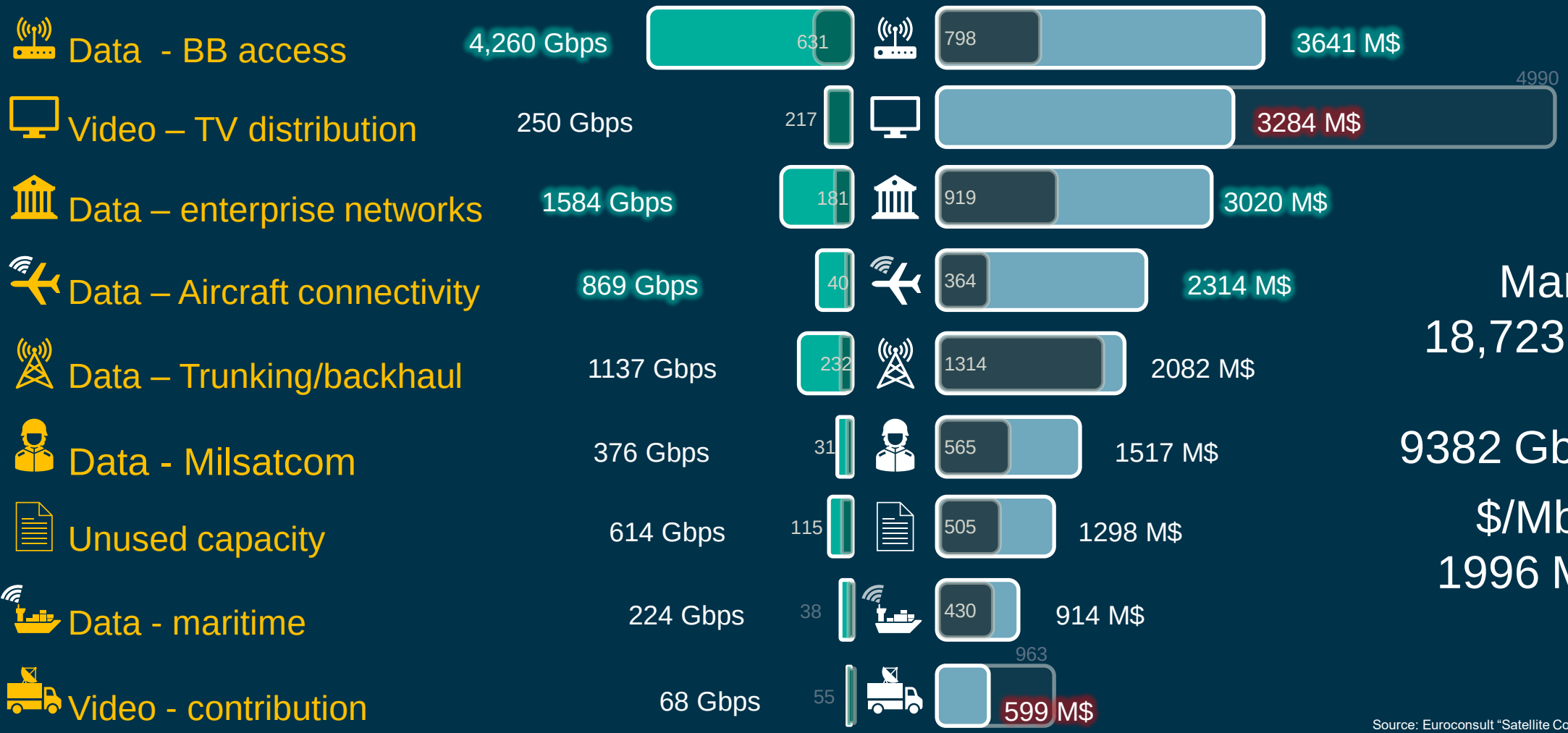
ESA SPL 5G/6G Collaboration with CELTIC-NEXT

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



Market volume
18,723 M$ (+72.5)
Demand
9382 Gbps (+510%)
$/Mbps/annum
1996 M$ (-71.7%)

Source: Euroconsult “Satellite Connectivity and Video Market” July 2020

3GPP Release 17

3GPP Release 17:

Completing the first phase of the 5G evolution

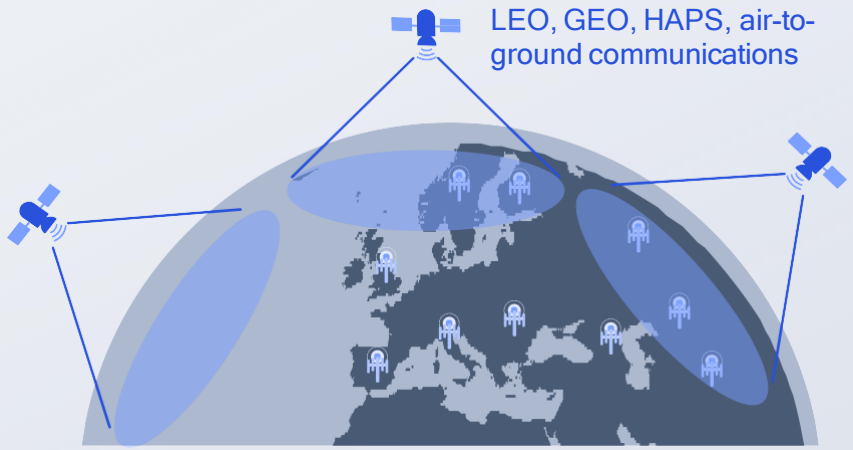
To bring new system capabilities and expand 5G to new devices, applications, and deployment

A key 5G milestone: 3GPP Release 17 Completion

- Functional freeze March 2022
- ASN.1 freezed in June 2022

5G NR for NTN

Complementing terrestrial networks in underserved areas



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

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[1] only in standalone network

Release 17 establishes 5G NR support for satellites communication

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

1 Enhanced Packet Core

Courtesy: Qualcomm

Roadmap

5G/6G Standardisation

5G/6G Product & Technology

5G/6G Partnerships & Services

5G/6G Strategy

Comm. Outreach

2025+

2023

2020

Edge Computing AI enabled

3D- NTN Space Networks

Digital Health

3GPP Rel.18+ 5G to 6G

Climate Change

Flying 5G

5G Systems Sunrise

ESG

Sustainable Connectivity

Sustainable Autonomous Mobility (DinOS5G, HSGR, DARWIN)

Agritech

3GPP Rel.17

Collaboration
CELTIC NEXT
SNS JU/6G-IA
National Initiatives
Global collaborations
Japan, Brazil, UAE

Seamless Integration

5G Broadcast/ 5G EMERGE

5G Hub

6G Hub

2025+ 6G

2020 5G

2020 5G

6G

Example of Key Satellite Systems Techniques

Adaptation to Satellite Channel Environment and AI

Higher Frequency Bands (Q/V, W), Optical

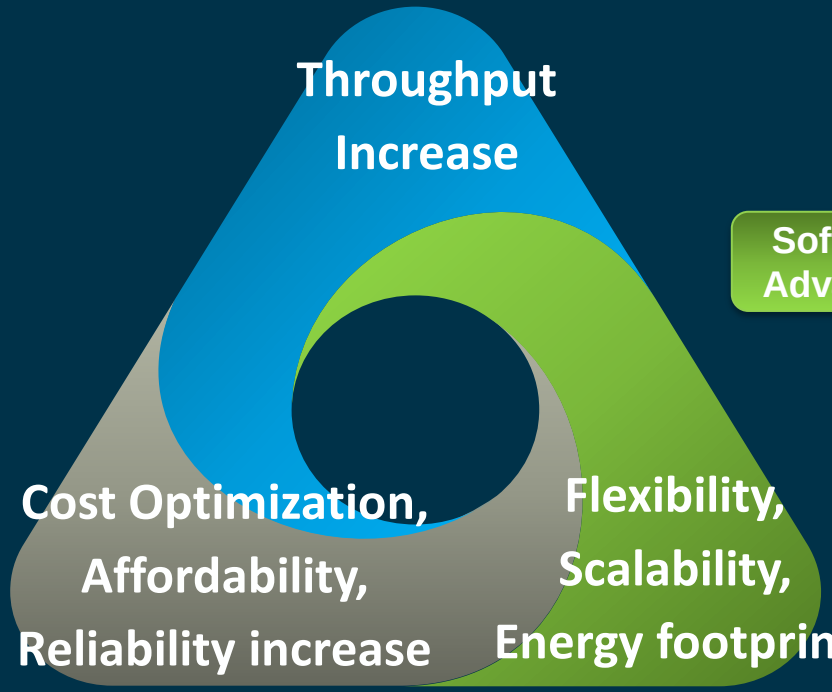
Digital Processors, Edge Computing onboard Context routing/ ICN

Jamming Detection and Mitigation

Active Antenna Arrays

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

Software Defined Payloads (SDN/SDR), Advanced Radio Resource Management



Broadcast/Multicast/Unicast Edge-Casting

Operations, Automation and AI integration

Multilayer Integration and Handover

Multi-layer 3D NTN topology & network management

Plug and Play Satellite – Terrestrial Integrated Networks

Communication, Computing, Caching, Cognition

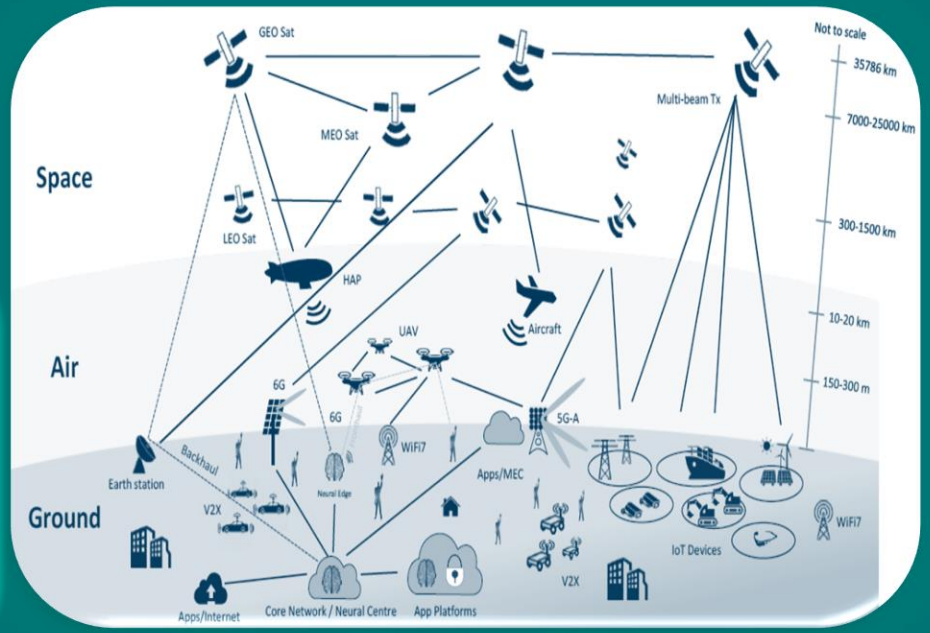
Support Software Defined Radio and SDN Implementation

ESA High priority B5G/6G targeted technology developments

Main Areas	
Software Defined Flexible Satellites	Fully flexible & reconfigurable to adapt to evolving 3GPP standards
Digital Regenerative Communication Payloads	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
Large DRA antennas / beam hopping solutions	Optimise energy consumption, and frequency reuse and sharing in TN/NTN
Cloudification of ground segment	Redesign the processing pipeline of modems and gateways to fit new IT software develops
Dynamic frequency management	Enable joint TN/NTN spectrum management & sharing
TN/NTN topology & network management layer	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
UE/CPE integration in several environments	Such as maritime, train/buses, mining, … , smart cities/regions, etc.

B5G/6G Non Terrestrial Networks

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

Σ-ESA JOINT COLLABORATIVE PROGRAMME

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

Antonio.Franchi@esa.int

Maria.Guta@esa.int

backups

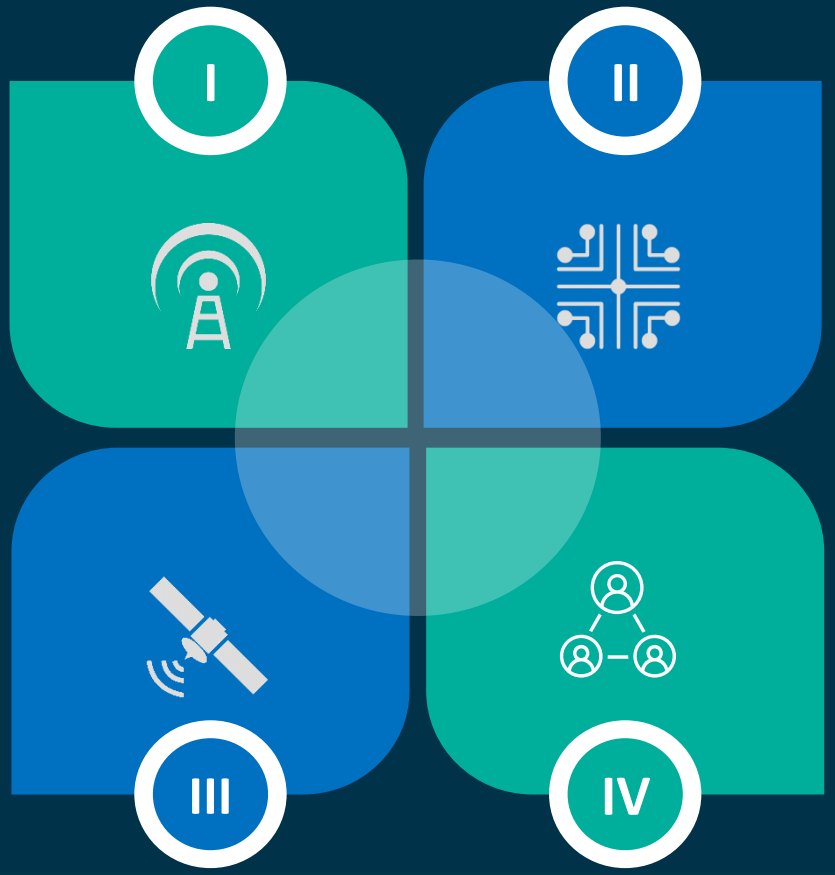
Future research directions for Satellite in 6G for a sustainable greener inter-compute system

Air interface & Spectrum efficiency

New optimised technologies need to be introduced to improve the spectral efficiency

Integrated network architectures

Terminals, air interface, protocols and security solutions unified in a new network architecture



Onboard Edge Computing - Dynamic routing – 3D-NTN space network orchestration

New dynamic routing technologies, SDN adaptation to space networks need to be developed

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