ThalesAlenia Space
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Horizon 2020 European Union Funding for Research & Innovation

Europe's Rail

AB4RAIL

AB4Rail Online Workshop
21st March 2022

SATELLITE SYSTEMS FOR SECURE SPACE CONNECTIVITY

Speakers: Vincenzo Schena and Alessia Miglietta

Date: 21/03/2022
Ref: AB4Rail online workshop
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SECURE SPACE CONNECTIVITY : AN OVERVIEW

/// The need for a secure and resilient global connectivity increases with the widespread digitisation of the economy and society, and the increasing geopolitical and cybersecurity threats.

/// Europe Union has the ambition to invest in the development of a new integrated, secure and autonomous space connectivity system, completing current space capacity, along with the EU's world leading satellite navigation and Earth-Observation systems, Galileo and Copernicus. This system shall provide:

- **High-speed Broadband Availability Throughout The Territory Of The European Union, Removing Dead Zones Through Integrating Terrestrial And Space Networks (Combined Technologies, 5G NTN, Etc.);**
- **Reliable, Secure And Cost-effective Governmental Communication Services That Support Protection Of Critical Infrastructures, Surveillance, External Actions And Crisis Management.**

/// The use of 5G technology and in particular of the Non-Terrestrial Network (NTN) version as regards access to the satellite, with its innovative features will greatly simplify the multiple access between the terrestrial network and the satellite network.

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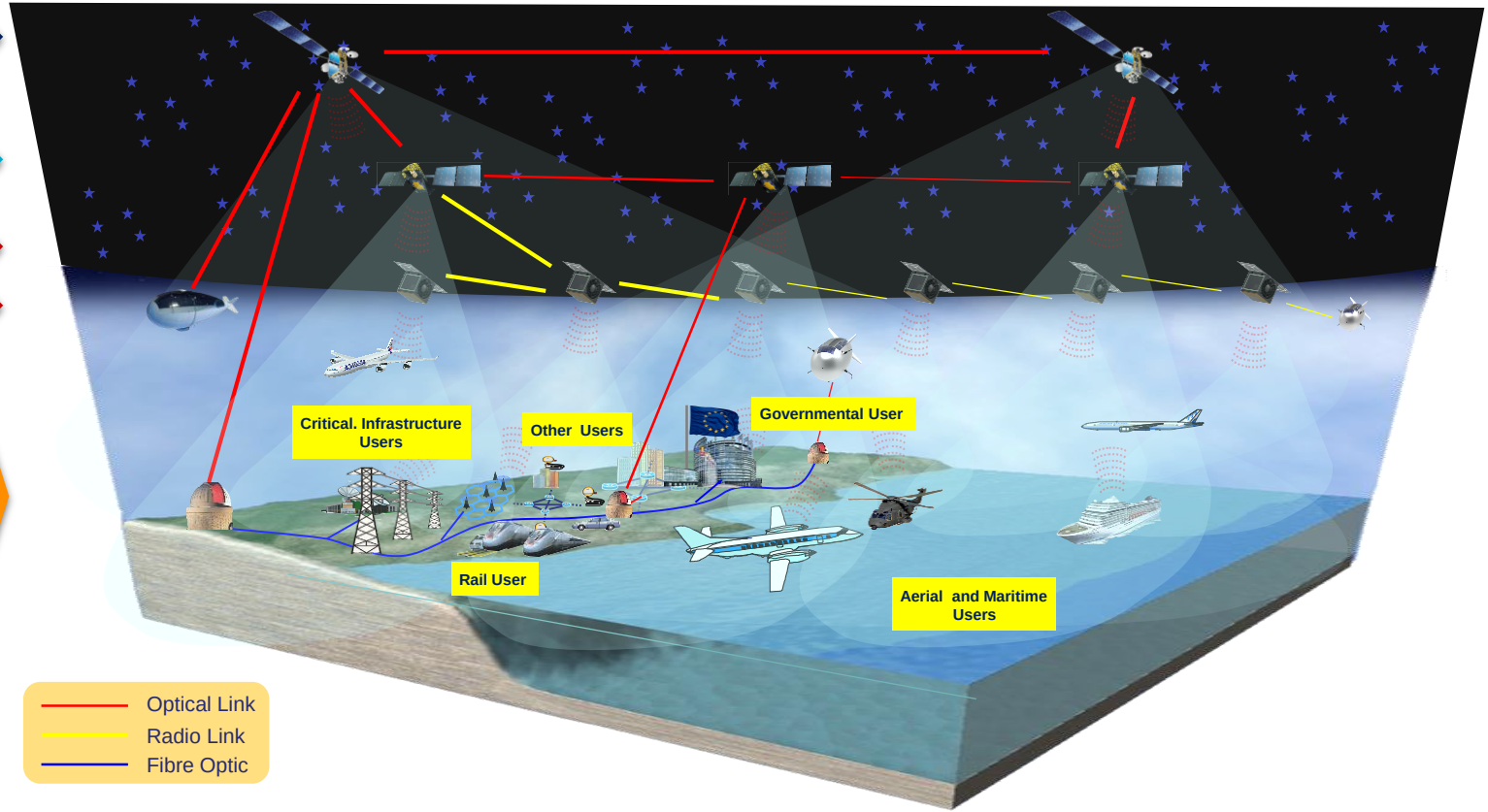
NEXT GENERATION INTEGRATED AND SECURE NETWORK SCENARIO

Next Generation Integrated Network Concept

- GEO to GEO
- MEO/LEO Constellation
- VLEO Constellation
- HAPS/Avionic
- Wireless/Wired Terrestrial Network



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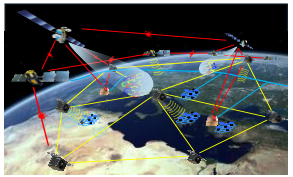
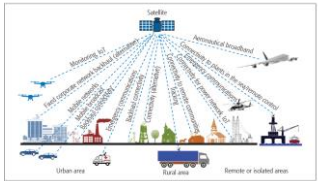
ENABLING NEW SPACE TECHNOLOGIES @TAS-I

Multi-Orbital Satellite Constellation Architecture



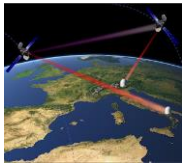
Satellite-Terrestrial High Throughput Optical Network (HydRON)

5G/Beyond 5G and 6G Non-Terrestrial Network (NTN)



[1]

Quantum Communication Infrastructure (QCI) and Quantum Key Distribution (QKD)



[2]

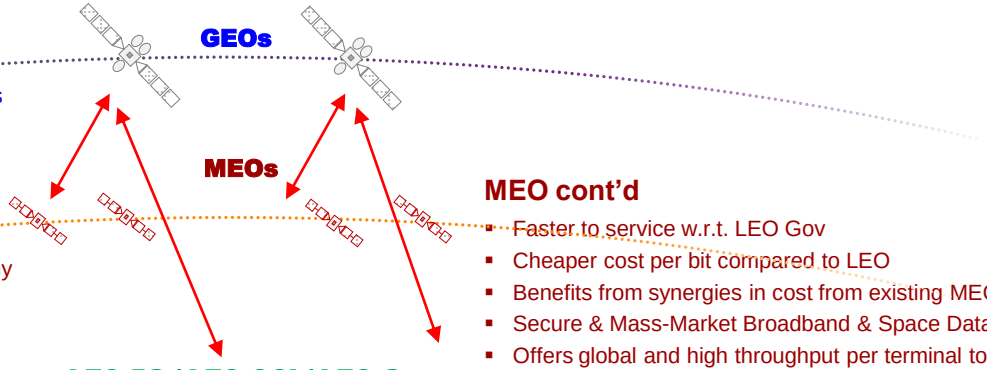
[1]: G. Giambene, S. Kota, P. Pillai; “Satellite-5G Integration: A Network Perspective”; IEEE Network, Vol. 32, Issue 5; 1 September 2018

[2]: http://www.2physics.com/2015/10/communicating-quantum-states-with-alice.html

MULTI-ORBITAL SATELLITE CONSTELLATION ARCHITECTURE

Commercial GEO Capacity

- Worldwide in constellation configuration
- Number of GEOs on a per needed basis (market driven)



MEO

- Early-entry from as early as today
- 100% owned and operated by European company
- Compatible with future MEO

MEO cont'd

- Faster to service w.r.t. LEO Gov
- Cheaper cost per bit compared to LEO
- Benefits from synergies in cost from existing MEO operations
- Secure & Mass-Market Broadband & Space Data Relay
- Offers global and high throughput per terminal to theatre of operations

LEO GovSatCom

- Optimized to maximize capacity over EU and Africa
- Special low latency connectivity introduced at the right time with maturity of users' needs
- Opportunity for hosted payloads

LEO QCI

- Demonstration phase and then deployment of a Quantum Communication Infrastructure, operable in conjunction with the broadband backbone, in order to reach an ultra-secured level of security for the most sensitive European needs

LEO 5G/6G

- Use of 5G framework allows a direct path to address existing mass market 5G capable handheld devices and 5G equipped mobility (e.g. Smartphones, rail, automotive,…)
- Direct to handheld & dongle & IoT
- Consumer and (some) Secure Broadband segments
- Emergency service & Global roaming
- Mass market potential to address digital divide reduction

5G NTN Architecture

- Satellite networks natively supported by 5G systems
- Security ensured through a dedicated security architecture
- A win-win approach for the terrestrial (cellular) & satellite ecosystems

Implementation Challenges

- Access to Spectrum for LEO 5G
- Deployment Schedule Milestones
- Implementation and combination of new space technologies (optic, 5G NTN, QCI/QKD, …….)
- Feasibility of new commercial markets
- Integration terrestrial and space networks;

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CAPABILITY AND PERFORMANCE CRITERIA

Key Elements

Capacity

Data rates expected by the users for the forward and return link and the associated commitment levels (minimum rate required)

Coverage

Distribution of the data usages specified by region with a clear separation for poles

Criticality

Includes availability, resilience (to human or natural hazards), guarantee of access and strategic autonomy

Security

Encompasses the notions of cryptography (of the satellite link) and resilience to jamming

Flexibility

Level of variability and predictability of user needs in terms of capacity and geography, required level of interoperability

Latency

Latency level expected by customers and degree of importance of the criteria

Terminal constraints

Terminal type, size, weight, ease of set up and price

SATELLITE-TERRESTRIAL HIGH THROUGHPUT OPTICAL NETWORK (HYDRON)

/// ***HydRON Phase A or HyPhA (2020-2021)***: the Study has been devoted to address the HydRON system from an end-to-end (E2E) point-of-view, defining and analysing the network aspects that is an essential part of the System. The main system elements as the Space segment (payload, platform accommodation, etc.) and the Ground segment, have been addressed in a level of detail sufficient to fulfil the objectives of a Phase A study. As conclusion a promising HydRON E2E System Architecture has been selected, analysing its elements for a following detailed design.

/// ***HydRON Simulator Testbed or HySIMULED (2021-2023)***: it will constitute an effective and preforming test, technology evaluation, system and sub-system verification and validation instrument to develop the HydRON Network, starting from the HydRON Demonstrator System up to the HydRON Mission System (the one will effectively provide services towards the Users). HySIMULED will make available the possibility to verify the protocols and algorithms that will make it work HydRON. It will measure the actual performances of HydRON giving the opportunity to facilitate its design and implementation.

/// **HydRON Demonstrator System Phase A/B1 or HyDEMO (2022-2023):** it covers all elements of the system architecture, namely the end-to-end service offered, the Space Segment, Ground Segment, User Segment, launcher aspects and the associated external/internal interfaces, to the extent required at Phase A/B1 level.
Operatively the HyDEMO defines a deployment model for the implementation of the HydRON “Tech-Driven” demonstration and the provision of a Mean Valuable Service (MVS), followed by additional HydRON “Service-Driven” stages targeting the HydRON-DS Service (also addressing commercial markets beyond ESA) that justifies and drives the definition of the associated demo / service infrastructure.

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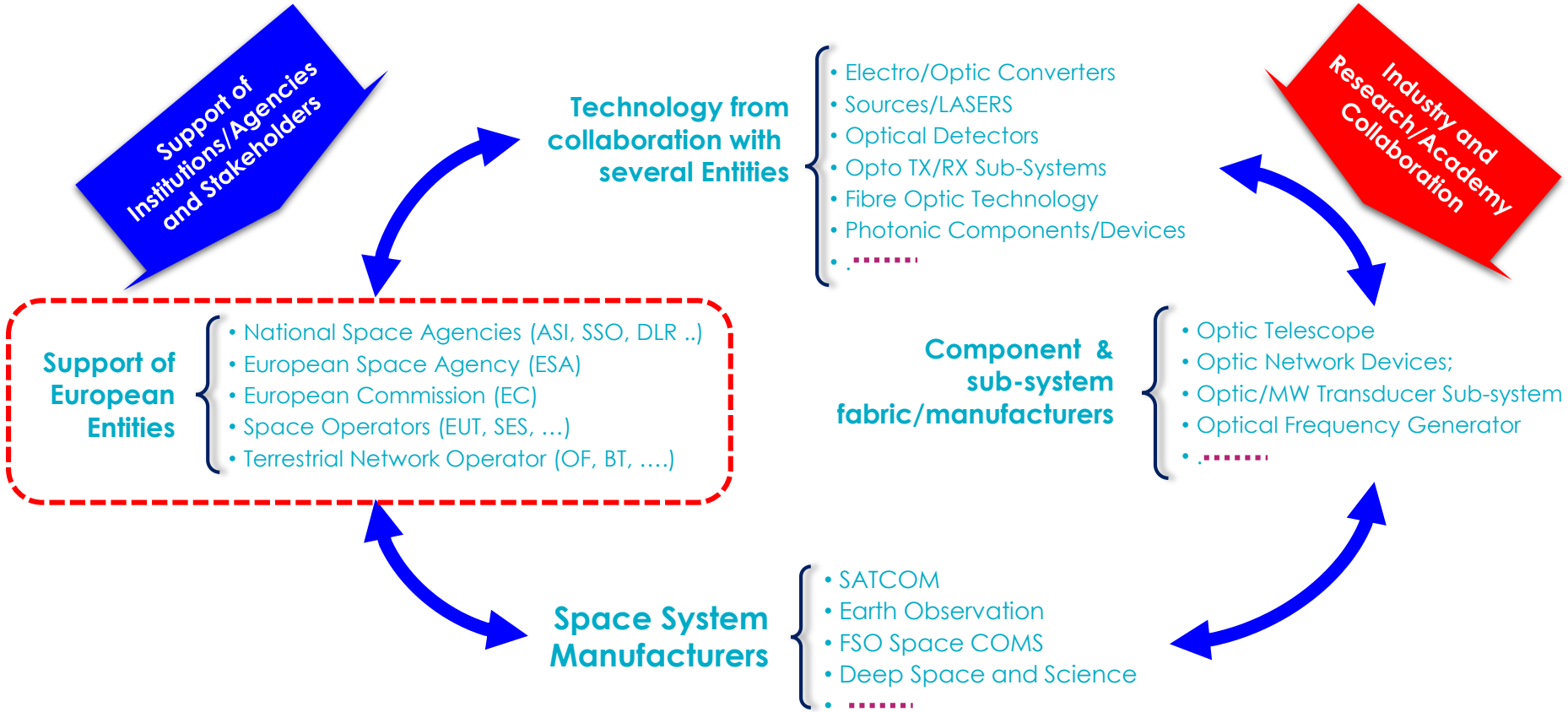
INVOLVED STAKEHOLDERS TO DEVELOP OPTICAL TECHNOLOGIES



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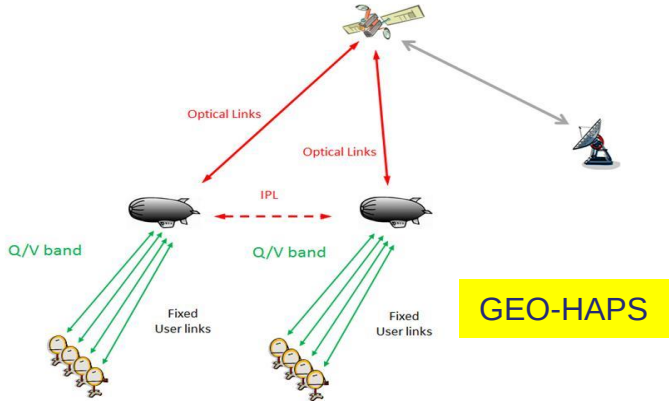
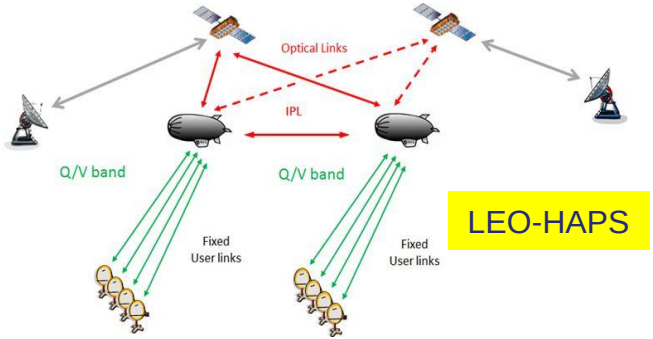
COMBINED SATELLITE-HAPS OPTICAL SYSTEMS

/// In this scenario the HAPS is also a useful complement of the satellite itself.

- **The System Benefits From The Very High Capacity Optical Links Supported By The Satellite While These Links Cannot Be Obstructed By Clouds.**
- **The Haps Adds A Concentration Function And Provide Statistical Multiplexing To The Terminals Connected To With High Peak Throughput (Hundreds Of Mbps)**

/// Being geostationary, the satellite introduces a one-way latency in the order of 250 ms and therefore in case of IP packet traffic it is necessary to implement suitable solution to manage the TCP to provide true data traffic services to end users (as with GEO HTS).





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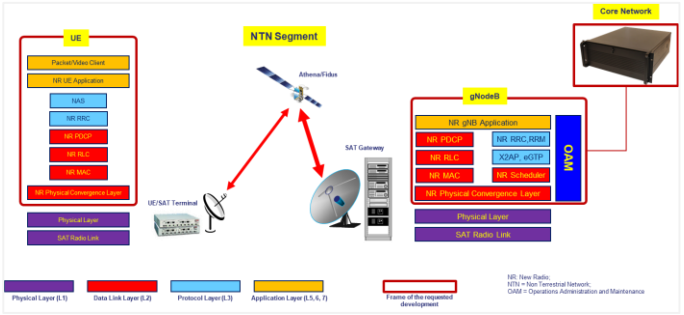
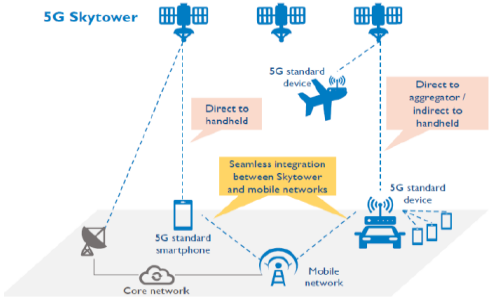
5G/BEYOND 5G AND 6G NON-TERRESTRIAL NETWORK (NTN)

First time opportunity for satellite and terrestrial network operators to combine in a seamless and transparent way the space and terrestrial networks.
LEO/MEO 5G constellation will provide low latency access for an affordable connectivity directly to mobile terminals (rail, maritime, road transport, avionic).
GEO system will provide aggregated traffic connectivity supported by optical technology.



"5G Enabled Ground Segment Technologies Over The Air Demonstrator" (GADGET) ESA Study
Development of a gNodeB (gNB) based gateway and the User Equipment (UE), compliant with the 5G standard Release 16 or above, for demonstrating the direct radio access connectivity in Non-Terrestrial Networks (NTN) i.e. satellite access network.

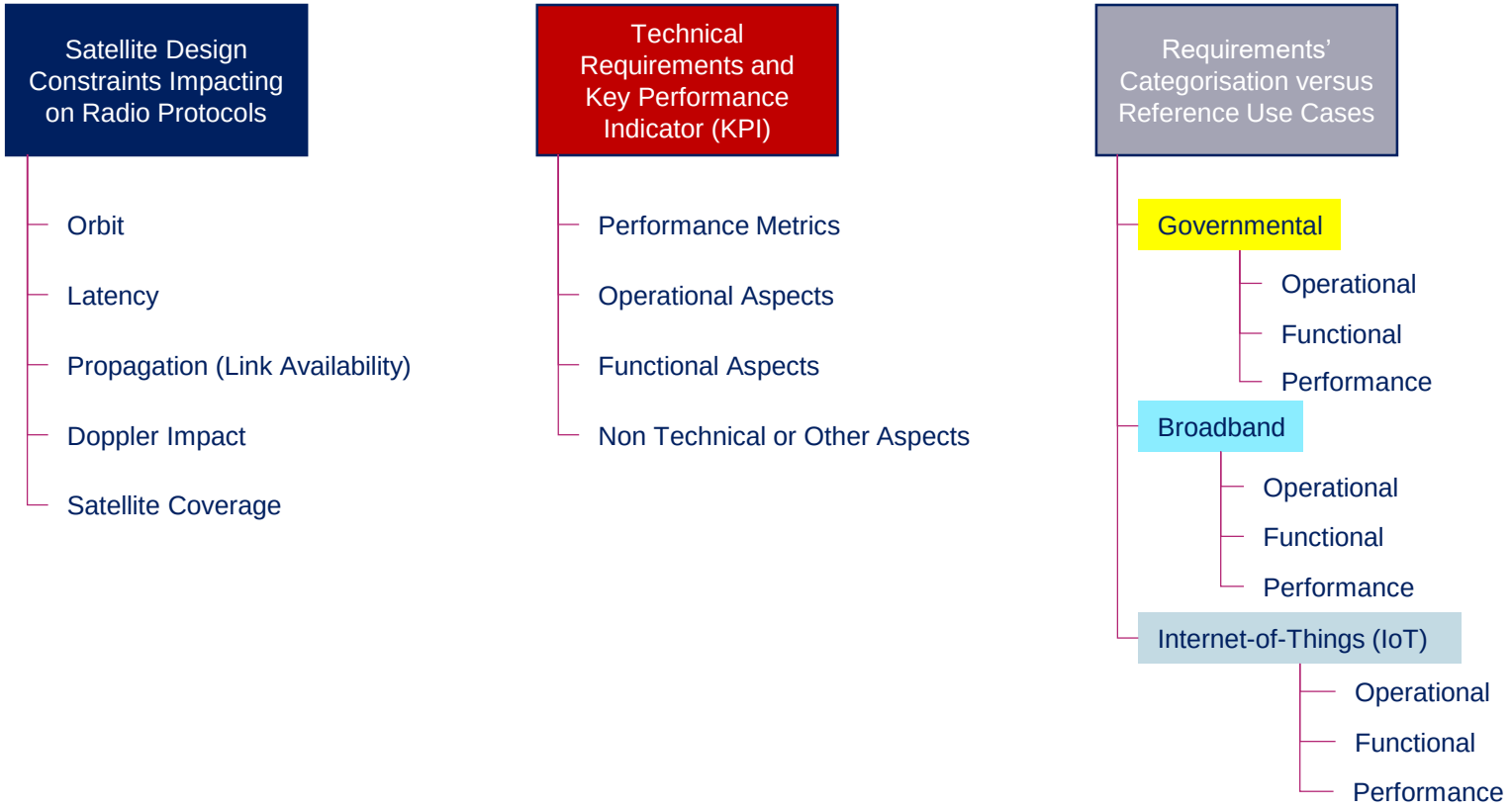


5G handheld for emergency communications service
Emergency messaging to all mobile subscribers + occasional voice for few subscribers at same time

European Secure System Use Cases

- External Action and Crisis Management: Police Interventions
  - External Action and Crisis Management: Civil Protection
    - Mass Market Commercial – Mobile Broadband Satellite Access: Mobile Mass Market Satellite Access
      - Mass Market Commercial – Mobile Broadband Satellite Access: Mobile Business Satellite Access

5G NTN SIGNAL DESIGN ELEMENTS



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BACKGROUND: ESA IRIS4RAIL STUDY – Y2018-2019

Iris 4 Railway Communications

/// Main objectives

- **PERFORM A FEASIBILITY ASSESSMENT OF THE IRIS SATCOM SOLUTION, SPECIFICALLY DEFINED FOR THE AERONAUTICS DOMAIN, IN THE RAILWAY OPERATIONAL SCENARIO**

/// Consortium: **TAS-I (Prime), Indra**

/// https://space4rail.esa.int/projects/iris4rail-iris-for-railway-communications

/// KEY TASKS AND OUTCOMES

- To **assess the suitability of the Iris service provision concept for the aeronautics domain in the railway domain**, highlighting differences and complementarities
- To **identify voice and data railway applications** supported simultaneously by SATCOM solution according to railway safety critical applications requirements
- To **develop a railway traffic dimensioning tool** to allow the estimation of communication traffic for a specific region
- To **identify the technical requirements and system architecture** of a SATCOM based solution (space, ground and user segment)
- **Provide a roadmap** of development and testing in line with ERA program and taking into account the necessary homologation/certification steps

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ONGOING: ESA SAIRCC - SATELLITE AIR INTERFACE FOR RAILWAY CONTROL COMMUNICATIONS STUDY - Y2020-2022

SAIRCC

/// **Goal of the project**

- **TO DEVELOP AND DEMONSTRATE A SATELLITE AIR INTERFACE FOR RAILWAY CONTROL COMMUNICATIONS TO BE USED AS AN ALTERNATIVE TO THE GSM-R SYSTEM**

/// **ESA-funded**

/// **Consortium: SITAEL (Prime), TAS-I, Magister Solutions (Finland), University of Salzburg**

/// Main Tasks

Results published at https://www.kaconf.com/2021/

1. Study and select the **most promising satellite scenarios** to be used as reference
2. **Revisit and refine the requirements defined in Iris4Rail ESA project and X2Rail-1 project of Shift2Rail**
3. Perform a railway **traffic and capacity analysis** at European level
4. **Design a satellite air interface** capable of addressing the identified needs
5. **Validate** the resulting air interface through realistic **packet-level simulations**
6. **Develop and validate a prototype implementation of the resulting air interface in a Software Defined Radio (SDR) platform**

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SOME CONCLUSIONS

The secure space links in a multi-orbital configuration, adopting the new technologies (optical links, 5G NTN, QKD, etc.) have to be provided of:

- Resilience in the radio link has to guarantee connectivity continuation in case of hard link conditions guaranteeing service continuation;
- Robustness towards the interferences and jammers mandatory for the utilisation, for example, in the services for critical infrastructure;
- Security, integrating in the waveform TRANSEC capabilities.

- The new technologies for the space application here summarised are providing new opportunities to open the space applications and capabilities to new markets and stakeholder requiring new applications (M2M/IoT from space, clouding, artificial intelligence in the space, rail signalling management, etc.).

.....Thank You .....

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