ESA SPL 5G/6G Collaboration with CELTIC-NEXT
European Space Agency
Strategic Programme Line Space for 5G/6G and Sustainable Connectivity

CELTIC-NEXT
Autumn Call Proposers Day
7 September 2022
SatCom Market Evolution 2019-2029

**CAPACITY DEMAND EVOLUTION 2019 - 2029 BY APPLICATION**

- **Data - BB access**: 4,260 Gbps
- **Video – TV distribution**: 250 Gbps
- **Data – enterprise networks**: 1,584 Gbps
- **Data – Aircraft connectivity**: 869 Gbps
- **Data – Trunking/backhaul**: 1,137 Gbps
- **Data - Milsatcom**: 376 Gbps
- **Unused capacity**: 614 Gbps
- **Data - maritime**: 224 Gbps
- **Video - contribution**: 68 Gbps

**CAPACITY DEMAND EVOLUTION 2019 - 2029 BY REVENUE**

- **Data - BB access**: 3,641 M$
- **Video – TV distribution**: 3,284 M$
- **Data – enterprise networks**: 3,020 M$
- **Data – Aircraft connectivity**: 2,314 M$
- **Data – Trunking/backhaul**: 2,082 M$
- **Data - Milsatcom**: 1,517 M$
- **Unused capacity**: 1,298 M$
- **Data - maritime**: 914 M$
- **Video - contribution**: 599 M$

**Market volume**
18,723 M$ (+72.5%)

**Demand**
9,382 Gbps (+510%)

$/Mbps/annum
1,996 M$ (-71.7%)

Source: Euroconsult “Satellite Connectivity and Video Market” July 2020
3GPP Release 17: Completing the first phase of the 5G evolution

To bring new system capabilities and expand 5G to new devices, applications, and deployment

A key 5G milestone: 3GPP Release 17 Completion

- Functional freeze March 2022
- ASN.1 freeze in June 2022
Release 17 establishes 5G NR support for satellites communication

**5G NR for NTN**
Complementing terrestrial networks in underserved areas

- LEO, GEO, HAPS, air-to-ground communications

Supporting satellites backhaul communication for CPEs and direct link to handhelds (e.g., smartphones) for low data rate services

Utilizing sub-7 GHz S-band with additional bands added in the future (e.g., 10+ GHz in Rel-18 proposed)

**5G IoT for NTN**
Expanding addressable market for the 5G massive IoT

- LEO, GEO, PC3/PC5 satellites with intermittent access link

Supporting diverse use cases, including transportation, utilities (e.g., solar, oil/gas), farming, mining, environmental monitoring

Utilizing sub-7 GHz band for both eMTC and NB-IoT, with LTE EPC only in standalone network

Source: RP-210908 (NTN Enhancements); RP-211601 (NB-IoT/eMTC support for Non-Terrestrial Networks)

1 Enhanced Packet Core

Courtesy: Qualcomm
Example of Key Satellite Systems Techniques

- Adaptation to Satellite Channel Environment and AI
- Higher Frequency Bands (Q/V, W), Optical
- Digital Processors, Edge Computing onboard Context routing/ICN
- Active Antenna Arrays
- Software Defined Payloads (SDN/SDR), Advanced Radio Resource Management
- Broadcast/Multicast/Unicast Edge-Casting
- Multilayer Integration and Handover
- Communication, Computing, Caching, Cognition
- Throughput Increase
- Cost Optimization, Affordability, Reliability increase
- Flexibility, Scalability, Energy footprint
- Plug and Play Satellite – Terrestrial Integrated Networks

Co-channel Interference Management, Frequency Spectrum Sharing, Massive-MIMO

Operations, Automation and AI integration

Multi-layer 3D NTN topology & network management

Support Software Defined Radio and SDN Implementation

Jamming Detection and Mitigation

Throughput Increase

Example of Key Satellite Systems Techniques
## ESA High priority B5G/6G targeted technology developments

<table>
<thead>
<tr>
<th>Main Areas</th>
<th>Description</th>
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<tbody>
<tr>
<td><strong>Software Defined Flexible Satellites</strong></td>
<td>Fully flexible &amp; reconfigurable to adapt to evolving 3GPP standards</td>
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<tr>
<td><strong>Digital Regenerative Communication Payloads</strong></td>
<td>Include 3GPP RAN and core network functionalities/applications processing – edge computing onboard and optimal onboard routing with dynamic data forwarding in changing satellite network topologies</td>
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<td><strong>Large DRA antennas / beam hopping solutions</strong></td>
<td>Optimise energy consumption, and frequency reuse and sharing in TN/NTN</td>
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<td><strong>Cloudification of ground segment</strong></td>
<td>Redesign the processing pipeline of modems and gateways to fit new IT software develops</td>
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<td><strong>Dynamic frequency management</strong></td>
<td>Enable joint TN/NTN spectrum management &amp; sharing</td>
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<tr>
<td><strong>TN/NTN topology &amp; network management layer</strong></td>
<td>Enable TN and NTN to communicate and interface in a convergent manner ultimately giving the option to use the same products for fault, configuration, accounting, performance and security. Consider satellite communications challenges such as large number of direct reachable UEs / VSAT edge nodes, predictability of mega-constellations etc</td>
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<tr>
<td><strong>UE/CPE integration in several environments</strong></td>
<td>Such as maritime, train/buses, mining, … , smart cities/regions, etc.</td>
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Satellites as nodes in a multi-layered 3D network realize flow from information gathering in space and on earth to value integrated space functions of **Communication, Computing, Caching (C3) and Sensing & Localization**

**Respond to European ambitions**

- **Advanced Technology** for new space infrastructure
  - Boost B5G/6G Technologies
  - Boost micro-electronic technologies
  - Dig into dynamics of European SME/Start-ups, New Space and established strong European Space and Terrestrial industry

**Opportunities for European Telecommunications Ecosystem**

- **Emergence of NTN 3D-space operator**
- **Strict collaboration with other initiatives and sectors**
- **Boost data economy**
- **Creation of NTN competence centres –synergies with active experimentation 5G B5G/6G platforms & test campus**
  
  New business models & exploration of services with superior performance such as autonomous cars, marine & new emerging 6G services
Collaboration with CELTIC NEXT

**Rationale:** High complementarity in members is incentive to join forces, to leverage on the association of respective communities, assets, forces

**Common Objectives:**
- Sustainable digital transformation of society and Industry
- European technology autonomy

**Way forward:** from loose to closer collaboration, from opening the dialogue between complementary communities to road-mapping, alignment of calls and joint projects

**Collaboration:**
- Common and continuous experimentation including open programmable space testbed (i.e. hosted experimental payloads & early missions opportunities), maturation of technologies and solutions addressing verticals and SDGs
- On viable hybrid services exploitation models
ESA CELTIC-NEXT Collaboration status

Since Mol Signed (Nov. 2021)

• CELTIC presented to ESA SPL 5G 5JAC Technical Committee and received high interest
• ESA presented to CELTIC Core Group Technical Meeting and received high interest
• Several ESA & CELTIC NEXT member states expressed interest in the collaboration
• Discussions have started in some countries between EUREKA and ESA PAs
• First drafts of Technical Roadmap in discussion (CELTIC and ESA sides)
• ESA and CELTIC prepare Business Canvas cases for various stakeholders
• First tangible collaboration case: ESA SPL 5G proposes an activity on Dynamic Spectrum management for 3D-NTN potentially extending CELTIC NEXT 6G Sky activity (early TRLs prototype to mature in Flagship)
• ESA and CELTIC NEXT to organise dedicated workshop(s) to
  • Increase awareness between stakeholders of respective communities
  • Present tutorial on 5G satellite systems and discuss roadmap
Step 1 (Σ CELTIC)
Studies
(topics generation & early exploration)

Step 2 (ESA ARTES+Σ CELTIC)
Joint Consultations & Road mapping

Step 3 (ESA ARTES+Σ CELTIC)
Aligned Calls (funding synch)
One or 2 streams

Step 4 (ESA SPL 5G/6G +Σ CELTIC)
Joint Projects & // Projects (R&D)

Step 5 (EUREKA)
Transfer / Industrialisation / Commercialisation

Step 1 (ESA SPL 5G/6G)
Workplan activities
(New concepts and early prototypes)

Step 5 (ESA ARTES 4.0)
Transfer / Industrialisation / Commercialisation

EUREKA CELTIC-NEXT PROGRAMME
(Bottom-ups, Flagships, ...)

Joint Collaborative Programme (ARTES 4.0)
From fully funded to co-funded

JOINT COLLABORATIVE PROGRAMME
(Alignment, Working Groups, Exploitation...)
/ Topics: Integrated TN/NTN Management, Dynamic Spectrum Management, Services Exploration...
ESA SPACE FOR 5G and 6G

Underpins the Digital Economy

Improves your daily life

Inspires future generations

EXPAND 5G SPACE

Seamless

Ubiquitous

Resilient

A WORLD WHERE SPACE ENABLES GLOBAL SEAMLESS CONNECTIVITY FOR INDUSTRY AND SOCIETY
Produced by

SPL 5G/6G and Sustainable Development

Thank you
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backups
Future research directions for Satellite in 6G for a sustainable greener inter-compute system

I. Air interface & Spectrum efficiency
   New optimised technologies need to be introduced to improve the spectral efficiency

II. Integrated network architectures
   Terminals, air interface, protocols and security solutions unified in a new network architecture

III. Onboard Edge Computing
    - Dynamic routing – 3D-NTN space network orchestration
    New dynamic routing technologies, SDN adaptation to space networks need to be developed

IV. Unified Data Architectures
    Data centric networking solutions need to be further exploited

The Satcom community joins R&D activities in 6G expanding the research field in important directions