Demonstration of a 5G g-NodeB in Space
AGENDA

- Welcome & Housekeeping
- 5G SPL - Space for 5G Introduction
- ESA 5G Work Plan and dependencies
- 5G NTN Standardisation roadmap
- Activity Description and Objectives and Procurement Strategy
- Q&A session
- Closing Remarks
□ This session will not be recorded, slides will be shared (Email and registration webpage)

□ Please keep video and mic OFF during the presentations

□ All Questions will be addressed at the end of the session (Q&A)

□ Please use the chat function to post your questions [addressed to ALL]

□ At the end of the session, a survey will be sent to participants, allowing attendants to provide specific feedback related to this activity.

□ Participants can use the Survey to share their point of contact with other webinar participants
Strategic Programme Line
Space for 5G/6G
Space for 5G and 6G: Connecting the globe beyond terrestrial 5G/6G

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

Challenges
• Development 5G/6G compliant satellite systems, aligned to terrestrial deployments
• Engage 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
Space for 5G and 6G – Focus Elements

Technology, Standardisation, Testbeds & Trials, Hubs

Transport & Logistics
5G Media Broadcasting

Satellite Constellations
IoT, AI, SW, Cloud, MEC
Spectrum Management
Space for 5G and 6G – Strategic Roadmap

- **5G/6G** Standardisation
- **5G/6G** Product & Technology
- **5G/6G** Large Projects
- **5G/6G** Applications

- SDGs
- **5G/6G** Strategy
- Agenda 2025
- Seamless Integration

- 3GPP Rel.17
- 3GPP Rel.18+

- D-band
- Flying 5G

- 5G Networks
- 5G Payloads
- 3D-Networks
- VLEO/LEO/GEOMEO

- Intelligent Spectrum
- Edge Intelligence

- Sustainable Autonomous Mobility
- Digital Health
- Climate Change

- Transport
- Fintech
- Agritech
- UAVs

- Flying 5G
- 5G Broadcast
- 5G Networks

- **THE EUROPEAN SPACE AGENCY**
5G Workplan and Dependencies

F. Zeppenfeldt
5G NTN Standardization Status
NTN Timeline in 5G Release 17

2020 Q3 | 2020 Q4 | 2021 Q1 | 2021Q2 | 2021 Q3 | 2021 Q4 | 2022 Q1

NR over NTN (LEO, GEO and transparent only, GNSS assumed)
- RAN 1 activities
- RAN 2 activities
- RAN 3 activities
- RAN 4 activities

IOT over NTN (GNSS assumed)
- RAN 1 activities
- RAN 2 activities
- RAN 3 activities

SA
- SA2: Integration of satellite in 5G architecture

CT
- CT1: Integration of satellite in 5G architecture

Rel. 18 Kick-off
NTN Roadmap: how we get into Release 17!

**Release 15**
- 2018 Q1: SA1/SI: Integration of NTN in 5G
- 2018 Q2: RAN/SI: NTN support in 5G-NR
- 2018 Q3: Look at TR 22.822
- 2018 Q4: Look at TR 38.811

**Release 16**
- 2019 Q1: Look at TR 38.811
- 2019 Q2: RAN1/SI: NTN solutions
- 2019 Q3: RAN2/SI: NTN solutions

**Service Requirements**
- SA1/WI: 5G Satellite services
- SA2/SI: Satellite in 5G system Architecture
- Look at TR 23.737

**System Architecture**
- Service Requirements
- System Architecture
- TR 23.737

**Physical layer**
- RAN1/SI: NTN solutions
- RAN2/SI: NTN solutions
- RAN3/SI: NTN solutions

**Access layer and Protocols**
- Look at TR 22.822

**Architecture and Interfaces**
- Look at TR 38.821
Satellite Architectures in Release 17

Direct access via transparent satellite

Impacts on Radio Access Network (RAN)

Backhaul via satellite network

No RAN impacts

Look at TS 23.501/502/503
NTN Assumptions for Direct Access

5G NTN Rel. 17 specifications are going to be completed in Q1/Q2 2022

For the direct access scenario, the following assumptions have been made:

- Transparent payload
- GEO and NGSO satellites with Earth fixed/moving beams
- FDD in FR1 (< 6GHz)
- UEs with GNSS capabilities
What next? … Release 18

- Release 18 package (e.g., new features and enhancements) will be approved in December 2021
- NTN is certainly included (both NR and NB-IoT/eMTC)
- Candidate topics/enhancements (tentative and partial list):
  - NR-NTN deployment in above 10 GHz bands and support for VSAT/ESIM NTN UE
  - NTN-TN and NTN-NTN mobility and service continuity enhancements
  - Coverage enhancement and power reduction
  - Regenerative payload and ISL
  - Study for downlink PAPR reduction and UE without GNSS
  - NTN support in Multicast-Broadcast services
  - Mobility and further enhancements for discontinuous coverage in NTN-IoT
5G Direct Access: Protocol Stack in Transparent Payload

User Plane (UP)

Control Plane (CP)
5G Direct Access:
Protocol Stack in Regenerative Payload

User Plane (UP)

Control Plane (CP)
Activity Description
ACTIVITY SUMMARY

- **TITLE**: Demonstration of an experimental 5G g-NodeB in Space (Ref 5G 2-.020)
- **PROGRAMME**: ARTES 5G Specific Programme Line
- **BUDGET**: 4,500 kEuro [ESA Fully Funded]
- **ITT ISSUE**: Q1 2022 (intended)
- **OBJECTIVES**: The objective of the activity is to develop and demonstrate in orbit an experimental 5G g-NodeB (gNB) distributed between a regenerative payload and a satellite gateway. The demonstration will focus on showing the main functionalities of a gNB for Enhanced Mobile Broadband services (eMBB) from LEO.

- **DELIVERABLES**:
  - Study Report and Technical Notes
  - Ground Test Bed Demonstrator
  - In Orbit Demonstration results

**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.
ACTIVITY BACKGROUND

- Very ambitious activity, targeting an end-to-end in-orbit DEMO encompassing a regenerative 5G system and its components
- ESA recognises the need for regenerative on board functions, currently not scoped in 3GPP Rel. 17
- Being ahead of 3GPP Standards implies:
  - going beyond the standardisation scope into uncharted waters
  - unavailability of key 5G building blocks as available COTS
  - Some engineering assumptions will need to be made
- This implies some challenges:
  - significant effort is required in modifying existing/relevant IP’s (not in commercial quality)
  - the outcomes of this activity might not necessarily be adopted in full by 3GPP future releases.
  - future 3GPP standard might diverge from the activity implemented architecture

However, this activity poses a unique an opportunity to influence the 3GPP Release 18
ESA is interested in demonstrating 5G on board functions, not flying a new mission

ESA intends to study the implementation of 5G Regenerative functions on board a satellite payload

The activity will include:

- Definition of the In-Orbit-Demonstration (DEMO) requirements, test scenarios and KPIs
- Study different DEMO 5G system architectures and on-board regeneration functions
- Trade off benefits versus complexity of the different architectures
- Design and validation the selected system architecture(s) and its components
- Design and manufacture a ground-based test-bed to support the DEMO system validation
- Manufacturing, deployment and commissioning of the DEMO system and its components
- Operation of the DEMO fulfilling all the baselined test scenarios
- Interactions with 3GPP standardisation bodies to support Release 18 work with the demo results
- Final Report and results dissemination
ACTIVITY OUTCOMES

- Demonstrate the implementation of On-Board 5G g-NB functions in an In Orbit Demonstration

- Based on Hands-on/real-world experience:
  - Quantify the **benefits** of an on-board regenerative gNB
  - Identify **limitations and challenges** of the on-board regenerative gNB
  - Identify interesting **use cases** that could benefit from a regenerative gNB architecture

- Provide **inputs to 3GPP to support future Standard Releases for** regenerative on-board functions

- Show case the **potential of the role of a regenerative 5G Satellite**

- **Identify** further **technology development needs**
The expected main system components of the In-Orbit Demonstration are shown below:

**Space Segment**
- Implements a 5G-enabled Payload
  - Dedicated Satellite
  - Hosted payload
  - S/W defined payload

**NETWORK Segment**
- Implements 5G Core Network
  - Dedicated elements
  - Shared infrastructure
  - Cloud service

**GROUND Segment**
- Implements 5G-enabled Gateway
  - Dedicated antennas
  - Shared infrastructure
  - Cloud services

**USER Segment**
- Implements 5G-enabled terminal(s)
  - Modified VSAT
  - Mobile Terminal
  - Handheld device
The g-NodeB, as specified in 3GPP Release 17 has a modular implementation
There are 8 defined options to split a g-NodeB with clearly defined interfaces
ESA ARTES FP 1B.119 “Quantifying Reconfiguration and Flexibility Requirements for Satellite Payloads Operating within the 5G Environment” (*) addresses different 5G satellite architectures and Onboard gNB implementations

(*) Final report will be available as part of the ITT
Regenerative architectures

- Several possible architectures are possible as a result of the g-NodeB Split
- Each architecture has several benefits and challenges to be traded-off
- User Plane and Control Planes might follow different approaches
IMPLEMENTATION STRATEGY

- Activity is proposed in 4 implementation steps:

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<tr>
<th>Step</th>
<th>Tasks</th>
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| **Step A** | - Definition of the DEMO requirements and Key Performance Indicators (KPI)  
- Definition of the necessary DEMO system architecture and its components |
| **Step B** | - Preliminary Design of the DEMO system architecture and its components  
- Implementation of a ground test bed to validate the proposed DEMO |
| **Step C** | - Detailed design of the system architecture and necessary components  
- Manufacture and validate the DEMO system and its components  
- Deploy and commission the components of the DEMO system |
| **Step D** | - Execute the end-to-end in orbit demonstration  
- Final Report and results dissemination |
The following bullets aim at providing some initial ideas and shall not be taken as requirements:

- The DEMO targets enhanced Mobility BroadBand (eMBB) use cases, without a specific vertical target.
- The DEMO will allow the test of different test scenarios, involving several scenarios of space-to-terrestrial user-to-user and user-to-gateway connectivity, for both terrestrial (TBC) and satellite users.
- The DEMO is not expected to be a commercial operational solution.
- The In Orbit DEMO targets a duration of 6 to 9 Months (TBC).
- The Space Segment will implement on-board at least a g-NB Distributed Unit (DU).
- No particular space asset orbit and size are required.
**PRELIMINARY ASSUMPTIONS**

- No particular frequency bands are specified
- No particular user terminal type or size is specified
- Bidders are welcome to propose innovative ways to implement (and deploy) the space segment
- The utilisation of the system components after the DEMO is concluded is out of the scope of this activity
- The outcomes of activity C.023 "OAI NTN Extensions" can be considered as inputs for this activity
- The outcomes of other ESA 5G SPL activities will be made available for reference
- ECSAT 5G/6G Hub can be considered
Activity procurement strategy

- 2 Contractual Phases:
  - **Phase 1**: Architectural study and test bed demonstrator [Step A and Step B]
  - **Phase 2**: In Orbit Demonstration [Step C and Step D]

- Phase 1: maximum ceiling TBD% of the overall activity budget

- Proposals shall cover both Phases

- Credible and consolidated **consortium covering both Phases**

- Support letter(s) from National Delegation(s):
  - **Mandatory for Phase 1** (Note: proposals without support letter for Phase 1 will be rejected at TOB)
  - **Optional for Phase 2** (*) (Lower marking under Criterion dedicated to tender conditions will be given to bidders providing support letter for Phase 1 only). The lack of letter of support for Phase 2 shall be justified and will lead to contract price being limited to Phase 1 only (Phase 2 will remain an option)

- Further details on the evaluation criteria and weighting factors will be available as part of the ITT pack

(*) RATIONALE: *this exceptional measure is proposed given the innovative nature of this activity, the associated technological challenges and the uncertainties on the required space segment components at the moment of the proposal. The proposed approach will allow the Agency control on the activity and ensure effective use of the activity budget*
Q&A

- All Questions will be addressed at the end of the session (Q&A)
- Please use the chat function to post your questions [addressed to ALL]
- Use the Raise function in Webex if you prefer to address your question orally
Closing Remarks

- Very ambitious activity, targeting an end-to-end DEMO encompassing a full 5G system and its components.
- Unique an **opportunity to influence** the 3GPP Release 18
- ESA is interested to see **innovative and ambitious** propositions
- **Slides and Survey Link will be shared via Email** and on the Webinar Webpage
- ESA welcomes **feedback/inputs** related to this activity from interested candidates **via Survey**
- Participants can **use the Survey to share their point of contact** with other webinar participants

<Survey Link to be provided>

Note: survey inputs will not be disseminated to participants. Gathered information will be considered during the ITT preparations

Note: survey will close on 1st December 2021
THANK YOU FOR YOUR TIME AND INTEREST

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