CONASENSE Symposium 2021

FROM 5G TO 6G: SPACE CONNECTING PLANET EARTH

FOR A SUSTAINABLE FUTURE

Session 2: Navigation–Satellite Communications

Maria Guta
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Digitalisation, Connectivity & Sustainability

Satellites will play a critical role as part of the 5G and 6G seamless networks, to fuel the lucrative 5G and 6G economy.

The New era of Digitalisation and Connectivity will transform the way we interact, produce, live and work.

5G & 6G will enable a large-scale Digital Transformation of Traditional Industry Sectors which are not digitalised yet. Satellites will play a critical role as part of the 5G and 6G seamless networks for truly global coverage and new connectivity networks will be designed to be Environmentally Sustainable

Seamless Connectivity for a Sustainable World

5G/6G Satellite enabled networks strongly contribute to the UN SDGs for a better, greener and sustainable world.

5G & 6G will provide infrastructure to bridge the Digital Divide, resulting in growth, efficiency and sustainability, with satellites helping to reduce environmental impact.

The 5G/6G Vision will ensure access to affordable, high quality, broadband Internet.

The Integration of Satellite Networks is strongly aligned to the UN SDGs (especially the 9 SDGs below)

Seamless Connectivity from 5G to 6G

6G Network will ensure:

- Extremely High Data Rates per device
- Massive number of connected devices
- Global Connectivity
- Very Low Latency
- Lowering the Energy Consumption of IoT
- Ultra-high Reliable Connectivity
- Connected Intelligence with ML capability

6G will use the Millimetre and Terahertz frequency Spectrum.

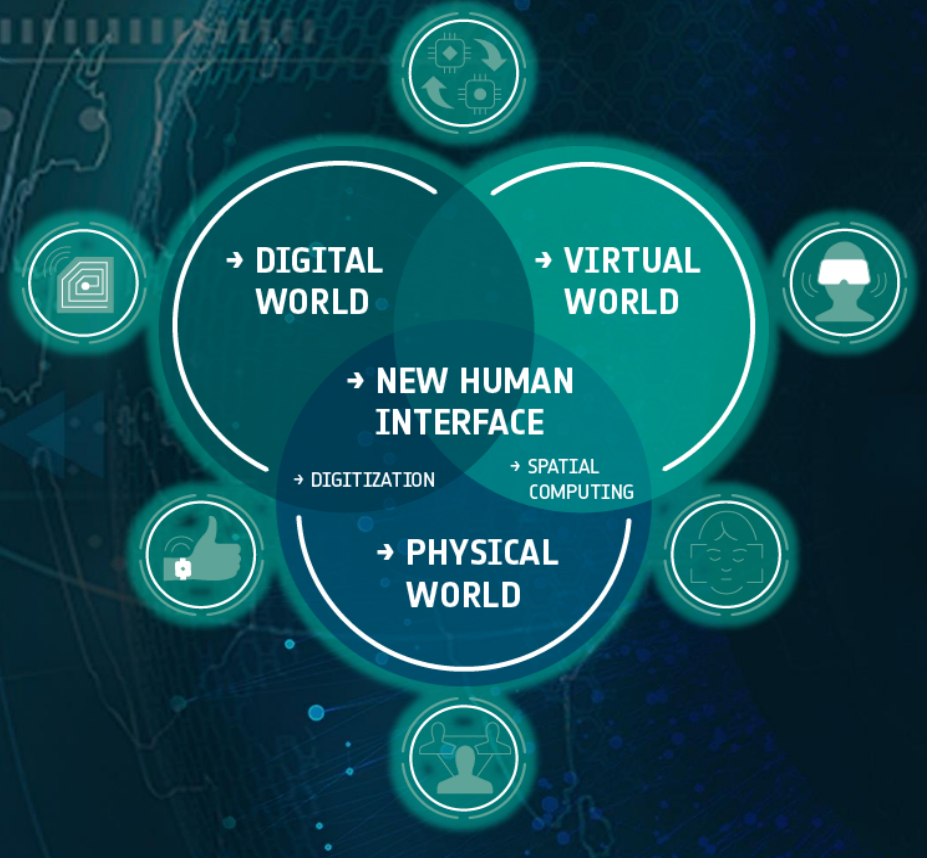
Satellite networks will play a crucial role in 6G Research Areas.

NTNs will ensure full earth coverage, combining different fronthaul, backhaul, midhaul and direct-access approaches.

The convergence of satellite and terrestrial networks is happening in 5G and will be fully realised in 6G networks.

FEATURE	4G	5G	6G Promises
PER DEVICE PEAK DATA RATE	1 Gbps	10 Gbps	1 Tbps
END-TO-END (E2E) LATENCY	<100 ms	<10 ms	<1 ms
MAXIMUM SPECTRAL EFFICIENCY	15 bps/Hz	30 bps/Hz	100 bps/Hz
MOBILITY SUPPORT [KM/HR]	Up to 350	Up to 500	Up to 1000
SATELLITE INTEGRATION	No	Partial	Fully
ARTIFICIAL INTELLIGENCE	No	Partial	Fully
AUTONOMOUS VEHICLE	No	Partial	Fully
XR EXTENDED REALITY	No	Partial	Fully
HAPTIC COMMUNICATION	No	Partial	Fully
THZ COMMUNICATION	No	Very limited	Widely
SERVICE LEVEL	Video	VR, AR	Tactile
MAXIMUM FREQUENCY	6 GHz	90 GHz	10 THz

6G Network Architecture Vision



6G will enable the fusion of digital, physical and virtual world.

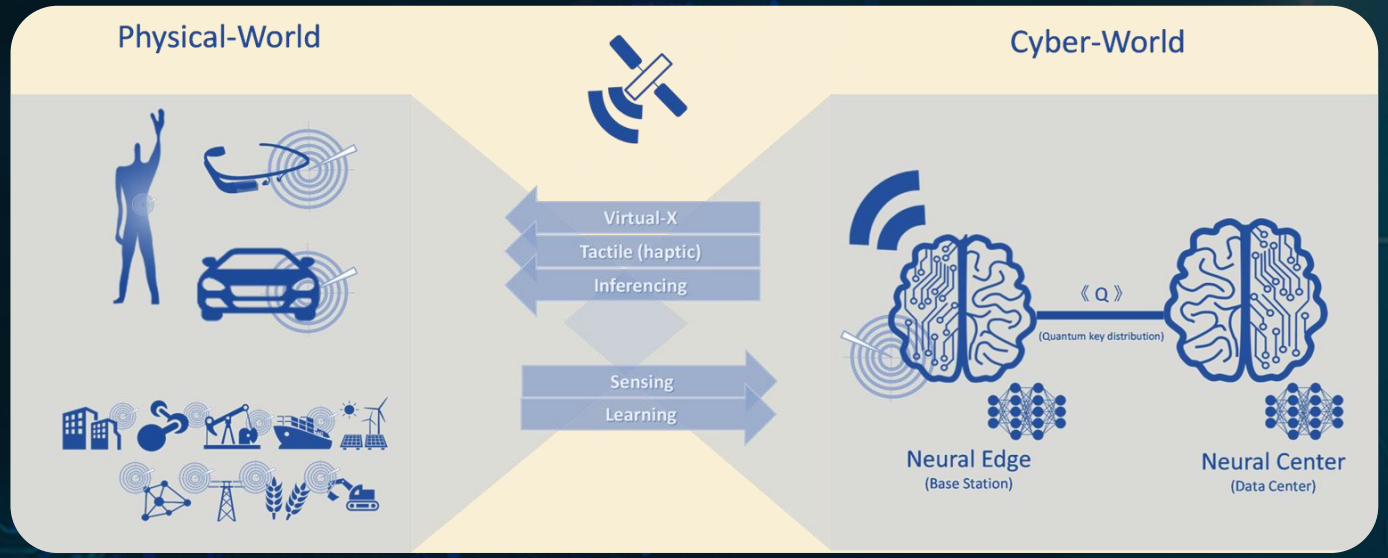
The 6G wireless architecture will have 5 key constituents:

Cyber to Physical:

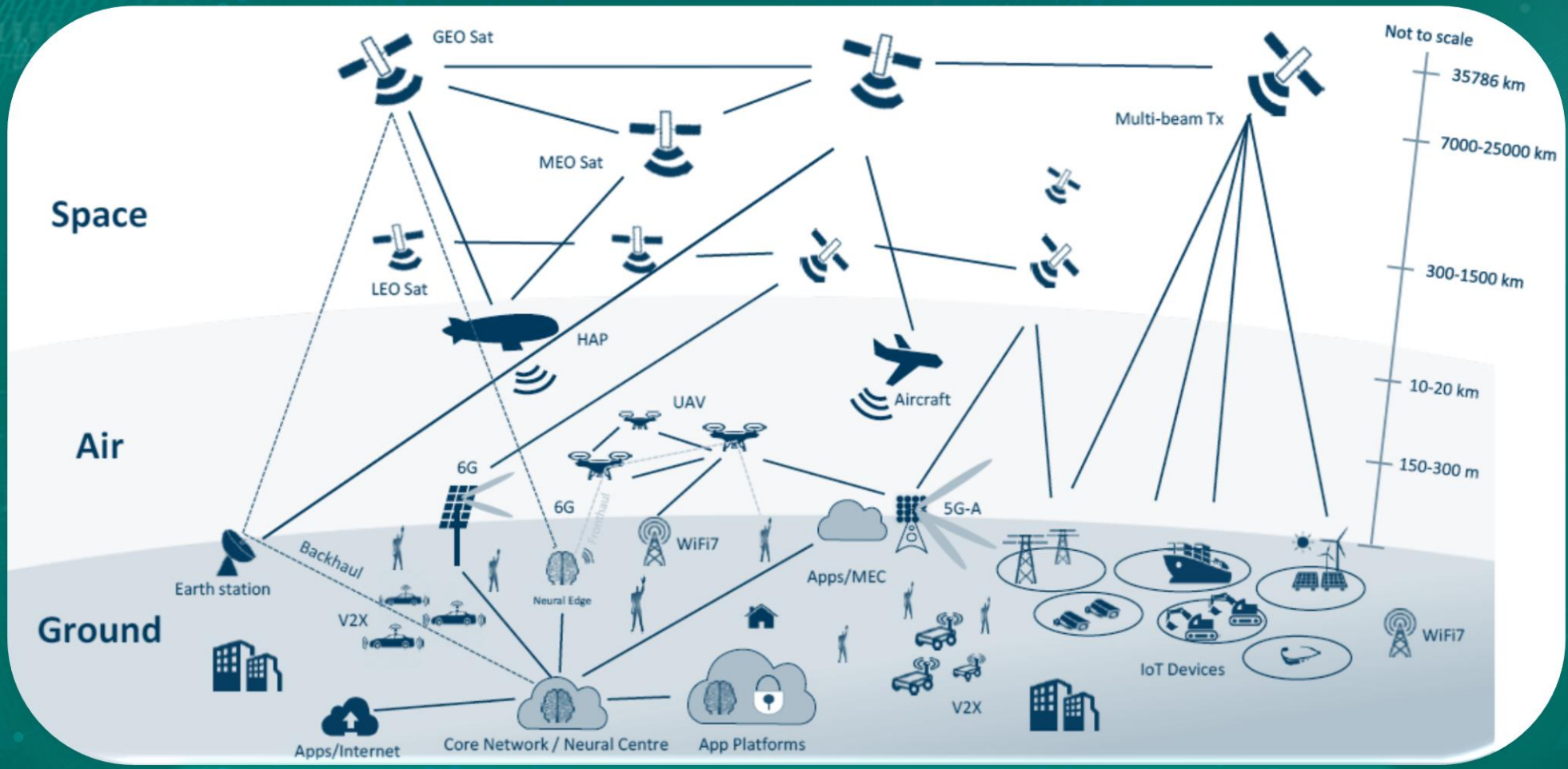
- Virtual-X → VR for everything
- Tactile channel
- Inferencing channel

Physical to Cyber:

- Enhanced Sensors technology
- Big data for Machine Learning



6G Network Architecture Vision



Non Terrestrial Networks (NTN) are an integral part of future 5G and 6G networks for seamless global coverage

Future research directions for Satellite in 6G/1

Air interface & Spectrum efficiency Advanced antennas

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

Integrated network architectures

Unified terminals, air interface, protocols security solutions in a new network architecture

Onboard Edge Computing / Sensing / Dynamic routing / AI

New dynamic routing technologies 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

Example of Key Satellite Systems Techniques

Adaptation to Satellite Channel Environment and AI

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

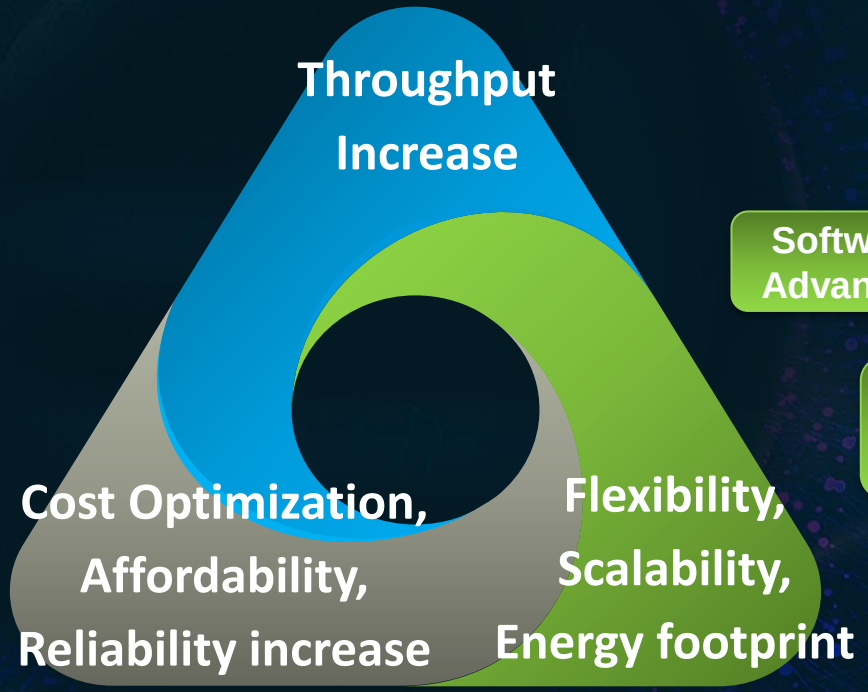
Digital Processors, Regenerative Payloads

Jamming Detection and Mitigation

Active Antenna Arrays

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

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



Hybrid Broadcast/Multicast/Unicast/Storage Edge-Casting

Operations, Automation and AI integration

Multilayer Integration and Handover

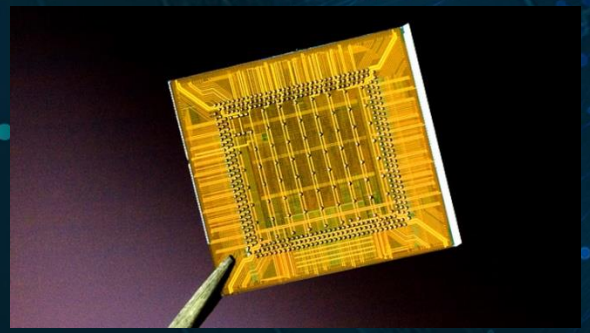
Support Software Defined Radio Implementation

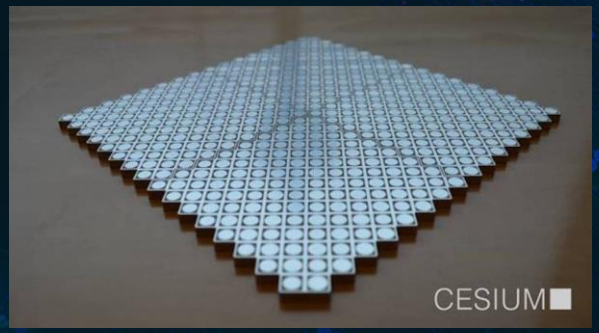
Plug and Play Satellite – Terrestrial Integrated Networks

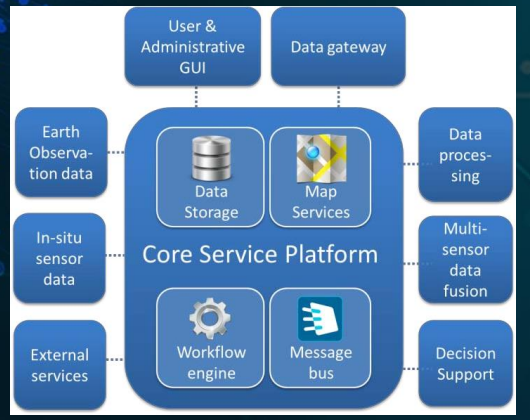
Communication, Computation, Storage

Examples of Key Space Segment Technologies

- **Ultra Deep Submicron technologies**: to support next generation space qualified circuits for more flexible and powerful telecom, navigation and Earth observation payloads;
- **Active antennas and digital processors** for highly reconfigurable telecom, navigation and Earth Observation missions
- **Generic, modular and cost-effective satellite platforms**
- **Increased on-board autonomy** and system flexibility leveraging on AI

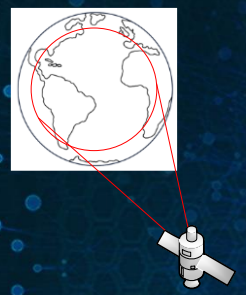






Satellite Systems – SoA

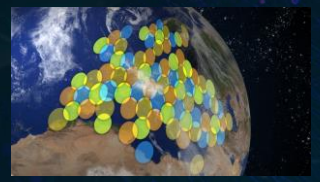
Support Variable Traffic Demand



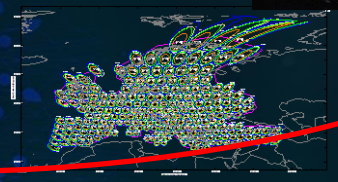
Global Beam
- Low Antenna Gain
- Low Data Rates
- Easily Accommodate Variable Traffic Demand
- Traditional FSS/DBS

Regional Beams
- Reduced Interconnectivity
- Domestic Broadcasting
- Reduced capability for traffic demand variability

Spot Beams (Broadband GEO)
- High Data Rate,
- High Offered throughput
- Segregated Interconnectivity
- Possible gap between offered capacity and useable capacity



Emerging Satellite Systems
- Flexible operations (Payload Resources, in-orbit redundancy, orbital slots Agnostic)
- Flexibility to adapt to evolving business conditions and traffic demands
- Reduced Non-Recurring Engineering
- Reconfigurable Missions
- Flexibility, modularity, scalability
- GEO and NGSO Solutions
- Joint Communication, Sensing



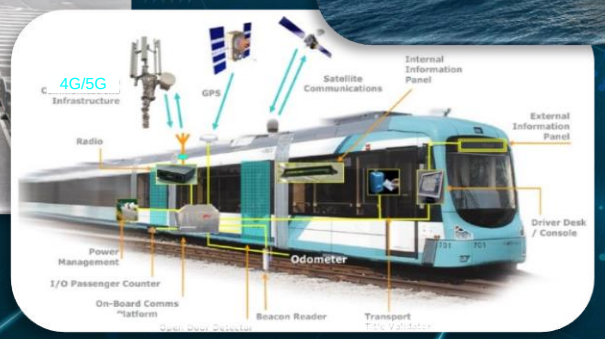
10 Gb/s | 100 Gb/s | 1 Tb/s | 10 Tb/s

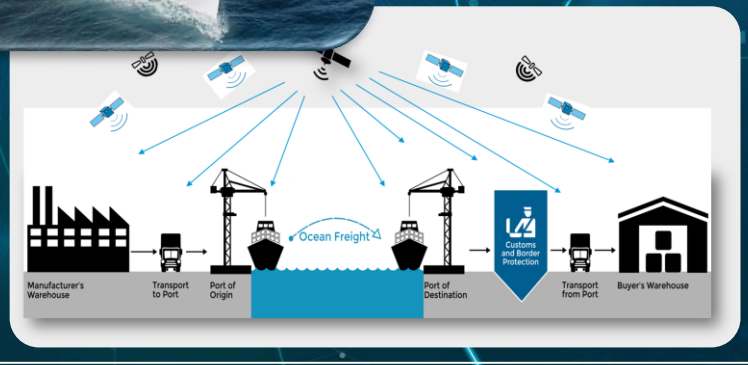
Offered Throughput

Space for 5G and 6G – Focus Elements

5G Media

Sustainable Mobility
Transport&Logistics



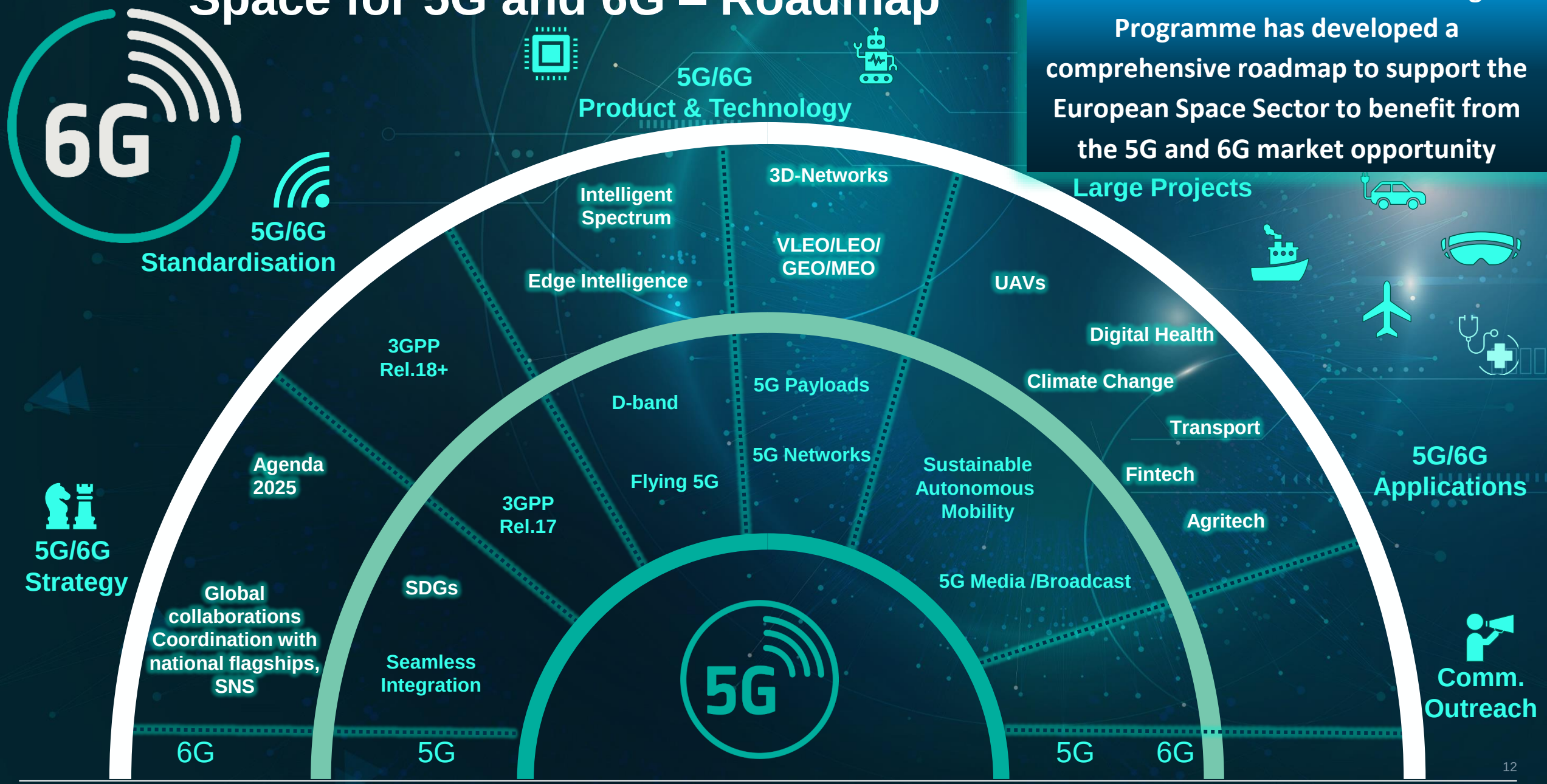


Space & Digital Health

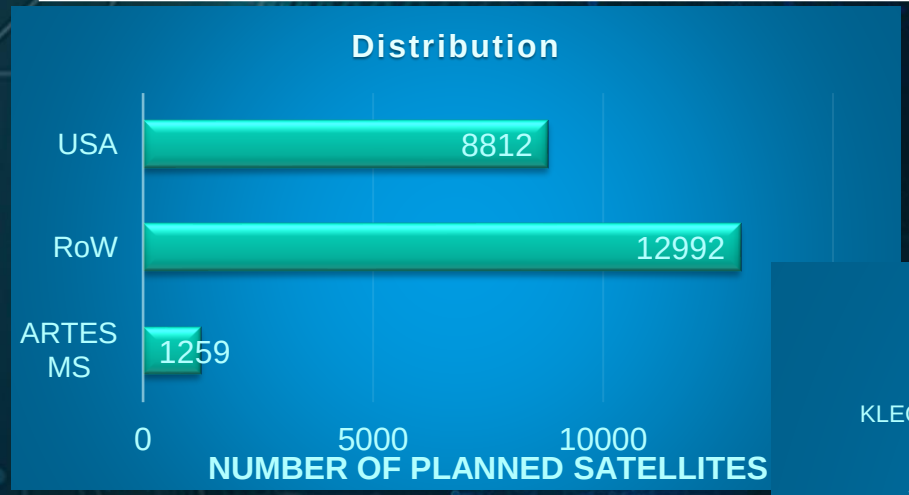
Satellite Constellations, IoT, Softwarisation, Intelligent edge computing and Spectrum Management

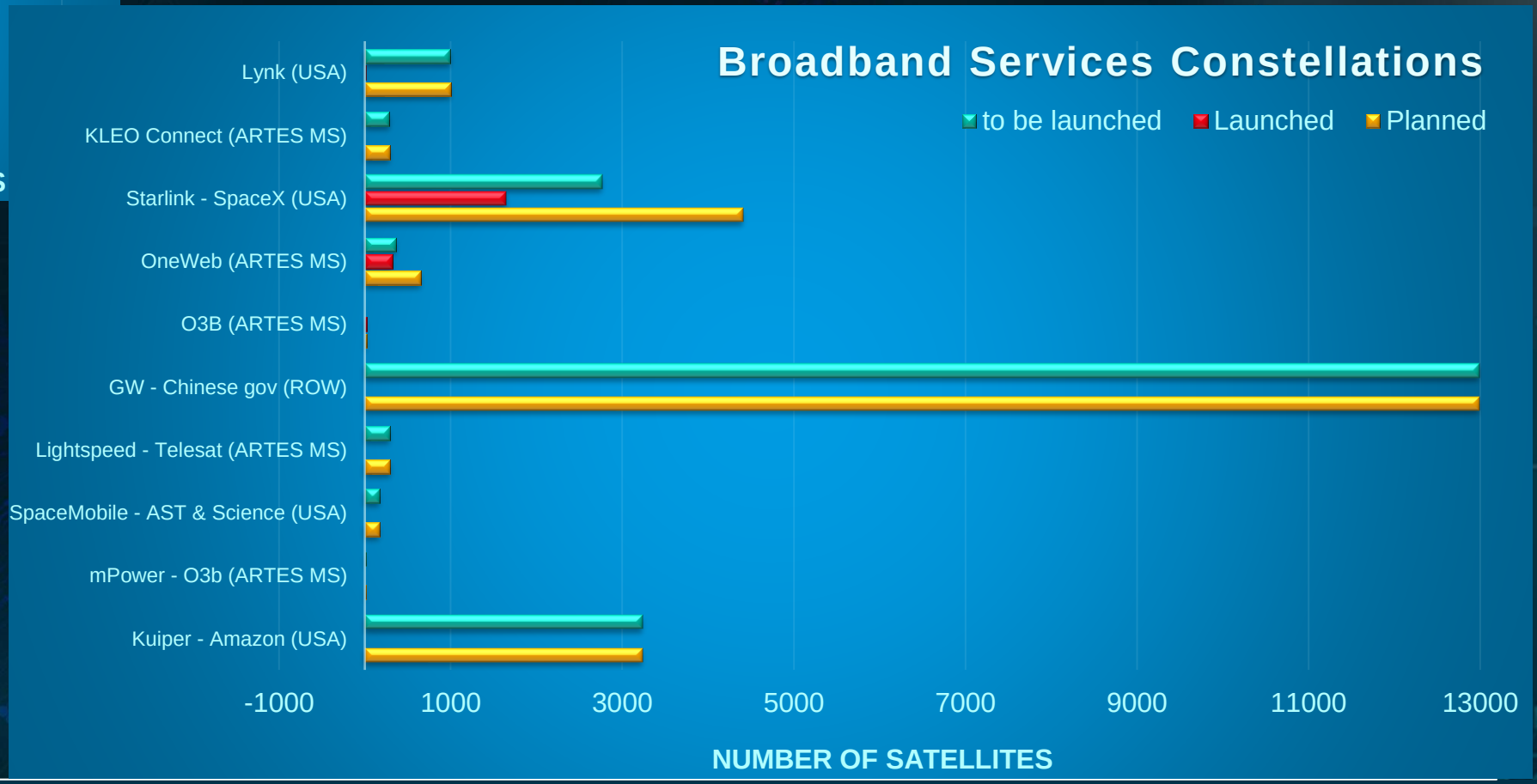
Space for 5G and 6G – Roadmap

ESA SPACE FOR 5G and 6G Strategic Programme has developed a comprehensive roadmap to support the European Space Sector to benefit from the 5G and 6G market opportunity



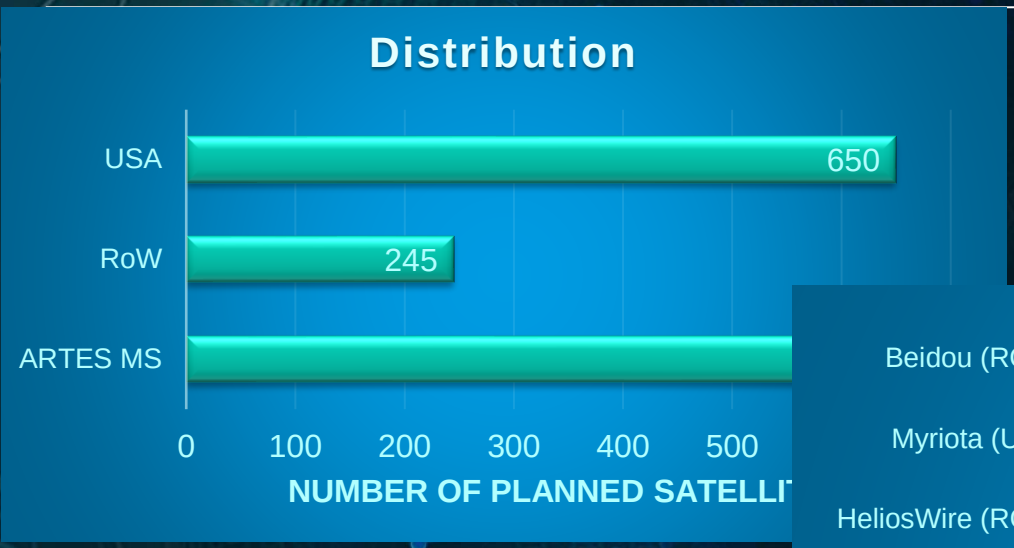
Megaconstellations /1 –Broadband Services

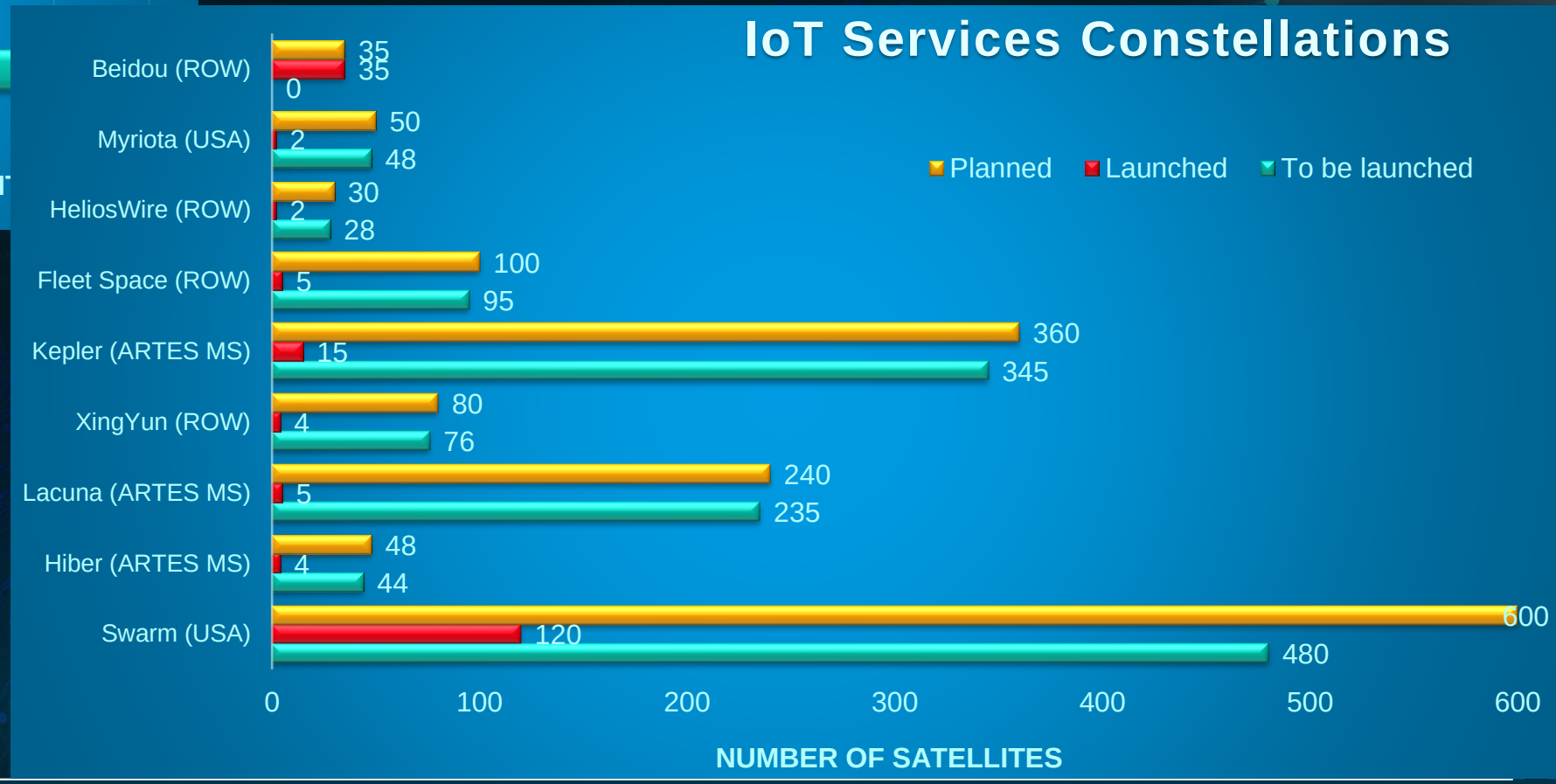




Non exhaustive list

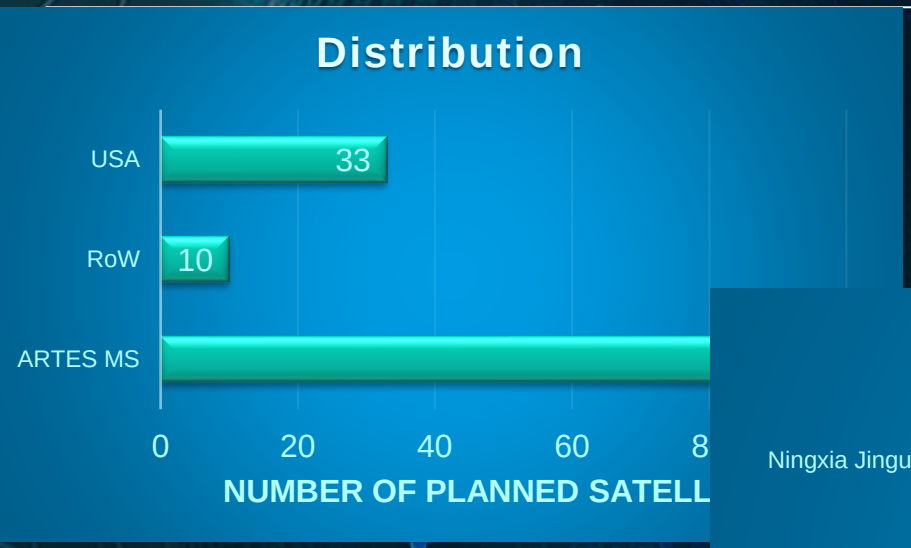
Megaconstellations /2 - IoT Services

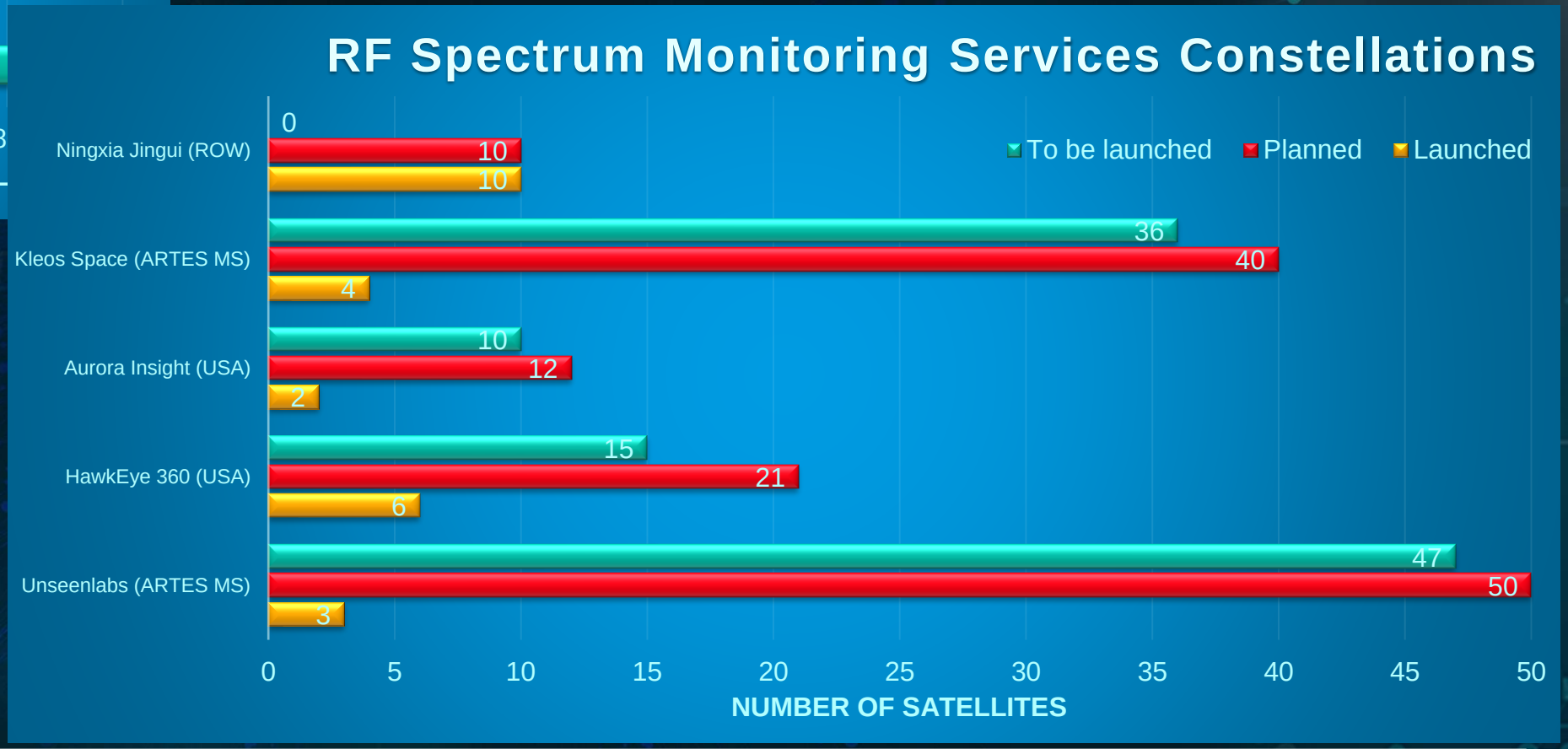




Non exhaustive list

Megaconstellations /3 - RF Spectrum Monitoring Services





Non exhaustive list

Digitalisation's Monetisation Enigma –The scene

INDUSTRIES

Competitive positioning

- Transform to remain sustainable
- Follow XaaS models
- New consumption and business models for MaaS
- Explore emerging profit pools –i.e., predictive maintenance of connected products & information services
- Interplay of verticals

Access to Data

- Huge Data warehouses – Curation of data
- Use and openness of data/Governance

SOCIETY

Improve citizens lives

- Connectivity, mobility
- Prosperity
- Health
- Productivity
- Jobs
- Bridge the Digital Divide –diversity and inclusions

Digitalisation's Monetisation Enigma –Satellites

Satellite Industry

Cultural Journey

- Agility and action (testing & learning & fast decisions)
- Stay ahead in technology innovation

Opportunities

- NTN in 3GPP ecosystem
- Synergies with 5G Private Networks and AI/edge computing
- Cross border and international connectivity

Customer focus

- Focus on customers' culture and ecosystem
- Relay on partnerships with –foster innovation by co-creation/co-design
  - *MNOs, micro-operators, vendors, vertical market stakeholders*
  - *Cities/regional actors*
  - *Private actors and public administration*
  - *Open and continuous experimentation (as essential building blocks for co-creation)*
  - *Use cross disciplinary research results*

Obstacles

- Satellite solutions still are/ perceived as expensive
- Need to demonstrate interoperability
- Availability and sharing of spectrum
- Regulations and licenses for new services
- Fragmentation of
  - *Market vertical actors; private and public actors*
  - *national/territorial/cities regulations*

Risks

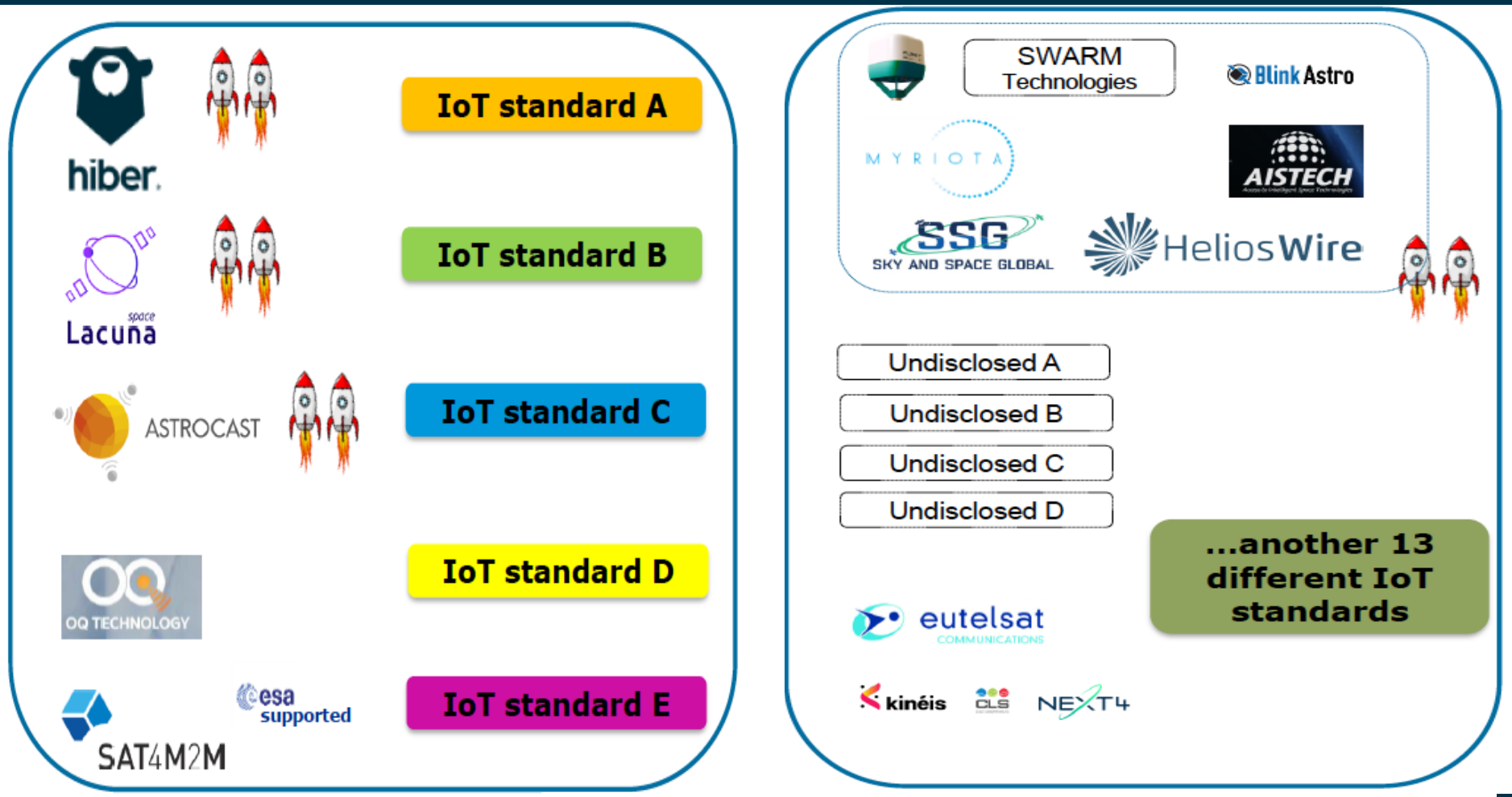
- Unavailability of chipsets, edge computing - MEC, NSA/SA technology

Thank you!

For more information, visit ‘Space for 5G and 6G’, or write at 5G@esa.int

Disclaimer: Opinions, interpretations, recommendations and conclusions presented here are those of the presenter and are not necessarily endorsed by the European Space Agency.

Existing landscape Q32019: LEO Small SATs for mMTC/IoT



> 25 Small sats launched

Using

28 different non-interoperable air interfaces

Excluded – possibly 3 to 4 additional systems

Nano-microsatellite definition