An international perspective on 6G: What role will spectrum access and sustainability play in service provision?

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Finnish 6G Flagship (2018-2026) approach and results

Wireless connectivity solutions

Device and circuit technologies

Distributed intelligent computing

Vertical applications and services

Input: Strategic Research Areas and 5G/6G Test Network

6G Flagship goals

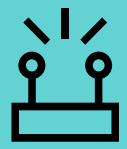
- Support industry in finalising 5G
- Develop fundamental technology for 6G
- Speed up digitalisation of society via 5G/6G

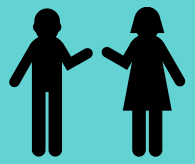
Output: 5G/6G components and systemic models

Impact

Short term: Applications and services in verticals

Long term: Business and societal well-being





- Health
- Industry
- Automotive
- Energy
- 5G driven digitalization
- 5G enabled growth and new jobs
- Commercial 6G by 2030

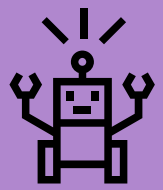
Vision for 2030

Our society is data-driven, enabled by near-instant, unlimited wireless connectivity.

6G FLAGSHIP
UNIVERSITY OF OULU

Results

Science: >1,100 peer-reviewed publications, 46 doctoral degrees, 6G Wireless Summits, Global 6G Research Vision and 6G White Papers, sustainable 6G supporting UN SDGs



Ecosystem: Global leadership in 6G research and ecosystem, >800 joint publications with collaborators, >130 new company collaborators, 85 companies investing in research portfolio

BUILDING A JOINT 6G VISION

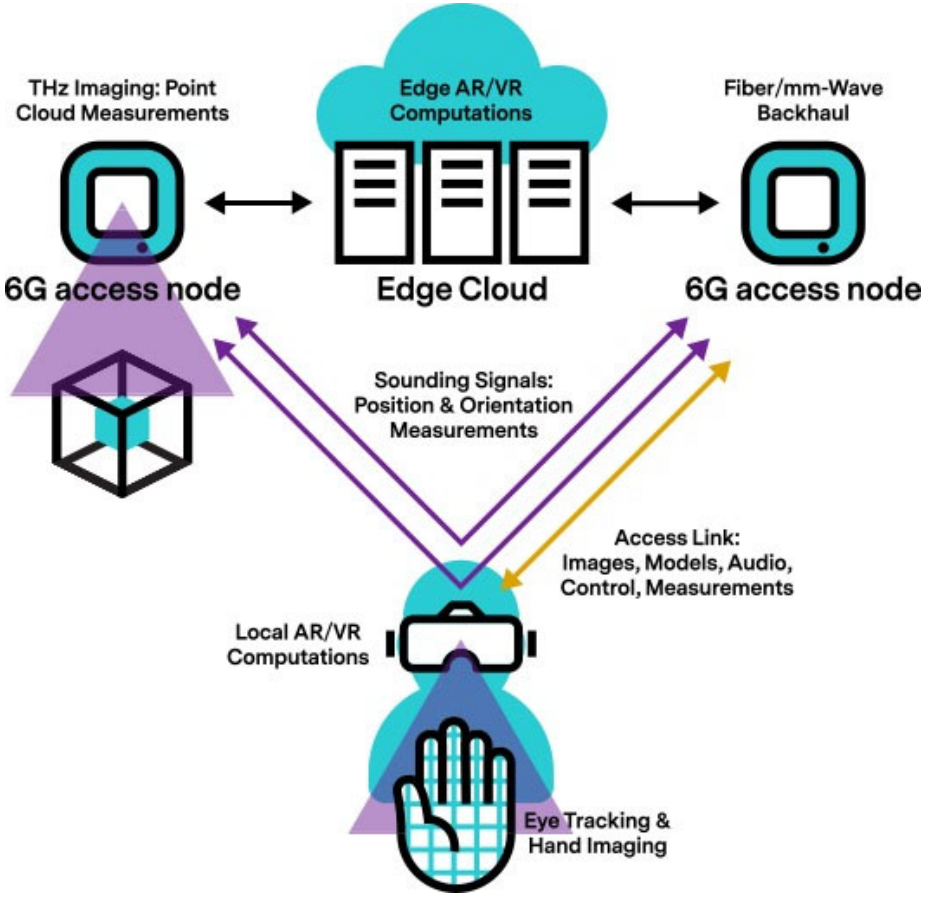
The World's first 6G White Paper 2019

- World's first 6G Wireless Summit gathered major telecom players to vision 6G in Finland in March 2019.
- The Summit launched 6G White Paper development with 70 experts from around the world.
- Consensus that 6G is driven by United Nations' Sustainable Development Goals (UN SDGs).

Published in September 2019:
http://6gflagship.com/6gwhitepaper/

6G Merges Communications with New Applications

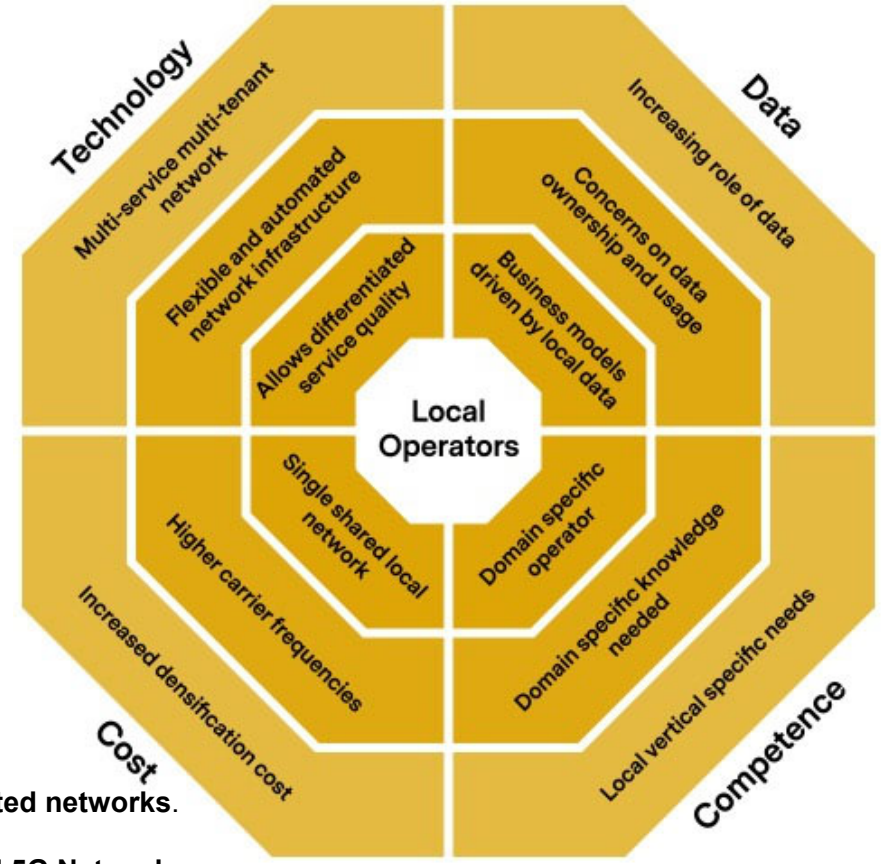
- **Going to higher frequencies (>100GHz), 6G will facilitate the integration of sensing, imaging, highly accurate positioning with communication service.**
- **New capabilities, combined with mobility and AI/ML, open a myriad of new applications with 6G leading to new business and a truly digitalized society, alleviating the digital divide.**



http://6gflagship.com/6gwhitepaper/

Towards Local Operator Paradigm

- **Stakeholder roles are changing. Different stakeholders can have their own local 5G/6G networks[1], independent of mobile network operators, through local spectrum licenses[2].**
- **Progress is slow and divergence in spectrum decisions between countries is high[3], leading to market fragmentation.**



[1]M. Matinmikko, et al. (2017) **Micro operators to boost local service delivery in 5G**. Wireless Personal Communications, 95(1), 69-82.
[2]M. Matinmikko, et al. (2018) **On regulations for 5G: Micro licensing for locally operated networks**. Telecommunications Policy, 42(8), 622-635.
[3]M. Matinmikko-Blue, et al. (2019) **Analysis of Spectrum Valuation Elements for Local 5G Networks: Case Study of 3.5-GHz Band**. IEEE Transactions on Cognitive Communications and Networking, 5(3), 741-753.

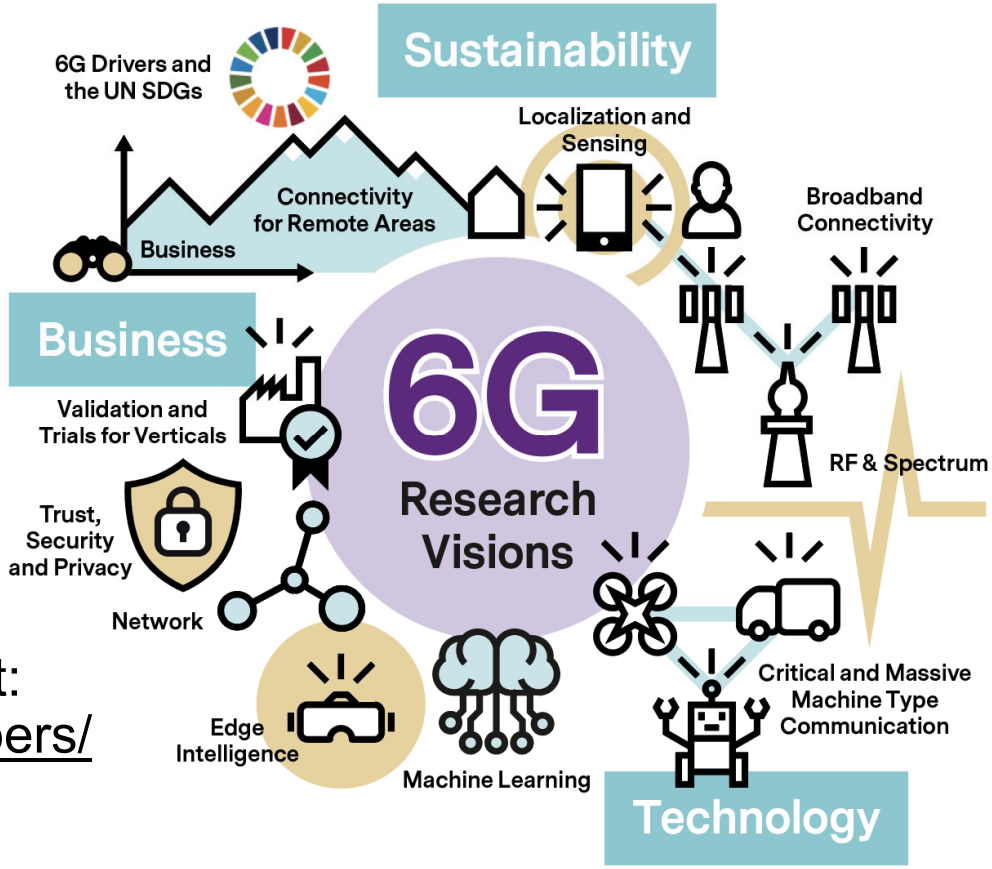
http://6gflagship.com/6gwhitepaper/


6G
THE 2020 EDITION OF 6G WHITE PAPERS:
MORE ABOUT SUSTAINABILITY

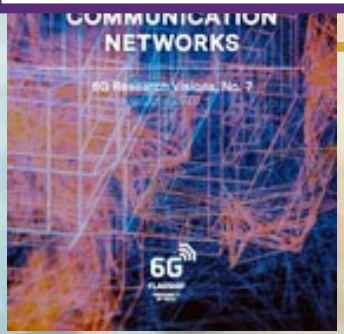
The 2020 edition of 6G White Papers – Sustainability, Technology and Business Perspectives

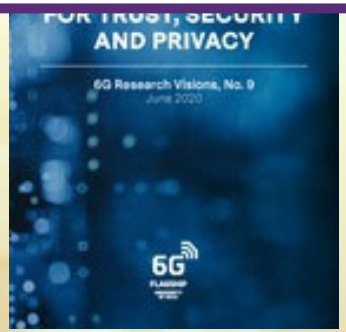
- Expert groups with **250 participants from 100 organizations and 30 countries** worked on 12 new white papers in conjunction with the 2nd 6G Wireless Summit held virtually in 2020. https://www.6gsummit.com/

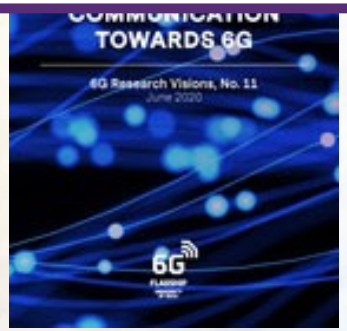
- 11 new 6G White Papers were published in June 2020, and one will appear later at: https://www.6gchannel.com/6g-white-papers/



6G and the UN SDGs – where is the connection?







White Paper on 6G Drivers and the UN SDGs
led by Marja Matinmikko-Blue

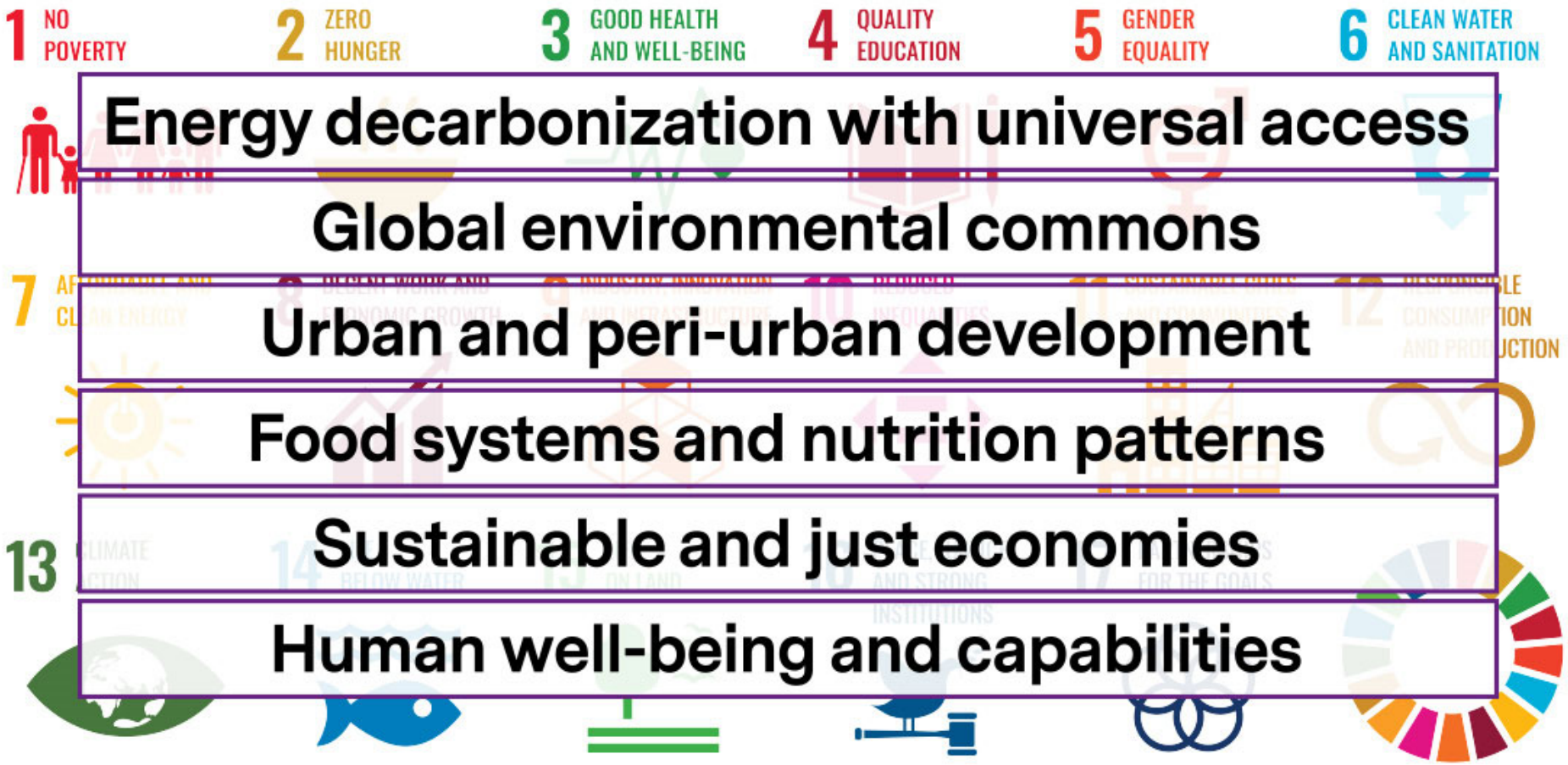
HIGHLIGHTS:

- We identify megatrends influencing the sustainable development of 6G.
- We develop a novel linkage between 6G and the UN SDGs that are both targeted for 2030.
- We envisage three-fold role of 6G as:
  1) a provider of services to help support activities towards reaching the UN SDGs,
  2) a measuring tool for reporting of indicators,
  3) a reinforcer of developing 6G in line with the UN SDG.

https://www.6gchannel.com/portfolio-posts/6g-white-paper-6g-drivers-un-sdgs/


1 NO POVERTY
2 ZERO HUNGER
3 GOOD HEALTH AND WELL-BEING
4 QUALITY EDUCATION
5 GENDER EQUALITY
6 CLEAN WATER AND SANITATION
7 AFFORDABLE AND CLEAN ENERGY
8 DECENT WORK AND ECONOMIC GROWTH
9 INDUSTRY, INNOVATION AND INFRASTRUCTURE
10 REDUCED INEQUALITIES
11 SUSTAINABLE CITIES AND COMMUNITIES
12 RESPONSIBLE CONSUMPTION AND PRODUCTION
13 CLIMATE ACTION
14 LIFE BELOW WATER
15 LIFE ON LAND
16 PEACE, JUSTICE AND STRONG INSTITUTIONS
17 PARTNERSHIPS FOR THE GOALS

The UN SDGs



The UN SDGs and six cross-cutting factors (“entry-points”).

Background: Current ICT indicators in UN SDG framework

SDG Goals / Targets

- **4.a** Build and upgrade education facilities that are child, disability and gender sensitive and provide safe, non-violent, inclusive and effective learning environments for all
- **4.4** By 2030, substantially increase the number of youth and

among existing mechanisms, in particular at the United Nations level, and through a global technology facilitation mechanism

- **17.8** Fully operationalize the technology bank and science, technology and innovation capacity building mechanism for least developed countries by 2017 and enhance the use of enabling technology, in particular information and communications technology

SDG Indicators:

- **4a: Proportion of schools with access to the Internet for pedagogical purposes**
- **4a: Proportion of schools with access to**

- **17.6: Fixed Internet broadband subscriptions, broken down by speed**
- **17.8: Proportion of individuals using the Internet**

There are only 7 ICT indicators in the UN SDG framework of 169 targets and 231 indicators.
In reality, the linkage to ICT is stronger.

Existing linkage between the UN SDGs and mobile communications/ICT

The UN SDGs	Existing linkage with mobile communications/ICT	Existing indicators from UN SDG framework	Other existing indicators
	Mobile communications can provide a communication infrastructure to stimulate local economy growth in poor communities. It can lower the barriers to access economic resources by providing access to mobile money and micro-financing and generate employment opportunities for people living in extreme poverty [GSMA 2018].	-	2G/3G/4G coverage; mobile penetration of the poorest 40%; mobile money penetration; number of transactions per account; average transaction volume; mobile money registered accounts [GSMA 2018]. Proportion of individuals using the Internet; proportion of households with Internet access; proportion of individuals owning a mobile phone; population covered by a mobile broadband network; proportion of individuals using the Internet for Internet banking [ITU et al. 2019].
	ICT can help farmers improve crop yields and business productivity through better access to market information, weather forecasts, training programs, and other tailored online content [ITU].	-	Mobile penetration; receiving of payments for agricultural products via mobile; number of people using mobile access that benefit their farm or fishery; use of mobile technology to access health services [GSMA 2018]. Proportion of individuals using the Internet; proportion of individuals owning a mobile phone; population covered by a mobile broadband network [ITU et al. 2019].

Existing linkage between the UN SDGs and mobile communications/ICT

The UN SDGs	Existing linkage with mobile communications/ICT	Existing indicators from UN SDG framework	Other existing indicators
	Mobile communications enable communication with medical practitioners, monitor well-being through mobile, provide access to health programs, provide digital identity service to access healthcare, and provides big data for epidemics [GSMA 2018].	-	Proportion of individuals owning a mobile phone; countries having adopted a national e-health record [ITU et al. 2019].
	ICT powers a revolution in digital learning; mobile devices allow students to access learning assets anytime, anywhere; teachers use mobile devices for everything from literacy and numerical training to interactive tutoring; mobile learning has the ability to help break down economic barriers, divides between rural and urban, as well as the gender divide [ITU].	Proportion of schools with access to the Internet for pedagogical purposes [UN 2017]. Proportion of schools with access to computers for pedagogical purposes [UN 2017]. Proportion of youth/adults with ICT skills, by the type of skill [UN 2017].	Proportion of indviduals using the Internet; enrolment in basic computer skills and/or computing courses in secondary education; proportion of graduates in ICT-related fields at post-secondary levels; Individuals with ICT skills by the type of skill; percentage of youths/adults who have achieved at least a minimum level of proficiency in digital literacy skills; learner-to-computer ratio; proportion of educational institutions with computers for pedagogical purposes; proportion of educational institutes with Internet for pedagogical purposes [ITU et al. 2019].

More about the existing linkage in the white paper:
https://www.6gchannel.com/portfolio-posts/6g-white-paper-6g-drivers-un-sdgs/

Role of 6G in UN SDGs

Linking 6G and UN SDGs via existing indicators

4 QUALITY EDUCATION

UN Targets	UN Indicators	6G can
4.2 By 2030, ensure that all girls and boys have access to quality early childhood development, care and pre-primary education so that they are ready for primary education	**4.2.1** Proportion of children under 5 years of age who are developmentally on track in health, learning and psycho-social well-being, by sex **4.2.2** Participation rate in organized learning (one year before the official primary entry age), by sex	**Increase access to remote learning and developmental activities** to children under 5 years. **Enable improved socialization** through virtual interactions. **Improve remote access to pediatrics** in locations with poor connectivity. **Facilitate remote and virtual training** of local pediatricians. **Help improve and develop the knowledge and skills** of local medical community. **Deliver prosthetic technologies** to support handicapped children. **Permit family and experts to monitor** the cognitive development of children with Brain-Computer Interfaces. **Help coordinate virtual meetings** for preschoolers.

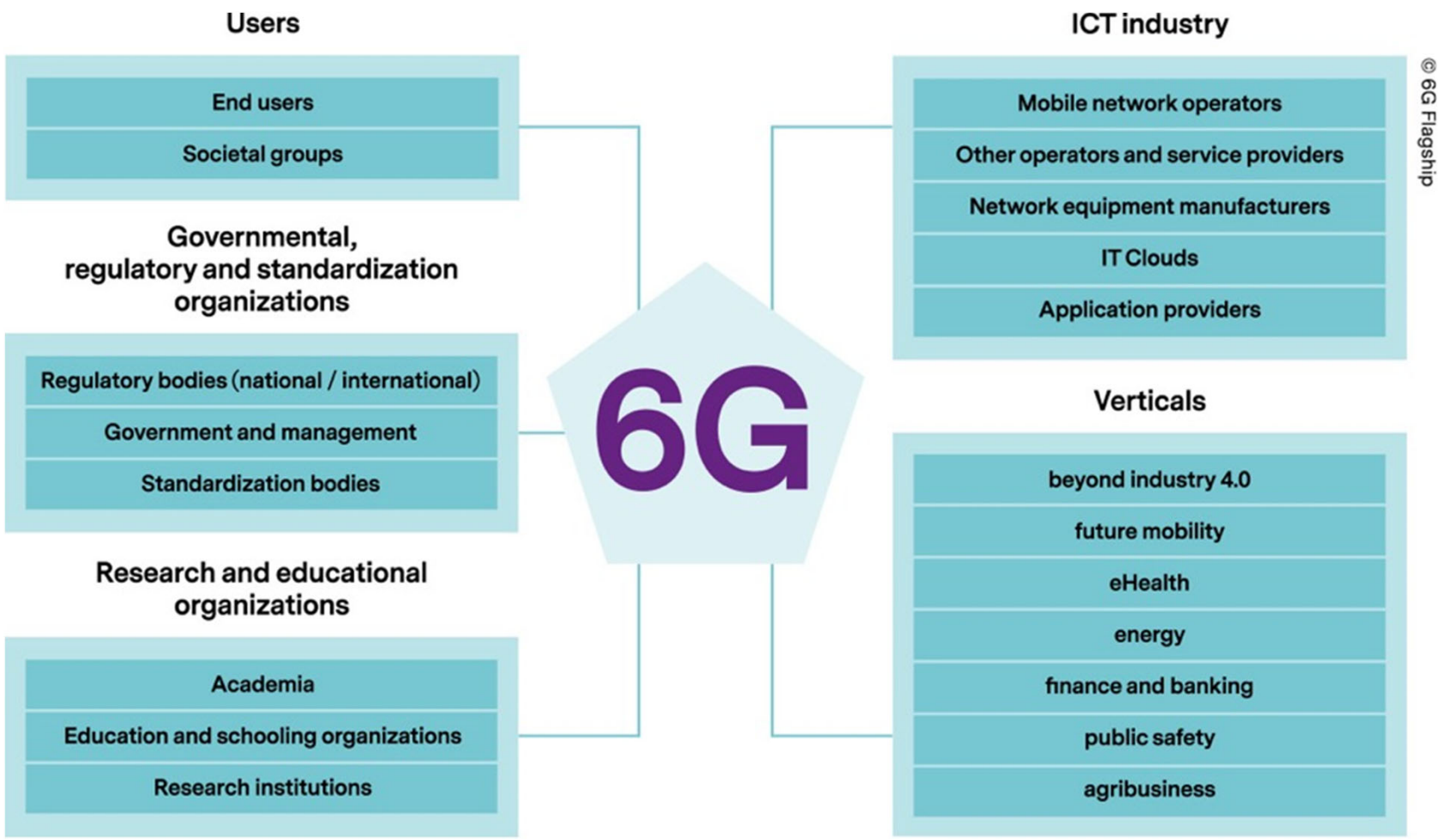
Developing 6G related indicators through UN SDG entry points

Entry points from UN SDG framework	6G as a provider of services	6G as an enabler of hyperlocal measuring tool	6G as a reinforcer of an ecosystem aligned with the SDGs
Sustainable and just economies	Mobile subscription considered a basic need in any given society (yes/no). Unrestricted access to Internet and mobile services (yes/no). Number of mobile birth registrations and personal electronic identification. Availability of public mobile services such as tax/license services, census, banking etc. Availability of mobile financial transactions (micro payments) (yes/no). Number of mobile services supporting circular economies.	Data subscription models available and their relative proportion. Use of data (i.e., what subscription models poor people use, do they even have access to data, who uses the data, only the rich?). Percentile of mobile devices suited for browsing and rich data consumption (chiefly: screen size and resolution) e.g. browsing/web sites, video consumption, gaming, video calls for work and social purposes. Share of value in the mobile ecosystem: distribution of monetary value gained and spent per actor in the mobile ecosystem (infrastructure providers such as electricity, operators; device manufacturers; retailers; remanufacturers; second-hand sellers; end-of life material recyclers; content providers; users; etc.).	Distribution of mobile terminals by price (how many expensive terminals are bought in a country). % global coverage covered by 6G. Business models of operators (just or not)? Circular economies in 6G devices. E-waste management of new devices.

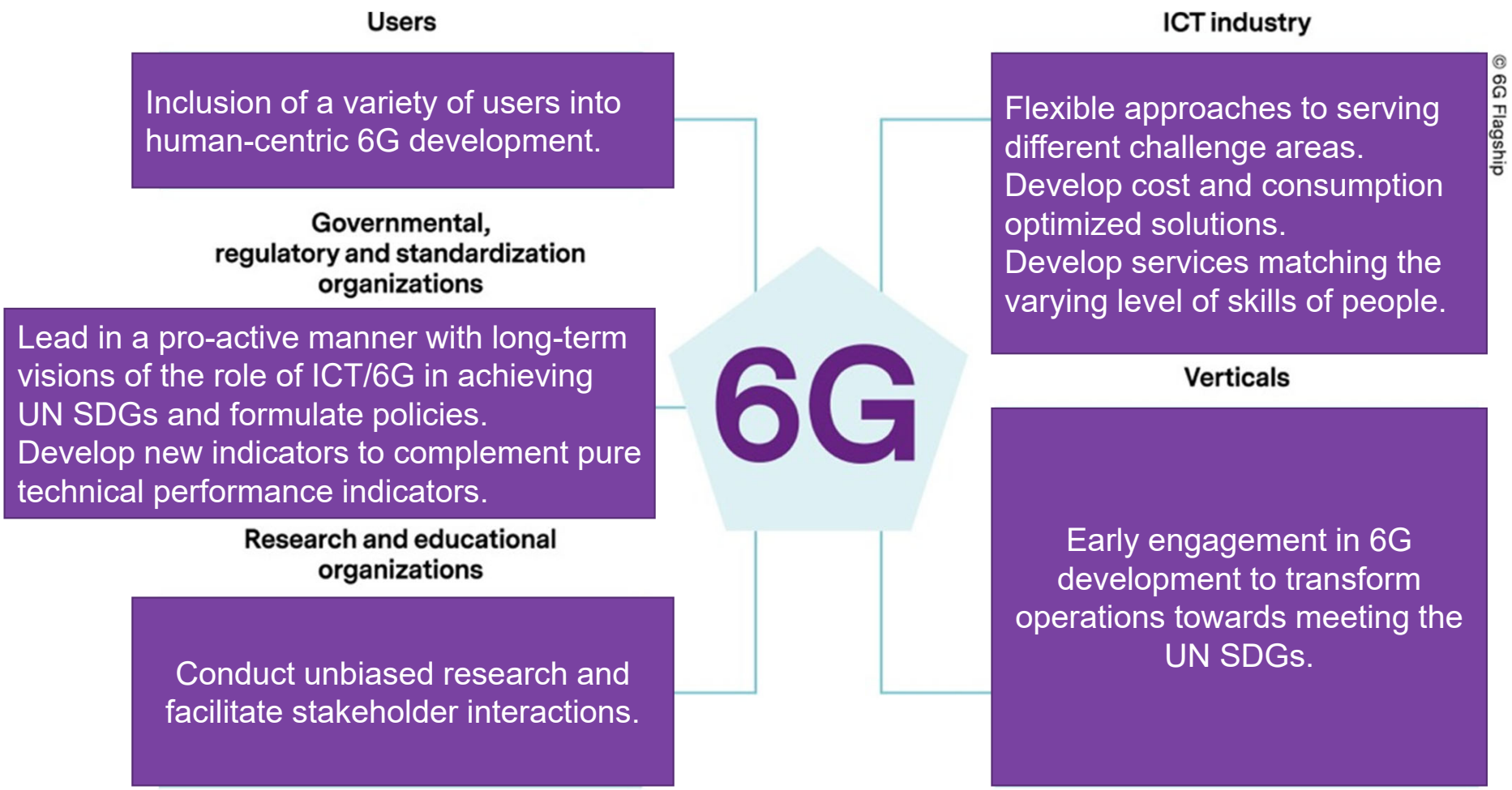
Developing 6G related indicators through UN SDG entry points

Entry points from UN SDG framework	6G as a provider of services	6G as an enabler of hyperlocal measuring tool	6G as a reinforcer of an ecosystem aligned with the SDGs
Global environmental commons	Coverage of monitoring systems used for protecting fauna and flora. Apps to report observations related to environmental changes. Coverage of IoT services for inhabitants.	Number of sensors monitoring fauna and flora. Number of people/ users reporting their local observations related to environmental changes with mobile devices/ apps. Number of homes using a certain defined level of IoT (electricity, water consumption, waste management).	Percentage of recycled materials in new 6G devices. Reductions in energy consumption in mobile phones, base stations, and batteries. Reductions in energy consumption due to 6G mobile networks.

Key stakeholders in 6G development



Preliminary action plan on 6G and the UN SDGs




BACK TO SPECTRUM ACCESS

Spectrum access and 6G

- Competition over the scarce spectrum resource continues to be fierce between the different wireless services. Spectrum sharing has not become the norm.
- Complexity of spectrum bands and access models has increased with 5G (admin allocation, market mechanisms, unlicensed commons).
- Market structures are changing – local 5G networks that were strongly opposed 4 years ago are appearing to some extent.
- High fragmentation between countries on who can deploy 5G networks, where and how. The same could continue in 6G.

Spectrum access and 6G

- Traditional split into radiocommunication services is not consistent with the use of wireless technologies (e.g., 5G, 6G) for digitalization of the entire society.
- Same devices operate in a variety of bands under different spectrum access models – end users do not even know the technology. 6G combines the communication service with other services which further blurs the split.
- Time-scales of international-level spectrum management do not match with the rapid technology development and changing user needs when the systems are used for multiple purposes.

Spectrum access and 6G

This ever increasing…

- variety of spectrum bands for mobile communications with drastically different propagation and deployment characteristics;
- fragmentation of spectrum management approaches;
- and rivalry between systems competing over spectrum access

…will lead to a situation where spectrum sharing finally becomes important.

However, **stakeholder management** is the bottleneck.

Managing the stakeholders – Introducing stakeholder analysis into wireless communications

- Spectrum decisions are a result of stakeholder analysis, but the reality is that those with existing strong market positions dominate. They also dominate the discussions about the future.
- Who oversees the process? Who makes sure there is room for innovation? Who looks after the interests of end users and those without dominant position?
- There is not enough spectrum for everybody. Stakeholders have different positions but only some are heard. If sharing is stakeholder's only opportunity to access spectrum, it becomes attractive.

Stakeholder analysis:

1) Identification of stakeholders
2) Stakeholder dynamics and interactions
3) Stakeholder management actions

M. Matinmikko-Blue. (2018) Stakeholder analysis for the development of sharing-based spectrum governance models. Doctoral thesis in Industrial Engineering and Management, University of Oulu, Finland.
http://jultika.oulu.fi/files/isbn9789526220512.pdf

Conclusions

- Finnish 6G Flagship has started to drive 6G research ventures for 2030 and engaged the larger community to participate since 2018.
- 12 White Papers present the current vision for 6G, prepared in close collaboration with experts globally.
- There is a common consensus that the UN SDGs are the starting point for 6G research and development. UN SDGS also influence the use of ICT to make verticals sustainable in the national level.
- Variety of bands and fragmentation keep increasing in 6G – the role of spectrum sharing is critical in the landscape of changing market structures and stakeholder needs.


6G
Webinar series on the new 6G White Papers available at:
6gchannel.com/events


6G
Keep up with all things in 6G – read the latest issue of the 6G Waves Magazine:
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