TNO innovation for life

EUROPEAN VISION FOR THE 6G NETWORK ECOSYSTEM

PRESENTATION FOR KIVI - 29 JUNE 2021 | TOON NORP

5G IA WHITEPAPER

The 5G Infrastructure Association (5G IA) publishes the White Paper 'European Vision for the 6G Network Ecosystem'

Brussels – June 7th, 2021 – Today the 5G IA published the **White Paper 'European Vision for the 6G Network Ecosystem'** (available at https://5g-ppp.eu/wp-content/uploads/2021/06/WhitePaper-6G-Europe.pdf) edited by the "Vision and Societal Challenges Work Group".

This White Paper is a major milestone at a time when the 5G IA is preparing for the next chapter in the mobile communications story with the new '**Smart Networks and Services' (SNS) European Partnership** in the framework of the Horizon Europe programme.

The SNS Partnership will contribute to enable the digital and green transitions and will allow European players to develop the technology capacities for 6G systems as the basis for future digital services. Additional information is available at https://5g-ia.eu/sns-horizon-europe/.

Within the SNS, the 5G IA will be the private side representative, jointly managing the Partnership with the EU.

The White Paper covers key areas related to 6G research from a technical, societal, policy and business perspective providing a vision for the future networks and services.

https://5g-ppp.eu/the-5g-infrastructure-association-5g-ia-publishes-the-white-paper-european-vision-for-the-6g-network-ecosystem/

SOCIETAL, POLICY AND BUSINESS DRIVERS FOR 6G

- **Society and global 6G activities**
  - Several ongoing initiatives worldwide
  - Need to address UN-defined Sustainable Development Goals (SGD)
  - Human-centric, benefit the whole society, needs to be trusted by the broadest possible public.

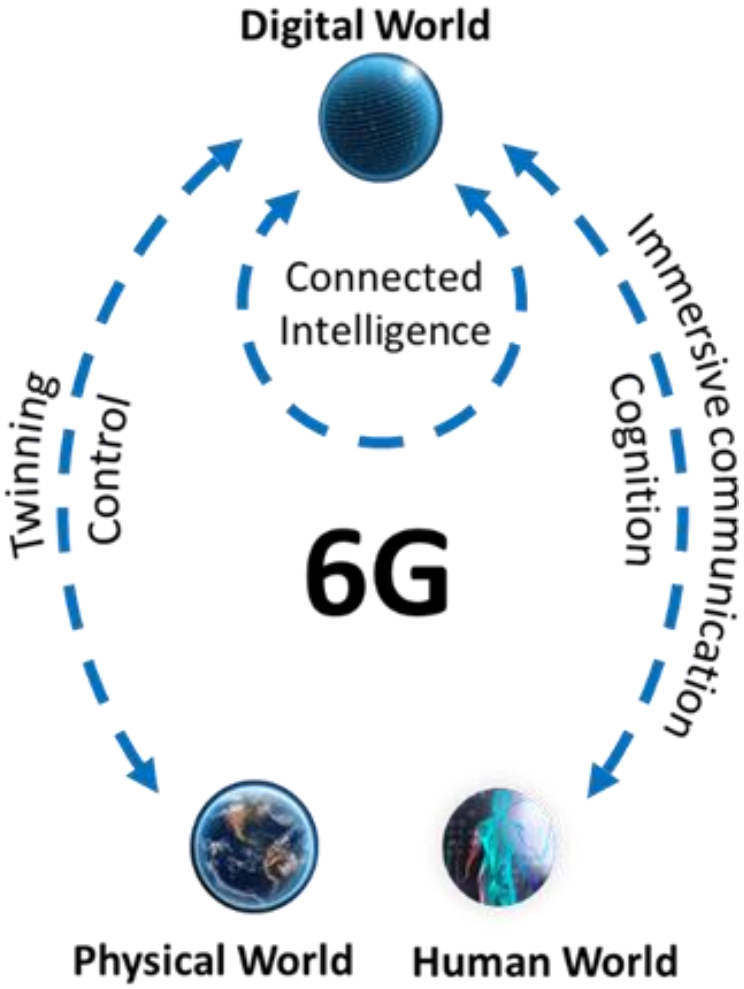
- **Policy Context**
  - Technology sovereignty, staying at the verge of technology, e.g., fostering needed soft skills in the academia and advocate for new chip-factories and assembly lines based in the EU.
  - Comply with EU values
- **Business**
  - 6G has the potential to massively improve the economies of the EU Member States
  - Cope with new challenges, like COVID-19
  - 6G will introduce new business models

MAIN GOALS OF 6G

Connected Intelligence	• Convergence of digital, physical, and personal domains -> support for digital twinning, immersive communication, cognition and connected intelligence
Programmability	• Provide flexibility and programmability
Determinism	• Support deterministic end-to-end services
Sensing	• Integrated sensing and communication which will enable high accuracy localization and high resolution sensing services
Sustainability	• Reduce footprint on energy, resources, and emissions and improve sustainability in other parts of society and industry
Trustworthy	• Truly trustworthy infrastructure that will become the basis of societies of the future
Affordable and scalable	• Inclusive for all people across the world, it needs to be scalable and affordable

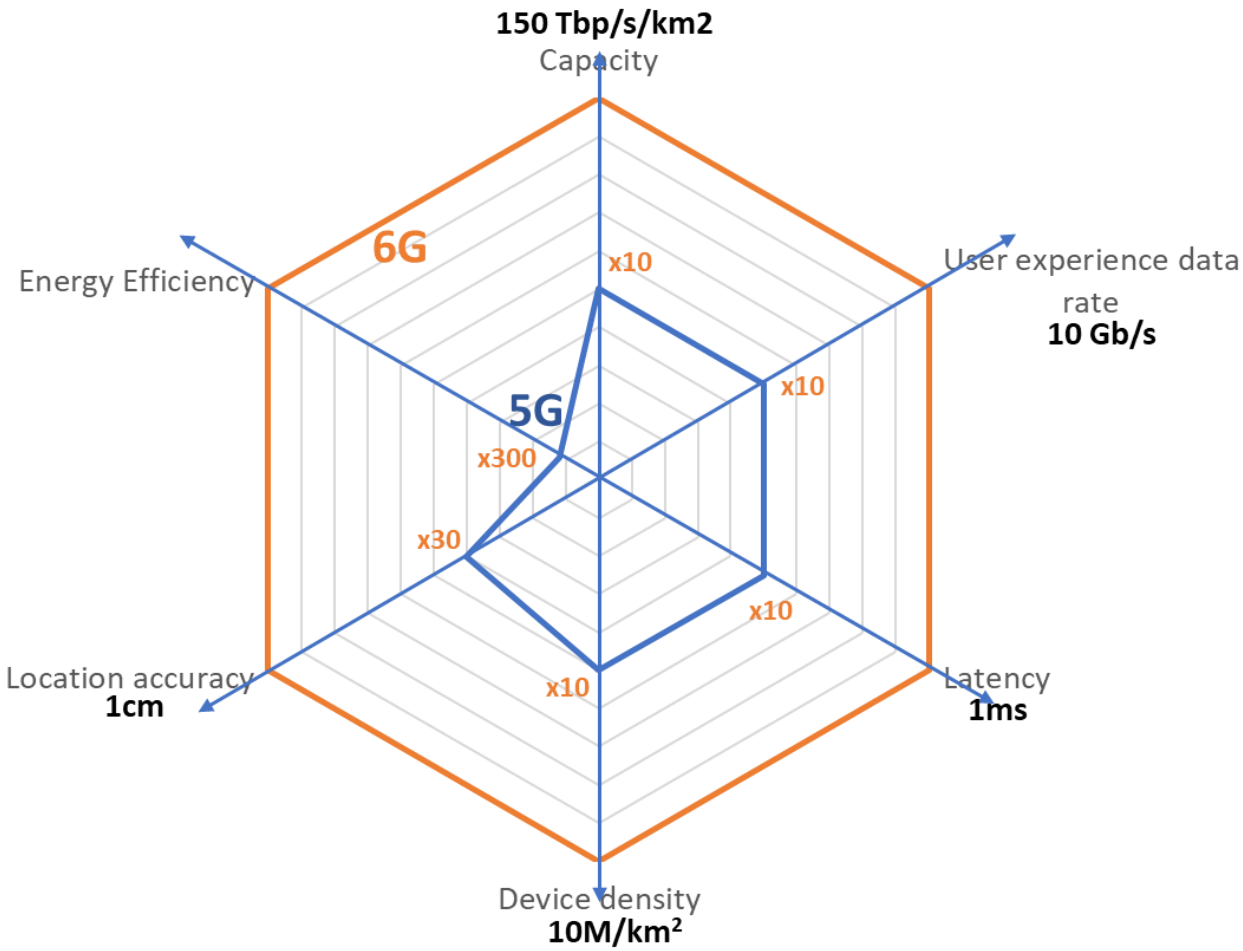
CONNECTED INTELLIGENCE

- Immersive communication, cognition and twinning, imply virtual representations in the digital world of entities in the physical and human world
- These virtual representations have dynamic relations with sensors, actuators, screens and cameras
- Connections between virtual representations in the digital world replace connections between mobile end-devices
- Fundamental impact on the mobile network

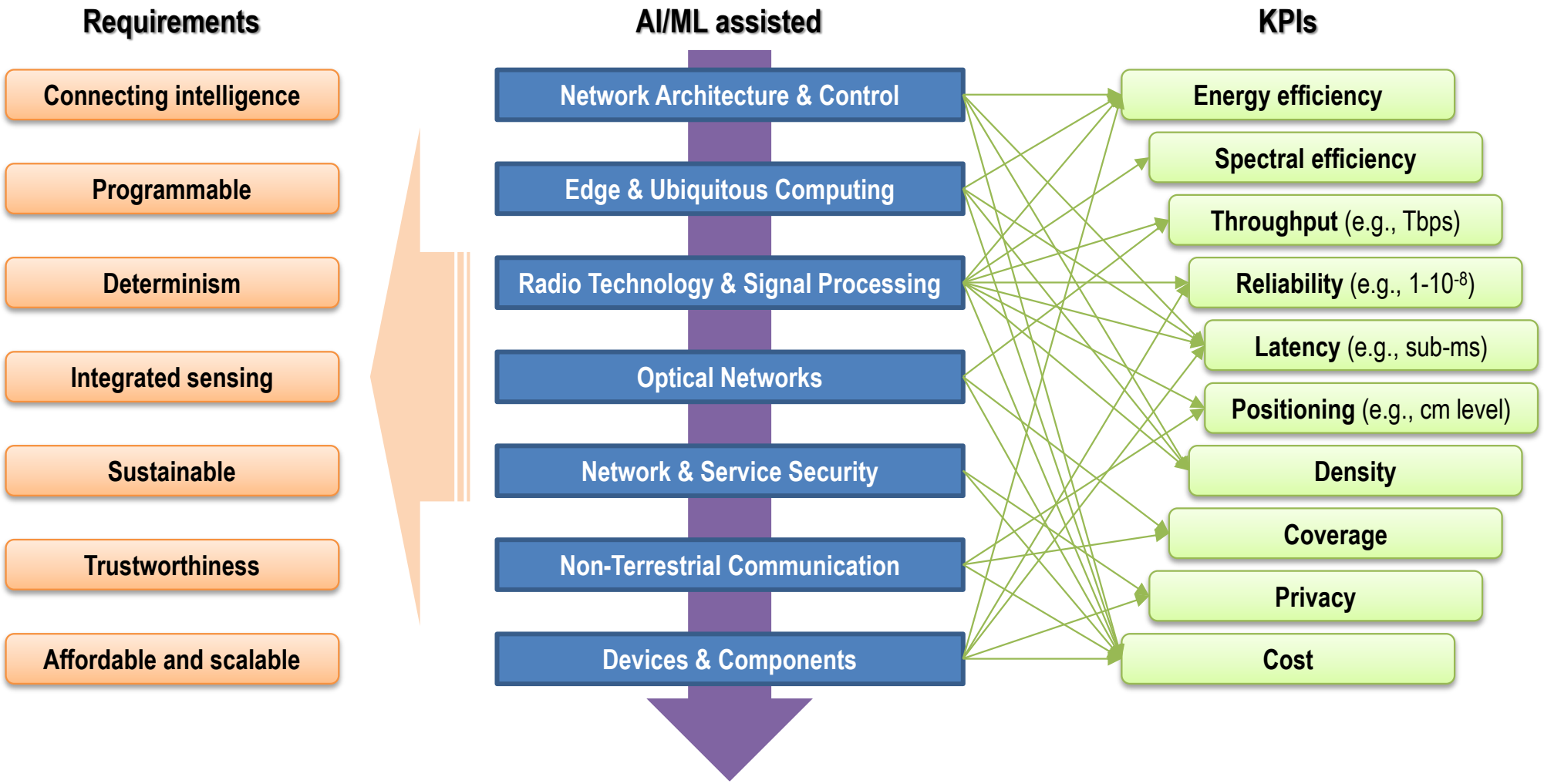


STRETCHING 5G KPIS

- More devices, more data, and higher data rates imply an increase of overall data traffic and required capacity
- Services like immersive communication and tactile internet require lower latency and higher data rates
- Better location accuracy will enable new applications
- Main improvement is needed in energy efficiency, to ensure overall power consumption does not grow beyond what it is now for 5G



ENVISAGED KEY TECHNOLOGIES FOR 6G



Technology areas with strong impact on different 6G requirements and KPIs.

SYSTEM NETWORK ARCHITECTURE

- Efficient, sustainable, smart and trustworthy **distributed computation**.
- **AI/ML** will be needed for operation cost-effectiveness.
- A very versatile, pervasive and **automatic resource control** is required.
- **Autonomic, distributed** mechanisms for of such resource control

EDGE AND UBIQUITOUS COMPUTING

- Edge computing is driven by massive IoT, Industry 4.0, Smart Cities, etc.
- Main goals are to **reduce delays**, increase **responsiveness** and reduce the volume of **data flows** between devices and centralized cloud resources.
- Transition toward **distributed service-based architecture**.
- Computing and networking resources will merge to a **single computing continuum**.

RADIO TECHNOLOGY AND SIGNAL PROCESSING

- 6G networks are expected to deal with more challenging applications requiring Tbps data throughput, sub-ms latency to the network layer, extremely low packet error rate, increased device density, ultra-low energy consumption, very high security, cm-level accuracy localization, etc.
- Key enabling technologies for 6G air interface design, e.g.:
  - Spectrum reutilization
  - mmWave communication
  - Optical wireless communication (OWC)
  - THz communication including semiconductor technologies and new materials
  - Massive and ultra-massive MIMO
  - Enhanced coding and modulation
  - Integrated positioning, sensing and communication

OPTICAL NETWORKS

- **Smart optical transport** connectivity is going to be foundation of 6G
- All dimensions in space and frequency to be exploited to approach Shannon's limits, opening **new optical wavelength bands** and **space division multiplexing**.
- Development of **novel packet/optical switching** architectures.
- Tighter integration optical-wireless technologies: adoption of a **common transmission and switching** platform

NETWORK AND SERVICE SECURITY

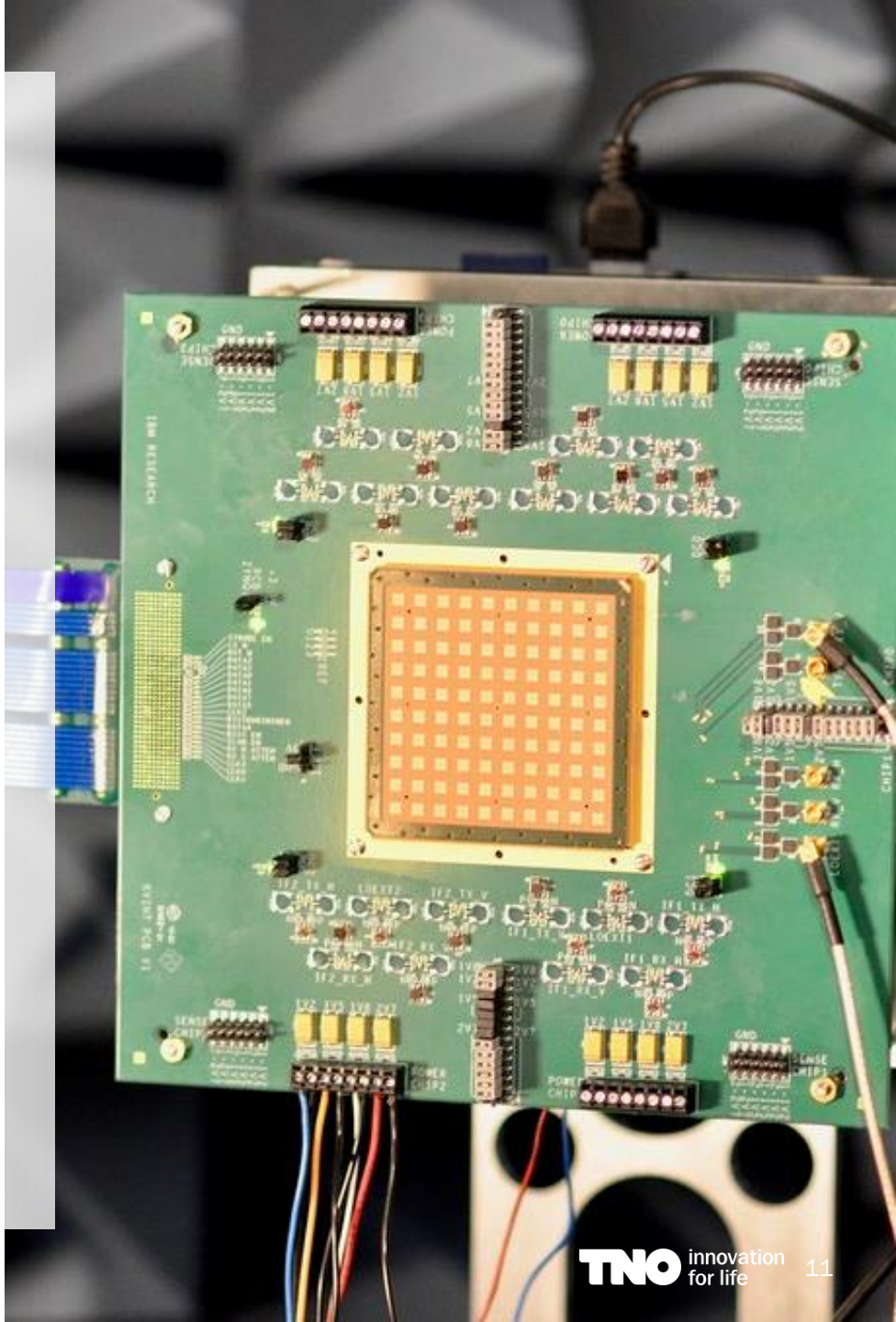
- **Cybersecurity must evolve** as the system does.
- Highly distributed computing and connectivity architecture of envisioned 6G with softwarization and automatization of critical management functionalities create an **attack surface far more wide and complex** than 5G.
- **New approaches for security in 6G**: Virtualization, softwarization, deception and moving target defense, holistic approaches for the whole life cycle, cloudification.

NON-TERRESTRIAL NETWORKS

- Architecture design as **a single access network**.
- Smart NTN with **computing and storage in the sky.**
- Software-defined payloads, new antenna designs, new components at THz.

COMPONENTS AND DEVICES

- **RF challenges**: Phase noise, MIMO/hybrid BF for large arrays, transceiver architectures, more power efficient converters, packaging, THz, on-chip antennas, …
- **Optical domain challenges**: Monolithic integration, CMOS processing, photonic devices, new on-chip components.
- Bridge the **gap between high-efficiency and high-flexibility** programming devices.
- **Hardware for security** needs increased reliability, graceful degradation and automatic recovery, and robustness to quantum computing attacks.



INTEGRATED 6G ARCHITECTURE VISION

5G has significantly increased both performance and flexibility of the provided service for users and service providers alike.

5G NR has introduced new radio modes as **URLLC, mMTC** and **eMBB**.

5GC supports radio flexibility through slicing.

5G adopts **service-oriented architecture**.

5G principles on a per-domain basis reuse the terminal, RAN or CN domain boundaries of 4G.

6G aims at direct integration of different resources from networking to computation and sensing.

Scope extended beyond the RAN and CN to terminals and data centers.

full end-to-end resource awareness.

Service-based architecture extends over the **whole network, across all planes and end-to-end, spanning the CN, RAN, and terminals**, providing for more deployment and operational flexibility.

6G ARCHITECTURE MAIN PRINCIPLES

6G should be the ability to handle a higher degree of flexibility and functionality.

1. Flexibility and functionality **should not add to the overall complexity**

   - **6G System** will require **softwarization**, **full cloud-native architecture** and **further developed SBA and software and hardware disaggregation.**

2. The **principle of "AI everywhere"** utilized to improve network performance and to deliver AI-as-a-Service in a federated network.

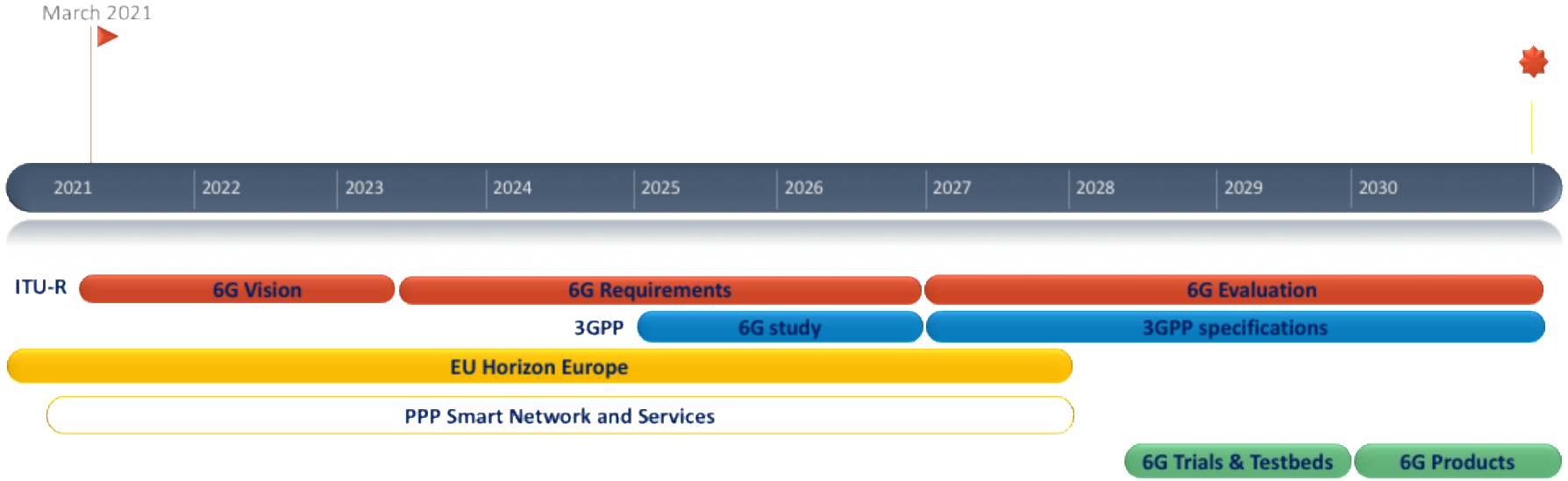
   - Capabilities that were previously only possible outside the network will be integrated into the **6G System**, as well as allow the **use of AI everywhere** in the network.
   - **6G System** must support a framework to efficiently collect the necessary information for the learning.

3. **Trustworthiness** is central

   - Related to **trustworthiness** is **digital inclusion** and global service coverage.
   - The **6G architecture** shall **enable coverage of remote places.**

CONCLUSIONS

- 6G will play a **key role for societies of the future**, with applications merging the digital, physical and personal domains (examples: holographic telepresence and AR/VR)
- **Global standards and renewed regulations** shall play a key role in the development and deployment of 6G Societal, policy and business drivers for 6G
- **AI/ML** and **cloud-native networking** will become crucial elements
- Reusing universal infrastructure is required to provide more diversified services and achieve the increased sustainability awareness
- Envisaged Timeline:



HORIZON EUROPE

CLUSTER 1: HEALTH

- Global Health EDCTP3
- Innovative Health Initiative
- Chemicals Risk Assessment
- Fostering an ERA for Health research
- Large-scale innovation and transformation of health systems in a digital and ageing society
- Personalised Medicine
- Rare Diseases
- One Health AMR

Cluster 5: CLIMATE, ENERGY AND MOBILITY

- Europe's Rail
- Single European ATM Research
- Clean Aviation
- Clean Hydrogen
- Built environment and construction
- Towards zero-emission road transport
- Mobility and Safety for Automated Road Transport★
- Batteries
- Clean Energy Transition
- Sustainable, Smart and Inclusive Cities and Communities
- Smart and zero-emission waterborne transport

49 CANDIDATES FOR EUROPEAN PARTNERSHIPS

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PILLAR III AND CROSS-PILLAR

- EIT Climate KIC
- EIT Health
- EIT Manufacturing
- EIT Food
- EIT InnoEnergy
- EIT Raw Materials
- EIT Digital
- EIT Urban Mobility
- EIT Cultural and Creative Industries
- Innovative SMEs
- European Open Science Cloud (EOSC)

SNS is one out of the 9 joint undertakings
900 Meuro public funding
2021-2027

Cluster 4: DIGITAL, INDUSTRY AND SPACE

- High Performance Computing
- Key Digital Technologies
- Smart Networks and Services
- AI, data and robotics
- Photonics Europe
- Clean Steel - Low Carbon Steelmaking
- European Metrology
- Made in Europe
- Carbon Neutral and Circular Industry
- Global competitive space systems
- European Geological Service

Cluster 6: FOOD, BIOECONOMY, NATURAL RESOURCES, AGRICULTURE AND ENVIRONMENT

Accelerating farming systems transition
Animal health: Fighting infectious diseases
Environmental Observations for a sustainable EU agriculture
Rescuing biodiversity to safeguard life on Earth
A climate neutral, sustainable and productive Blue Economy
Safe and Sustainable Food System for People, Planet & Climate
Circular bio-based Europe
Water4All: Water security for the planet

PROPOSED STRUCTURE OF THE WORK PROGRAMME

5G Evolution (40%)

Stream A (20% - RIA): Smart communication components, systems and networks for 5G mid-term Evolution systems

Stream D (20% - IA): Large Scale SNS Trials and Pilots with Verticals

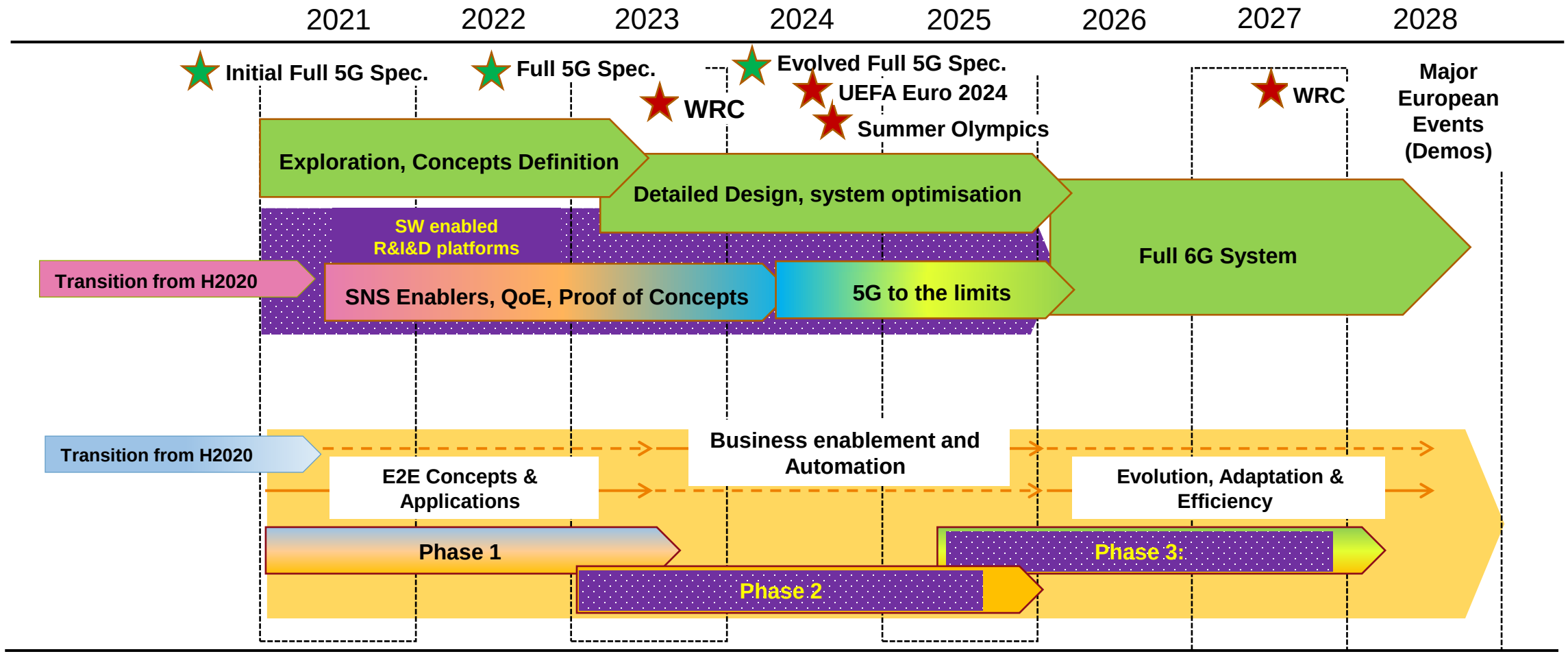
6G (60%)

Stream B (50% - RIA): Research for radical technology advancement towards 6G

Stream C (10% - IA): SNS experimental infrastructures

CSAs - TBD

SNS ROADMAP


2021
2022
2023
2024
2025
2026
2027
2028
Initial Full 5G Spec.
Full 5G Spec.
WRC
Evolved Full 5G Spec.
UEFA Euro 2024
Summer Olympics
WRC
Major European Events (Demos)
Exploration, Concepts Definition
Detailed Design, system optimisation
SW enabled R&I&D platforms
Transition from H2020
SNS Enablers, QoE, Proof of Concepts
5G to the limits
Full 6G System
Transition from H2020
Business enablement and Automation
E2E Concepts & Applications
Evolution, Adaptation & Efficiency
Phase 1
Phase 3:
Phase 2

THANK YOU FOR YOUR TIME

Links:
https://5g-ia.eu/
https://5g-ppp.eu/wp-content/uploads/2021/06/WhitePaper-6G-Europe.pdf

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