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Final document of service scenarios/applications for PoC

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Abstract

This deliverable lists the use cases, scenarios and applications for the design of the Proofs of Concepts (PoC) field trials to be conducted in Work Package 5 (WP5). Three main use cases have been identified: Broadband moving hotspot network, Simultaneous satellite and cellular multi-connectivity, and Public safety. For each of them, a set of scenarios – technologies – aimed at validating them, are defined. The PoC field trials will be realized thanks to the following tools: European (EU) testbed (EU-Testbed), Korean (KR) trial platform (KR-Trial), EU trial platform (EU-Trial) and joint KR-EU trial platform (Joint-Trial). The Key Performance Indicators for each scenario are also stated.

Keywords

Proof of Concept, field trials, use cases, scenarios, enabling technologies, Key Performance Indicators

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Executive Summary

5G-ALLSTAR aims to deliver various types of PoC demonstration with key technologies developed in each WP, and for potential use cases of 5G-ALLSTAR identified in deliverable D2.1, this deliverable is responsible for providing a description of PoC service scenarios, applications and target KPIs with different types of testbeds and trial platforms whose architectures and interfaces are specified in deliverable D2.3. The PoC use case in this deliverable consists of three main standalone PoC use cases, which are Broadband moving hotspot network, Simultaneous satellite and cellular multi-connectivity, and Public safety, and one joint KR-EU PoC use case for intercontinental interoperability. Each PoC use case contains multiple scenarios, and each scenario will be demonstrated through a corresponding testbed or a trial platform to verify a set of associated KPIs. In particular, the joint KR-EU PoC demonstration for intercontinental interoperability services will be carried out during Roland Garros 2021 as part of the closing ceremony of this project. The visitors will be able to experience 5G services of 5G-ALLSTAR by playing a VR tennis game with a player in the trial site (Toulouse). They will also see other PoC demonstrations highlighting the technical achievements of the project. In addition, in this deliverable, the target PoC KPIs identified in deliverable D2.3 are updated by taking implementation feasibility and constraints of testbeds/trial platforms into account. Through the PoC demonstrations, the 5G-ALLSTAR project will be able to verify the feasibility and superiority of developed technologies, and it is expected to eventually contribute to the technical evolution of 5G, paving a road for the next-generation communications.

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List of Abbreviations

3D	Three dimensions
3GPP	Third Generation Partnership Project
5G	Fifth Generation
BLER	Block Error Rate
DNC	Direct To Node broadcast
EU	European
GEO	Geostationary Orbit / Geostationary Orbit Satellite
gNB	Next Generation NodeB
GSE	Generic Stream Encapsulation
HD	High Definition
IP	Internet Protocol
KPI	Key Performance Indicator
KR	Korean
LoS	Line of Sight
MC	Multi-Connectivity
MCC	Mobile Cell Connectivity
MCH	Mobile Cell Hybrid connectivity
mmWave	Millimeter wave
NR	New Radio
OAI	Open Air Interface
PHY	Physical Layer
PoC	Proof of Concept
QoS	Quality of Service
RAT	Radio Access Technology
RRM	Radio Resource Management
SNR	Signal-to-Noise Ratio
TR	Technical Report
TS	Technical Specification
TV	Television
UE	User Equipment
UHD	Ultra High Definition
V2I/N	Vehicle-to-Infrastructure/Network
VR	Virtual Reality
WP	Work Package

1. Introduction

The key roles of Work Package 2 (WP2) are

- Identification of potential use cases and Key Performance Indicators (KPIs) of 5G-ALLSTAR technologies,
- Defining service scenarios/applications and target KPIs for Proofs of Concepts (PoC) to be conducted in WP5,
- Architectural framework providing other technical WPs with the design of system architecture, required interfaces, and key components,
- Business assessment for vertical markets empowerment,

and the results are reported in the five deliverables D2.1 to D2.5.

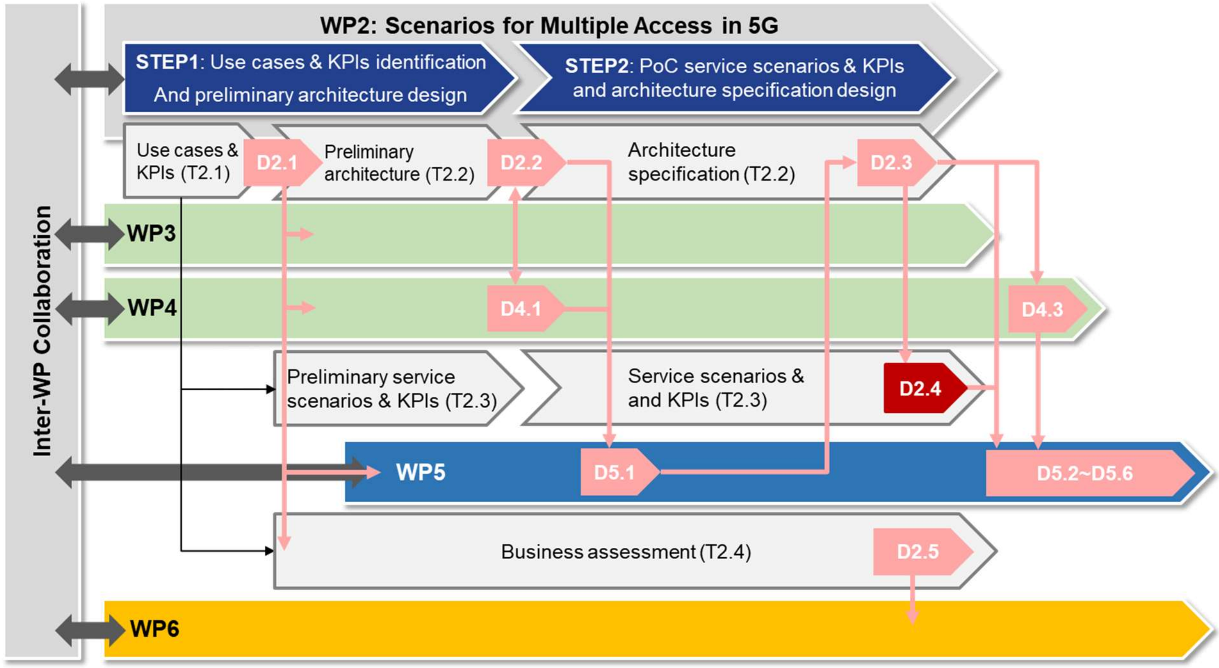

Figure 1-1: Relationship between WP2 and other WPs.

Figure 1-1 illustrates the relationship between WP2 and other technical WPs, mainly highlighting the impact of WP2 deliverables on the activities and deliverables of other WPs. This deliverable lists the scenarios and applications for the design of the PoC field trials to be conducted in WP5, and also provides the updates on the target KPIs, which plays an important role in providing the PoC guidelines to achieve the goals of the project. The field trials will be realized with the tools summarized in Table 1-1.

Table 1-1: Tools for PoC field trials

Tool	Description
KR-Trial0	Korean (KR) trial platform without Multi-Connectivity (MC) support (see details in §2.3.1 and §3.1 of [3])
KR-Trial1	KR trial platform with MC support (see details in §2.3.1 and §3.1 of [3])
EU-Testbed	European (EU) testbed (see details in §2.3.2.1, §3.2.1, §3.2.2, §3.2.3 of [3])
EU-Trial	EU trial platform (see details in §2.3.2.2, §3.2.4, §3.2.5, §3.2.6 of [3])
Joint-Trial	Joint KR-EU trial platform (see details in §2.3.3, §3.3 of [3])

The architectures, the components and the interfaces of these tools have been described in deliverables D2.3 [3] and D5.1 [4]. In [3], Key Performance Indicators (KPIs) targetted for PoC field trials are listed.

This document is organized as follows. In the first four chapters, four main use cases have been identified as

- Broadband Moving Hotspot Network (§2),
- Simultaneous Satellite / Cellular MC (§3),
- Public Safety (§4),
- Intercontinental Interoperability (§5),

and the conclusion is drawn in §6. Each use case is composed of several scenarios, and each scenario may be seen as a given technology that allows to validate/verify all or part of the use case. Furthermore, each scenario demonstrates all or part of a 5G-ALLSTAR concept. The 5G-ALLSTAR concepts were defined in the technical annex and are recalled below:

- Spectrum sharing,
- Interference management,
- Beam switching,
- MC between heterogeneous access links:
    - Link aggregation,
    - Traffic switching,
    - Traffic splitting,
- Inter Radio Access Technology (RAT) Radio Resource Management (RRM),
- Testbed prototyping for 5G:
    - Testbed prototyping for mobile backhaul,
    - Open Air Interface (OAI) and prototyping of 5G New Radio (NR) based satellite access.

Then, for each scenario: (i) the applications, i.e. how the scenario may translate to the user, are detailed; (ii) the targetted KPIs, extracted from [3] and some of which are refined, are listed, and (iii) the means of demonstration of the scenario are provided.

For each scenario, considering the proposed PoC, the opportunities that it demonstrates for vertical markets are discussed. Four core dimensions are identified:

- The addressed vertical, with particular emphasis on the main target verticals in the area of transport (e.g. public safety, railway transportation sectors, etc.), public safety, and rural communities.
- The customer activity that preconizes the tasks, problems or wish the customers are intended to deal with, solve or satisfy and that could be interested by the demonstrated technological capability.
- The customer profile that identified a pertinent target customer, that may spur a market segment.
- The demonstrated value driver that abstract customer's perceived value of the demonstrated technological innovation.

This document is dedicated to scenarios for PoCs; it is important to note that some of the 5G-ALLSTAR concepts will be demonstrated through software simulations in the corresponding WPs, i.e. WP3 – Spectrum Sharing and WP4 – Multi Connectivity. The results will be provided in the following deliverables:

- Deliverable 3.3, “Interference mitigation techniques,” due June 2020.

- Deliverable 4.2, “Design and simulation of the multi-RAT load balancing algorithms”, December 2019.
- Deliverable 4.3, “Implementation of the multi-RAT load balancing algorithms and technical specifications of the relevant interfaces,” due December 2020.

2. Use case 1: Broadband moving hotspot network

This use case is related to the following 3GPP use cases or use case series, identified in deliverable D2.1 [1]:

- Mobile broadband for hotspots scenario, in TR 22.891 [5];
- Higher User Mobility, in TR 22.891 [5];
- Connectivity everywhere, in TR 22.891 [5];
- Vehicular Internet & Infotainment, in TR 22.891 [5];
- Deployment and Coverage, in TR 22.863 [6];
- Mobility support, in TR 22.864 [7];
- Mobile Cell Connectivity (MCC), in TR 22.863 [6] and TS 22.261 [7]:
    - MCC3 (Extension to bus, as moving platform);
- Mobile Cell Hybrid connectivity (MCH), in TR 22.863 [6], TR 22.862 [9] and TS 22.261 [7]:
    - MCH1 (the cellular connectivity is intermittent), and
    - MCH2 (the cellular connectivity is permanent);
- Direct To Node broadcast (DNC), in TR 22.864 [7] and TS 22.261 [7]:
    - DNC2 (TV or multimedia service delivery to onboard moving platform);

2.1 Scenario 1: beam switching technique for mmWave-band vehicular communications

2.1.1 Description

In urban and highway scenarios, with the developed beam switching technique, broadband and reliable communication Vehicle-to-Infrastructure/Network (V2I/N) links can be maintained for moving vehicles even when overtaking or driving on a curve, which allows onboard passengers to enjoy their in-vehicle mobile services (e.g., broadband Wi-Fi services and 3D/UHD video streaming).

In this PoC scenario, the following 5G-ALLSTAR concepts are addressed:

- Beam switching,
- Testbed prototyping for 5G:
    - Testbed prototyping for mobile backhaul,

and as described in Technical Annex, the testbed prototyping for mobile backhaul includes two key technical aspects:

- Improvement of beam management and interference management, and scheduling of the multiple mobile backhaul links to vehicles,
- MC with non-terrestrial access links (e.g., satellite link will be pursued for improved reliability and coverage).

This deliverable further elaborates on the two aspects, which are described in this section and §2.2, respectively. For the first aspect, mmWave-band 5G NR-based mobile wireless backhaul for vehicles will be designed and implemented both on KR-Trial0 and KR-Trial1, which will be deployed and tested on a vehicle (e.g., bus). Since the mobility pattern of the vehicle is very complex as compared with trains, a proper beam switching technique is needed, and the interference management will be studied through simulation as part of WP3 activities. In addition, the multiple access and scheduling for multiple mobile backhaul links to vehicles will be also implemented on KR-Trial0 and KR-Trial1.

2.1.2 Applications

Following applications are considered for this scenario:

- Broadband Wi-Fi services,
- High-quality video (e.g., 4K/8K or 360-degree video) streaming.

2.1.3 Target KPIs and means of demonstration

Table 2-1 summarizes the target KPIs and corresponding tools of demonstration for PoC scenario 1.1. The KPIs were first defined in deliverable D2.3 [3], and each KPI can be mapped to one of overall target KPIs listed both in deliverables D2.2 [2] and D2.3 [3], which were originally specified in Technical Annex

Table 2-1: Target KPI and mean of demonstration for PoC scenario 1.1

KPI label	Target KPI description		Value	PoC tool (Table 1-1)	Associated KPI (Table 4-1 of [3])
KPI0-KR0	Average physical layer (PHY) data rate of cellular access link to a bus (downlink)		500 Mbps	KR-Trial0	KPI0
KPI0-KR1	Average user-experienced data rate (downlink)		50 Mbps	KR-Trial0	KPI0
KPI1-KR0	Latency (cellular)	UP latency	8 ms	KR-Trial0	KPI1
KPI2-KR0		CP latency	20 ms	KR-Trial0	KPI2
KPI4-KR0	Handover latency		4 ms	KR-Trial0	KPI4

2.2 Scenario 2: cellular and satellite multi-connectivity for mmWave-band vehicular communications

2.2.1 Description

For mmWave-band vehicular communications in urban and highway environments, Line-of-Sight (LoS) path is often not secured due to an unexpected blockage by the vehicles or/and various structures (e.g., building) around the transceiver, which causes very lethal performance degradation. In addition, in rural highway scenarios, due to the limited deployment of network infrastructures, the quality of the terrestrial link is insufficient to provide satisfactory performance. To address this issue, MC technology integrating cellular and satellite links is developed and implemented on KR-Trial1 to show the benefits of this technology by mainly evaluating the target KPIs of the project related to reliability and service continuity.

In this PoC scenario, the following 5G-ALLSTAR concepts are addressed:

- Beam switching,
- MC between heterogeneous access links:
    - Link switching,
        - the basic architecture is specified in deliverable D2.3 [3],
        - the algorithm and technical specifications for the relevant interfaces to be implemented on KR-Trial1 will be specified in deliverable D4.3,
- Testbed prototyping for 5G:
    - Testbed prototyping for mobile backhaul.

Vehicular communications is one of the most promising use cases that can gain maximum benefit from MC technology since the satellite transceiver with a large dimension can be deployed at a vehicle. Hence, this scenario demonstrates the MC technology that can properly switch links between mmWave-band 5G NR-based mobile wireless backhaul link and Ku-band

GEO satellite link for vehicular communications and showcases the benefit by showing its improved reliability and service continuity.

2.2.2 Applications

The application considered for this scenario is high-quality video (e.g., 4K/8K or 360-degree video).

2.2.3 Target KPIs and means of demonstration

Table 2-2 summarizes the target KPIs and corresponding tools of demonstration for PoC scenario 1.2. For the reliability of satellite link, E_b/N_0, which is a normalized Signal-to-Noise Ratio (SNR) measure and also known as the "SNR per bit", is considered, and the target values for different Modulation and Coding (referred to as MODCOD) γ_{th} are defined in Table 2-3.

Table 2-2: Target KPI and mean of demonstration for PoC scenario 1.2

KPI label	Target KPI description	Value	PoC tool (Table 1-1)	Associated KPI (Table 4-1 of [3])
KPI0-KR2	Average PHY data rate of cellular access link to a bus (downlink)	500 Mbps	KR-Trial1	KPI0
KPI0-KR3	Average PHY data rate of satellite access link to a bus (downlink)	2 Mbps NOTE1	KR-Trial1	KPI0
KPI3-KR0	Reliability of cellular link: Block Error Rate (BLER)	$< 10^{-1}$	KR-Trial1	KPI3
KPI3-KR1	Reliability of satellite link: E_b/N_0 NOTE3 for Quasi Error Free (QEF) NOTE4	$>\gamma_{\mathrm{th}}$ dB NOTE1	KR-Trial1	KPI3
KPI4-KR1	Service continuity	No video streaming in-terruption NOTE2	KR-Trial1	KPI4

NOTE1: This is the target data rate to be measured under the satellite bandwidth of 2 MHz (1.6 MHz for downlink and 0.4 MHz for uplink).

NOTE2: This can be demonstrated by showing that video streaming is maintained without interruption even when the cellular link is lost.

NOTE3: $E_b/N_0 = C/N - 10\log_{10}(K_b/N_s)$, where C/N is the ratio of signal power spectral density to noise power spectral density at the modem input, K_b is the number of payload bits per baseband frame and N_s is the number of transmitted symbols per PHY frame. Internet Protocol (IP) and other network layer packets are transported on the baseband frame using the highly efficient DVB-S2 Generic Stream Encapsulation (GSE) protocol. The parameter K_b does not include the moderate GSE overhead (roughly 1 to 2%).

NOTE4: QEF operation is defined as no BBHEADER CRC-8 errors with BER better than $1e^{-8}$ for an IF-loopback (L-band).

Table 2-3: SNR threshold for Evolution X7 series remotes [10]

MODCOD Index	MODCOD Type	Payload bits per Frame (K_b)	Symbols per Frame (N_s)	Spectral Efficiency 2 (bps)	E_b/N_o for QEF (γ_{th}, dB)	C/N for QEF (dB)
1	QPSK Rate 1/4	2960	8370	0.35	2.8	-1.7
2	QPSK Rate 1/3	5120	8370	0.61	1.4	-0.7
3	QPSK Rate 2/5	6200	8370	0.74	1.4	0.1
4	QPSK Rate 1/2	6920	8370	0.83	1.8	1
5	QPSK Rate 3/5	9440	8370	1.13	2	2.5
6	QPSK Rate 2/3	10520	8370	1.26	2.3	3.3

7	QPSK Rate 3/4	11600	8370	1.39	2.9	4.3
8	QPSK Rate 4/5	12320	8370	1.47	3.2	4.9
9	QPSK Rate 5/6	13040	8370	1.56	3.6	5.5
10	QPSK Rate 8/9	14120	8370	1.69	4.3	6.6
12	8PSK rate 3/5	9440	5598	1.69	4	6.3
13	8PSK Rate 2/3	10520	5598	1.88	4.7	7.4
14	8PSK Rate 3/4	11600	5598	2.07	5.3	8.5
15	8PSK Rate 5/6	13040	5598	2.33	5.9	9.6
16	8PSK Rate 8/9	14120	5598	2.52	6.8	10.8
18	16APSK Rate 2/3	10520	4212	2.5	5.4	9.4
19	16APSK Rate 3/4	11600	4212	2.75	6.1	10.5
20	16APSK Rate 4/5	12320	4212	2.92	6.6	11.3
21	16APSK Rate 5/6	13040	4212	3.1	7	11.9
22	16APSK Rate 8/9	14120	4212	3.35	7.9	13.2
24	32APSK Rate 3/4	11600	3402	3.41	9.5	14.8
25	32APSK Rate 4/5	12320	3402	3.62	10.5	16.1
26	32APSK Rate 5/6	13040	3402	3.83	11.4	17.2
27	32APSK Rate 8/9	14120	3402	4.15	12.4	18.6

2.3 Demonstrated opportunities for vertical markets

The proposed scenarios are illustrative of the opportunity of multi-connectivity for vehicular communication.

Use case 1.1 mainly focuses on mmWave, broadband and reliable communication where V2I/N links can be maintained for moving vehicles, whereas use case 1.2 focuses in showing the technological feasibility of a reliable multi-connectivity communication both in mobility and in presence of obstacles in urban or highways areas. Transport and public safety are therefore the main vertical markets addressed.

The value driver demonstrated relates to the high service continuity offered and the high average data rate. In particular, the PoC demonstrate the emerging opportunity of vehicles as communication platforms. The focus on downlink enables the exploration of data-consumption scenario, complementary to the not explored data-creation one for which the uplink should be considered.

From a consumer market perspective, service continuity will enable for a constant access to information and services, increasing the opportunity for streaming-based or data intensive entertainment services (e.g., video and audio content). The growing data consumption per user and the increasing mobility of knowledge workers (e.g., digital nomads) will may entail the creation of new forms of work habits, yet to be explored.

From a business market perspective, the emergence of distributed backhaul platforms, opens to interesting scenarios of assets visibility, IoT coordination, and added value services relying on data link continuity being offered by transport services providers for internal efficiency of as new or improved services to their customers. While the proposed scenarios focus on buses, the multiplicity of vehicles that could act as platform (e.g., ships, UAVs, suggest

As already recognized, satellite 5G and multi-connectivity appear an ideal solution for public safety and in case of network degradation or failure in case of disaster. The deployment of mobile backhauls platforms enabling heterogeneous access links would be invaluable relief in case of emergency.

Table 2-4: Demonstrated opportunities for vertical markets of PoC 1 scenarios

Vertical	Customer Activity	Customer Profile	Demonstrated Value Driver
Transport	Entertainment	General public streaming service	Service continuity and data rate
	Work	Knowledge workers, digital nomads	
	Provide transport service	Bus company, taxy company, companies with large fleets of vehicles	
Public safety	Situational Awareness, Coordination	Public safety agencies Local administrations	
	Network resilience and recovery	Public safety agencies Local administrations	
Rural areas	Network access	Local administrations, general public	

3. Use case 2: Simultaneous satellite and cellular multi-connectivity

This use case is related to the following 3GPP use cases or use case series, identified in deliverable D2.1 [1]:

- Flexible application traffic routing, in TR 22.891 [5];
- Best Connection per Traffic Type, in TR 22.891 [5];
- Multi-Access network integration, in TR 22.891 [5];
- Multiple RAT connectivity and RAT selection, in TR 22.891 [5];
- Delivery Assurance for High Latency Tolerant Services, in TR 22.891 [5];
- Priority, QoS and Policy Control, in TR 22.891 [5];
- Higher data rates, in TR 22.863 [6];
- System flexibility, in TR 22.864 [7];
- Scalability, in TR 22.864 [7];
- Access, in TR 22.864 [7];
- Network resilience, in TR 22.862 and TS 22.261 [7];
- MC, in TR 22.864 [7], TR 22.863 [6] and TS 22.261 [7]:
  - MC1 (Users in underserved areas are connected to the 5G network via multiple network technologies and benefit from 50 Mbps+),
  - MC2 (extension of MC1 for Handset UE), and
  - MC3 (Delay sensitive traffic may be routed over short-latency links while less delay-sensitive traffic can be routed over the long latency links);

3.1 Scenario 1: simultaneous cellular and satellite access with enhanced total throughput

3.1.1 Description

In this scenario, a UE benefits from dual satellite/terrestrial connectivity, for the same (non-QoS stringent) service and at the same time. Some packets are routed on the terrestrial RAT and the others on the satellite RAT. The UE therefore transparently benefits from more bandwidth.

In this PoC scenario, the following 5G-ALLSTAR concepts are addressed:

- MC between heterogeneous access links:
  - Link aggregation
- Inter-RAT RRM
- Testbed prototyping for 5G:
  - OAI and prototyping of 5G NR based satellite access.

3.1.2 Applications

A user is enjoying a video streaming via a cellular RAT, with a given quality, e.g. HD; at a given time, as the user is moving, the satellite becomes also available: more bandwidth is therefore available. The multi-RAT system then allocates resources to that user on cellular and satellite and the video can be streamed with higher quality, e.g. 4K.

3.1.3 Target KPIs and means of demonstration

The target performance indicator for this scenario is the PHY data rate on the downlink, see Table 3-1. This KPI will be demonstrated thanks to the EU testbed.

Table 3-1: Target KPI and mean of demonstration for PoC scenario 2.1

KPI label	Target KPI description	Value	PoC tool (Table 1-1)
KPI0-EU0	Average PHY data rate of UE access link (downlink)	Downlink: 100 Mbps	EU-Testbed

3.2 Scenario 2: simultaneous satellite non-stringent QoS services and cellular stringent QoS services delivery to UE

3.2.1 Description

The UE benefits from the simultaneous connection to cellular and satellite RATs: services with stringent QoS (e.g. voice over IP or remote conference) are routed to the cellular RAT while services with non-stringent QoS (e.g. video streaming) are routed to the satellite RAT. The enablers for this scenario are traffic steering – defined as the function of distributing the traffic load optimally across different network entities and spectrum bands, considering operator and user preferences – and RRM.

In this PoC scenario, the following 5G-ALLSTAR concepts are addressed:

- MC between heterogeneous access links:
  - Link aggregation
  - Traffic switching
- Inter-RAT RRM
- Testbed prototyping for 5G:
  - OAI and prototyping of 5G NR based satellite access.

3.2.2 Applications

Video conference is one possible application of this scenario. The video stream is transmitted via the satellite RAT while the voice is transmitted through the terrestrial network.

3.2.3 Target KPIs and means of demonstration

The target performance indicators for this scenario are the reliability and the throughput of the satellite link and the latency on the terrestrial link, see Table 3-2. These KPIs will be demonstrated thanks to the EU testbed and the EU trial platform.

Table 3-2: Target KPI and mean of demonstration for PoC scenario 2.2

KPI label	Target KPI description	Value	PoC tool (Table 1-1)
KPI0-EU0	Average PHY data rate of UE access link (downlink)	Downlink: 100 Mbps	EU-Trial / EU-Testbed
KPI1-EU0	User-plane latency (terrestrial)	< 4 ms	EU-Trial / EU-Testbed
KPI2-EU0	Control-plane latency (terrestrial)	< 20 ms	EU-Trial / EU-Testbed

3.3 Demonstrated opportunities for vertical markets

This second series of scenarios illustrates a different aspect of 5G-ALLSTAR developments by focusing on link aggregation and intelligent traffic switching. Use case 2.1 illustrates how both cellular and satellite networks can be combined for providing a higher bandwidth, Use 2.2 instead, demonstrates how multi-connectivity can be purposely and leveraged for adapting to the requirements of the service.

The value driver demonstrated relates to the transparent link aggregation for meeting service demand. In particular, the PoC demonstrate the opportunity of higher bandwidth and QoS based traffic switching.

From a consumer market perspective, the scenarios demonstrate the opportunity for services to maintain the same user experience despite the heterogeneity of environments and network conditions. As already discussed, these scenarios well depict the opportunity for streaming-based or data intensive entertainment services. Link aggregation will then provide the ability to meet, under certain conditions, both objectives of low latency and broadband communication demonstrates entertainment opportunities aligned to the ongoing trends in the entertainment industry (e.g., cloud gaming, game streaming, and VR based entertainment), and open to new form of entertainment and information (e.g., augmented and mixed reality).

From a business perspective, the opportunities to reach customers with enhanced connectivity and with broadband and low latency supports distance and mobile scenario of existing services. The demonstrated opportunity for GEO satellite to deliver high bandwidth services to potentially a large number of connected devices, either fixed or mobile, untap the potential for services specifically addressing remote areas not reached or with limited connectivity.

Table 3-3: Demonstrated opportunities for vertical markets of PoC 2 scenarios

Vertical	Customer Activity	Customer Profile	Demonstrated Value Driver
Transport	Entertainment	General public, gamers	Data rate, low latency communication
	Work	Knowledge workers, digital nomads	
	Provide transport service	Bus company, taxy company, companies with large fleets of vehicles	
Rural areas	Network access	Local administrations, general public	

4. Use case 3: Public safety

This use case is related to the following 3GPP use cases or use case series, identified in deliverable D2.1 [1]:

- Connectivity everywhere, in TR 22.891 [5];
- Connectivity in rural areas that are hard to cover using terrestrial networks, in TR 22.891 [5];
- Wide area public safety, in TR 22.862 [9] and TS 22.261 [7];
- Local area public safety, in TR 22.862 [9] and TS 22.261 [7];
- Regional area public safety, in TR 22.862 [9] and TS 22.261 [7].

4.1 Scenario 1: unpredictable traffic switching

4.1.1 Description

The satellite access protects the cellular access, following an unpredictable cellular connectivity failure. The services and traffic are switched on the satellite access.

In this PoC scenario, the following 5G-ALLSTAR concepts are addressed:

- MC between heterogeneous access links:
  - Traffic switching
- Testbed prototyping for 5G:
  - OAI and prototyping of 5G NR based satellite access.

4.1.2 Applications

The rescue services are using cellular telecommunication services at a scene of a fire or storm. The cellular access suddenly shuts down due to fire or wind. They may be able to communicate via a satellite system.

4.1.3 Target KPIs and means of demonstration

Table 4-1: Target KPI and mean of demonstration for PoC scenario 3.1

KPI label	Target KPI description	Value	PoC tool (Table 1-1)
KPI4-EU1	Service continuity (if link failure)	Interruption time: 4 ms	EU-Testbed

4.2 Scenario 2: predictable traffic switching

4.2.1 Description

The cellular access protects the satellite access, following a predictable satellite connectivity breakdown. The services and traffic are switched on the cellular access. The enabler for such a scenario is traffic splitting. Traffic Splitting is the function that enables the duplication of a traffic flow over two (or potentially more) different access points or radio technologies, allowing an increase of connection reliability and stricter QoS requirement satisfaction for certain services.

In this PoC scenario, the following 5G-ALLSTAR concepts are addressed:

- MC between heterogeneous access links:
  - Link splitting
- Inter-RAT RRM
- Testbed prototyping for 5G:

- OAI and prototyping of 5G NR based satellite access.

4.2.2 Applications

The rescue services are using satellite communications while going to a scene of the disaster in an urban environment where the satellite is not available, but where cellular RAT is available. Just before the predictable satellite to cellular handover, the system may split the traffic on terrestrial and satellite links, in order to have zero interruption time when the satellite link is lost.

4.2.3 Target KPIs and means of demonstration

The target performance indicator for this scenario is the service continuity, see Table 4-2. This KPI will be demonstrated thanks to the EU testbed.

Table 4-2: Target KPI and mean of demonstration for PoC scenario 3.2

KPI label	Target KPI description	Value	PoC tool (Table 1-1)
KPI4-EU0	Service continuity (if both satellite and terrestrial links available)	Interruption time: 0 ms	EU-Testbed
KPI4-EU2	Service continuity (if buffering)	Interruption time: 0 ms	

4.3 Demonstrated opportunities for vertical markets

This third series of scenarios illustrates a peculiar aspect of 5G-ALLSTAR developments demonstrating a different use of link aggregation and splitting. Use case 3.1 illustrates how both cellular and satellite networks can be combined for providing service continuity and connection reliability in case of an unpredictable cellular or satellite connectivity failure. Use case 3.2 instead, demonstrates how multi-connectivity can be purposely managed and leveraged through redundancy, for providing highly reliable services.

The value driver demonstrated relates then to the reliability of the connectivity, supporting high availability services and service continuity for public safety. The scenarios proposed well illustrate the need for reliable connections and services in cases of adverse conditions disrupting cellular and satellite communications.

From a market perspective, the scenarios demonstrate the opportunity to support public safety agents and assets in multiple tasks including surveillance, rescue, deployment, and intelligence. The market opportunity is, however, larger than the direct support of public safety as a reliable infrastructure could be offered as a service by emerging specialized actors in both the connectivity and service space. The decreasing costs of deployment of privately managed and corporate drones fleets, for example, hits toward the potential for this actors to both act as novel infrastructure and service providers with novel value propositions in the consumer (e.g., surveillance of private properties, home healthcare/monitoring) and business (e.g., crop management, surveillance).

Table 4-3: Demonstrated opportunities for vertical markets of PoC 3 scenarios

Vertical	Customer Activity	Customer Profile	Demonstrated Value Driver
Public safety	Surveillance	General public streaming service	Service and communication continuity
	Communication	Public safety agencies Local administrations	

	Provide transport service	Bus company, taxy company, companies with large fleets of vehicles	
	Situational Awareness, Coordination	Public safety agencies Local administrations	
	Network resilience and recovery	Public safety agencies Local administrations	

5. Use case 4: Intercontinental interoperability

Use case 4, intercontinental interoperability, will be possibly demonstrated at the Roland Garros 2021 tennis tournament (the possibility is still under discussion). This use case is a comprehensive use case encompassing use cases 1, 2, and 3 using Joint-Trial, which is a KR-EU integrated PoC system, see Table 1-1.

The purpose of this use case is to showcase that providing users with a seamless, reliable, and ubiquitous broadband service and an intercontinental interoperability service is possible thanks to the 5G-ALLSTAR technologies that enable to effectively integrate the cellular and satellite networks.

We have identified some PoC scenarios for this use case, and the overall scenario is depicted in Figure 5-1. The services of these scenarios can be largely categorized into Virtual Reality (VR) tennis game and VR tennis followers, the details of which are respectively described in §5.1 and §5.2.

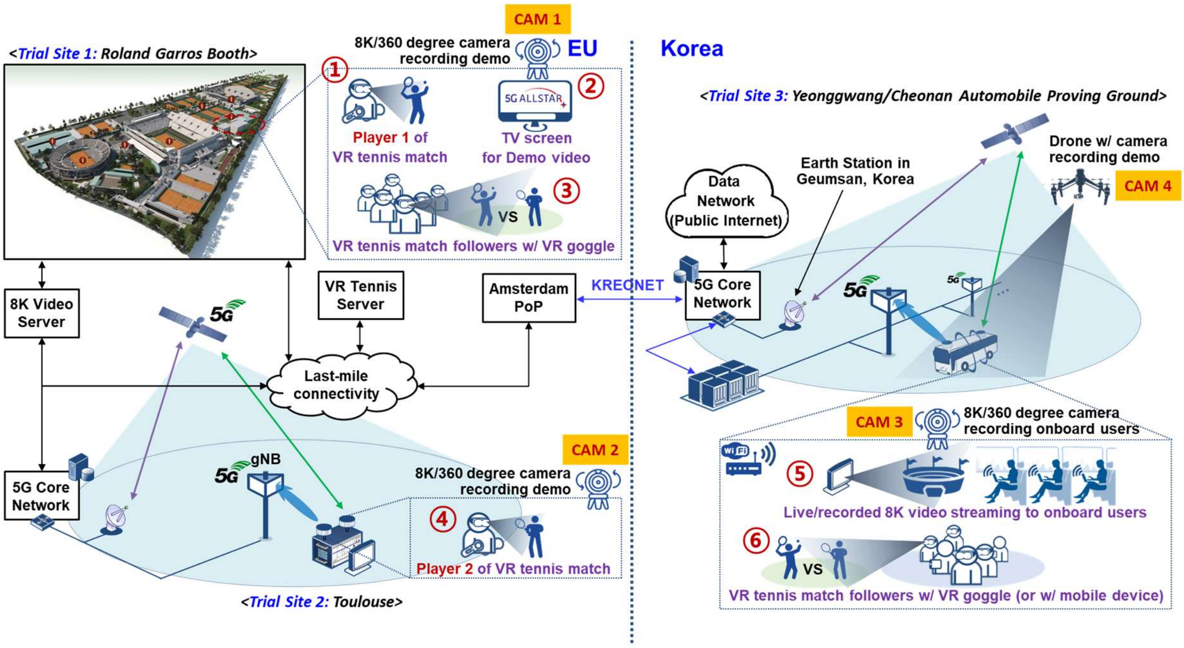

Figure 5-1: Intercontinental interoperability services.

5.1 Scenario 1: VR tennis game

5.1.1 Description

This use case with Joint-Trial platform mainly showcases the scenario where the two players located in remote places play VR tennis game thanks to the technologies introduced in EU-Testbed/EU-Trial (e.g., MC support and spectrum sharing). The VR tennis game is called Tennis Kings VR, which is developed by Appnori Inc., and the details are provided in deliverable D2.3 [3].

In this PoC scenario, the following 5G-ALLSTAR concepts are addressed:

- MC between heterogeneous access links:
    - Link aggregation (depends on the game implementation that is to be refined in the next months),
- Inter-RAT RRM,
- Testbed prototyping for 5G:
    - OAI and prototyping of 5G NR based satellite access.

5.1.2 Applications

The application considered for this scenario is VR tennis game, which corresponds to ① and ④ in Figure 5-1, and details for the VR game called Tennis Kings VR is described in [3].

5.1.3 Target KPIs and means of demonstration

The target performance indicators for this scenario are provided below.

Table 5-1: Target KPIs for joint PoC of KR and EU trial platforms

KPI label	Target KPI description	Value	PoC tool (Table 1-1)	Associated KPI (Table 4-1 of [3])
KPI1-JE0	Latency of VR tennis game	20 ms	Joint-Trial	KPI1
KPI0-JE0	Average PHY data rate of link from Toulouse site to Paris site.	100 Mbps	Joint-Trial	KPI0

5.2 Scenario 2: VR tennis followers

5.2.1 Description

As illustrated in Figure 5-1, Scenario 5.2 will demonstrate an intercontinental interoperability service with Joint-Trial platform showcasing that passengers on a moving vehicle are able to watch the VR tennis match thanks to the technologies introduced in EU-Testbed/EU-Trial and KR-Trial0/KR-Trial1. The passengers can watch VR tennis match with their own mobile devices (e.g., mobile phones, VR headset) or a TV screen installed on the bus.

In this PoC scenario, the following 5G-ALLSTAR concepts are addressed:

- Beam switching,
- MC between heterogeneous access links:
  - Link aggregation,
  - Traffic switching,
- Inter Radio Access Technology (RAT) Radio Resource Management (RRM),
- Testbed prototyping for 5G:
  - Testbed prototyping for mobile backhaul,
  - OAI and prototyping of 5G NR based satellite access.

5.2.2 Applications

Following applications are considered for this scenario:

- 4K/8K video streaming through a TV or passengers' mobile devices, which corresponds to ⑤ of Figure 5-1: real-time or recorded video of Players 1 and 2 filmed by CAM 1 and CAM 2 will be transferred to the audiences onboard a bus in Trial Site 3.
- Another possible application is for the audiences (visitors to Roland Garros and audiences on the bus in Trial Site 3) to watch the VR tennis match through VR headsets, which corresponds to ③ and ⑥ of Figure 5-1. This requires an additional function to be implemented in the Tennis Kings VR during in the third year of the project, but the final confirmation for the implementation has yet to be done at the time of this document being written.
- In addition, CAM 3 and CAM 4 may be installed in Trial Site 3 to transfer real-time or recorded video to Trial Site 1 in order to maximize the demonstration effect and to promote the technical achievements of the project during Roland Garros 2021. This

allows visitors to Roland Garros to watch the demonstration in Trial Site 3, which corresponds to ② of Figure 5-1.

5.2.3 Target KPIs and means of demonstration

Table 5-2: Target KPIs for joint PoC of KR and EU trial platforms

KPI label	Target KPI description	Value	PoC tool (Table 1-1)	Associated KPI (Table 4-1 of [3])
KPI0-JK0	Average PHY data rate of link to a bus (downlink with MC)	500 Mbps	Joint-Trial	KPI0

5.3 Demonstrated opportunities for vertical markets

This fourth series of scenarios are designed to illustrate the full extent of 5G-ALLSTAR developments demonstrating the possibility offered by a seamless, reliable and ubiquitous broadband service in an intercontinental setting based on multi-connectivity. Use case 4.1 illustrates the technological capabilities by enabling players in two continents to enjoy a VR game, whereas use case 4.2 demonstrates the case of 4K/8K intercontinental streaming while in mobility.

The value driver demonstrated is a combination of those previously analyzed but focuses mainly on a seamless, reliable and ubiquitous broadband services, available in an intercontinental setting.

From a market perspective, the scenarios provided mainly focuses on usages in mobile settings and wireless broadband service needs. As previously introduced, the PoCs well illustrate the entertainment opportunities aligned to the ongoing trends in the entertainment industry (e.g., cloud gaming, game streaming, and VR based entertainment), but supporting the development of new forms of entertainment and information (e.g., augmented and mixed reality). VR, augmented and mixed reality have been traditionally constrained by the available contexts in which they could be valuable and provide a smooth user experience. The demonstrated technologies may further support high bandwidth remote controls and operations including cyber physical systems such as smart grid, autonomous automobile systems, medical equipment for monitoring patients, industrial and robotics systems, and vehicles.

Table 5-3: Demonstrated opportunities for vertical markets of PoC 3 scenarios

Vertical	Customer Activity	Customer Profile	Demonstrated Value Driver
Transport	Entertainment	General public, gamers	Seamless, reliable and ubiquitous broadband services
	Work	Knowledge workers, digital nomads	
	Provide transport service	Bus company, taxy company, companies with large fleets of vehicles	

6. Conclusion

This document presented the strategy for the demonstration of the 5G-ALLSTAR concepts, based on field trials. Four use cases were identified: Broadband moving hotspot network, Simultaneous Satellite/Cellular MC, Public safety and Intercontinental interoperability. For each of these use cases, scenarios have been described, each of them allowing the demonstration of one or several concepts. Some concepts will be verified by software simulations in WP3 and WP4. Table 6-1 shows the mapping of concepts on use cases.

Table 6-1: Mapping of concepts to use cases

		Use cases				
		Broadband moving hotspot network	Simultaneous Satellite / Cellular multi-connectivity	Public safety	Intercontinental interoperability	Simulations
Concepts	Spectrum sharing					✓
	Interference management					✓
	Beam switching	✓			✓	
	Link aggregation		✓		✓	
	Traffic switching	✓	✓	✓	✓	✓
	Traffic splitting			✓		✓
	Inter-RAT RRM		✓	✓	✓	✓
	Testbed prototyping for mobile backhaul	✓			✓	
	OAI and prototyping of 5G NR based satellite access		✓	✓	✓	

The mapping of concepts on platforms (described in Table 1-1) is provided below.

Table 6-2: Mapping of concepts to platforms

		Platforms					
		KR-Trial0	KR-Trial1	EU-Testbed	EU-Trial	Joint-Trial	Simulations
Concepts	Spectrum sharing						✓
	Interference management						✓
	Beam switching	✓	✓			✓	
	Link aggregation			✓	✓		
	Traffic switching		✓	✓	✓	✓	✓
	Traffic splitting			✓			✓
	Inter-RAT RRM			✓	✓	✓	✓
	Testbed prototyping for mobile backhaul	✓	✓			✓	
	OAI and prototyping of 5G NR based satellite access			✓	✓	✓	

For each scenario, an early assessment of the demonstrated opportunity for vertical market is discussed. Starting from the identification of the core value driver demonstrated in each scenario, the target vertical, the customer activity and the customer profile are identified. The identification of customer activities and value drivers provides the initial evidence on which starting the development of more refined customer profiles for which novel value propositions could be advanced.

7. References

[1] 5G-ALLSTAR deliverable D2.1, "Vision, Scope and Goals," October 30th 2018.

[2] 5G-ALLSTAR deliverable D2.2, "Preliminary document of 5G-ALLSTAR architecture, API and interface specifications," April 30th 2019.

[3] 5G-ALLSTAR deliverable D2.3, "Final document of 5G-ALLSTAR architecture, API, interface specifications and KPIs for PoC," January 31st 2020.

[4] 5G-ALLSTAR deliverable D5.1, "Specification of the European Testbed of 5G cellular and satellite access networks," June 30th 2019.

[5] 3GPP TR 22.891, "Study on New Services and Markets Technology Enablers," V14.2.0, Sep. 2016.

[6] 3GPP TR 22.863, "Feasibility Study on New Services and Markets Technology Enablers - Enhanced Mobile Broadband; Stage 1," V14.1.0, Sep. 2016.

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[10] iDIRECT, "Link Budget Analysis Guide," iDX Release 4.1.x, Sep. 2018.