

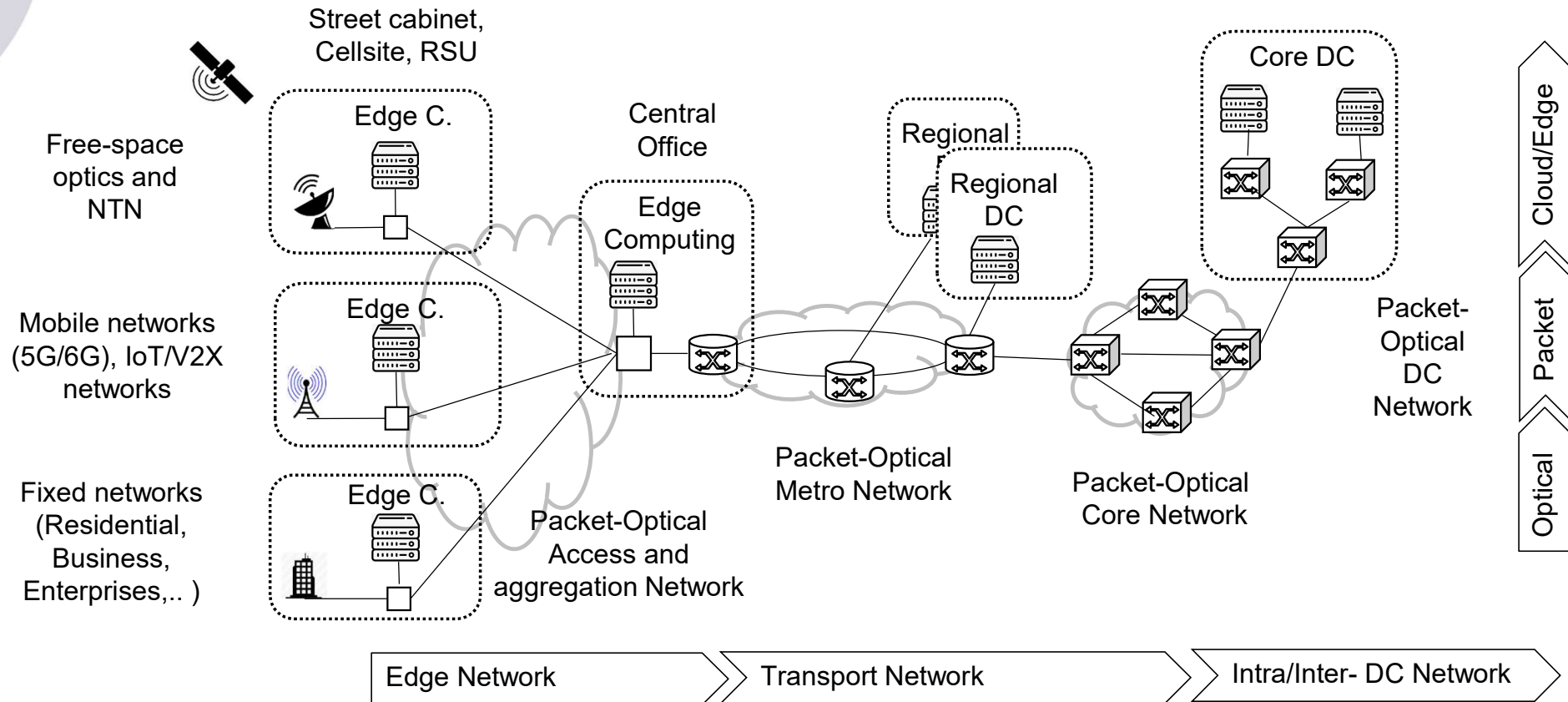
EVOLUTION TOWARDS THE 6TH GENERATION FIXED NETWORK (F6G): RESEARCH CHALLENGES AND STANDARD ROADMAP.

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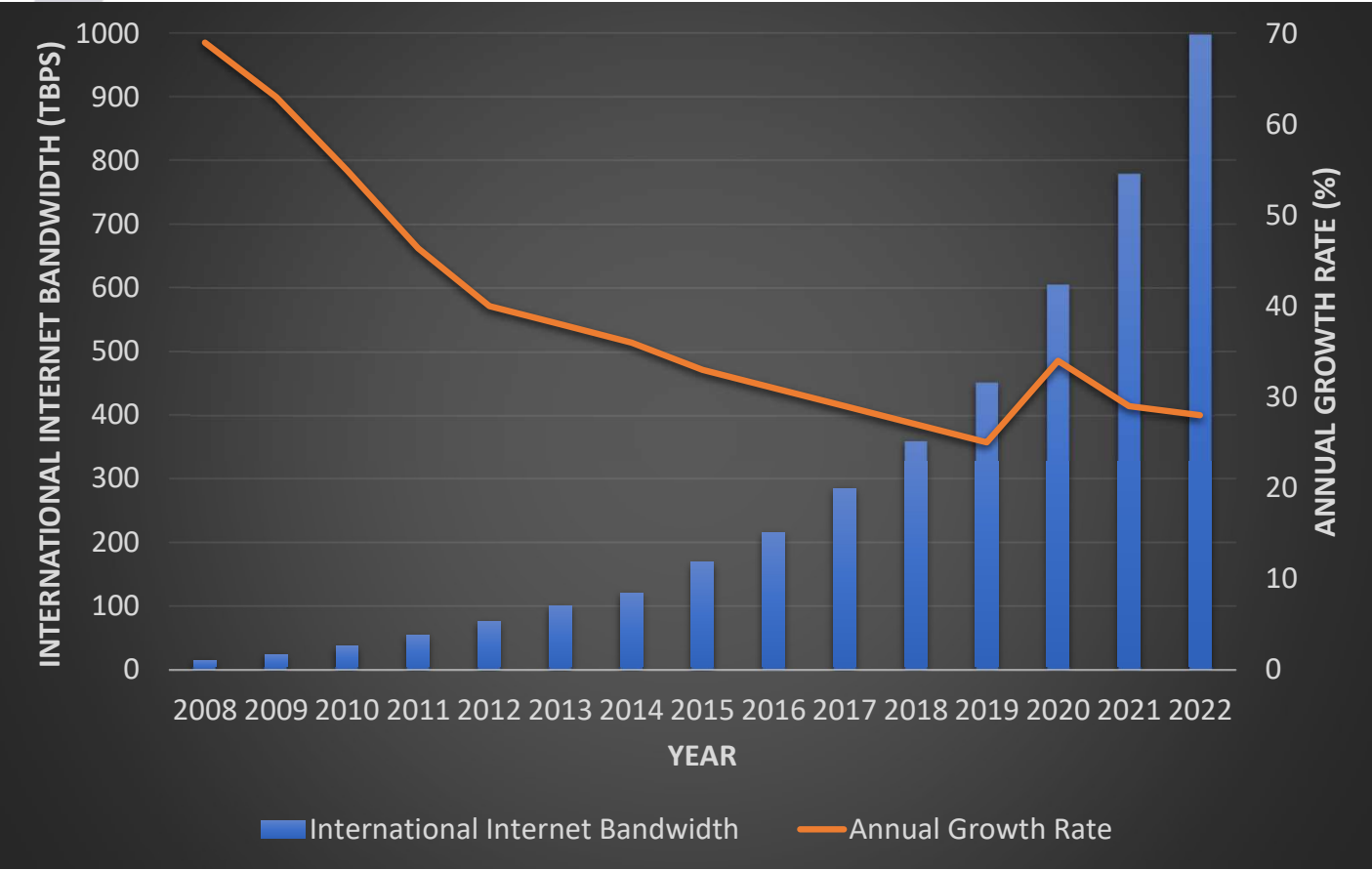


RESEARCH CHALLENGES: NETWORK EUROPE STRATEGIC RESEARCH AND INNOVATION AGENDA (SRIA)

VISION: END-TO-END FIXED NETWORKS



INTERNATIONAL INTERNET BANDWIDTH GROWTH (2008-2022)



Compound annual growth rate (CAGR):

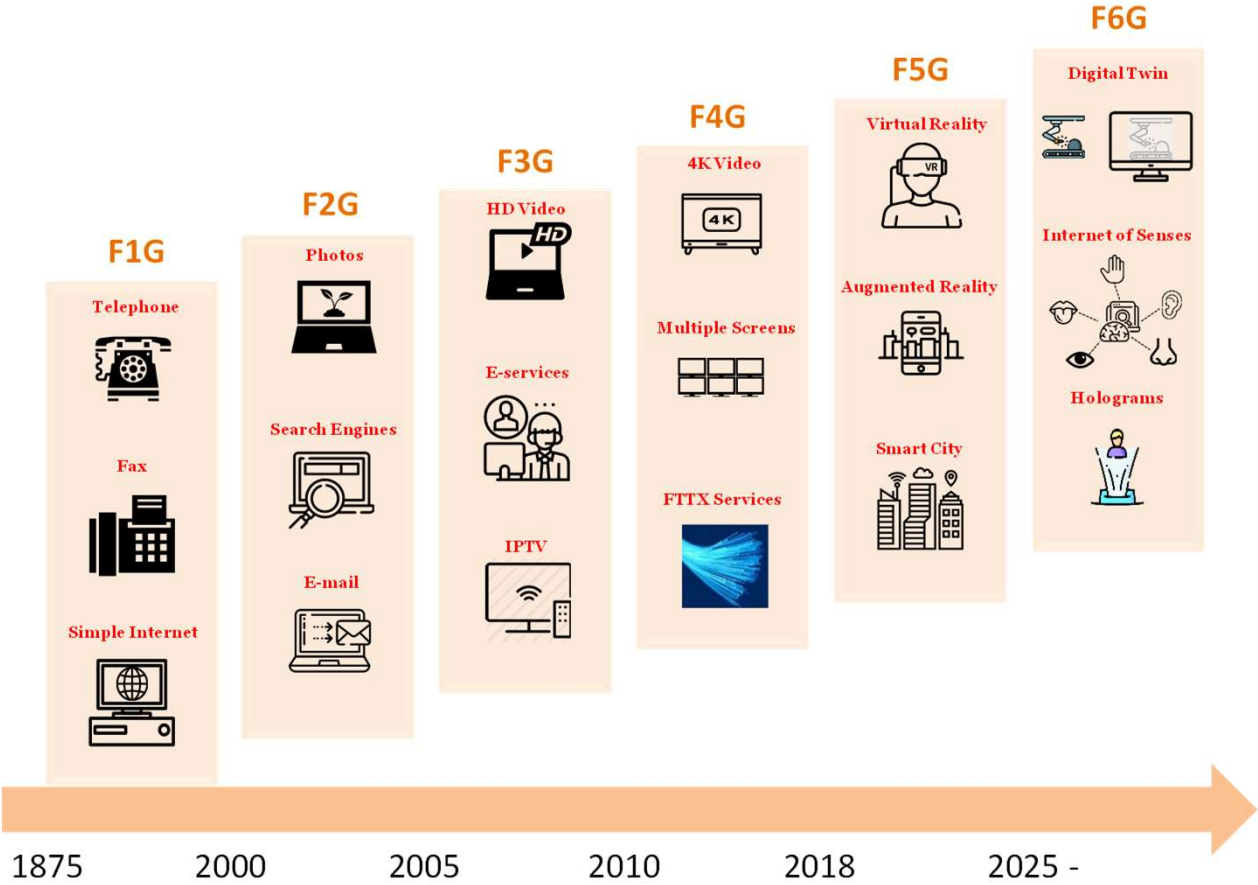
- 2018-2022 (4 years): 29%
- 2014-2018 (4 years): 30%
- 2008-2014 (6 years): 46%

CAGR in 2022-2030?



Source data: TeleGeography (telegeography.com)

REPRESENTATIVE SERVICES OVER FIXED NETWORK GENERATIONS



Uzunidis, Dimitris, et al. "A Vision of 6th Generation of Fixed Networks (F6G): Challenges and Proposed Directions." (2023). [A Vision of 6th Generation of Fixed Networks \(F6G\): Challenges and Proposed Directions\[v1\] | Preprints.org](#)

OPTICAL KEY PERFORMANCE INDICATORS (KPIs) DEFINED IN THE NETWORKLDEUROPE SRIA 2022

	Target KPI	Current	Short-term Evo	Mid-term Evo	Long-term Evo
		2022	~2025	~2028	~2031
Metro/Core	Spectrum ¹	5THz	10THz	20THz	50THz
	Port speed ²	400Gb/s	1.6Tb/s	3.2Tb/s	6.4Tb/s
	Bandwidth ³	<75GHz	<300GHz	<600GHz	<1200GHz
	Line capacity ⁴	25Tb/s	100Tb/s	300Tb/s	1Pb/s
	Node capacity ⁵	150Tb/s	600Tb/s	1.8Pb/s	6Pb/s
Access	PON speeds	25Gb/s	50Gb/s	100Gb/s	>200Gb/s
	User data rate ⁶ (consumer)	~500Mb/s	~1Gb/s	>2.5Gb/s	>5Gb/s
	User data rate ⁶ (business)	~5Gb/s	~10Gb/s	>25Gb/s	>50Gb/s
	Latency ⁷	<1ms	<100μs	<10μs	<1μs
Network	Power consumption ⁸	100% (baseline)	40%	30%	20%
	Service provisioning	Hour	Min	Second	Sub-second
	Network operations	Operator-controlled, reactive	Intent-based, proactive	Self-diagnosing	Self-optimizing

¹ 25% CAGR, in line with conservative traffic predictions.

² Extrapolation of Ethernet roadmap

³ Using 400G DP-16QAM as baseline

⁴ 50% CAGR, in line with internet content provider traffic predictions.

Assumes exploitation of frequency and space domain.

⁵ Based on degree 4 node with 50% local add/drop

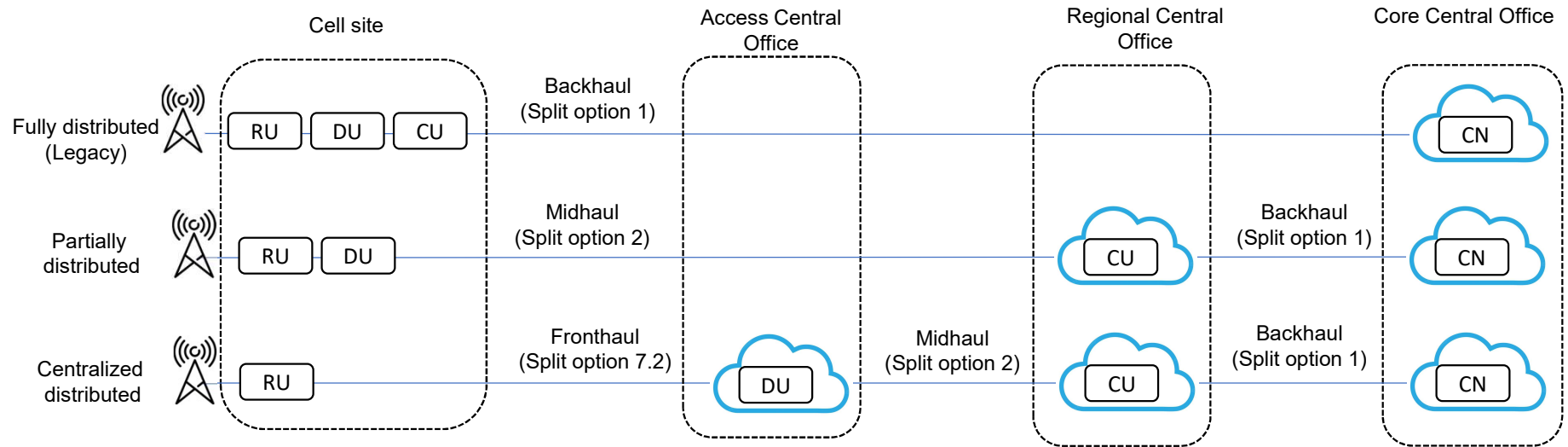
⁶ typical user data rate, averaged over different deployment scenarios and system configurations

⁷ Excluding propagation delay

⁸ 15% reduction per Gb/s p.a., extrapolated from past transponder data

Source data: Network Europe SRIA 2022 ([Microsoft Word - SRIA 2022 Technical Annex 20221208 - AFPC - cleaned.docx \(5g-ppp.eu\)](#))

6G WILL BE A GAME CHANGER FOR TRANSPORT NETWORKS



Reference Parameters	4G	5G	6G
Channel bandwidth	20 MHz (DL/UL)	100 MHz (DL/UL)	400 MHz – 1 GHz (DL/UL)
Modulation	64QAM (DL), 16QAM (UL)	256QAM (DL), 64QAM	256QAM – 1024QAM (DL), 256QAM (UL)
Number of MIMO layers	2 (DL), 1 (UL)	8 (DL/UL)	8 – 16 (DL/UL)
Number of antenna ports	8 (DL/UL)	32 (DL/UL)	64 – 128 (DL/UL)
Sampling Rate		30.72 samples/s (DL/UL)	[4–10]*30.72 Msamples/s (DL/UL)

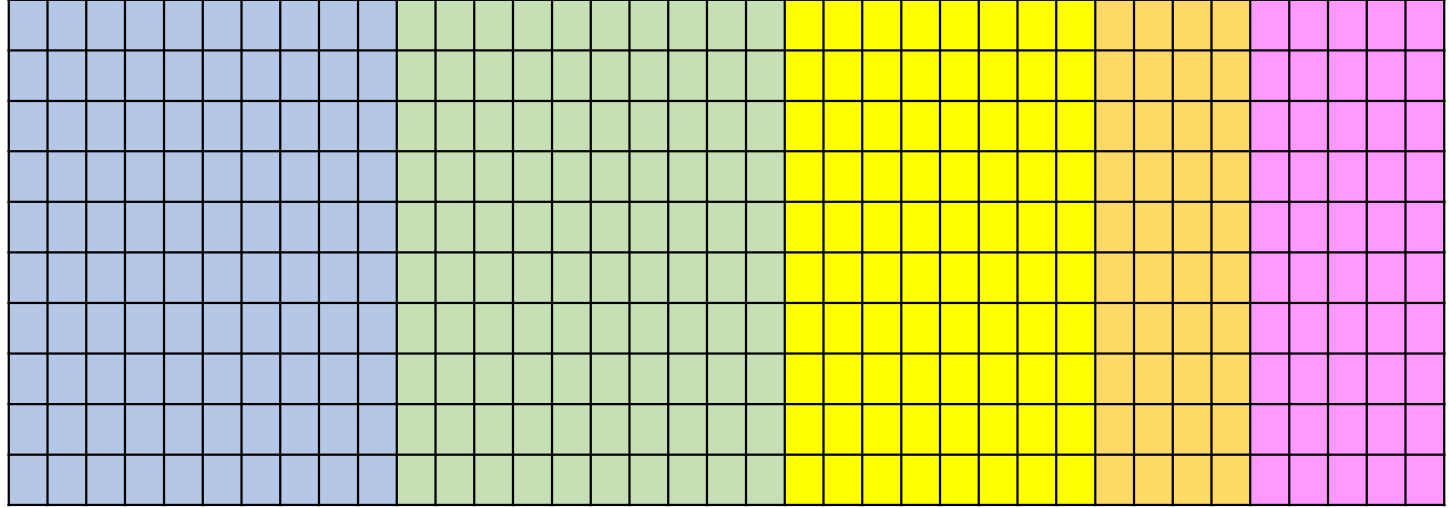
Functional split option	5G	6G basic	6G advanced
1	DL: 4Gbps, UL: 3Gbps	DL/UL: 16Gbps	DL: 100Gbps, UL: 80Gbps
2	DL: 4.016Gbps, UL: 3.024Gbps	DL: 16.016Gbps, UL: 16.024Gbps	DL: 100.02Gbps, UL: 80.024Gbps
7-2	DL: 22.204Gbps, UL: 21.624Gbps	DL: 86.71Gbps, UL: 86.13Gbps	DL: 430.78Gbps, UL: 430.20Gbps
8	DL/UL: 157.29Gbps	DL/UL: 1.25Tbps	DL/UL: 6.29Tbps

HOW CAN WE INCREASE THE NODE THROUGHPUT AND LINK CAPACITY?

Ultra wide band Wavelength dimension

O-band (1260-1360nm) E-band (1360-1460nm) S-band (1460-1530nm) C-band (1535-1565nm) L-band (1565-1625nm)

Spatial dimension





RESEARCH CHALLENGES: NETWORLDEUROPE SRIA 2022 OPTICAL NETWORKS CHAPTER

- Sustainable capacity scaling (Editor: Nokia Bell Labs France)
 - i) Scaling to Petabit/s capacities in core and metro networks, ii) Next generation terabit/s transceivers.
- New switching paradigms (Editor: Fraunhofer HHI)
 - i) Ultra-fast Multi-granular Switching Nodes, ii) Switching Architectures guided by Energy-Efficiency
- Deterministic networking (Editor: ADVA Optical Networking)
 - i) Resilient solutions for high-precision, Network-assisted timing distribution, ii) Reliable data & control plane solutions for deterministic network services, iii) tools for service assurance in deterministic networks.
- Optical technologies for radio networks and systems (Editor: Ericsson)
 - i) Optical technologies for radio access networks, ii) High speed optical interconnects in radio systems, iii) Optically enabled radio functions.
- Optical network automation (Editor: CTTC)
 - i) Network Telemetry and Optical Network Sensing, ii) Control and Orchestration architectures for Network Automation, iii) AI/ML in support of Network Operation, iv) Reliability and Security of Control, Orchestration and Management, v) Optical Network Digital Twin.

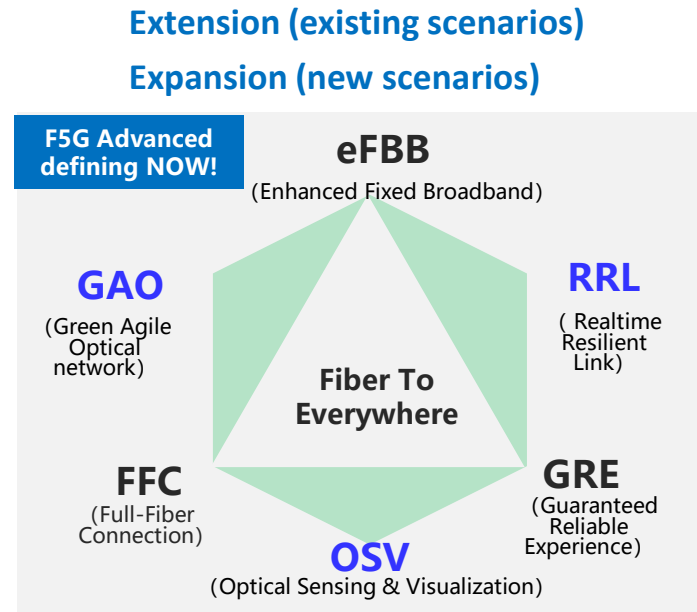
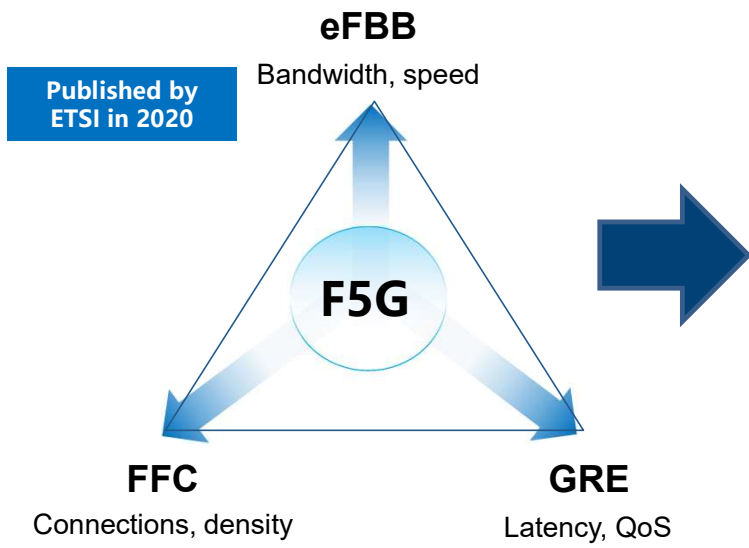
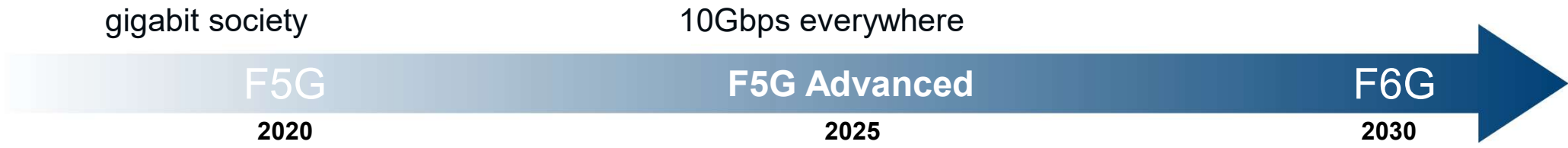
RESEARCH CHALLENGES: NETWORLDEUROPE SRIA 2022 OPTICAL NETWORKS CHAPTER

- Security for mission critical services (Editor: ADVA Network Security)
 - i) Quantum-safe cryptography, ii) Physical layer security, iii) Network resilience, iv) Intrusion detection and mitigation
- Ultra-high energy efficiency (Editor: Infinera)
 - i) Simplified and fully configurable flexible E2E optical networks, ii) energy efficient transceivers, iii) energy-aware optical networks and components, iv) zero-electronic waste and scalable optical networks.
- Optical integration 2.0 (Editor: ADVA Network Security)
 - i) Multi-band exploitation, ii) High-capacity interfaces for spectrally and spatially multiplexed systems, iii) Optical chip interconnects, iv) Multi-platform manufacturing, v) Photonic-electronic integration, vi) Reliability and repeatability.
- Optical access beyond FTTH (Editor: Nokia Bell Labs Germany)
 - i) Increased capacities and flexible configuration, ii) Flexible real time and non-real time resource assignment, Redundant, iii) meshed and flexible optical layer network architectures, iv) Optical layer multi-tenancy in access networks.



F6G STANDARD ROADMAP: ETSI INDUSTRY SPECIFICATION GROUP (ISG) FIFTH GENERATION FIXED NETWORK (F5G)

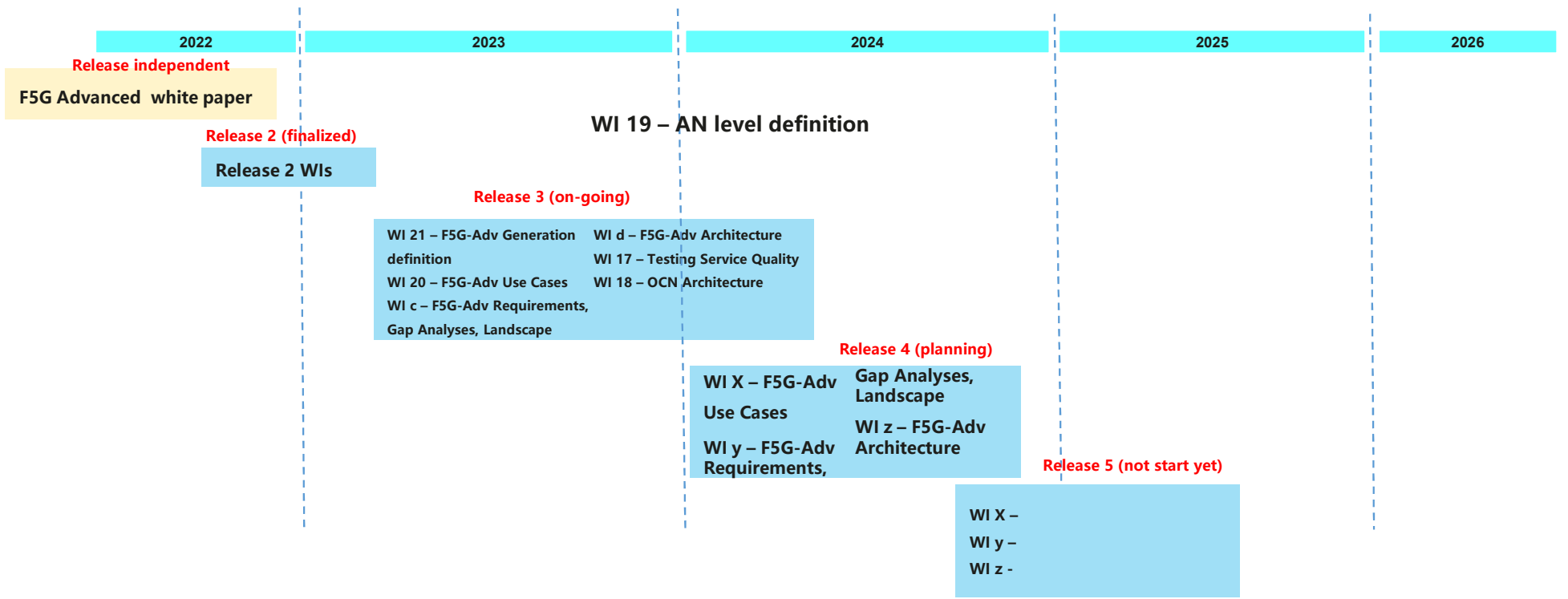
Evolving F5G to F5G Advanced for 10Gbps everywhere



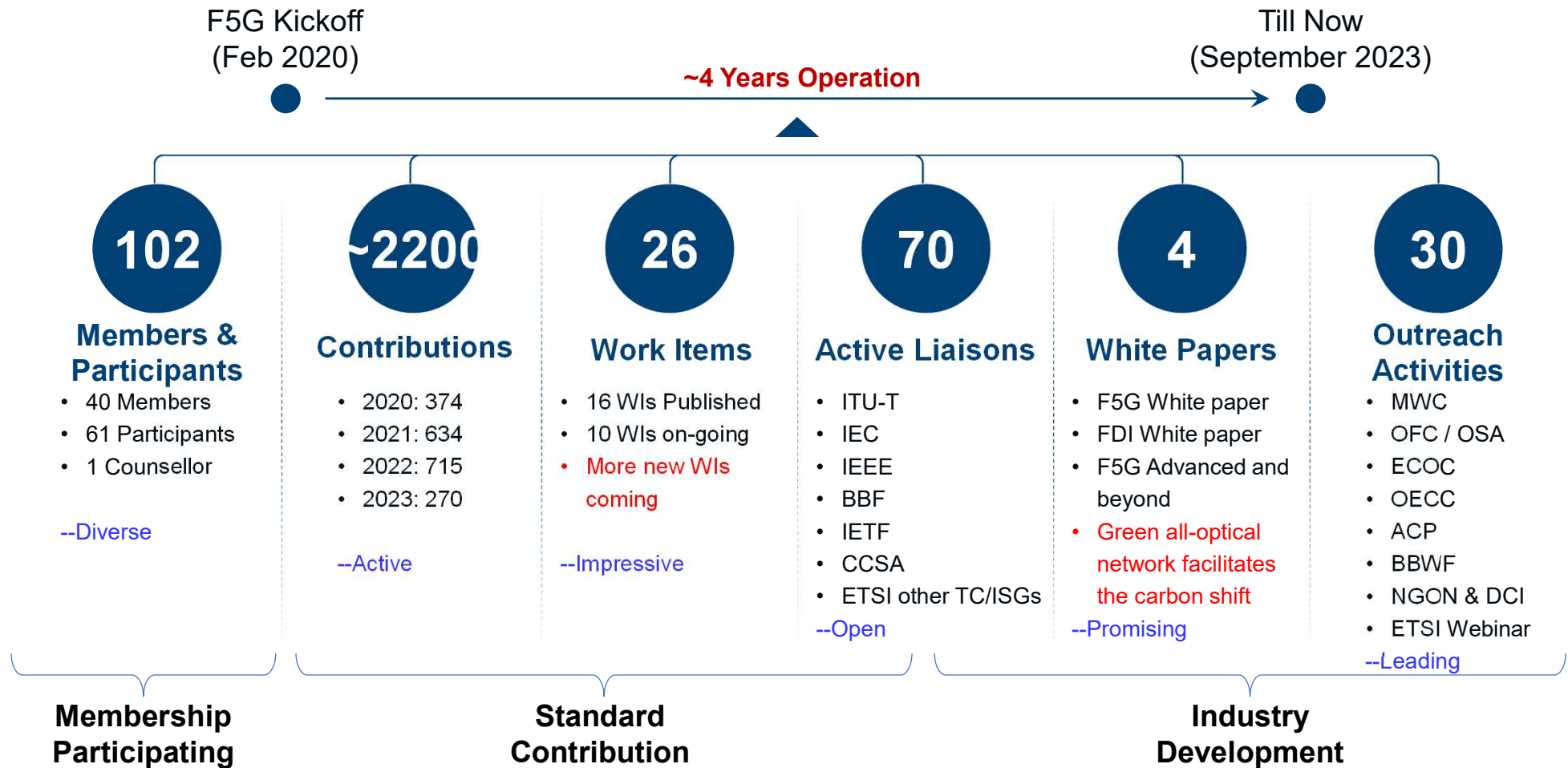
Plan for ISG F5G (1) –release and evolution roadmap

• ISG F5G planned to finished F5G-Advanced in three release and then move to F6G in 2027

ISG F5G Created	Release 1 F5G	Release 2 F5G	Release 3 • F5G Advanced	Release 4 • F5G Advanced	Release 5 • F5G Advanced • F6G Vision	Release 6 • F5G-Advanced • F6G	Release 7				
2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030



Key figures of ISG F5G



Thank you!

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Advanced research for everyday life

