

# 6G Satellite Precursor – Open In-Orbit 6G Laboratory

Online Webinar  
European Space Agency  
8th March 2023

## AGENDA

- ❑ Welcome & Introduction (Fabrizio De Paolis)
- ❑ 5G SPL – Space for 5G/6G and Sustainable Connectivity: Introduction and 2023 Workplan (Antonio Franchi)
- ❑ Motivation, Description and Objectives of 6G Satellite Laboratory (Xavier Lobao)
- ❑ 5G/6G NTN Standardisation roadmap (Stefano Cioni)
- ❑ Closing Remarks (Fabrizio De Paolis)
- ❑ Q&A session – Moderator (Fabrizio De Paolis)

TODAY'S SPEAKERS



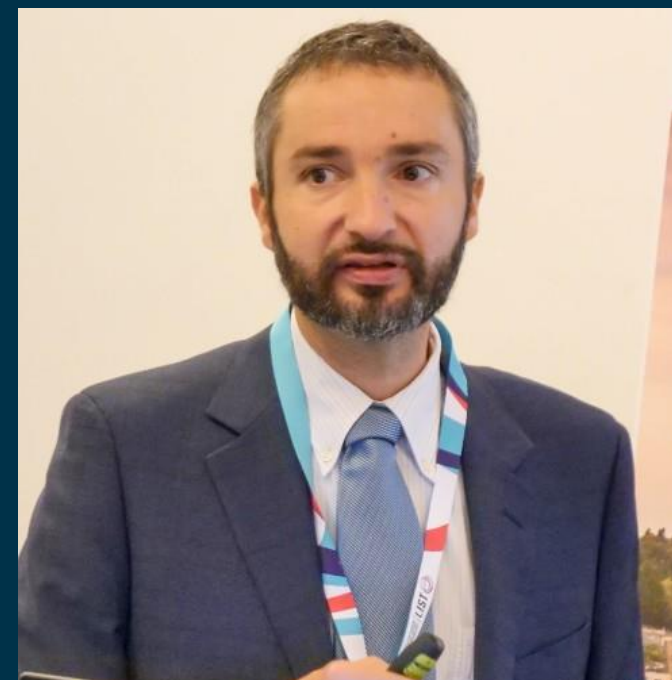
Antonio Franchi

Head of Space for 5G and 6G  
Strategic Programme Line



Xavier Lobao

Head of Future Projects Division



Stefano Cioni

Telecommunication Systems Engineer

# Space for 5G/6G and Sustainable Connectivity Strategic Programme Line



## CONNECTING THE GLOBE BEYOND TERRESTRIAL 5G/6G

### Objectives

- Achieve full integration of satellite with terrestrial 5G networks
- Engage vertical market stakeholders in 5G integrated pilots (satellite and terrestrial)
- Drive standardisation activities to ensure full inclusion of satellite in 5G standards

### Challenges

- Development of 5G/6G compliant satellite systems, aligned to terrestrial deployments
- Engagement with Mobile Network Operators, ICT technology providers and selected verticals.
- Acceleration of Satellite Operators' transition to 5G and ignite their interest for 6G



### 5G ECONOMIC IMPACT

**\$ 13.2 trillion**

Annual Global Economic benefit  
5G/6G output by 2035 (HIS Markit)

**\$ 530 billion**

Benefit from  
Space 5G/6G



- ESA publishes yearly workplans to develop the elements of 5G/6G NTN
- Fully funded – and competitively tendered – activities. Support letter from National Delegation required.
- See full details on: [2023 Work Plan](https://esastar-publication.sso.esa.int/news/details/760) (<https://esastar-publication.sso.esa.int/news/details/760>)

Activity Ref.	Title	Planned for
	<b>5G.02 – 5G System Infrastructure Study</b>	
5A.084	Study and demonstrator of HEO payload architecture for 5G-connected mobile services	Q2 2023
	<b>5G.03 – 5G New Radio – Radio Access Network (NR-RAN) Developments</b>	
3A.181	5G New Radio (NR) Non-Terrestrial Networks control plane demonstrator for NGSO constellations	Q2 2023
	<b>5G.05 – 5G Testbed Infrastructure</b>	
5A.083	5G regenerative processor and associated system test-bed	Q2 2023
3A.182	Vehicle-to-everything (V2X) services demonstration over satellite	Q4 2023
3A.183	NGSO simulator for 5G vehicle-to-everything (V2X)	Q1 2023
	<b>5G.06 – 5G Universal Satellite-Terrestrial User Equipment (UE)</b>	
6B.119	Artificial intelligence/machine learning front-end module for satcom 5G/6G integrated access-backhaul transceivers	Q4 2023
7C.082	Highly efficient 20 W S-band amplifier for 5G-connected cars	
7C.084	5G automotive antenna prototype and demonstration	Q3 2023
	<b>5G.07 – 5G Hub for Over the Air Validations</b>	Q2 2023
7C.086	End-to-end demonstration of 5G New Radio (NR) for future railway mobile communication systems	Q3 2023
	<b>5G.08 – 5G Satellite Proof-of-Concept Missions</b>	
3E.019	Open reprogrammable space infrastructure testbed for beyond 5G (B5G) end-to-end solutions and services	Q3 2023
3E.011	<b>6G Satellite Precursor</b>	Q1 2023
	<b>5G.09 – 5G Beyond 5G (B5G) and 6G</b>	
3A.184	Beyond 5G (B5G) and 6G non-terrestrial networks edge computing satellites	Q2 2023
3A.185	Spectrum sharing techniques for Beyond 5G (B5G) and 6G 3D networks	Q4 2023
	Check for schedule updates: <a href="https://artes.esa.int/artes-40-planned-activities-summary-table-scyllight-4s-and-5g">https://artes.esa.int/artes-40-planned-activities-summary-table-scyllight-4s-and-5g</a>	

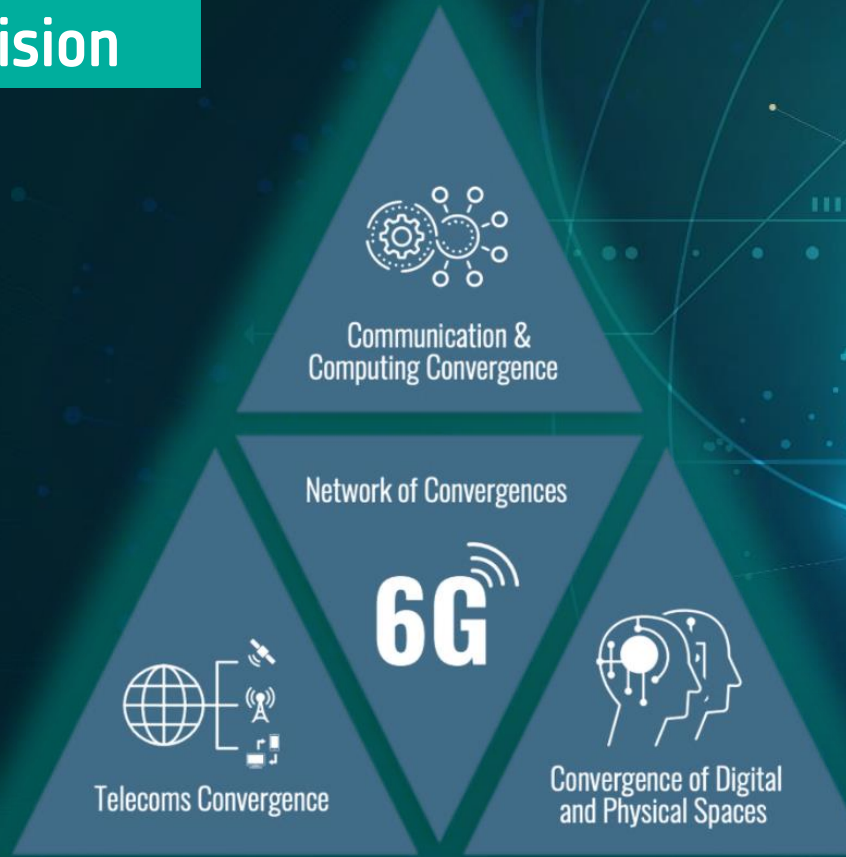


# Motivation, Description and Objectives of 6G Satellite Laboratory

X. Lobao

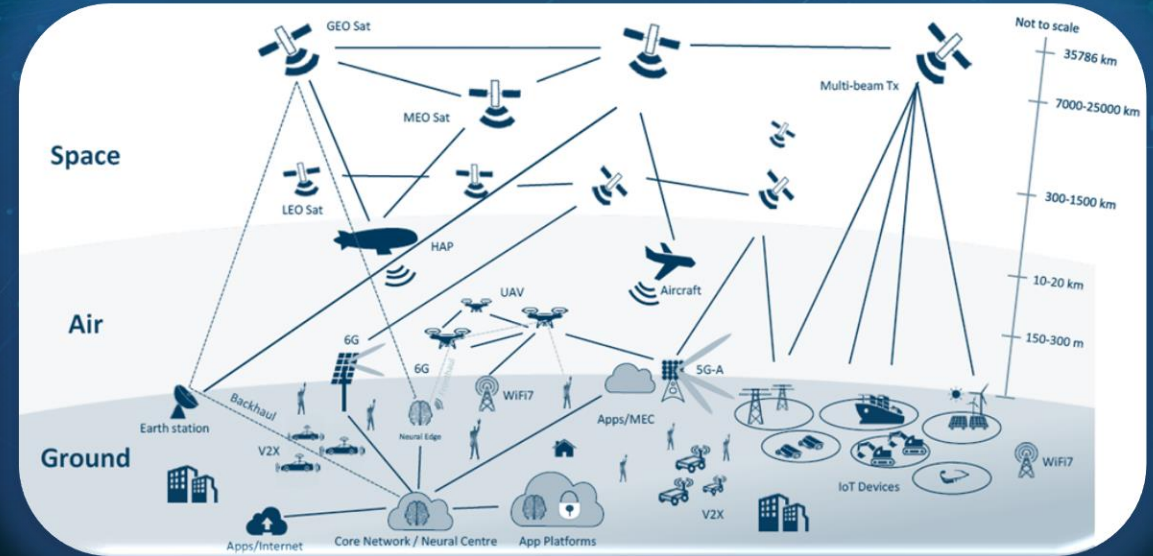






6G is not fully defined but clear trends are appearing, e.g.:

- convergence of connectivity and computation
- end-to-end network orchestration (TN & NTN)
- AI/ML everywhere - distributed intelligence
- ultra-high levels of security



# 6G European Satellite Open Innovation Lab - Motivation

Satellite is necessary to deliver 6G  
(broad consensus among worldwide 6G initiatives)

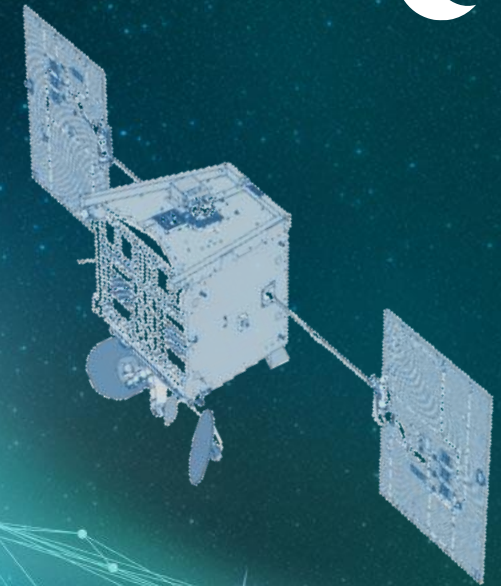
Opportunity to co-engineer and co-create the 3GPP standard ensuring NT+NTN integration

Requires availability of **satellite in-orbit laboratory**

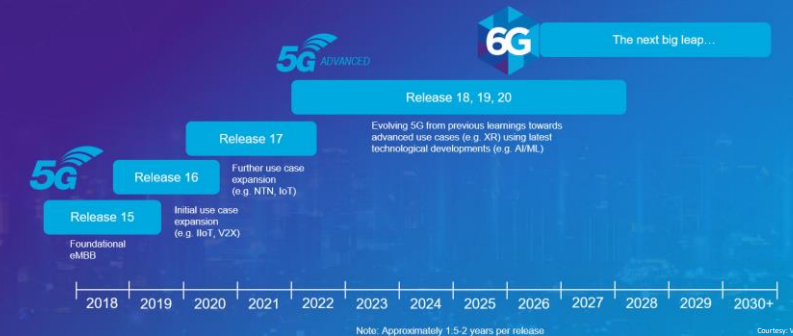
To test **seamless integration and interoperability** with terrestrial 6G R&D in networks and equipment

To test key technologies for satellite in 6G networks:

- Seamless end-to-end service-based orchestration
- AI-assisted dynamic spectrum allocation & resource management
- Self-optimised air interface
- Sub-THz transmission
- Neuromorphic processors
- Cognitive radios
- Ultra-high end-to-end security



## 3GPP Evolution from 5G and Beyond



## ACTIVITY SUMMARY

- ❑ **TITLE:** 6G Satellite Precursor (Ref 3E.011)
- ❑ **PROGRAMME:** ARTES Space for 5G/6G and Sustainable Connectivity
- ❑ **BUDGET:** 8 M€ [**Fully Funded**]
- ❑ **ITT ISSUE:** End of March 2023 (intended)



**DISCLAIMER:** The information presented in the following slides does not bind the Agency with respect in releasing the ITT and/or placing any resulting contract. The final details related to this activity will only be made available in the Invitation To Tender (ITT), once published by ESA.

# KEY ACTIVITY OBJECTIVES AND CONSIDERATIONS

Establish an **open innovation laboratory** to experiment and test 6G satellite technologies and NT+NTN integration

Timing is critical. **6G satellite laboratory** has to be **in-orbit** in **2025** to allow testing with terrestrial R&D groups before formal 3GPP standardisation phase (estimated 2026)

6G satellite laboratory for **experimentation**. Software-defined payload with max use of COTS components

Set up of open innovation laboratory: **virtual lab** with **different entry points**, managed by **neutral and competent** entity / entities providing specialised support

Entry points:

- Satellite technologies, system elements (on-board and on-ground): phy, protocols, networking, AI optimisation, orchestration, edge computing, cloud, security,...
- Terrestrial network equipment (core, RAN, cloud, E2E system orchestration, E2E security,...)
- UE and chipsets
- Vertical use cases (e.g. automotive, transport, logistics, industrial,...)

## ACTIVITY OUTCOMES

Established **open innovation laboratory** ready to interact with satellite & terrestrial R&D groups

**SLA** for 6G **satellite laboratory maintenance** (on-board software / firmware development) and open innovation laboratory **engineering support** during lifetime

Demonstrate benefits of satellite in the context of **6G use-cases**, based on hands-on/real-world experience

Provide inputs to 3GPP to support future Standard Releases for 6G NTN based on seamless TN-NTN integration and interoperability

Identify **further technology development needs** for 6G

## PRELIMINARY ASSUMPTIONS

The following bullets aim at providing some initial ideas and shall not be taken as requirements



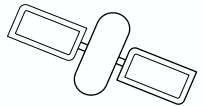
The 6G Satellite shall target advanced 5G/6G use cases, without a specific vertical target  
 The laboratory shall allow the test of different test scenarios relevant to both satellite and terrestrial users, in the areas of Core Network, Edge Computing, Radio Intelligence Control, Radio Access Network, Antenna Beam Steering, Remote Software Re-configuration and On-board Security



The activity shall define the laboratory business model for operation during lifetime, commercial operational solution is not expected



The In Orbit Laboratory targets a duration of 2 – 3 years (TBC)



The Satellite could be based on any low-cost small platform compatible with 2025 launch



No particular orbit but LEO expected

## PRELIMINARY ASSUMPTIONS

The following bullets aim at providing some initial ideas and shall not be taken as requirements



No particular frequency bands are specified but S-, C-, Ka and W-band expected to be considered in the analysis



No particular user terminal type or size is specified. Engineering laboratory so no commercial UE expected



Bidders are welcome to propose innovative ways to deploy both space / ground segment and to set up open innovative (virtual) laboratory with different entry points



Commercial-off-the-shelf (COTS) components could be used on-board. Cutting edge technology and performance with adaptations to survive space environment



The outcomes of the ESA Concurrent Design Facility (CDF) Study **6G STERLING** will be made available for reference to verified bidders

The use of the **ESA/ECSAT 5G/6G Hub** can be considered as entry point to virtual lab

Anyone willing to partner with other companies on the implementation of this mission can send us an email at [5G@esa.int](mailto:5G@esa.int) with the following information:

- Company Name
- Country
- Preferred Role: Prime/ Subco
- Competence domain: Explain what your company can bring to the consortia
- Point of Contact: Name, email/ telephone of the key point of contact



ESA will set up a list with all contacts provided and share it with the participants of this webinar and other interested parties in this mission to facilitate the consortium making



# 5G NTN Standardisation Status

S. Cioni



2020

2021

2022

2023

2024

2025

2026

**Release 17**

**Release 18**

**Release 19**

**Release 20**

**Definitions/Scenarios:**

- Transparent satellites (both GEO and LEO)
- 5G-NR and eMTC/NB-IoT
- UEs with GNSS
- FDD in FR1 (i.e., <6 GHz)
- Earth moving and Earth fixed radio cells

**Enhancements**

- Coverage enhanc.
- NR-NTN deployment in above 10 GHz bands
- Network verified UE location
- Improved GNSS oper.
- Mobility enhancements
- Discontinuous coverage enhancements

**Further Enhancements**

- Ideas for June 2023
- Decisions in December
- Possible ideas:  
Regenerative payload /  
Automotive /  
Broadcasting / ...



- ✓ Artificial Intelligence and Machine Learning
  - Regenerative payload and on-board edge-computing
- ✓ New waveform designed/optimized for both TN and NTN
  - Non-Orthogonal Multiple Access (NOMA)
  - Orthogonal Time Frequency Space (OTFS) modulation
- ✓ Reflecting/Refracting Intelligent Surfaces

- ❑ Very ambitious activity, delivering an open innovation laboratory concept with in-orbit laboratory hosting a payload solution that is compatible with known 6G trends
- ❑ Such a laboratory would allow testing of satellite capabilities and integration of 6G TN+NTN
- ❑ It would allow the satellite telecommunications community to actively participate in the definition of 6G standards by interacting with terrestrial players
- ❑ Unique **opportunity to influence** future 3GPP Releases for 6G
- ❑ ESA is interested to see **innovative and ambitious** proposals



THANK YOU FOR YOUR TIME AND INTEREST

**5G@esa.int**

