



FLAGSHIP
UNIVERSITY
OF OULU

From 5GTN to 6GTN – Three Pronged Approach

Prof. Ari Pouttu
University of Oulu

Kindly presented by

Prof Riku Jäntti
Aalto University





FLAGSHIP
UNIVERSITY
OF OULU

But first ...

6G Flagship – Results of Phase 1 in a Nutsell

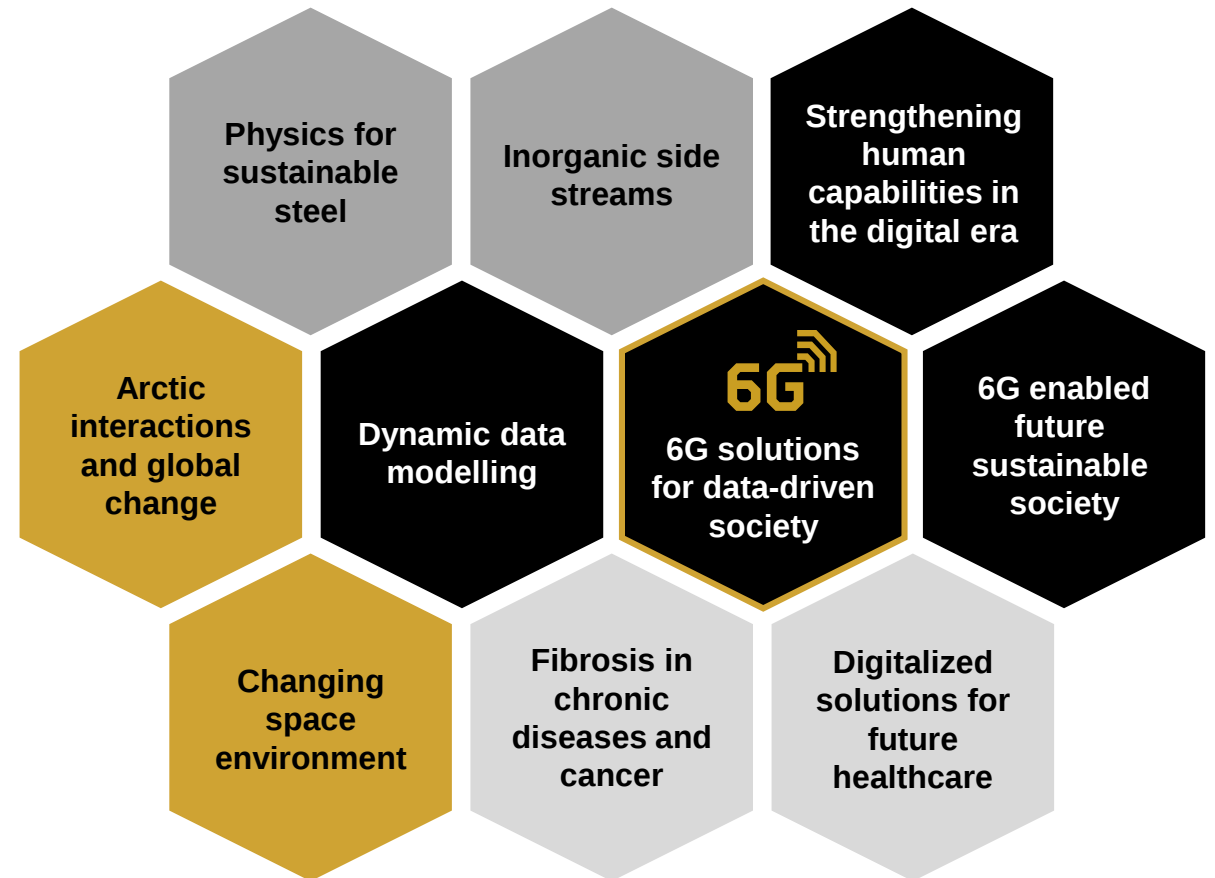


At the heart of Oulu University's research profile

- 6G Flagship program 2018-2026.
- 6G Flagship budget total will be 292,2M€
- Academy of Finland and University of Oulu the biggest financers.
- University of Oulu's funding 123,3M€ during 2018-2028.



LEARN MORE ABOUT
OUR RESEARCH



Strategic profiling themes at the University of Oulu.

KPIs 2018 – 2022



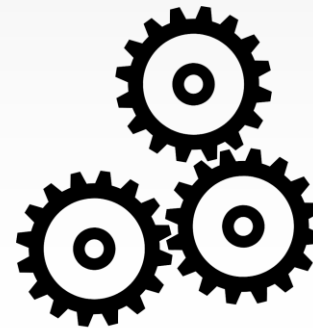
Science

- 1,891** Peer-reviewed Publications
- 24,7% Publications in Top 10% citation percentile
 - 2,29 Field-weighted Citation Impact (FWCI)
 - 1244 (65,8%) Joint international publications
 - 1,803 Open access / self-archived publications
- 73** Doctoral degrees
- 265,416 Doctoral thesis downloads
- 3** ERC Advanced Grants
- 2** Academy of Finland Professors



Co-creation and business impact

- 337** Research projects, external funding
- 428** Company collaborators
- 140** Companies funding projects
- 221** Joint publications with companies
- 7,575** participants in co-creation forums
- 994,579** 6G White Paper downloads
- 170,000** Vision video downloads



Societal impact

- 8,501** Social media followers
- 1,189,185 Tweet views
- 5,738** Articles in independent media
- 309,995** 6G Waves downloads



Staff

- 446** Staff (20% female)
- 48** Nationalities (44% Finns)
- 32** Professors and tenures

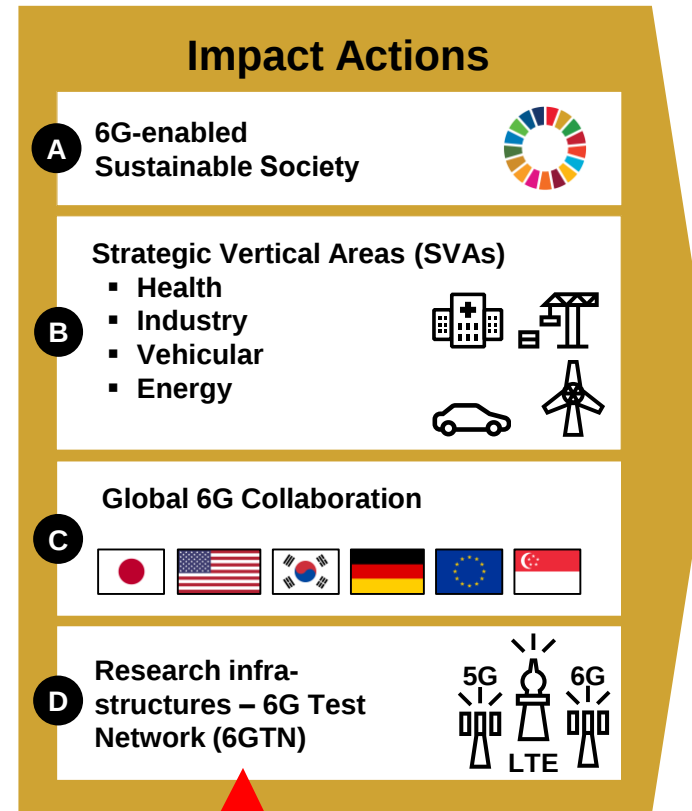
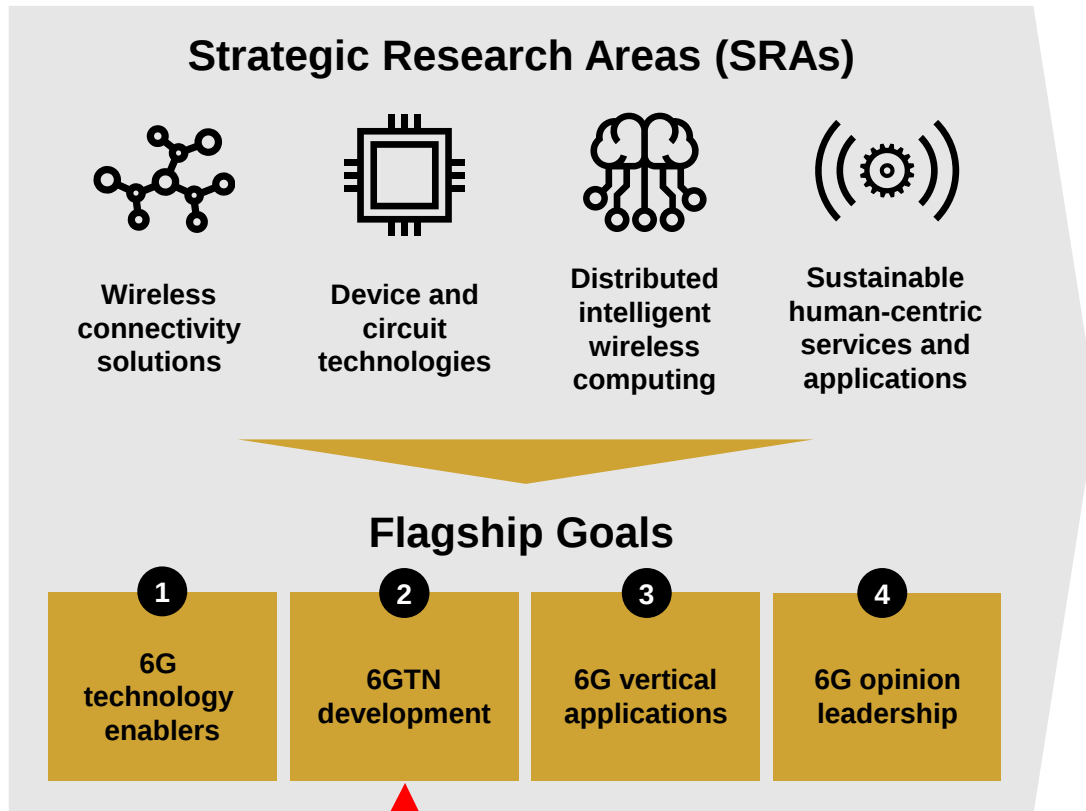


VISION FOR 6G FLAGSHIP PHASE II (2022 – 2026)

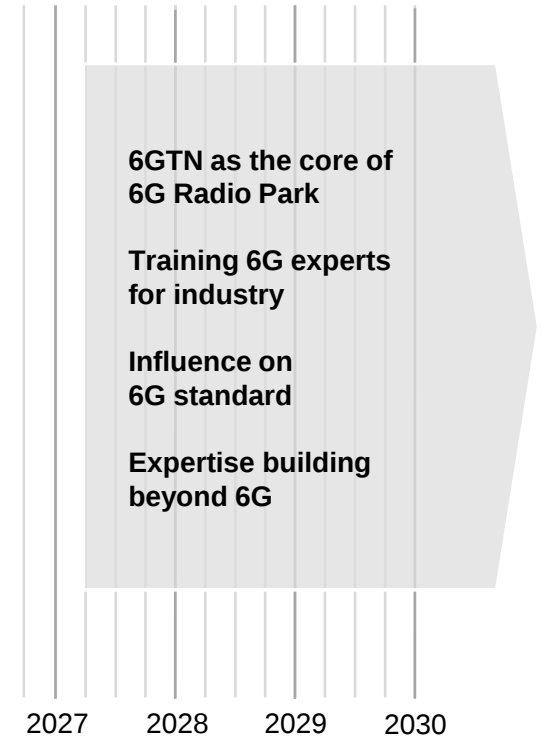
And second ...

6G Flagship – Approach for Phase 2 - 2022-2026

Overview of Flagship Phase II



Beyond 6G Flagship





STRATEGIC RESEARCH AREA 1

Wireless Connectivity

SRA 1 – Structure



LEADER
Prof. Matti Latva-aho



SRA1 Wireless Connectivity



COORDINATOR
Dr. Nurul Huda Mahmood

THEME A Advanced Networking Technologies

LEADER
Prof. Tarik Taleb



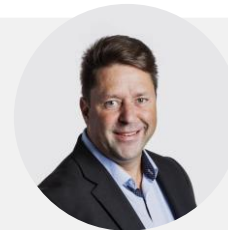
KEYWORDS

- 6G Core, Telco Cloud
- Edge Cloud Fabric/Continuum
- AI-Synthesized Networking
- Trust & Security



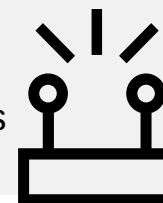
THEME B Wireless Broadband Access

LEADER
Prof. Matti Latva-aho



KEYWORDS

- Modulation and coding
- Millimeter wave and terahertz
- Massive MIMO techniques



THEME C Massive Wireless Automation

LEADER
Asc. Prof. Hirley Alves



KEYWORDS

- Resilient communications
- Massive machine type communications
- Sustainable IoT





STRATEGIC RESEARCH AREA 2

Device and Circuit Technologies and Implementations

SRA 2 – Structure



LEADER
Prof. Aarno Pärssinen

SRA2 Devices and Circuit Technologies



COORDINATOR
Assoc. Prof. Ping Jack Soh

THEME A Radio platforms

LEADER
Prof. Aarno Pärssinen



KEYWORDS

- Radio platform system design
- Hardware architectures
- Signal processing



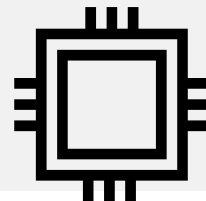
THEME B Radio hardware

LEADER
Prof. Timo Rahkonen



KEYWORDS

- Radio-frequency integrated circuits
- Digital signal processing hardware
- Components, antennas, packaging and materials



THEME C Experiments and proofs of concept

LEADER
DSc Tech. Marko Leinonen



KEYWORDS

- Proofs of concept
- Radio frequency testing
- Fabrication technologies





STRATEGIC RESEARCH AREA 3

Distributed Intelligence

SRA 3 – Structure



LEADER
Prof. Olli Silvén



SRA3 Distributed Intelligence



COORDINATOR
Assoc. Prof. Miguel
Bordallo López

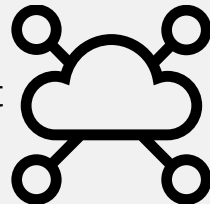
THEME A Computing on edge-to-cloud continuum

LEADER
Research Director
Susanna Pirttikangas



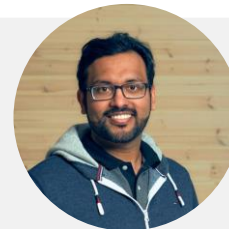
KEYWORDS

- Distributed computing
- Dynamic node placement
- AI-for-edge, edge-for-AI



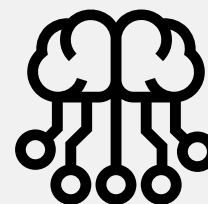
THEME B Distributed AI

LEADER
Assist. Prof.
Sumudu Samarakoon



KEYWORDS

- Distributed inference
- Privacy-preserving AI
- Self-organizing architecture



THEME C Distributed Sensing and Modelling

LEADER
Prof. Janne Heikkilä



KEYWORDS

- Coordinated sensing & communication
- Multimodal 3D modeling
- Data locality





STRATEGIC RESEARCH AREA 4

Human-centric Wireless Services

SRA 4 – Structure



LEADER
Prof. Ari Pouttu



SRA4 Human-centric Wireless Services



COORDINATOR
Dr. Tuomo Hänninen

THEME A 5GTN to 6GTN

LEADER
Olli Liinamaa



KEYWORDS

- 5G NSA, 5G SA, 6G Core
- Open and Multi Access Edge Computing
- Multiple RATs



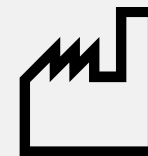
THEME B Strategic Vertical Areas

LEADER
Adj. Prof. Jussi Haapola



KEYWORDS

- Wireless for Energy
- Wireless for Health
- Wireless for Industry
- Wireless for Vehicular



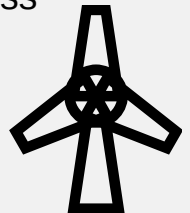
THEME C Sustainability and Business

LEADER
Dr. Marja Matinmikko-Blue



KEYWORDS

- Future 6G enabled Business
- Sustainable development and 6G
- Regulation for 6G



And now

From 5GTN to 6GTN – Three Pronged Approach

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Test Network - key tool for co-creation

6G



First open test network
(<https://services.5gtn.fi/>).

5G mmW trials in Olympics
with ETRI and Nokia

Operator grade
live 5G micro-
operator network

Selection to AoF
FIRI roadmap

Selection to ESFRI
FIRI roadmap

First 6G
PoC devices

First 6G
"network"

6G Standardization
begins

2015

2018

2019

2020

2021

2023

2025

2026

5GTN

4G-LTE

5G PoC

5G NR

5G+

5G+

...

6G

6GTN



LTE small cell
@2.1 and 2.6 GHz



5G PoC/5G NR



5G Macros at 3.5GHz
For IoT - NB IoT/LTE-M



Cloud RAN based 5G
@3.5GHz
5G NR @24 GHz

Next steps: Three development avenues

Providing e.g. coverage, medium data rate, latency & Jitter,
zero carbon footprint solutions, RedCap Devices

3GPP path Rel. 17...Rel. 20

Providing e.g. low capex with moderate performance, high opex,
studying security, energy consumption, jitter/latency perf., stability

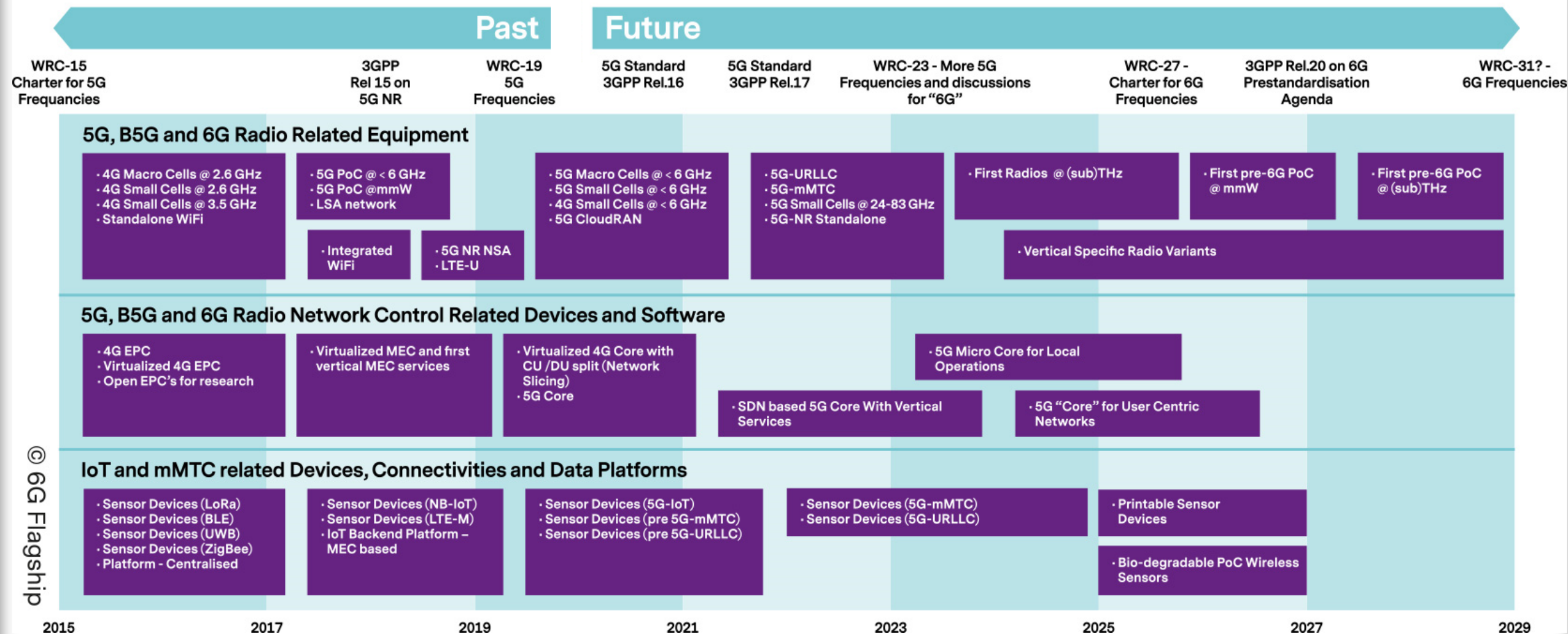
O-RAN path

Providing e.g. 1 Tbps, joint com&sensing, low latency and jitter,
sub-cm positioning, reflective surfaces, Sub-THz transceivers

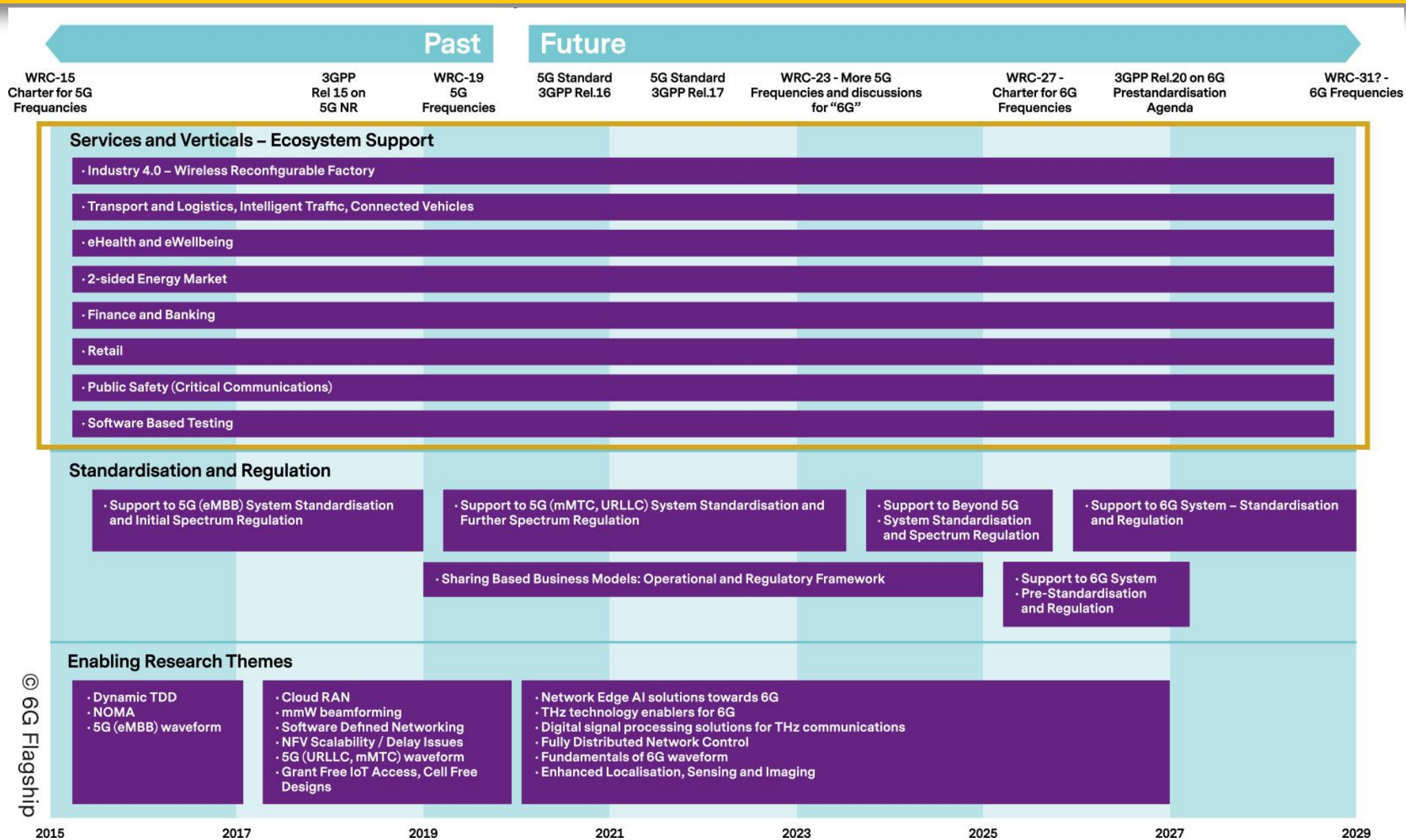
Disruptive 6G path

6G

Starting the journey towards 6G ...



... but it's not just technology



Why bother with experimental test networks?

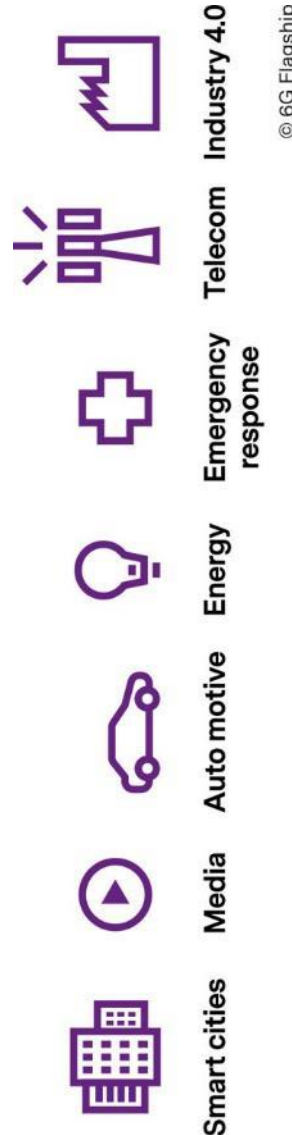


Answer: Versatility of Vertical Requirements

Examples of KPIs for verticals

Vertical	Link DataRate	Latency	LinkBudget	Jitter	Density	Energy Efficiency	Reliability	Capacity	Mobility
Industry mMTC	< 1 Mbps	< 100ms	+ 10 dB	100 μ s	100/m ³	High	1-10 ⁻⁶	< 10 Gbps	240 km/h
Industry eURLLC	< 5 Mbps	< 100 μ s	+ 20 dB	< 1 μ s	10/m ³	Nominal	1-10 ⁻⁹	< 100 Mbps	240 km/h
Mobility	<10 Gbps	< 100 μ s	+ 20 dB	100 μ s	100/m ³	Nominal	1-10 ⁻⁷	1 Tbps	1200 km/h
eHealth	< 1 Gbps	< 1 ms	+ 10 dB	100 μ s	1/m ³	High	1-10 ⁻⁹	< 10 Gbps	240 km/h
Energy	<1 Mbps	< 500 μ s	+ 40 dB	< 1 μ s	10/m ³	Nominal	1-10 ⁻⁶	< 100 Mbps	N/A
Finance	< 1 Gbps	< 10 ms	varies	N/A	1/m ³	High	1-10 ⁻⁹	< 10 Gbps	Low
Public Safety	<1 Gbps	< 1 ms	+ 20 dB	100 μ s	1/m ³	Nominal	1-10 ⁻⁷	< 10 Gbps	240 km/h
Agri-business	100 Mbps	< 10 ms	+ 40 dB	100 μ s	100/km ²	Nominal	1-10 ⁻⁷	1 Gbps	240 km/h

How do we facilitate service pull and avoid technology push!



Versatility of Vertical Requirements



Examples of Key Performance Indicators (KPIs) for verticals*

Vertical	Cost Importance	Position	RF Imaging Resolution	EMF values	Security	Coverage
Industry mMTC	High	< 1 cm	Nominal	Nominal	Nominal	< 1km
Industry eURLLC	Nominal	< 1cm	High	Nominal	High	< 50m
Mobility	Nominal	< 10 cm	High	High	High	< 10 km
eHealth	High	< 1 cm	High	Nominal	High	< 500 m
Energy	Nominal	< 1 m	Low	Nominal	High	< 1 km
Finance	High	< 1 m	High (biometrics)	Nominal	High	< 500 m
Public Safety	Nominal	< 10 cm	High	Low	High	> 10 km
Agri-business	High	< 10 cm	High (Precision agriculture)	Low	High	> 50 km



Smart cities



Emergency response



Media



Telecom



Auto motive



Industry 4.0

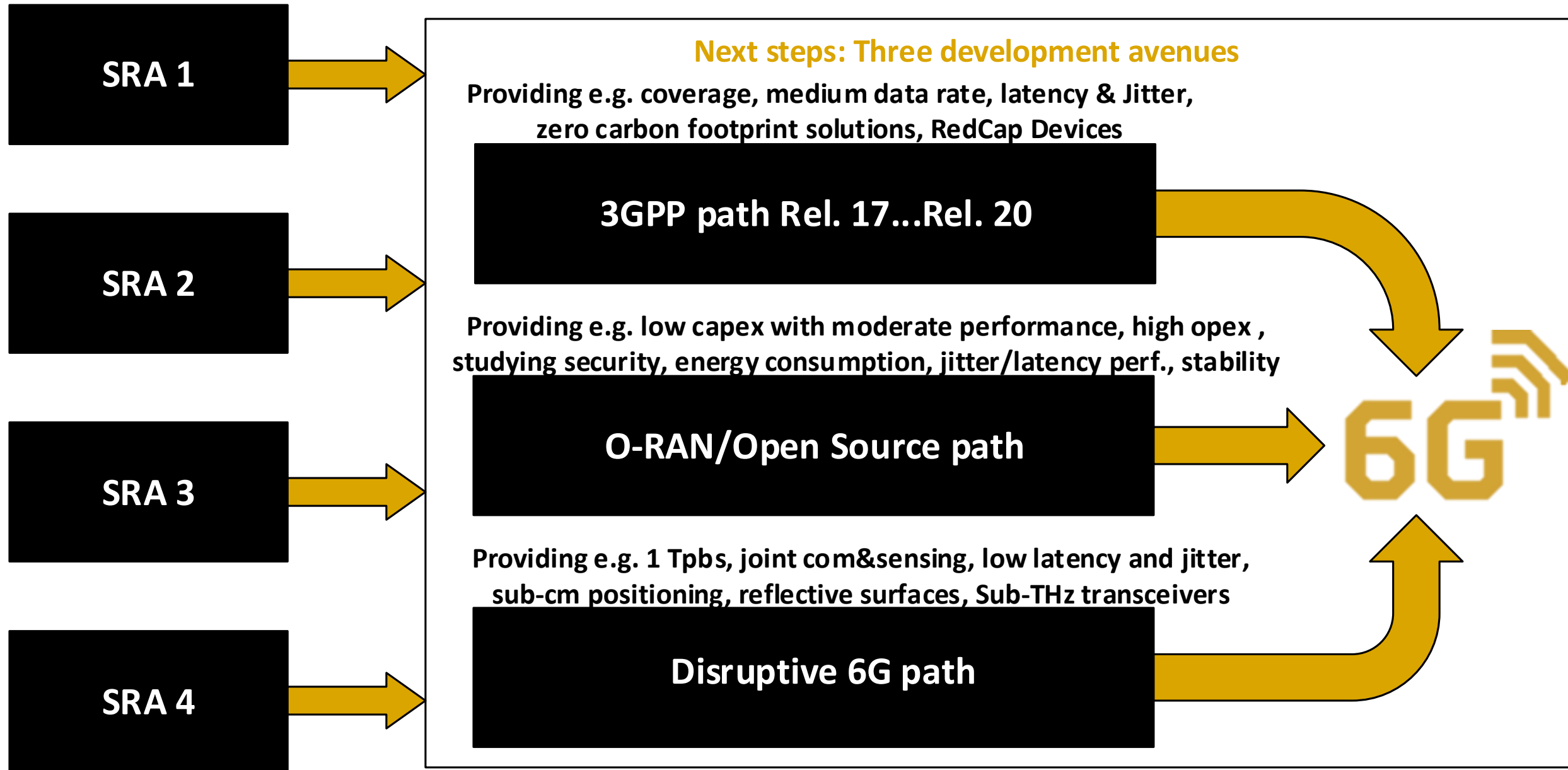


Energy

© 6G Flagship

Transition to higher frequencies and increasing role of indoor networks will boost network sharing in cities and indoor spaces, and drive the complementary “local operator” paradigm.

And to best support the versatility – Three-Pronged Development Path for our test platform



Thank you!



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