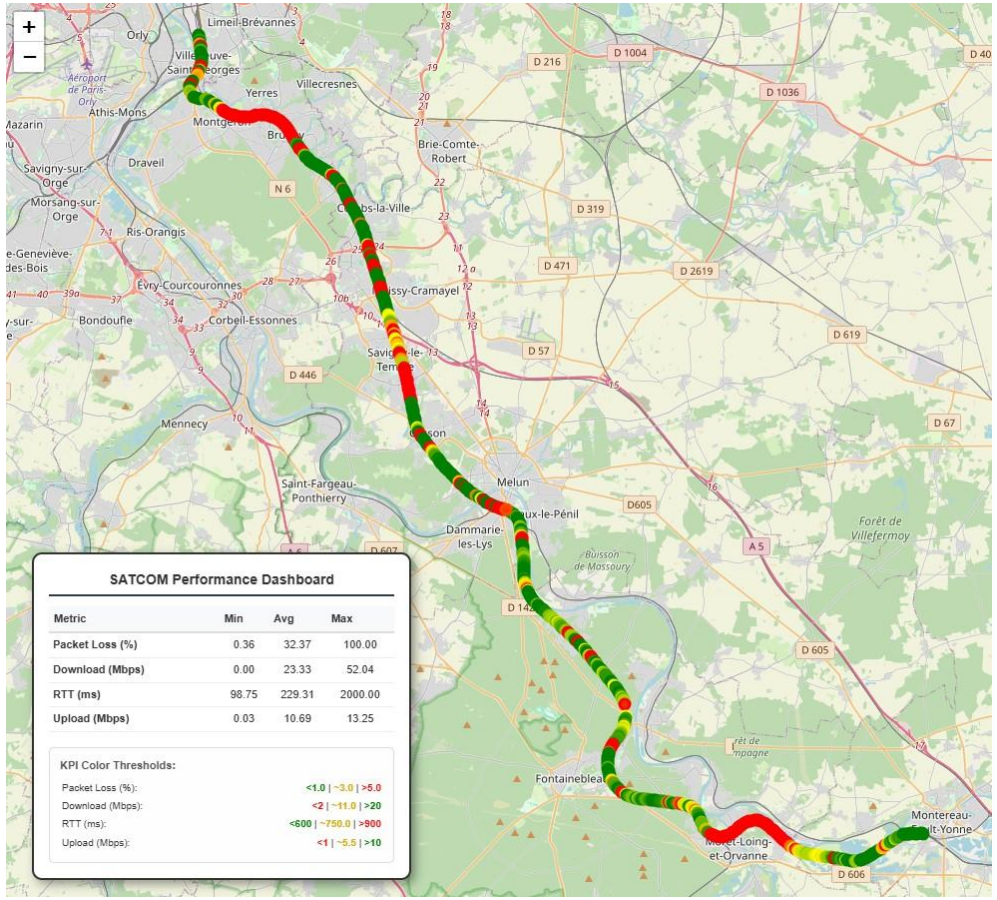


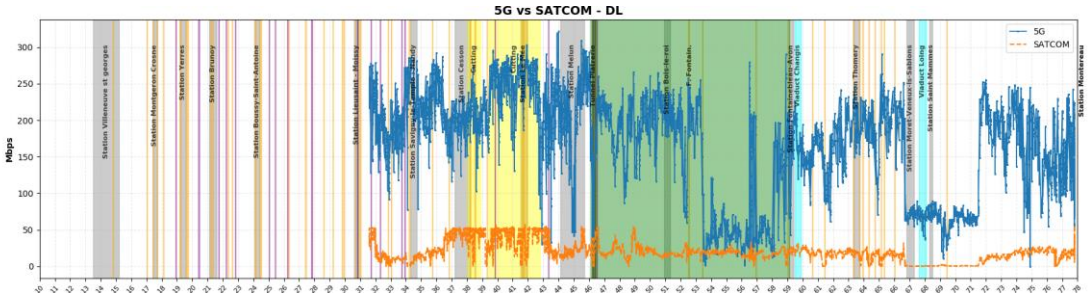


Main observations

- No 5G connectivity outage during the trials
- Peak RTT: 244.4 ms in the tunnel
- Downlink peak reported in the paper: 321.6 Mbps
- Fontainebleau forest is the principal capacity bottleneck

SATCOM results: coverage value with obstruction sensitivity





Main observations

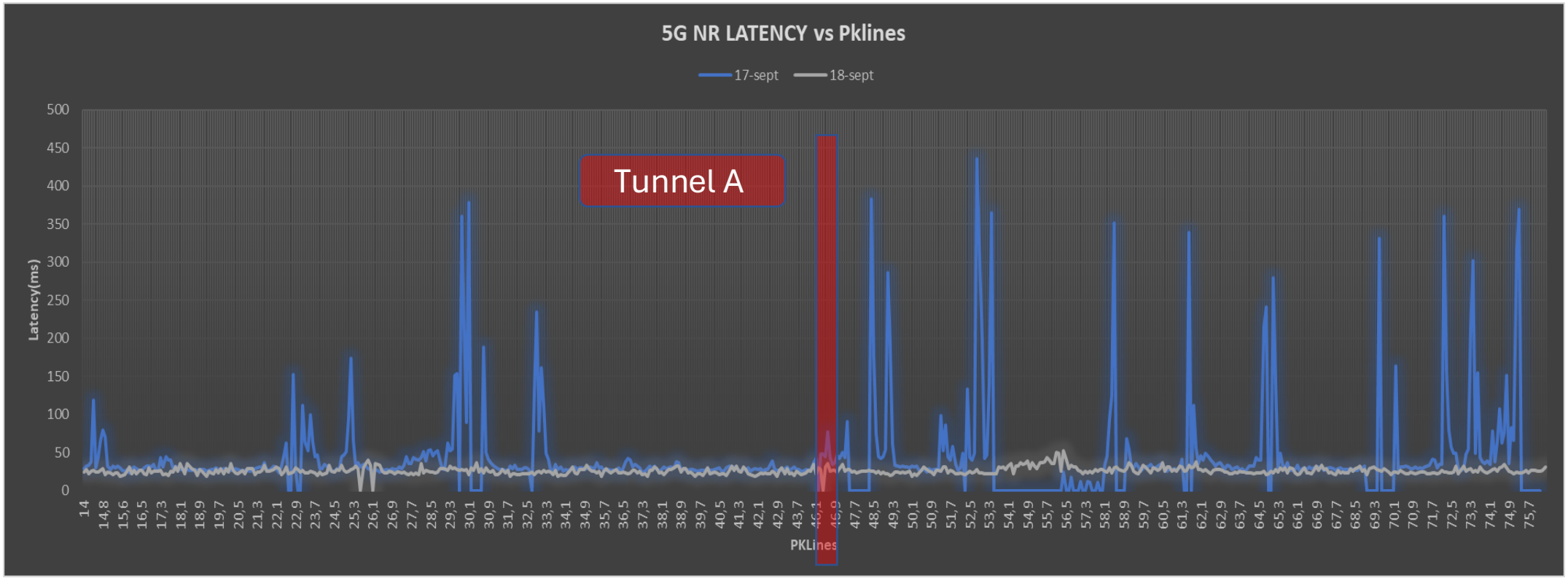
- Commercial profile capped at 50 Mbps DL and 10 Mbps UL
- Urban masking, under-bridges and the tunnel cause degradations or outages
- SATCOM unavailability represented 4.89% of the trip duration

Test Analysis



Bridge and Tunnel Effect

- No Major effect cause of the bridges.
  - **1 tunnel point shows the signifiant affect on the delay.**

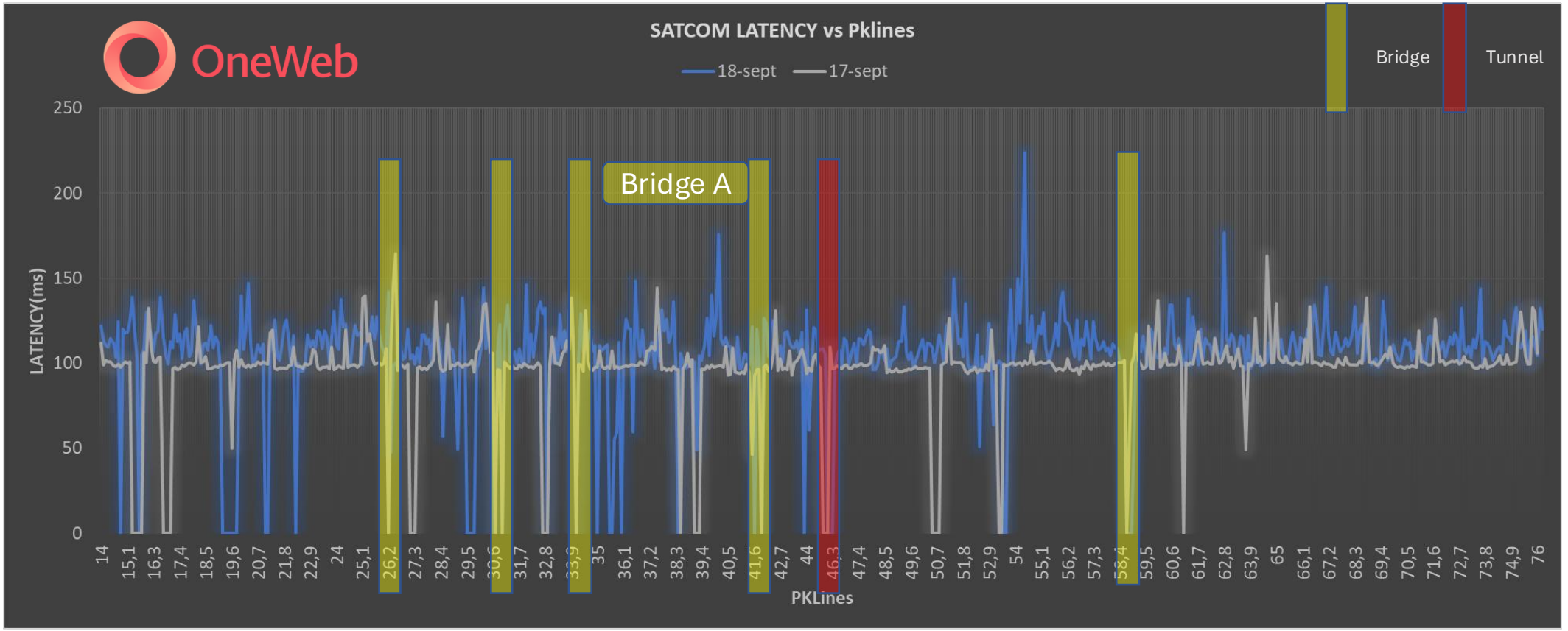


Test Analysis



Bridge and Tunnel Effect

- SATCOM is more fragile than 5G.
  - **5 bridges and 1 tunnel points show the signifiant affect on the delay.**



Environment-driven complementarity



Tunnel

Both bearers degrade; SATCOM may disconnect.



Under-bridge

SATCOM is temporarily masked; 5G generally remains available.



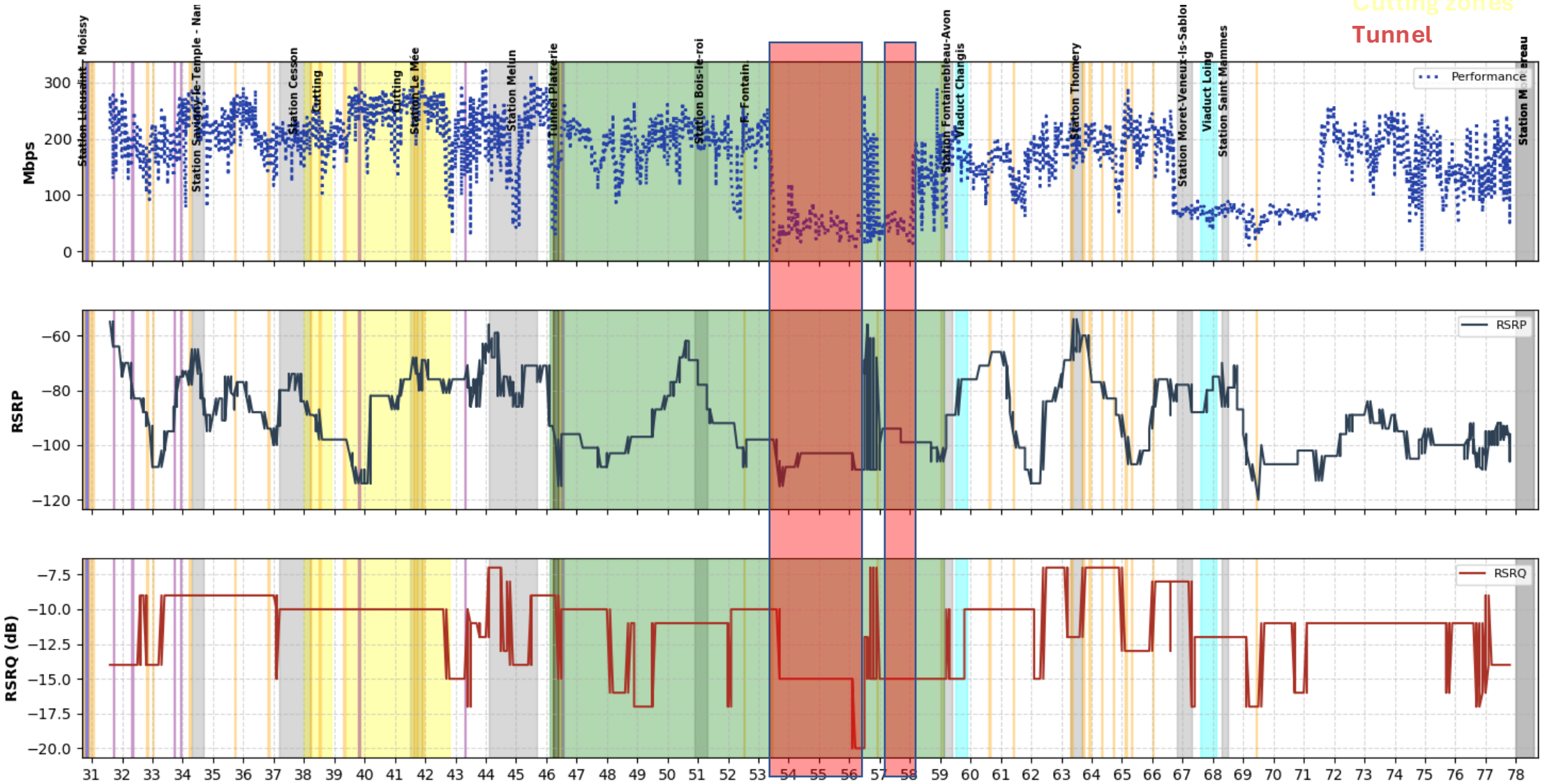
Forest

5G degrades strongly; SATCOM can provide an alternative path.

Critical zones rarely overlap, creating a strong case for multi-bearer switching.

Focus on 5G coverage

Forest Fontainebleau
Stations
Viaducts
Under bridges
Cutting zones
Tunnel



5G unavailable: 0.16% of trip | SATCOM unavailable: 4.89% of trip

Hybridisation value for railway operations

Circulation		ETCS	Voice	Video LQ	Video HQ
#1	RTT 5G	100%*	99.95%*	100%*	
#1	RTT SATCOM	100%*	96.08%*	99.26%*	
#2	BW UL 5G	100%	100%	99.2%	95.44%
#2	BW UL SATCOM	99.84%	99.43%	94.43%	91.99%
#3	BW DL 5G	100%	100%	99.98%	99.86%
#3	BW DL SATCOM	97.02%	95.61%	85.37%	83.64%
#5	BW UL 5G	100%	100%	99.64%	96.91
#5	BW UL SATCOM	99.65%	99.17%	94.82	93.07%
#6	RTT 5G	100%*	99.64%*	99.84%*	
#6	RTT SATCOM	100%*	89.95%*	98.98%*	

Operational principle

Use 5G as the primary high-capacity bearer and switch toward LEO SATCOM when terrestrial performance becomes insufficient. Parallel use could further improve reliability when both paths are stable.

Conclusions and next steps

Validated findings

- The integrated multi-partner test bench operated successfully
- Railway environments affect 5G and SATCOM differently
- 5G and LEO SATCOM are complementary on the selected line

Engineering conclusion

Hybridisation is a robust approach for improving service continuity. ACS can select the best available bearer according to local performance and application needs.

Future work

- Reproduce field conditions in the S5LECT laboratory
- Benchmark ACS algorithms
- Validate seamless handover under controlled conditions
- Explore parallel bearer use

Q&A



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Edge & CybersecuriTy



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