Smart Networks and Services International and European Cooperation Ecosystem

## SNS ICE International landscape survey

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- A 6-step approach to enhancing International collaboration has been devised by SNS ICE partners

- The approach ensures bi-directional communication with key International stakeholders

  - Monitoring & reporting global trends

  - Promoting SNS results & vision

  - Supporting dialogues among key stakeholders

  - Providing feedback to SNS stakeholders

- Ultimate goal to promote one single *global 6G standard*

Monitor Trends / Impact

Analyse Global activities

Create awareness within SNS community

Organize events with International stakeholders

Promote SNS Results + Position SNS Vision

Increase synergies & Build consensus

- Global Activities around 6G R&D

- Each global region has established a relevant organization / association for the promotion and R&I activities on 6G

- Global organizations have published their views regarding 6G use cases and requirements

- **SNS ICE has**

  - Analysed the key trends in 6G R&I in major regions of the world

  - Connected with the representative organizations of each region

  - Engaged with global stakeholders under multiple formats
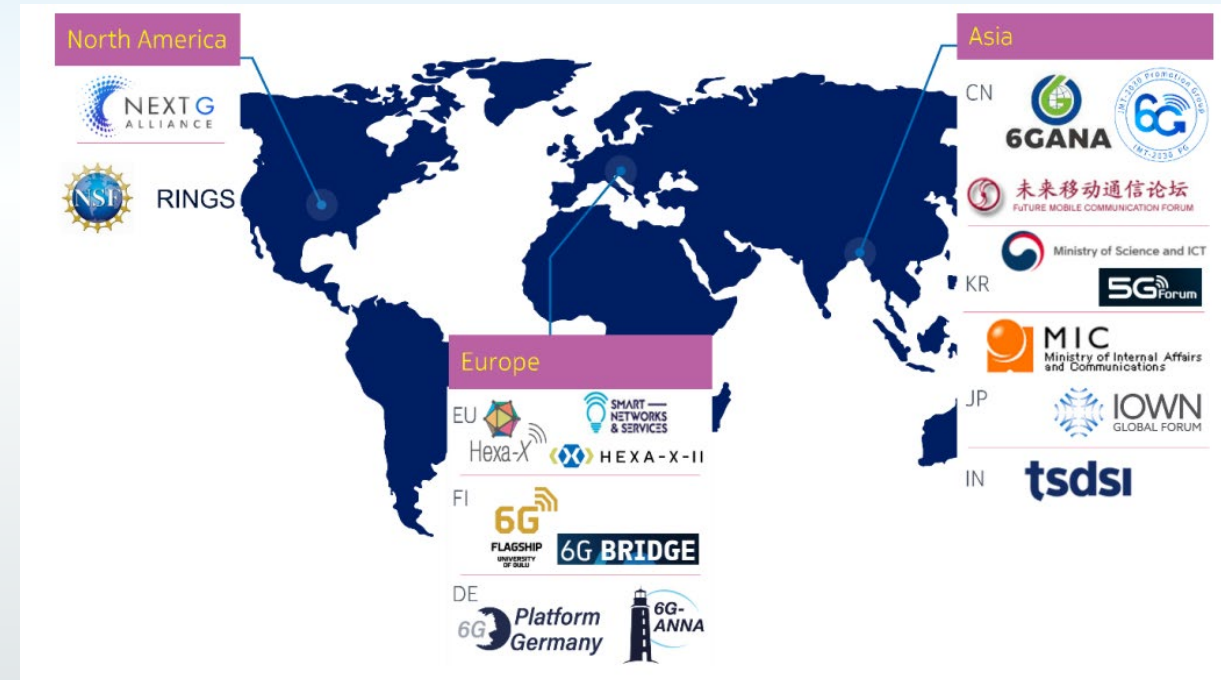
6G Use Cases Prioritized

- Substantial number of UCs / applications covered across the globe

- Most stakeholders envision a **broad portfolio of use cases** supported by 6G (up to 13 for some)

- **Top priorities** around the world

  - Holographic Communications

  - Cyber-Physical Systems

  - Digital Twins

  - Manufacturing

  - Multi-Sensory xR

  - Gaming/Entertainment

  - Tactile/Haptic Communications

  - Medical/Health Vertical, Telesurgery

  - Cooperative Operation among a Group of Service Robots / drones.

6G Use Cases	Networld Europe SRIA 2022 [1]	5G Americas / Next G Alliance [3][4]	Huawei (China) [5]	B5G Consortium (Japan) [6]	TSDSI (India) [7][8]	MediaTek (Taiwan) [9]	Survey Paper [10]	ITU IMT-2030 [2]
Holographic Communications	√	√	√	√	√	√	√	√
Cyber-Physical Systems, Digital Twin, Manufacturing	√	√	√	√	√	√	√	√
Multi-Sensory xR, Gaming/Entertainment	√	√	√	√	√	√	√	√
Tactile/Haptic Communications	√	√	√	√	√	√		√
Medical/Health Vertical, Telesurgery	√	√	√	√	√	√	√	
Cooperative Operation among a Group of Service Robots / drones	√	√	√	√	√		√	√
Imaging and Sensing	√	√	√	√	√			√
Transportation Vertical (automotive, logistics, aerial, marine, etc.)	√	√	√	√	√		√	
Space-Terrestrial integrated network	√	√		√	√		√	√
Intelligent Operation Network	√	√			√		√	√
Critical Infra, Government/National Security	√	√		√				
First Responder/Emergency Services		√		√	√			
Smart Buildings			√	√	√			
Agriculture / Smart Farming				√	√			

Source: SNS ICE Deliverable D1.2 Impact analysis and SNS promotional report 2.0

Targeted 6G KPIs

- **8 main technical KPIs** that almost all global regions target

- Despite the different backgrounds & UC focus, the **requirements in terms of performance are well aligned**

- KPI targets of the regional associations and stakeholders **align well with the ITU adopted values**

- Different definitions and approaches can be found regarding **Energy Efficiency** targets

- Network improvements in terms of KPIs usually **come with a cost** (complexity of equipment, additional spectrum, increased energy consumption, etc.)

- Important not only to **set ambitious targets** but also to have a **clear reasoning** if the targeted use cases need these improvements

KPIs	Networld Europe SRIA 2022 [1]	5G Americas / Next G Alliance [3][4]	Huawei (China) [5]	B5G Consortium (Japan) [6]	TSDSI (India) [7][8]	MediaTek (Taiwan) [9]	Survey Paper [10]	ITU IMT-2030 [2]
Peak Data Rate	1 Tb/s	0.5-1 Tbps	1 Tbps	100-200 Gbps	0.5-1 Tbps	1 Tbps	1 Tbps	50-200 Gbps
User Data Rate	10 Gbps	DL: up to 1 Gbps UL: up to 1 Gbps	10-100 Gbps	10-100 Gbps	DL: up to 10 Gbps UL: up to 5 Gbps	> 1 Gbps	1 Gbps	300-500 Mbps
Density	10^6 devices/km2	10^6 devices/km2	10^6 devices/km2	10^6 devices/km2	10^6 devices/km2	n/a	10^6 devices/km2	10^6 - 10^8 devices/km2
Reliability [BLER]	>1-10-8	>1-10-8	>1-10-7	>1-10-7	>1-10-7	n/a	>1-10-9	~1-10-5 - 1-10-7
U-Plane Latency	<0.1 ms	0.1-1 ms	0.1 ms	0.1-1 ms	0.1-1 ms	0.5-5 ms	0.01-0.1 ms	0.1-1 ms
Energy Efficiency (Network/Terminal)	>100% gain vs IMT-2020	Extremely low power / never charging devices	Network: 100x w.r.t 5G Device: 20 years battery	Network: 100x w.r.t 5G	Battery life-time up to 20 years	n/a	Network: 100x w.r.t 5G	n/a
Mobility	<1000 Km/h	> 500 km/h	n/a	Up to 1000 km/h	Up to 1000 km/h	n/a	Up to 1000 km/h	500 - 1000 km/h
Positioning accuracy	<1 cm	1 mm - 10 cm Six degrees of motion: (x,y,z)	Outdoor: 50 cm Indoor: 1 cm	1-2 cm	< 1 cm	n/a	1 cm	1-10 cm

Source: SNS ICE Deliverable D1.2 Impact analysis and SNS promotional report 2.0
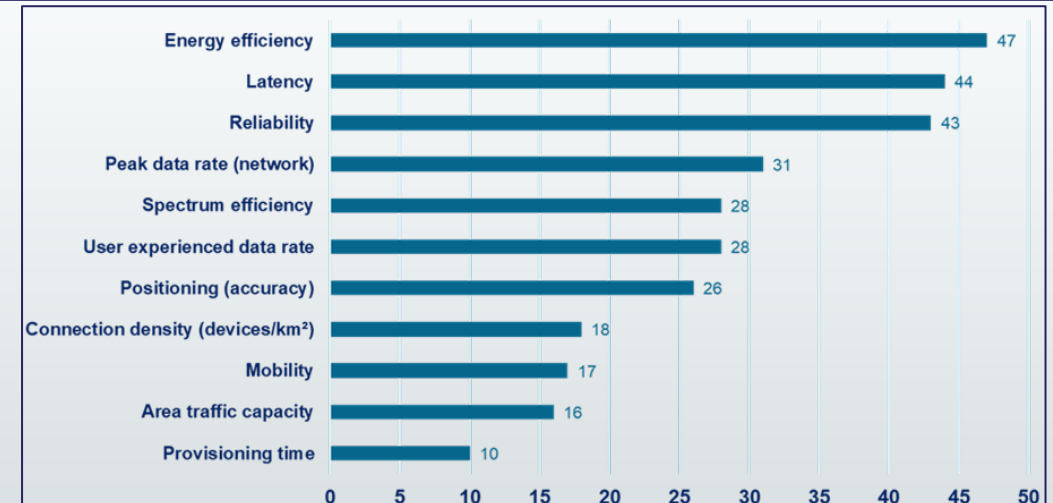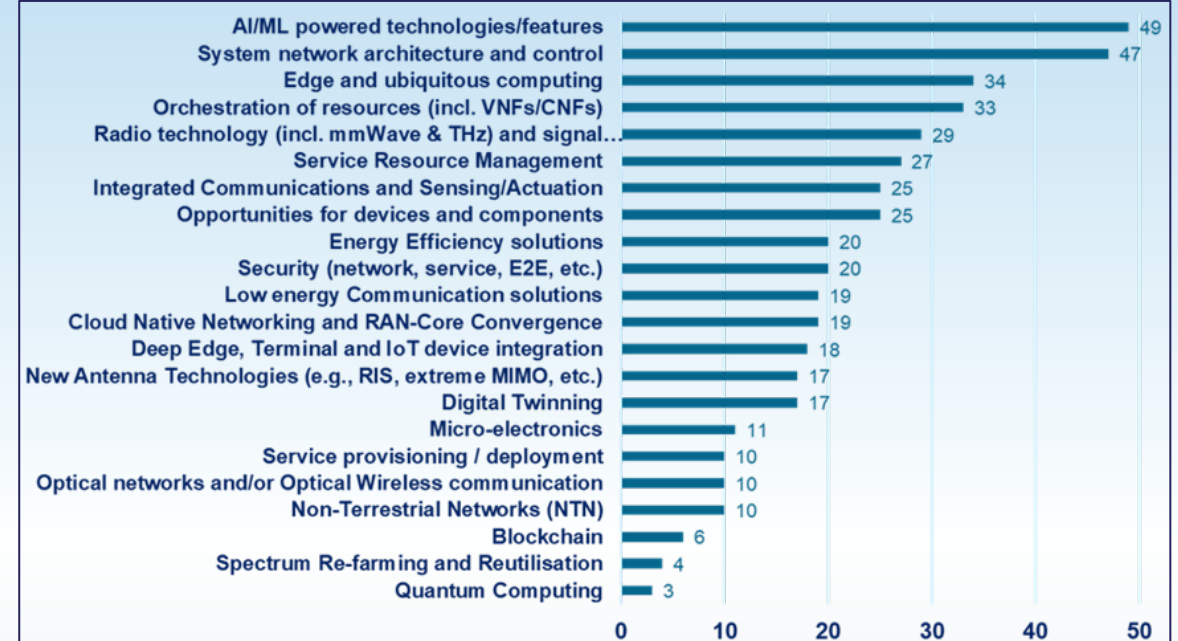
6G Enabling Technologies

- A total of **14** enabling technologies were identified as **Key Enabling Technologies** for 6G

- Most stakeholders identify **ten or more** of these enablers as necessary for the development of 6G networks

- Expectation that **multiple technological advancements are required** to deliver on the global vision of 6G and enable the targeted use cases

- **Top Enablers** around the world

  - AI related enablers (Edge, RAN, AIaaS)

  - Cloud Native Network and RAN-Core Convergence

  - mmWave and THz Radio

  - Communications and Sensing co-design (ISAC)

  - Spectrum Migration

  - Integrated Satellite hybrid infrastructures (NTN)

  - New Antenna Technologies (e.g., RIS)

  - Trustworthiness / Multilateral trust architecture

Enabling Technologies	Networld Europe SRIA 2022 [1]	5G Americas / Next G Alliance [3][4]	Huawei (China) [5]	B5G Consortium (Japan) [6]	TSDSI (India) [7][8]	MediaTek (Taiwan) [9]	Survey Paper [10]	ITU IMT-2030 [2]
Artificial Intelligence at the Network Edge	√	√	√	√		√	√	√
AI/ML in the RAN	√	√	√	√	√	√	√	√
AI as a Service: Data / network autonomous management	√		√	√	√	√	√	√
Fully Service Based – Cloud Native Networking and RAN-Core Convergence	√	√	√	√	√	√		√
mmWave and THz Radio	√	√	√	√	√	√	√	√
Communications and Sensing co-design (ISAC)	√	√	√	√	√	√	√	√
Spectrum Migration	√	√	√	√	√	√	√	
Integrated Satellite hybrid infrastructures (NTN)	√	√	√	√	√	√	√	√
New Antenna Technologies (RIS)	√	√	√	√		√	√	√
Trustworthiness / Multilateral trust architecture		√	√	√	√	√		√
Deep Edge, Terminal and IoT device integration	√				√	√		
Optical Wireless communication	√			√			√	√
Blockchain	√			√			√	
Quantum Computing				√	√	√	√	

Source: SNS ICE Deliverable D1.2 Impact analysis and SNS promotional report 2.0

Alignment of priorities with SNS JU

- **SNS JU research** in terms of key enabling technologies and KPI targets is **very well aligned** with the global trends / focus

- **No major research gaps detected** within the SNS JU compared to the rest of the world

- The majority of SNS projects are working on:

  - AI/ML enabled solutions

  - system architecture and control issues

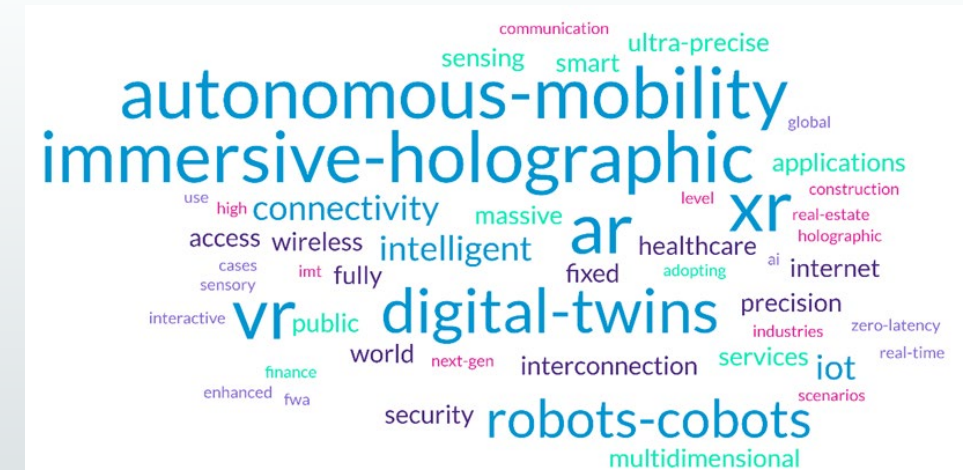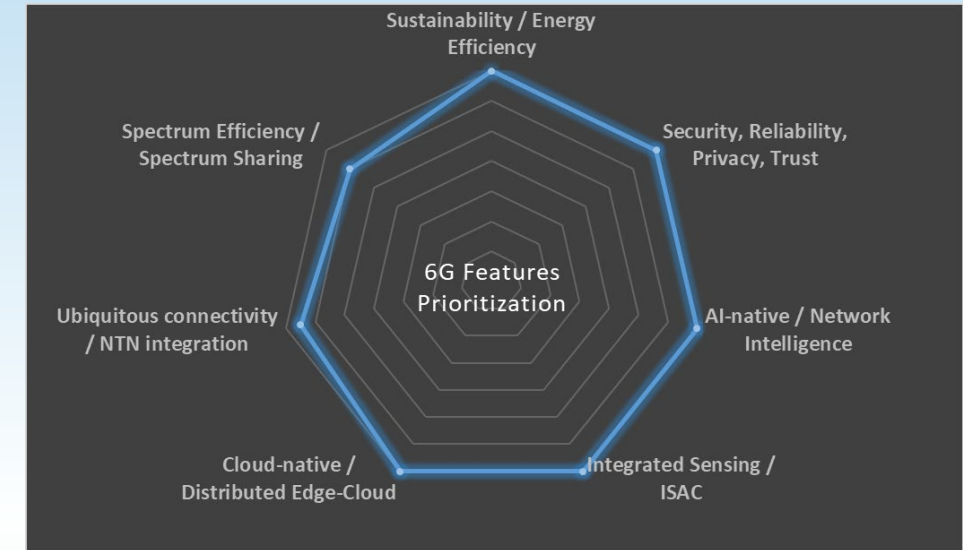- Energy Efficiency is very important within the SNS JU, followed by URLLC KPIs

Chart 1 data:
- AI/ML powered technologies/features — 49
- System network architecture and control — 47
- Edge and ubiquitous computing — 34
- Orchestration of resources (incl. VNFs/CNFs) — 33
- Radio technology (incl. mmWave & THz) and signal… — 29
- Service Resource Management — 27
- Integrated Communications and Sensing/Actuation — 25
- Opportunities for devices and components — 25
- Energy Efficiency solutions — 20
- Security (network, service, E2E, etc.) — 20
- Low energy Communication solutions — 19
- Cloud Native Networking and RAN-Core Convergence — 19
- Deep Edge, Terminal and IoT device integration — 18
- New Antenna Technologies (e.g., RIS, extreme MIMO, etc.) — 17
- Digital Twinning — 17
- Micro-electronics — 11
- Service provisioning / deployment — 10
- Optical networks and/or Optical Wireless communication — 10
- Non-Terrestrial Networks (NTN) — 10
- Blockchain — 6
- Spectrum Re-farming and Reutilisation — 4
- Quantum Computing — 3

Chart 2 data:
- Energy efficiency — 47
- Latency — 44
- Reliability — 43
- Peak data rate (network) — 31
- Spectrum efficiency — 28
- User experienced data rate — 28
- Positioning (accuracy) — 26
- Connection density (devices/km²) — 18
- Mobility — 17
- Area traffic capacity — 16
- Provisioning time — 10

Source: SNS ICE Deliverable D1.2 Impact analysis and SNS promotional report 2.0

- The publication of the **ITU-R Recommendations** (IMT-2030 Targets) affected global 6G R&I activities

- All major regions followed up with new/updated white/position papers on their **6G Vision**

- SNS ICE performed an additional global landscape analysis into the updated vision & global priorities

  - **Europe** (SNS-JU /6G-IA)

    - +2 Large European vendors

  - **North America** (ATIS-NGA)

  - **India** (Bharat6G)

  - **Japan** (NICT & B5G PG)

  - **South Korea** (SK Telecom)

  - **China** (IMT-2030 PG)

  - **Taiwan** (TAICS)

Source: SNS ICE Deliverable D1.3 Evaluation of the acceptance for the SNS Phase 1

- **Key drivers, features, and technologies for 6G**

  - Once again, a **significant degree of alignment** was detected among the global stakeholders

  - **Seven drivers / features stand out** (universal acceptance among global stakeholders)

  - World-wide acceptance of these features/technologies indicates that they are expected to be the **main building blocks** of future 6G networks

- **6G Use Cases prioritized**

  - Certain UCs seem to attract everyone's attention

  - Local needs and societal challenges do play a role in slightly differentiating the respective local vision / targeted UCs.

- EU / SNS-JU vision, targets and research efforts are still **well aligned with the global initiatives without any significant gaps**.

Source: SNS ICE Deliverable D1.3 Evaluation of the acceptance for the SNS Phase 1

Key Themes / Region	Europe	USA	South Korea	Japan	China	India
Architecture	• Interoperability • Resource Awareness – Resource Brokering • Service-Awareness • Multi-Tenant Federation • AI-Native Network • Sustainability • Dependable Communications • TN / NTN Integration • Trustworthiness (Security, Privacy, Reliability)	• Trust, Security, and Resilience • Enhanced Digital World Experience • Cost Efficiency • Distributed Cloud and Communications • AI-Native Future Network • Sustainability	• AI & cloud-native network • Green-native network • Quantum Security Networks • Disaggregated RANs • Integration with NTN	• All Photonics Network (APN) • Data-Centric Infrastructure (DCI) • Computing Resources • Autonomous management, optimization • User-centric communication	• Space-Air-ground integrated network • AI native network • Deterministic networking • Computing aware network • Information centric network • Digital twin network	• Distributed & Hierarhichal network • Integrated computing • AI native • Sustainability • Coreless RAN • Marketplace design • Cloud interoperability
Wireless Tech	• JCAS • Higher Frequencies (THz) • FR3 spectrum • Spectrum sharing • AI-native air interface • umMIMO • HW / Materials / Devices • Intelligent Surfaces (RIS)	• JCAS • Higher Frequencies (THz) • FR3 spectrum • Signal processing • umMIMO • HW / Materials / Devices • Intelligent Surfaces (RIS)	• JCAS • Higher Frequencies (THz) • FR3 spectrum • Spectrum sharing • umMIMO • HW / Materials / Devices	• JCAS • Higher Frequencies (THz) • FR3 spectrum • umMIMO • HW / Materials / Devices	• JCAS • Higher Frequencies (THz) • FR3 spectrum • Spectrum sharing / allocation • umMIMO • HW / Materials / Devices	• JCAS • Higher Frequencies (THz) • FR3 spectrum • umMIMO
AI/ML Landscape	• AI for Healthcare • AI for Energy Efficiency • AI for Climate Change • AI for Smart Cities • AI or Manufacturing/I4.0 • AI Legal Framework • Trustworthy AI • Ethical AI • AI-native 6G networks	• Natural language processing (NLP) • AI in STEM education • AI for climate-smart agriculture • Trustworthy AI • Ethical AI • Cross-disciplinary AI • AI Safety Institute	• AI semiconductors • AI Autonomous Vehicles AI powered healthcare • Edge AI • Real-time NLP • AI for Climate Change	• AI for Manufacturing/I4.0 • AI for Healthcare • AI for Transportation • AI for societal challenges • AI for disaster management • AI Safety Institute	• AI Intelligent Robotics • AI Autonomous Vehicles • AI for Healthcare • AI-driven Diagnostics • AI Defence Technologies • Exascale supercomputers	• AI for Healthcare • AI for Agriculture • AI for Education • Natural Language Processing (NLP) • AI for Climate Change • Exascale supercomputers

Source: SNS ICE Deliverable D1.3 Evaluation of the acceptance for the SNS Phase 1

Overview of global focus themes

Key Themes / Region	Europe	USA	South Korea	Japan	China	India
Cloud	• Cloud-native 6G networks • Telco Cloud • Edge Cloud Continuum • Cloud interoperability • Sustainable Cloud • Cyber-secure Cloud • Multi Provider Cloud • Connected Collaborative Computing" Network (3C)	• Hyperscalers • Cloud-native 6G networks • Cloud interoperability • Quantum Technologies • Cloud Computing • Edge Cloud	• Cloud-native 6G networks • Telco Cloud • Edge Cloud • Cloud interoperability	• Cloud-native 6G networks • Telco Cloud • Edge Cloud • Cloud Management • Multi-cloud environments	• Cloud-native 6G networks • AI Cloud • Cloud Computing	• Cloud-native 6G networks • AI Cloud • Cloud Computing • Edge Cloud • Cloud Management
Micro-electronics	• Domestic chip production • Supply chain resilience • AI Hardware • 5G/6G wireless • Quantum technology • Energy-efficient chips • Next-gen semiconductors	• Domestic chip production • Supply chain resilience • Electromagnetic warfare • Secure computing at tactical edge • AI Hardware • 5G/6G wireless • Quantum technology	• Domestic chip production • Supply chain resilience • AI Hardware • Large-scale manufacturing	• Domestic chip production • Supply chain resilience • 2-nanometer (nm) chips • AI Hardware • Next-gen semiconductors • Human capital	• Domestic chip production • Supply chain resilience • AI Hardware • Large-scale manufacturing • Human capital development	• N/A
Security	• Trustworthiness • Secure and sustainable digital infrastructures • Common, interoperable security standards • Seamless critical communication • Quantum-safe digital infrastructure	• Trustworthiness • Confidential computing • Post-quantum cryptography • Data-centric security • Zero-trust architecture • AI-driven security	• National Cybersecurity Strategy • Cyber-attacks on public sector • Verifying security suitability • Cryptographic modules	• Trustworthiness • Quantum-resistant encryption • AI based security • Enhanced security monitoring • Sustainable security • National defence (submarine cables)	• National security • Personal data protection • Cross-border data transfers • Responsibilities of internet • Platform providers	• Critical infrastructure protection • National cyber defence framework • Global cybersecurity alliances
Optical / Photonics	• THz photonics • AI-driven photonics • Optical transceivers • Energy-efficient optics • Quantum-enhanced optical networking • Fibre-optic communication	• THz photonics • Silicon photonics • AI-driven photonics • Photonic quantum communications • Optical computing	• N/A	• THz photonics • Photonic Integrated Circuits • Optical transceivers • Optoelectronic computing • Advanced fibre-optic materials • Quantum photonics	• THz photonics • Quantum photonics • High-speed optical backhaul • Photonic crystal technologies • All-optical signal processing	• Fibre-optic enhancements • Visible light communication • Silicon photonics • Photonics-driven 6G networks

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Thank you for you attention!

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