A report on 5G trials & pilots in new application domains

(and what comes next in SNS – JU)

Carles Antón-Haro, PhD, MBA

Trials WG Chair, 6G-IA Governing Board, JU-SNS Governing Board

Director of EU Programmes and Industrial Contracts, CTTC

European 5G Observatory, 5th Stakeholder Workshop25 October 2023

AGENDA

- Overview of 5G -PPP pan-European Trials & Pilots
- Selected T&Ps and sources of information
- Coming up next: Trials and Pilots in SNS-JU
- Co-creation event on 5G Verticals @ 5G Techritory
- Key Takeaways

OVERVIEW OF 5G -PPP PAN-EUROPEAN TRIALS & PILOTS

5G Research in the 5G PPP

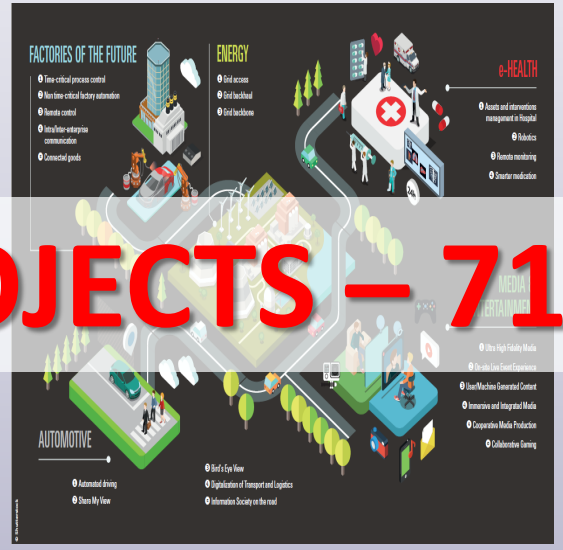
PHASE 1:
5G Core Research

main achievements:

- 5G System design & Evaluation aspects
- 5G Air interface innovations
- Network management & Security innovations
- Virtualization & Service deployment innovations
- 100s of contributions to standardization

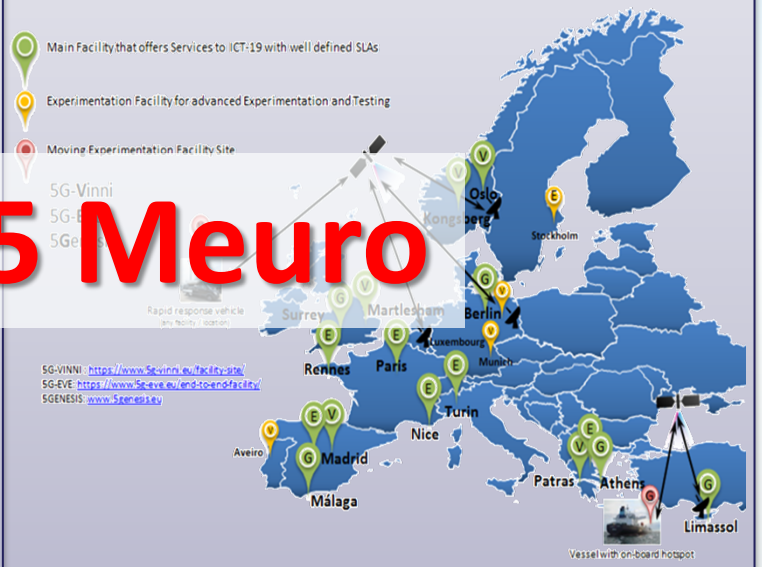
19 PROJECTS – 129.8 Meuro

PHASE 2:
5G Application to Verticals



21 PROJECTS – 143.2 Meuro

PHASE 3:
5G Platforms
and Vertical Large-Scale Pilots



53 PROJECTS – 439,5 Meuro

93 PROJECTS – 712.5 Meuro

Mid 2015 Mid 2017 Mid 2018 2020+

Phase 2 – Vertical Trials & Pilots

Connected and Automated Mobility

Smart Cities

Industry 4.0

Projects	Vertical Stakeholders	ITU Service Types	Locations
5GCAR	VOLVO, PSA GROUPE, BOSCH	eMBB, URLLC	Montlhéry (FR)
5GCity	City councils of Barcelona, Bristol and Lucca	eMBB, URLLC (mMTC)	Barcelona (ES) Bristol (UK) Lucca (IT)
[illegible]	bre, [illegible], ferrovial	eMBB	Watford (UK) Paris (FR) Madrid (ES)
5GXCAST	BBC, EBU, LiveU	eMBB	Surrey (UK) Munich (DE) Turku (FI)
5G ESSENCE	SMART MOBILE LABS	eMBB	Egaleo (EL)
5G MEDIA	IRT, rtve	eMBB	Athens (EL) Thessaloniki (EL) Madrid (ES) Rome (IT)
5GtangoX	NUROGAMES	eMBB, URLLC	Aveiro (PT) Athens (EL)
5G TRANSFORMER	CRF, S.M.U.S.	URLLC	Turin (IT), Pisa (IT) Madrid(ES) Nice (FR)

Projects	Vertical Stakeholders	ITU Service Types	Locations
5G-MONARCH	HPA Hamburg Port Authority	mMTC	Hamburg (DE) Turin (IT)
NRG-5	ENGIE, ROMGAZ, Emotion, ASM	mMTC, URLLC, (eMBB)	Terni (IT)
5GtangoX	Weidmüller	mMTC (URLLC)	Detmold (DE)
(Phase 1) VIRTUWIND	SIEMENS Siemens Wind Power	URLLC	Brande (DK)
5G-PICTURE	FGC Ferrocarrils, COMSA	mMTC, URLLC, eMBB	Barcelona (ES) Bristol (UK)
NGpaas	Vertical M2M, Virtual Open Systems	mMTC, URLLC	Paris, Grenoble (FR)
5G ESSENCE	THALES	URLLC, eMBB	Coventry (UK)
MATILDA	internet INSTITUTE	URLLC (eMBB)	Genoa (IT) Ljubljana (SL)

Consumer and Professional Services

Transport

Public Safety & Digital Divide

Phase 3 – 5G Platforms for Vertical Large-scale Trials

Source: https://5g-ppp.eu/5g-trials-roadmap/

Phase 3 – 5G Trial Platforms as Validation Enablers

Platform Projects

Vertical Projects (Phase 3.3)	5G EVE	5Genesis	5G-VINNI
5G!DRONES	√	√	
5G HEART	√	√	√
5GROWTH	√		√
5G smart	√		
5G SOLUTIONS (5G Solutions for European Citizens)	√		√
5G-TOURS	√		
5G VICTORI	√	√	√

Platform projects were used to test a number of vertical use cases coming from the dedicated 5G vertical industry-related projects.

- Phase 3.1: Infrastructure Projects (platform projects)
- Phase 3.2: Automotive Projects
- Phase 3.3: Adv. 5G validation trials across multiple vertical industries
- Phase 3.4: 5G Long Term Evolution
- Phase 3.5: 5G Core Technologies innovation and 5G for Connected and Automated Mobility (CAM)
- Phase 3.6: 5G innovations for verticals with third party services & Smart Connectivity beyond 5G

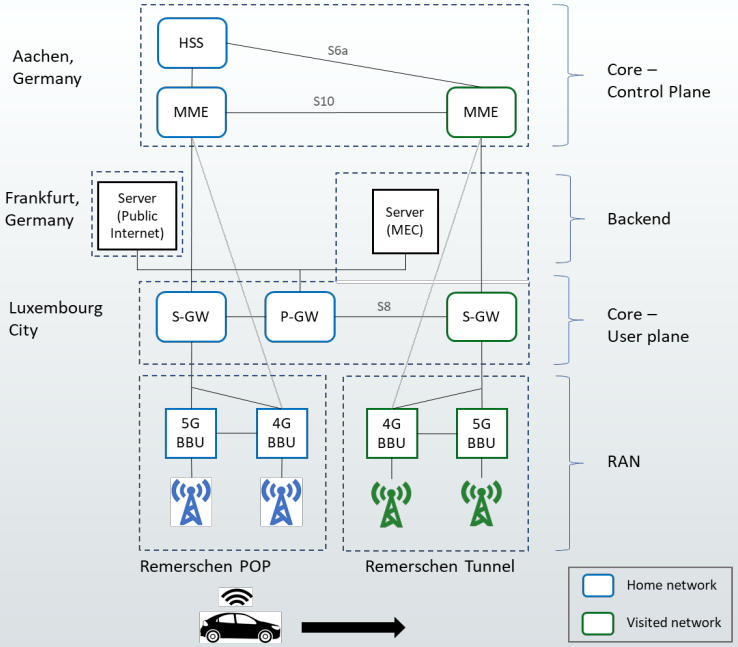
Vertical Use Cases Addressed in Phase 3 Projects (selected)

- **Goal**: to measure how 5G can impact the performance and the overall operation of vertical industries in the path to full digitization.
- Multiple verticals addressed by each project !!

	Industry 4.0	Agriculture & agri-food	Automotive	Transport & logistics	Smart Cities & utilities	Public Safety	Smart (air)ports	EnergY	eHealth & wellness	Media & entertain.
5G EVE	√		√		√	√		√	√	√
5GENESIS				√	√	√				√
5G VINNI	√			√		√		√		
5G!DRONES				√		√				√
5G HEART		√	√	√					√	
5GROWTH	√			√				√		
5G SMART	√									
5G SOLUTIONS	√				√		√	√		√
5G TOURS				√	√		√		√	√
5G VICTORI	√			√				√		√

Selected T&Ps and Sources of Information

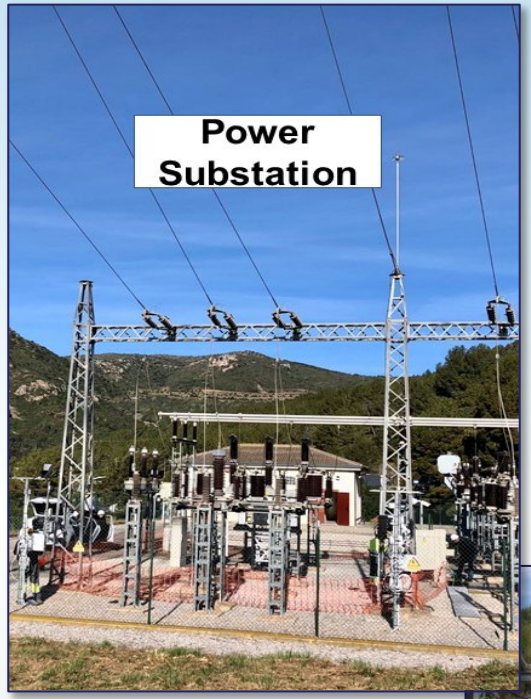
5G Cross-border Service Continuity for Tele-operated Driving

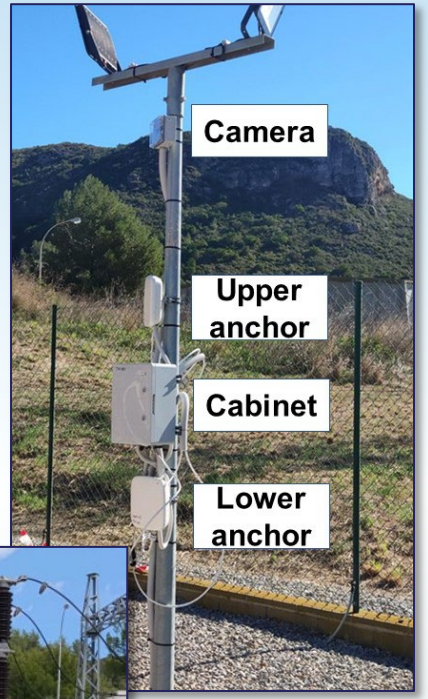


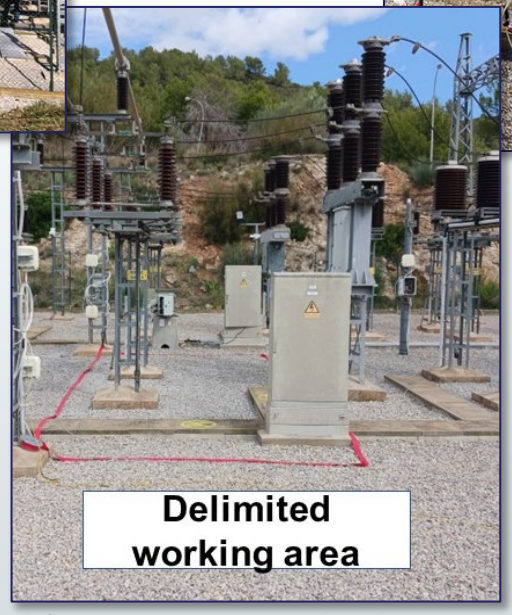
5GCroCo

- Uninterrupted network connectivity: cross-MNO handovers
- Very demanding use case:
  - Low latency and high reliability: control
  - High-thoughput: LIDAR, multiple video streams
- Fenced and open roads: Luxembourg-Germany, France-Germany (Control Center in Schengen).
- Bosch, DTAG, ///, POST, Orange, TUM, Huawei, and VW (Oct. 2021)
- ToD requirements satisfied, handover almost imperceptible (~100 ms).

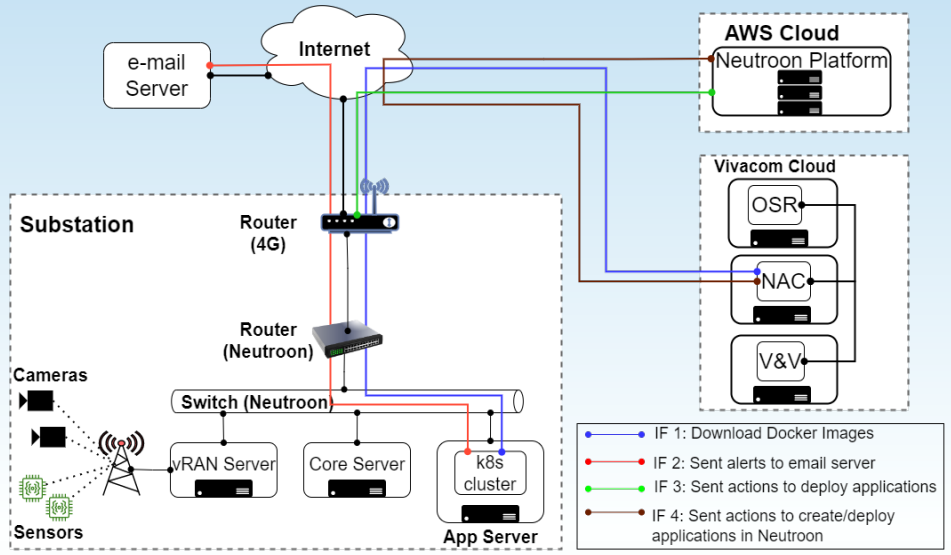
Remote monitoring of workers at distribution substations





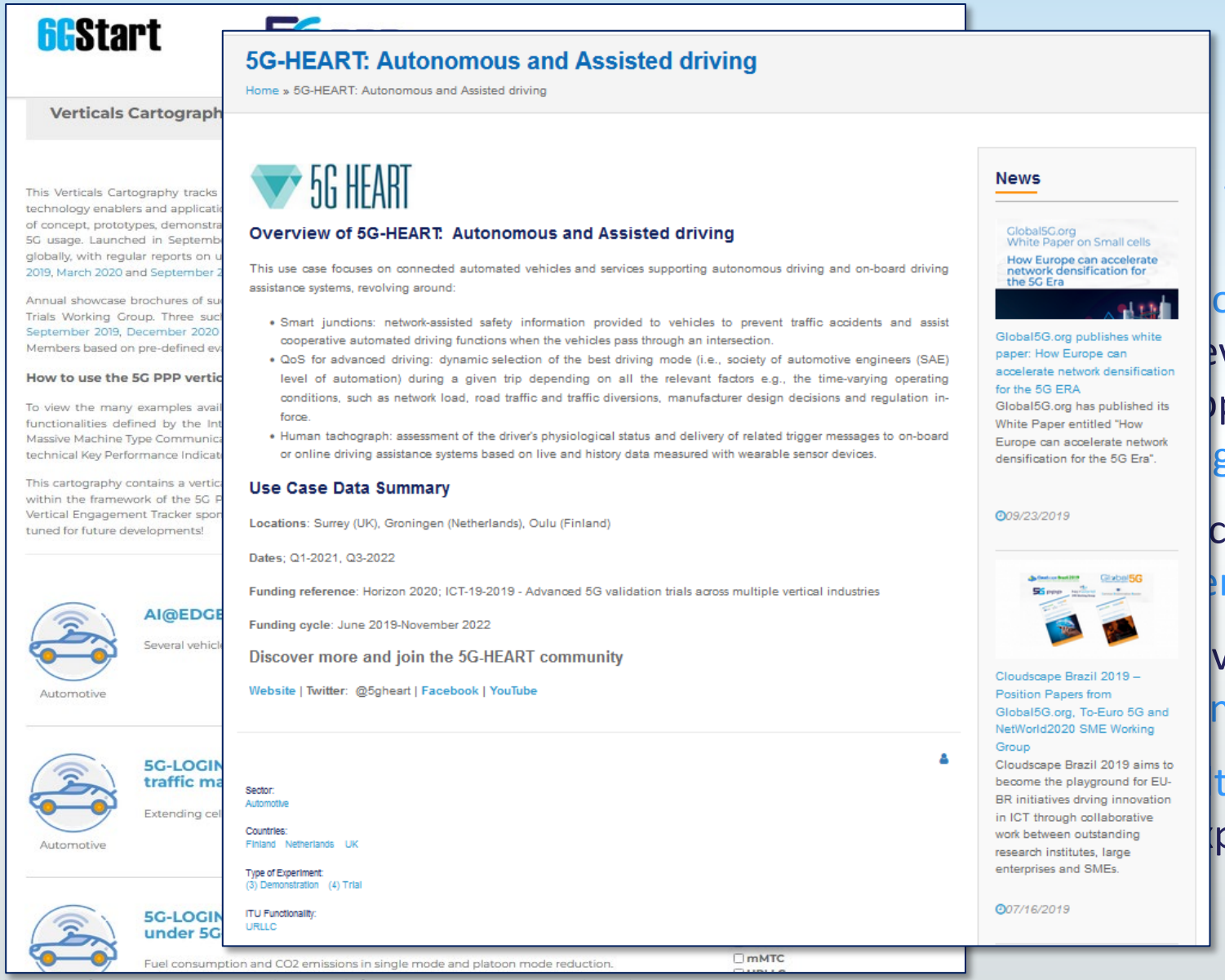


Smart5Grid



- Real-time monitoring and positioning of workers and tools: increased safety.
- Equipment:
  - UWB bracelets and 3D cameras.
  - Private 5G network incl. edge computing.
- Triggers audio-visual and physical warnings if safety zone trespassed, SOS button, sudden fall of worker.
- Requirements for the remote monitoring satisfied: availability (100%/3 weeks), reliability, slice isolation.
- 5G outperforms WiFi equivalents.

A Comprehensive 5G-PPP Verticals Cartography



Verticals Cartography

https://verticals-cartography.5g-ppp.eu

onitor progress of Europe's 5G PPP in
eveloping 5G technology enablers and
plications across diverse market
gments through a large set of use cases.

cludes proofs of concept, prototypes,
emonstrations, trials and pilots.

ve consumers and vertical end-users
ngible examples of 5G usage.

ters: vertical industry. Country, type of
periment, ITU functionality

Trials & Pilots Brochures – the story so far

Available from:
https://5g-ppp.eu/wp-content/uploads/2019/09/5GInfraPPP_10TPs_Brochure_FINAL_low_singlepages.pdf
https://5g-ppp.eu/wp-content/uploads/2020/12/5GInfraPPP_10TPs_Brochure2.pdf
https://5g-ppp.eu/wp-content/uploads/2021/10/5GInfraPPP_10TPs_Brochure2021_v1.0.pdf

- Boost the visibility of selected T&Ps conducted by 5G-PPP projects – open to all !!
- Joint activity between the 5G-IA Trials WG and the 5G Initiative Technology Board.
- Three brochures to date: 2019-20-21.
- Brochure no. 4: release by end of October.
- 10 T&Ps portrayed in each brochure. Dedicated selection panel (10-15 members)
- Dissemination beyond the R&D community: politicians, decision makers, general audience.
- Large-scale dissemination via newsletter, website. social networks, EC services, events (e.g., IEEE 5G World Summit), 5G observatory, member states, etc.
- Professional layout.

Trials & Pilots Brochure no. 3 – contents and layout

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COOPERATIVE MEDIA PRODUCTION

OVERVIEW

5G-SOLUTIONS is a 5G PPP project supporting the EC's 5G policy aiming to validate that 5G provides prominent industry verticals with ubiquitous access to a wide range of services with orders of magnitude of improvement over 4G, thus bringing the 5G vision closer to realisation. Cooperative Media Production became the new standard for production companies.

Wireless At-Home/Cloud Production solutions allow broadcasters to reduce costs producing live shows from a centralised studios instead of on-site production. At-home production solves inefficiencies and reduced support of live events allowing sending only the camera and audio teams to the field, whereas the production is done in the professional studio facility. In this use-case several cameras are each connected in the field to cellular transmission devices, including bonding devices to provide the utmost reliability and bandwidth.

LiveU was used as the bonding server for video encoders-transmitters. It used its Precision Timing feature to support the synchronization of the video streams. Video quality was up to 4K from each camera provided by Fothnet-NOVA.The partners that participated in the trials are: LIVEU, Forthnet-NOVA, University of Patras (UoP), Centre Tecnològic de Telecomunicacions de Catalunya (CTTC) and Nokia. Trials were held between Oct. 2020 and Jun. 2021.

ARCHITECTURE

The use-case architecture using bonding equipment and 4K cameras is illustrated in Figure 1.

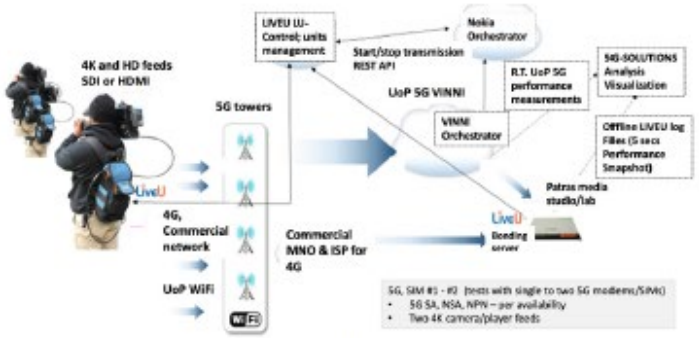


Figure 1 High Level Architecture

The use-case included LIVEU units, Forthnet-NOVA cameras, the 5G-VINNI tested on the University of Patras, Nokia's Cross Domain Service Orchestrator (CSDO), and APP-ART's Visualization System (VS) to collect the trial KPIs.

DEPLOYMENT

The use-case aimed at measuring uplink bandwidth and latency under different conditions and sub-scenarios. Multi-camera feeds at low (<0.6 sec to allow remote interviews), consistent latency and uplink bandwidth validate and evaluate 5G-bonding using multi-link bonding, multi-link with WiFi, multi-link of 5G with 4G, etc. combinations the uplink contribution at various network conditions such as cell-edge, and impact of uplink congestion on said performance.

Several products were used – LU600 and LU800 which have multi camera built-in capabilities.

Figure 2: LiveU Deployment Setup and LiveU unit and 5G base station at University of Patras

RESULTS

In the table below the key service KPIs are illustrated. All target values were met during the trials.

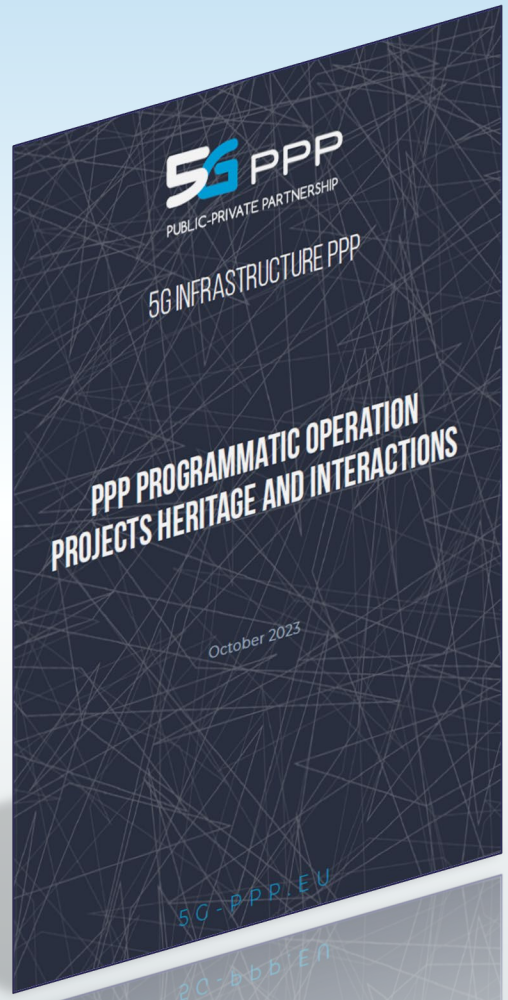
	Trial Target	Measurement Method
5G latency	< 20 ms	Measure 5G RAN + network latency
E2E Uplink stream latency	< 0,6 s	Including video capture, compression, and transmission to cloud/studio and decoding.
5G latency sustainability	< ~1% fluctuations over > 3 hours continuous transmission durations	Application and network parameters at various scenarios
Uplink Bandwidth per camera	> 40 Mbps, consistent over > 3 hours transmission	Transmission with LiveU LU800, single and bonded 5G (same operator, as this is what's available at VINNI)

5G EMPOWERMENT

5G is required in order to solve issues of the current on-site production allowing the production to be done remotely while sending to the field only the cameras and the cameramen. 5G is expected to provide higher uplink bandwidth, consistency, latency sustainability and overall uplink guaranteed SLA/QoS for multiple uplink cameras/feeds. This is expected to be done with SA with slices/services, PN and NPN networks. In this UC 5G can turn the impossible to possible. High upload bandwidth is required for live multi-camera production at high quality video (full HD, 4K and 8K). Latency stability is required to support this synchronization as well as to allow the remote production studio to output the live streams in confidence.

5gsolutionsproject.eu

5G-PPP HERITAGE BROCHURE - NEW



Available from: https://5g-ppp.eu/5g-ppp-heritage-2023/

5G PPP

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Projects follow up	2
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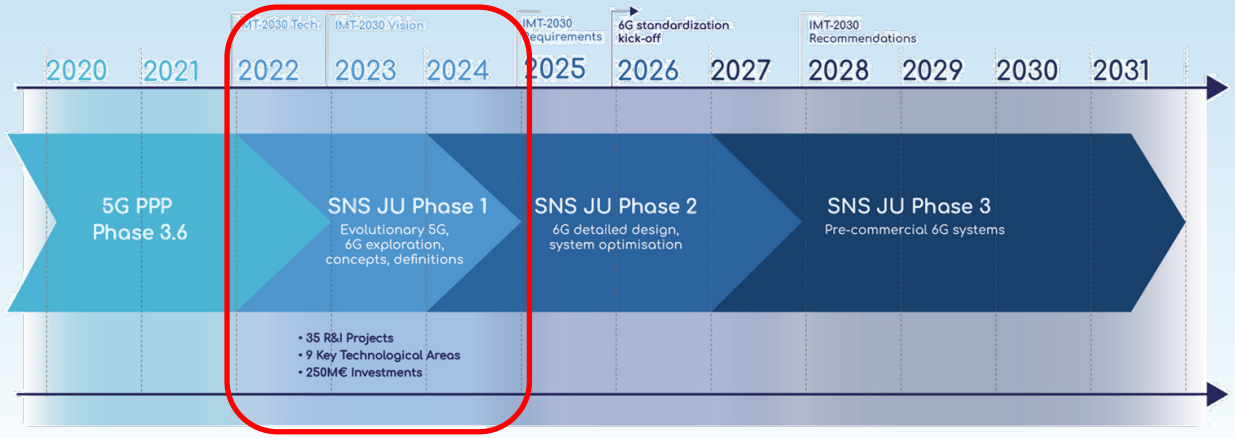
5G PPP

Phase 3 Projects	Phase 2,1,3 Projects	Components Use / Re-use
ICT-18 Automotive		
5G-MOBIX	5G-EVE	5G-EVE Athens 5G testbed used for the testing and validation of the WINGS OBU and Application, before deployment at the borders.
	5GCAR	Cooperative perception for manoeuvres of connected vehicles (through on-board camera and laser support.
	INSPIRE-5Gplus	Aligned testing scenarios with 5G-MOBIX with a reference vehicular test-case provided with cybersecurity and GDPR assurance modules.
ICT-19 Advanced 5G validation trials across multiple vertical industries		
5G HEART	5G-VINNI	Norwegian testbed: 5G NSA core and RAN used for healthcare and fishfarming use-cases. Utilized KPI performance test tools.
	5GENESIS	5GENESIS: 5G SA testbed consisting of Rel. 16 5G core and RAN nodes used mainly for transport use-cases and KPI performance testing.
5Growth	5G-TRANSFORMER	Leveraged slice/automation and Verticals support.
	5GEx	Leveraged multi-domain and federation topics.
5G-SMART	METIS-II	Reused algorithms and analysis of spectrum deployment options, latency and capacity assessments.
	5G-EVE	Built on concepts regarding 5G deployment developed for 5G-EVE.
	5G-RECORDS	5G-RECORDS was using parts of the same 5G infrastructure that 5G-SMART used.
5G-SOLUTIONS	METIS-II	5G RAN, spectrum management architecture, air interface harmonisation, resource management framework used and extended to assist with the definition of a functional architecture, the technical specifications, the network service interfaces, spectrum management and 5G components integration.

COMING UP NEXT: TRIALS AND PILOTS IN SNS-JU

Trials & Pilots in SNS Joint Undertaking



5G ADVANCED

5G Evolution (40%) → evolutionary path

Stream A (17,5% - RIA): Smart communication components, systems and networks for 5G mid-term Evolution systems

Stream D (~20% - IA): Large Scale SNS Trials and Pilots with Verticals

6G

6G (60%) → revolutionary path

Stream B (~50% - RIA): Research for revolutionary technology advancement towards 6G

Stream C (~10% - RIA): SNS experimental infrastructures

- **Stream D in Call 1: Large Scale SNS Trials & Pilots with Verticals**
  - Starting date and duration: 1st January 2023, 24-36 months
  - 4 projects (out of 35), 46 M€ granted (out of 240 M€)

TARGET-X — Trial Platform for 5G Evolution Cross-Industry on Large Scale

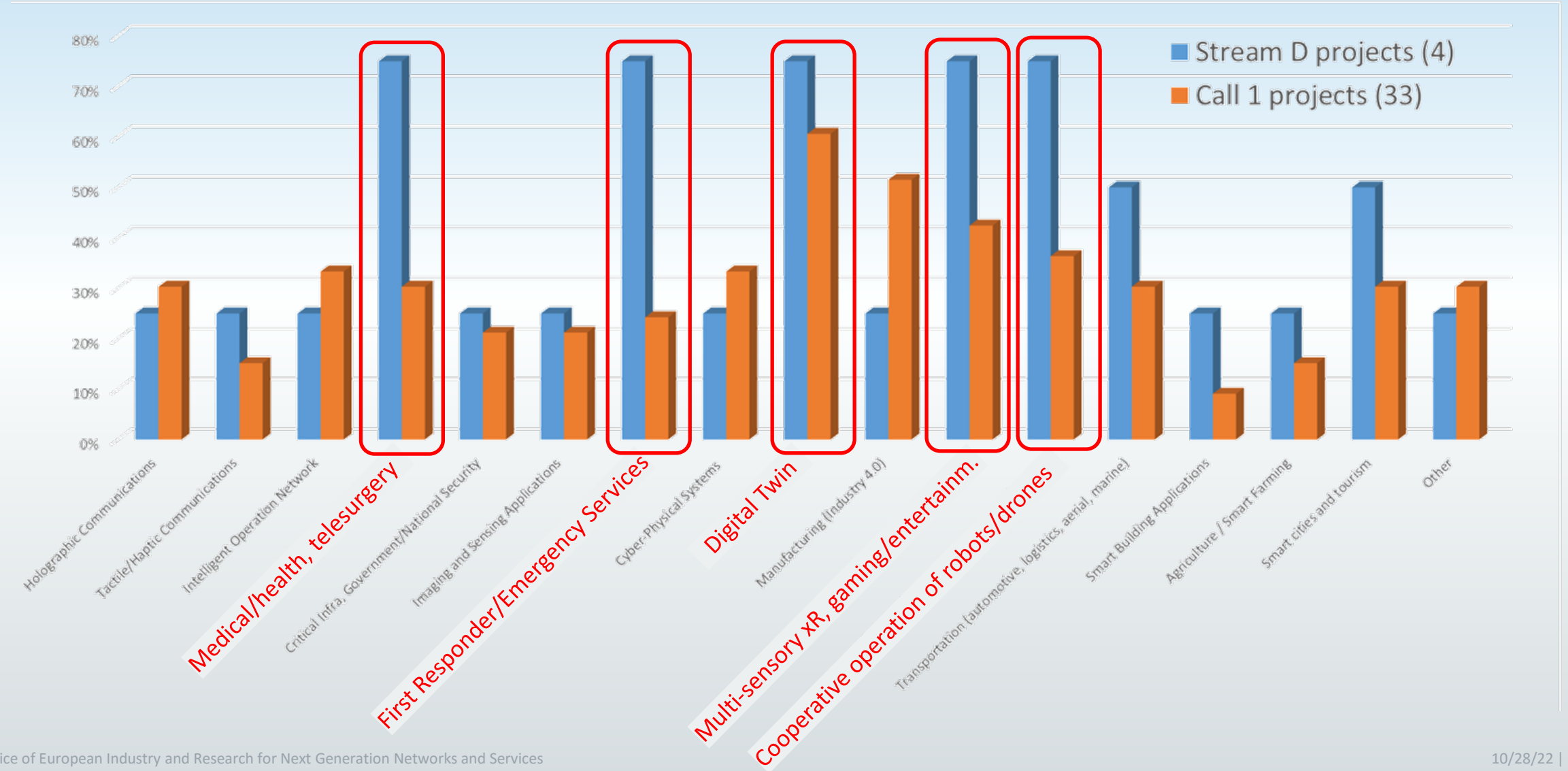
TRIALSNET — TRials Supported By Smart Networks Beyond 5G

fidal — Field Trials beyond 5G

Imagine B-5G — Advanced 5G Open Platform For Large Scale Trials And Pilots Across Europe

- **Stream D in Call 2:**
  - 2 projects (under negotiation), Connected and Automated Mobility / Health, Smart Cities, Farming, or Education.
  - 26 Meuro granted

Use cases/applications in SNS Call 1 projects

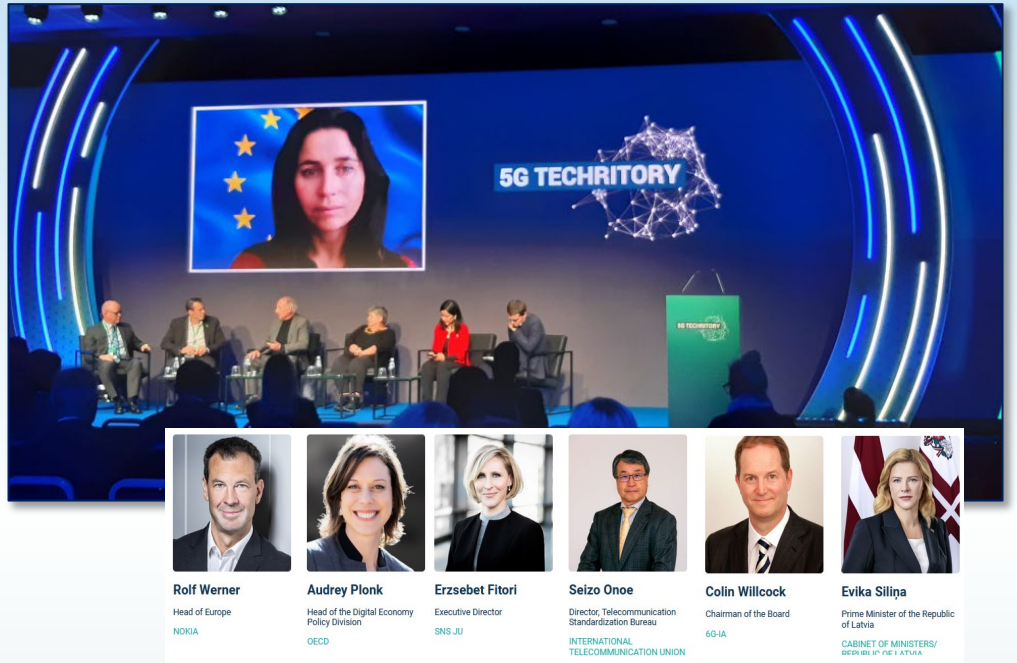


Co-creation event on 5G Verticals @ 5G Techritory

5G for verticals: from large scale trials to adoption, driving economic value in Europe

5G TECHRITORY (Oct. 18-19, 2023 in Riga, Latvia)

- 120 speakers and 2000+ registered attendees from +81 countries
- Policymakers, scientists, telecoms specialists, businesses, and governments
- Keynote speeches, co-creation events, panel discussions.



5G FOR VERTICALS CO-CREATION EVENT - AGENDA

1) **Welcome and introduction to the co-creation workshop** [R. de Peppe, TIM; C. Antón-Haro, CTTC]
2) **Large-scale 5G Trials and Pilots in Europe**:
   - An overview of 5G -PPP pan-European T&Ps with Verticals [C. Antón-Haro, CTTC]
   - 5G trials for smart assisted navigation: practical experiences from VITAL-5G project [G. Landi, Nextworks]
   - NTN systems and technology developments in support of 5G verticals [M. Guta, ESA]
3) **5G Success Stories: commercial deployments in selected verticals**
   - 5G in the railway/logistics sector [S. Alsina, Cellnex] [V. Kaukomaa, Nokia]
   - 5G-enabled AR/VR for defense applications [E. Lidere, LMT]
4) **5G Economic Impact** [P. Castells, GSMA]
5) **Panel discussion: 5G for verticals - lessons learnt, challenges and what comes next**

Lessons learnt from Trials & Pilots and early 5G deployments

- T&P helpful in bringing together several different perspectives and get a good impression of what the performance will be in real deployments.
  - Verticals need to be involved from early stages of research: cascade funding
  - Participation of the entire ecosystem (value chain) in trials, etc. is very important.
  - The business part is as important as the technical part of research projects → better business models.
- Key to understand the needs/pain points of the customer.
  - Can be challenging (e.g., when trying to build a private network)
  - New use cases ahead? Sometimes it is more about doing the same thing more efficiently.
- Slicing with SA a basic enabler of differentiated services for verticals (e.g., 3 service layers in rail)..but not in full action yet.

- Private networks can be a powerful enabler for updated and new services
  - Transport & logistics domain presents opportunity for significant gains in terms of man-hours and fuel efficiency.
  - 5G for defence: increasing safety & efficiency (e.g., AR/VR military training)

Economic and Societal Impact of 5G for Verticals

- 5G has the potential to drive digital transformation in various vertical sectors, especially enterprise applications.
- Benefits on society need to be weighted when calculating the value of the technology
  - How to deal with the conflict between a non-economically viable use case with great societal advantages (e.g., connected ambulance)? Who will invest?
- About 15% of operators claim that private networks and IoT will bring a significant part of their revenue [GSMA]
- Non-Terrestrial/Satellite Networks becoming an integral part of 6G networks and can cover use cases from multiple verticals
  - Verticals keen on using NTN communications, but ready to assume the associated cost?
- Expenses for new networks mostly born by MNOs but revenues go to third parties. Viability?
- Deployment cost also problematic: verticals to assist with use of their property/land?

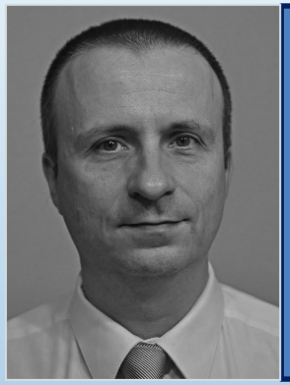
KEY TAKEAWAYS

Key Takeaways

- Strong and sustained EU investment in 5G-PPP Trials and Pilots in Horizon 2020 (2014-2020).
- Phased approach: 5G application to specific verticals, platforms, large-scale pilots for multiple verticals.
- Comprehensive coverage of verticals: automotive, transport & logistics, industry 4.0, public safety. e-health, media and entertainment, agriculture, smart cities...
- Many sources of information available: verticals cartography, T&P brochures, etc.
- Large-scale Trials and Pilots to continue in 6G Smart Networks and Services Joint Undertaking (2021-2027).
- Valuable lessons learnt from Trials & Pilots and early 5G deployments in verticals markets: role of verticals and their needs, key 5G technologies, economic and societal impact of 5G.

Thank You! Questions?

The Voice of European Industry and Research for Next Generation Networks and Services



Carles Antón Haro, PhD, MBA

Trials WG chair, member of the Governing Board 6G IA, 6G-SNS JU

Director of European Programmes & Industrial Contracts , CTTC

carles.anton@cttc.es