Transcontinental Internet Network Architectures

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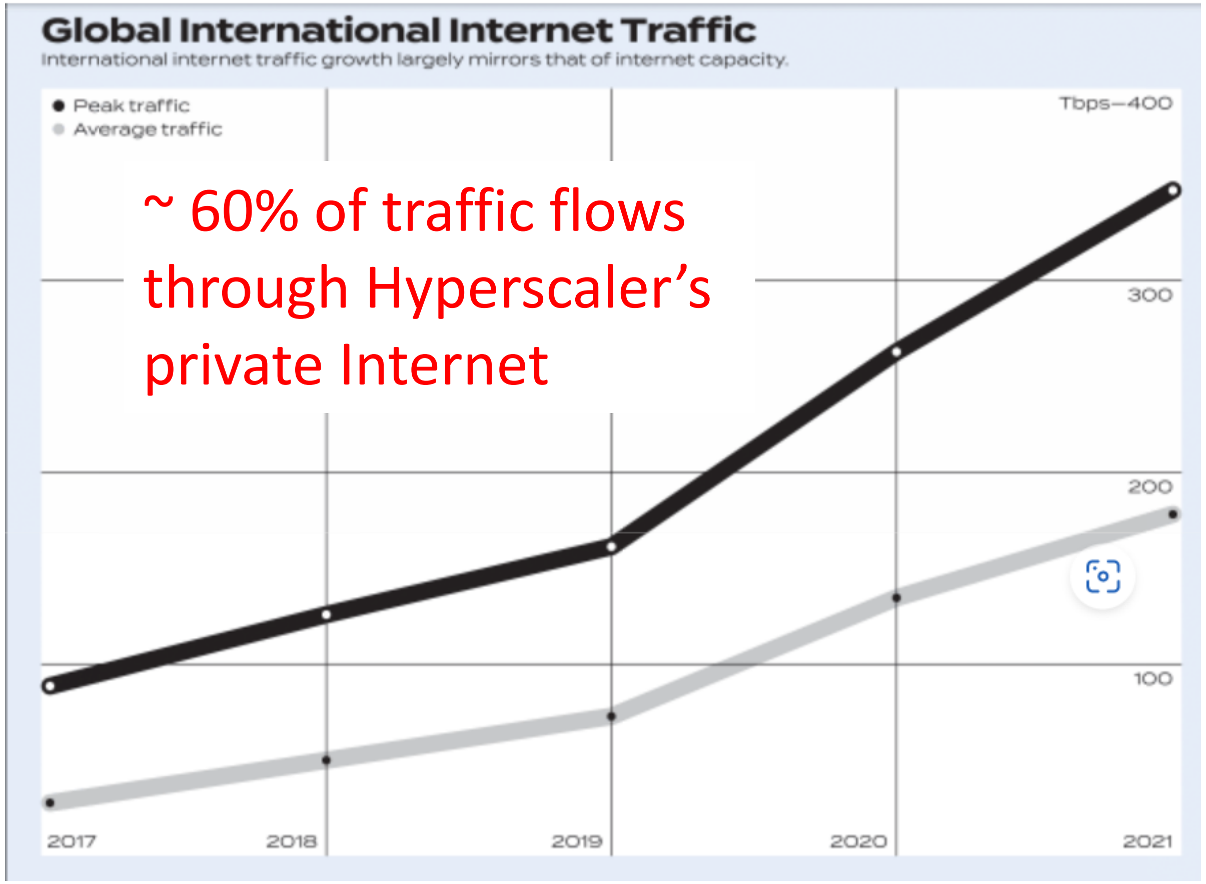
Le Reti Internet Transcontinentali

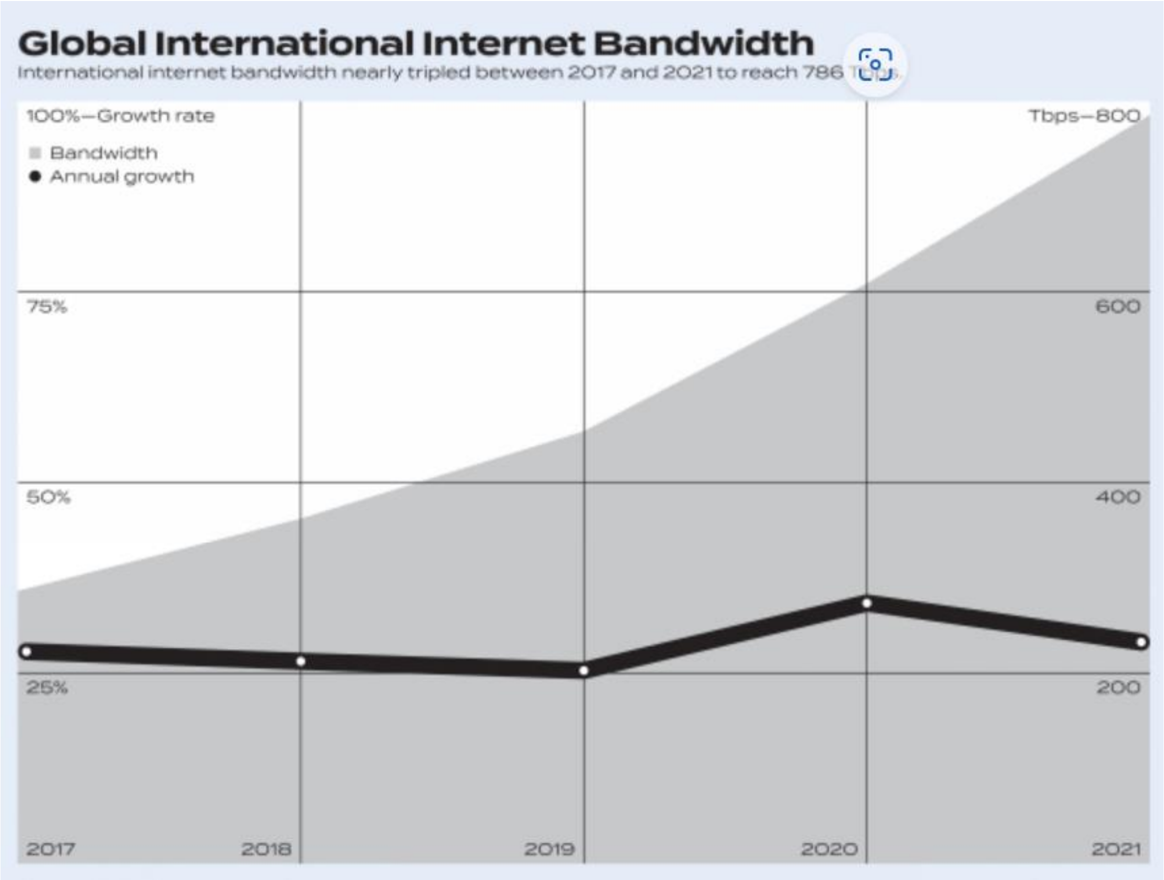
Transcontinental Internet Map (Gigabit/s)

~2/3 of traffic flows through US & Canada

Source: TeleGeography, 2022

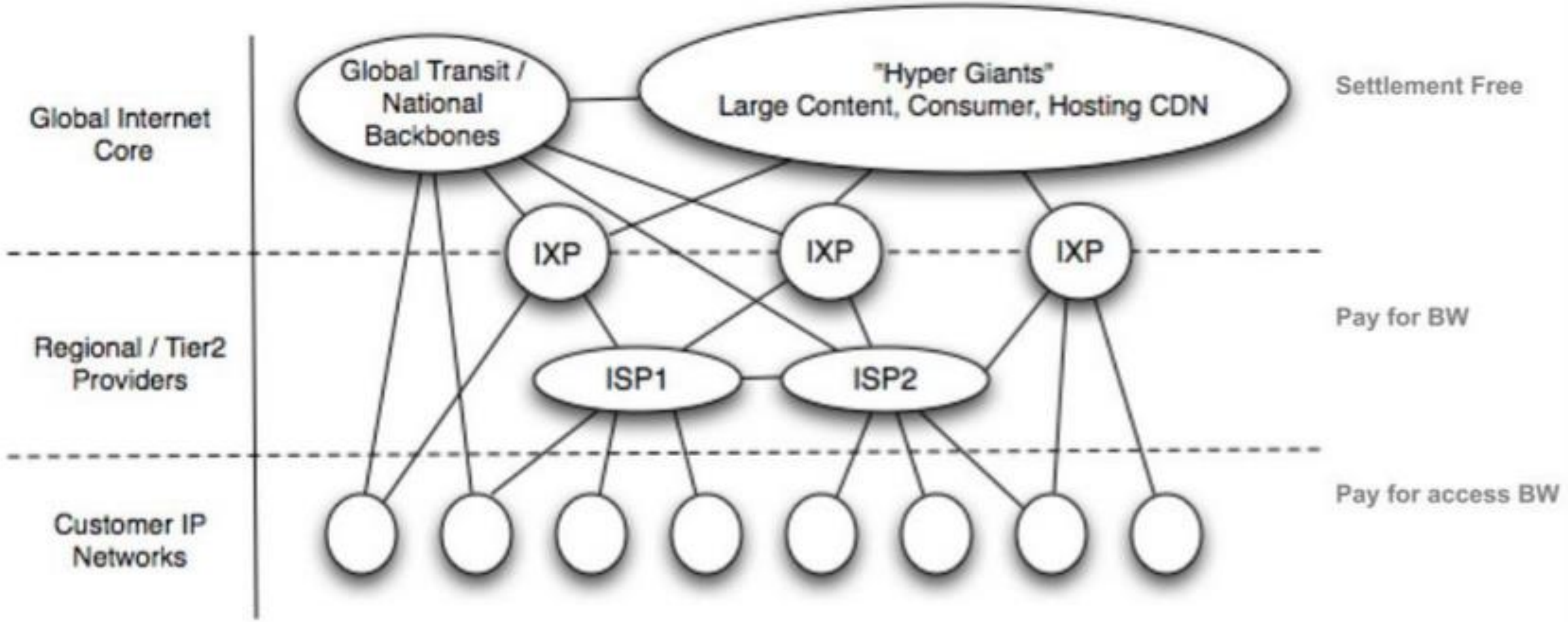
Global Internet Traffic & Bandwidth





Source: TeleGeography, 2022

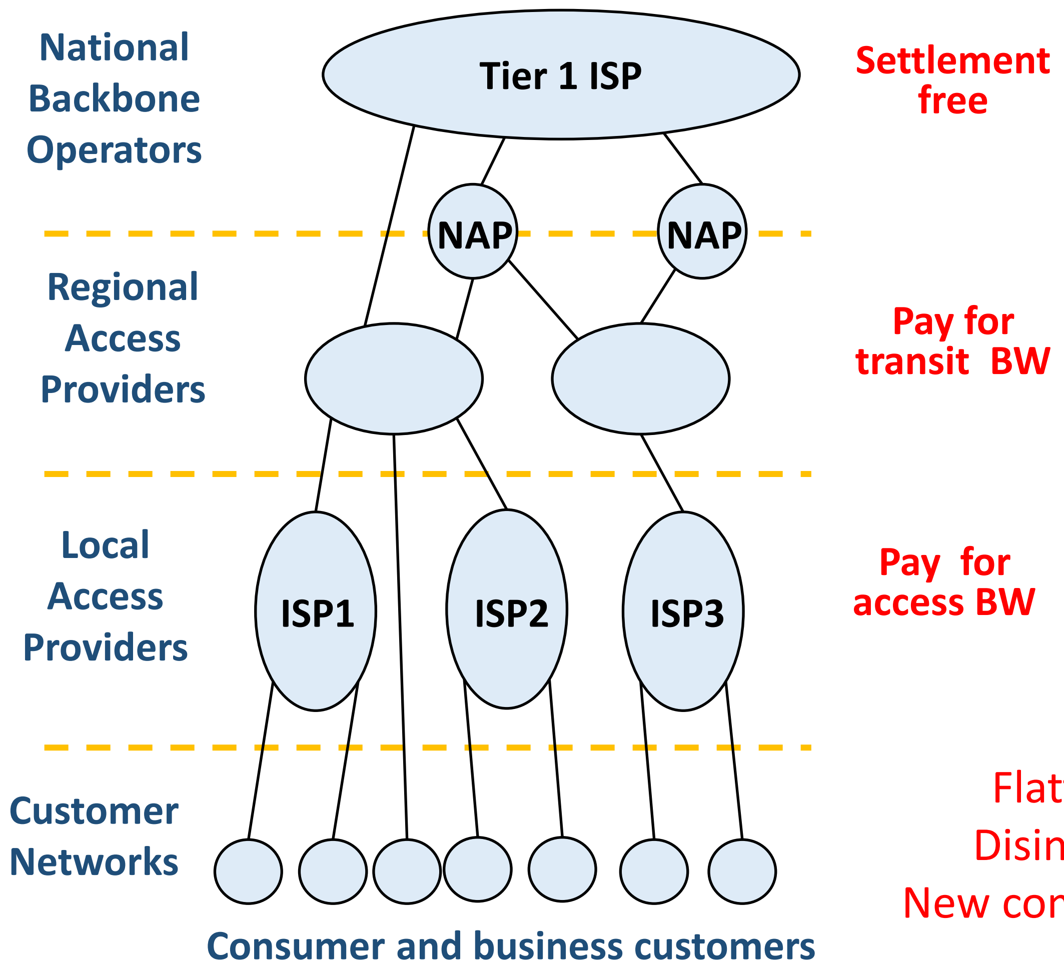
The New Internet

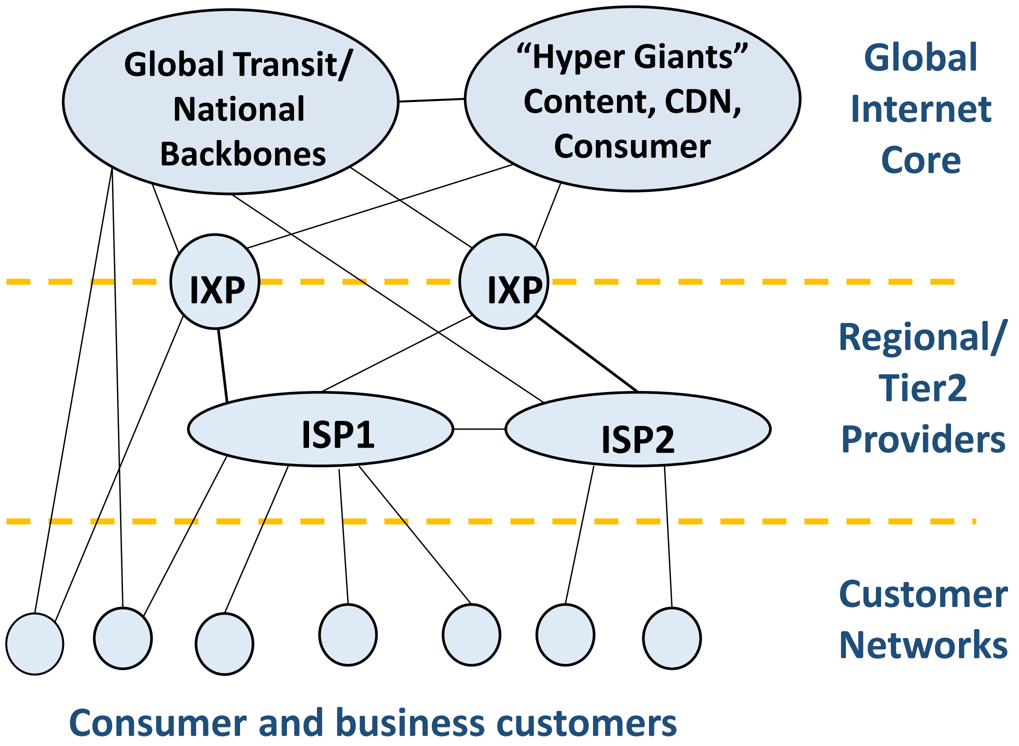


- Flatter and much more densely interconnected Internet
- Disintermediation between content and eyeball networks
- Complex commercial models between content, consumer and transit

Source: Craig Labowitz, Arbor Networks , 2011

Old and New Internet Architectures





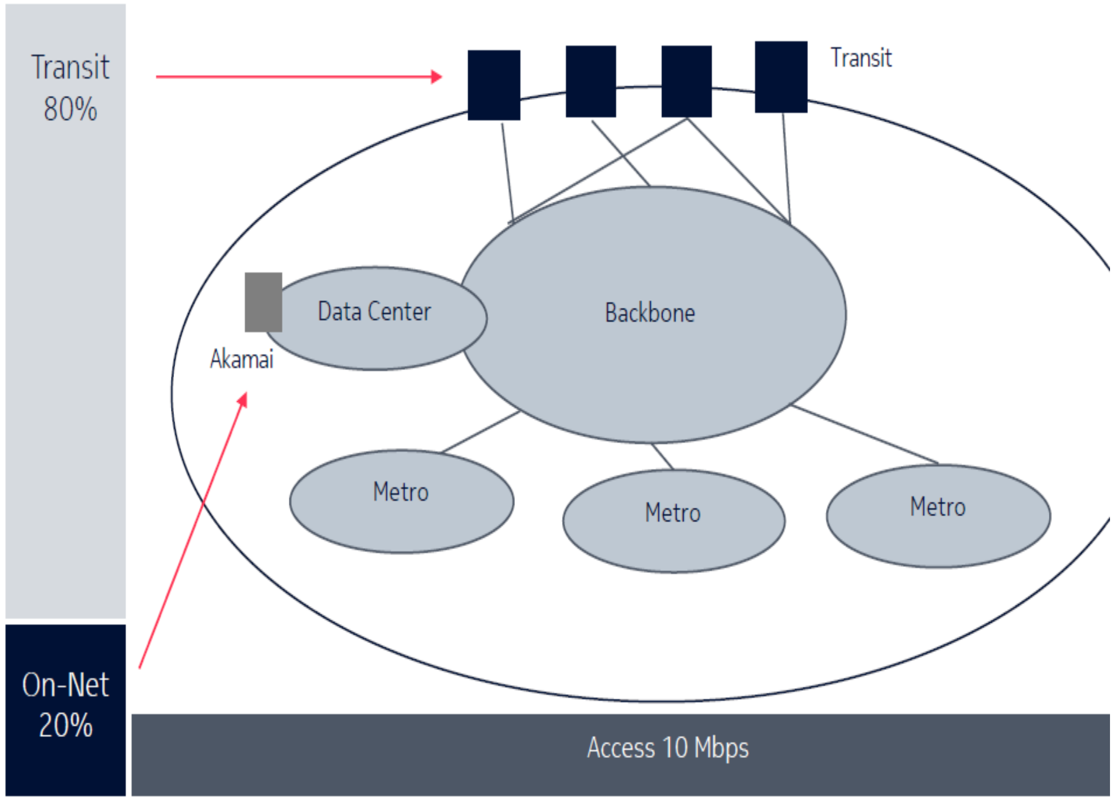
Flatter and much more densely interconnected Internet
Disintermediation between content and eyeball networks
New commercial models between content, consumer and transit

NAP: Neutral Access Point IXP: Internet Exchange Point

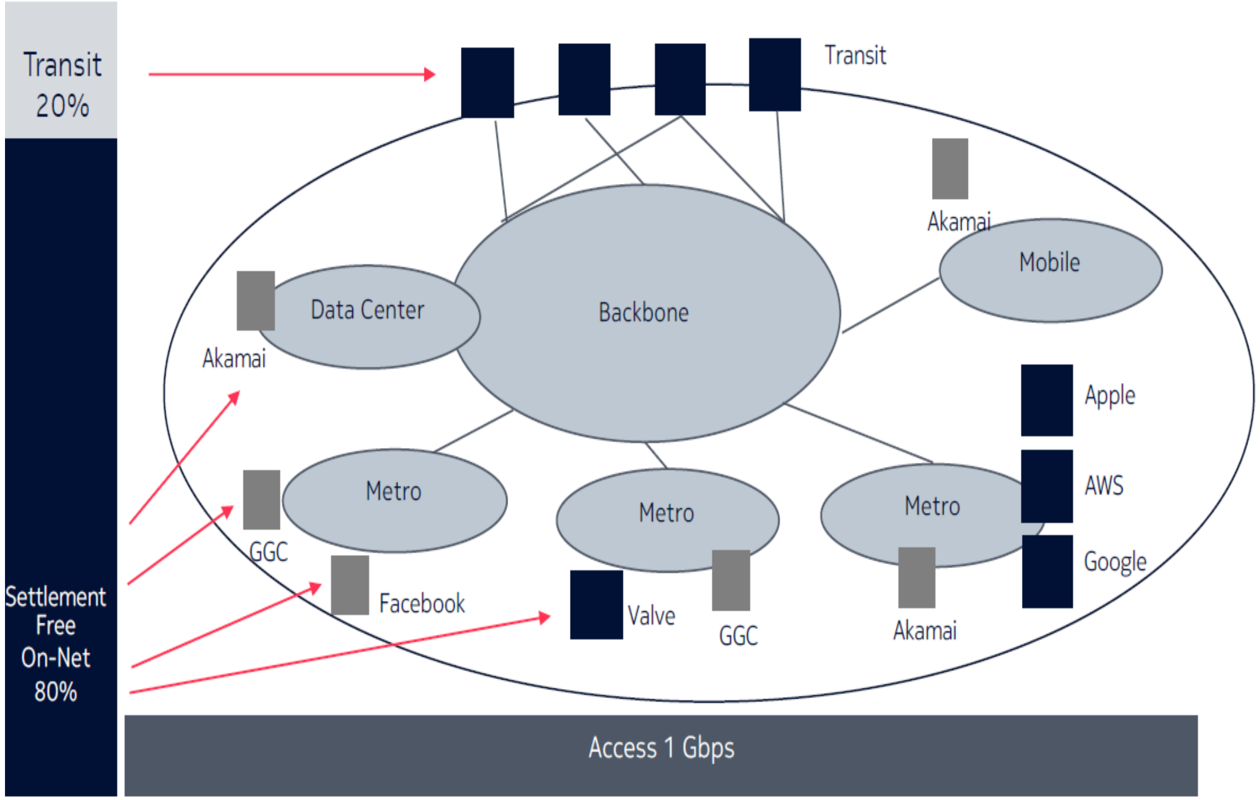
Source: Craig Labowitz, Arbor Networks , 2011

2009-2019 Internet Disruptive Evolution

2009 most Internet traffic is transit



2019 Most Internet traffic is settlement free or on-net cache



Source: Craig Labowitz, Nokia , 2020

Internet Traffic 2022

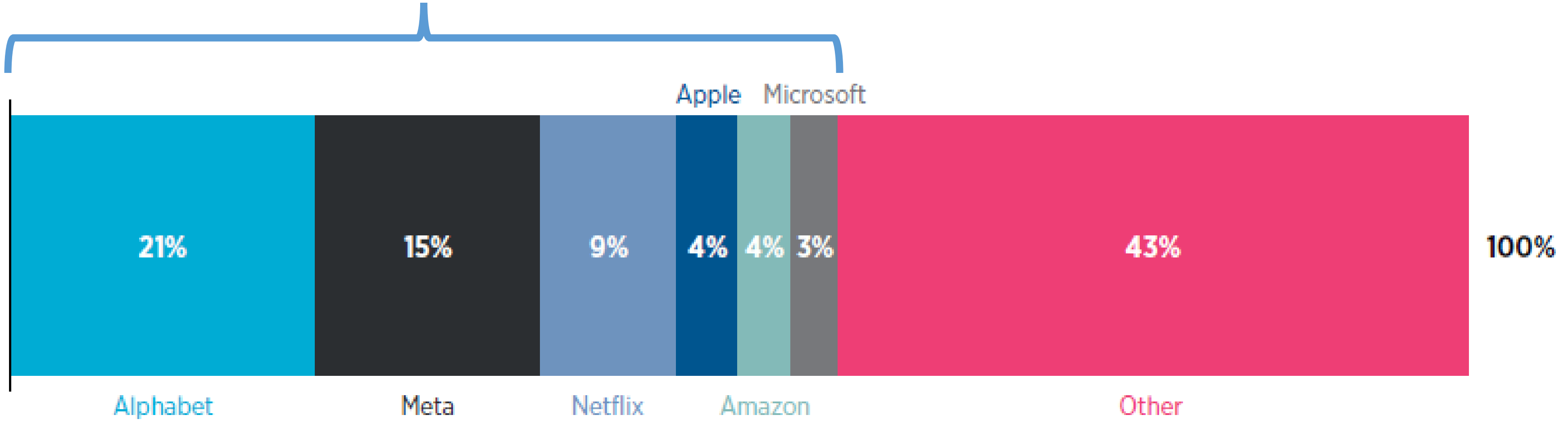
Internet traffic by content *(*)*

In 2020, a share of around **80%** of traffic comes mainly from three segments: **video**, **social media** and **video games**

(*) Source: WIK 2022 «Competitive conditions on transit and peering markets. Implications for European digital sovereignty”

Larger OTTs represent 57% of internet traffic

Internet traffic by Large Traffic Generators



Source: Sandvine Global Internet Phenomena Report, January 2022

Transcontinental Internet Networks

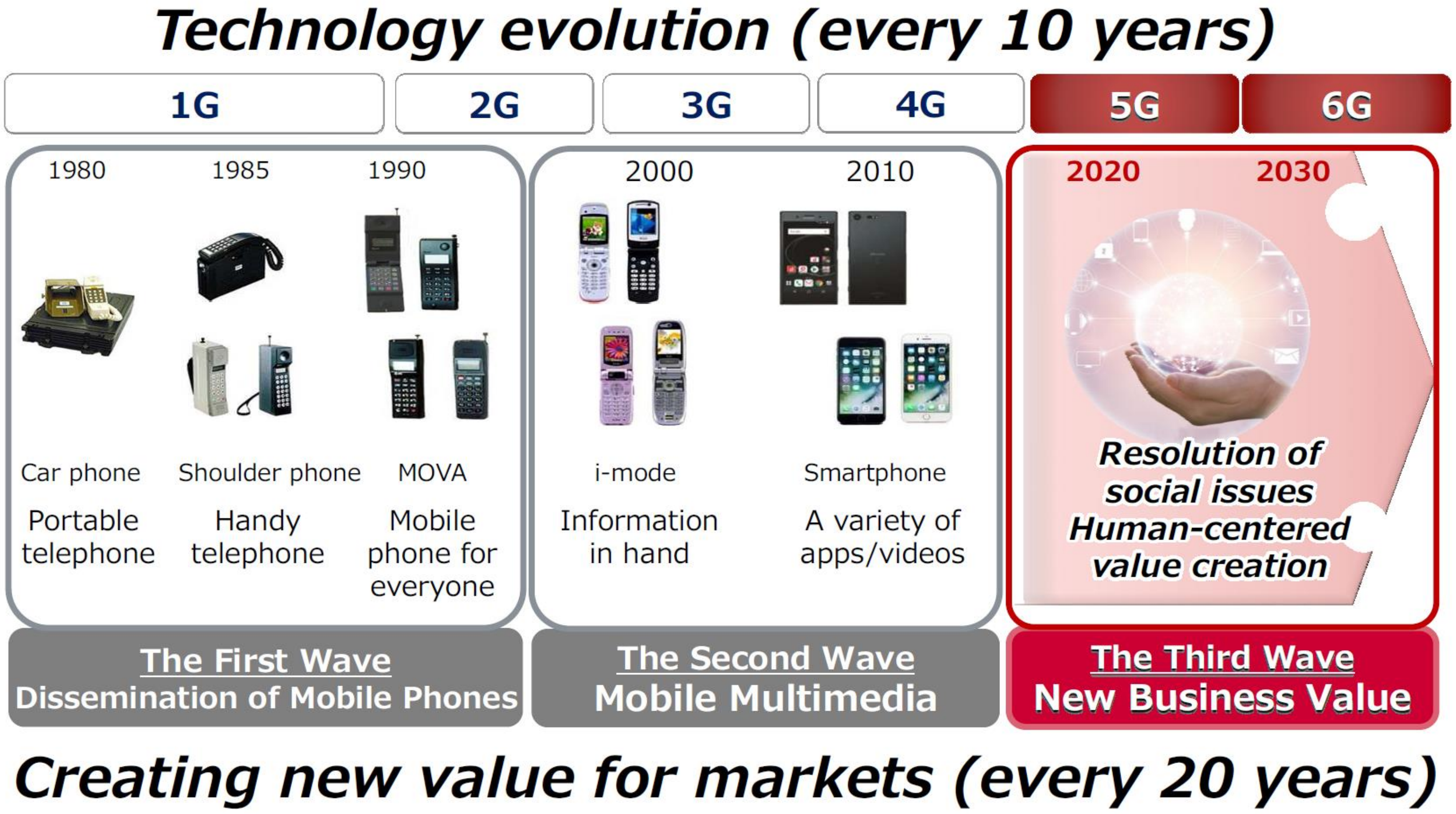
Terrestrial Networks: Cable & Radio (Mobile & Fixed)

Space/Satellite Networks (GEO, LEO, HAP & UAV)

Submarine Cable Networks

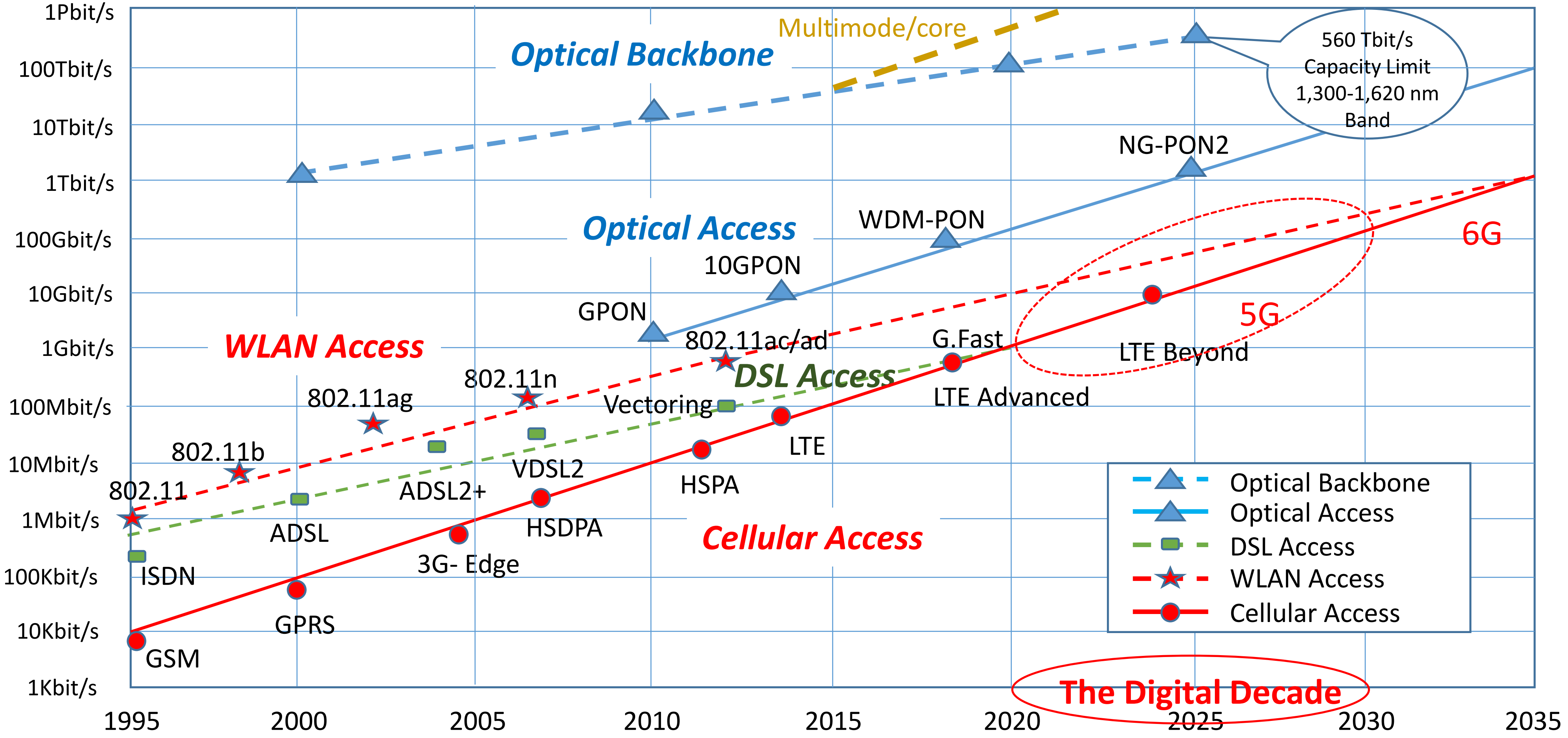
Undersea Netwoks

Cellular Waves Every 20 Years



Source: NTT DOCOMO, 2020

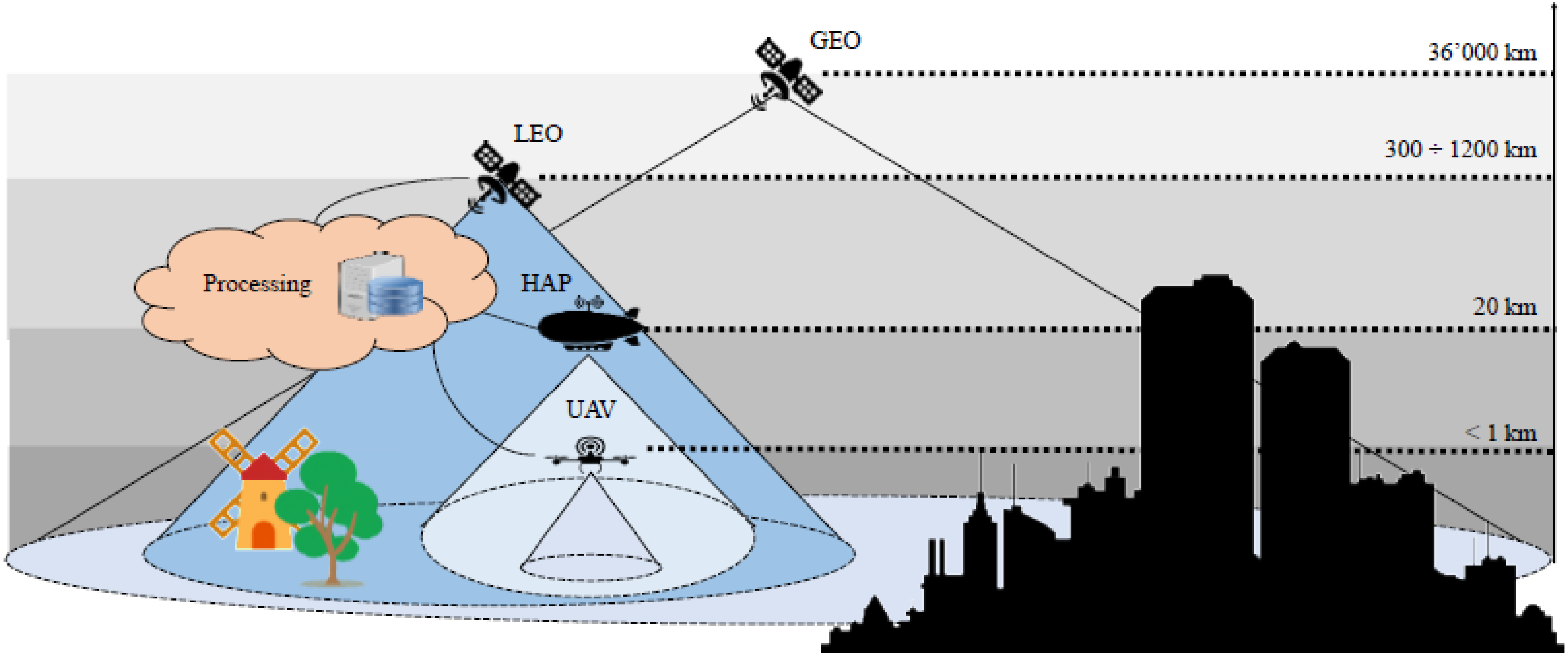
Benchmark of Wired and Wireless Technologies with Projections



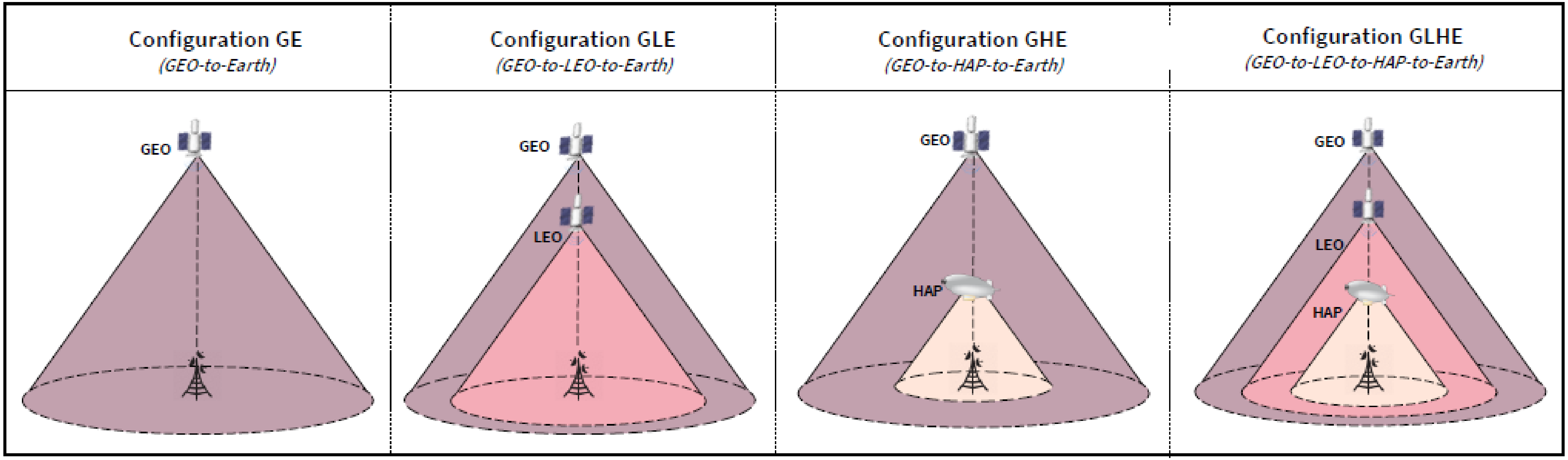
Source: M. Dècina, 2014, based on data by Bell Labs, G. Fettweis, and others

Satellite & Space Networks

GEO + LEO + UAV + HAP

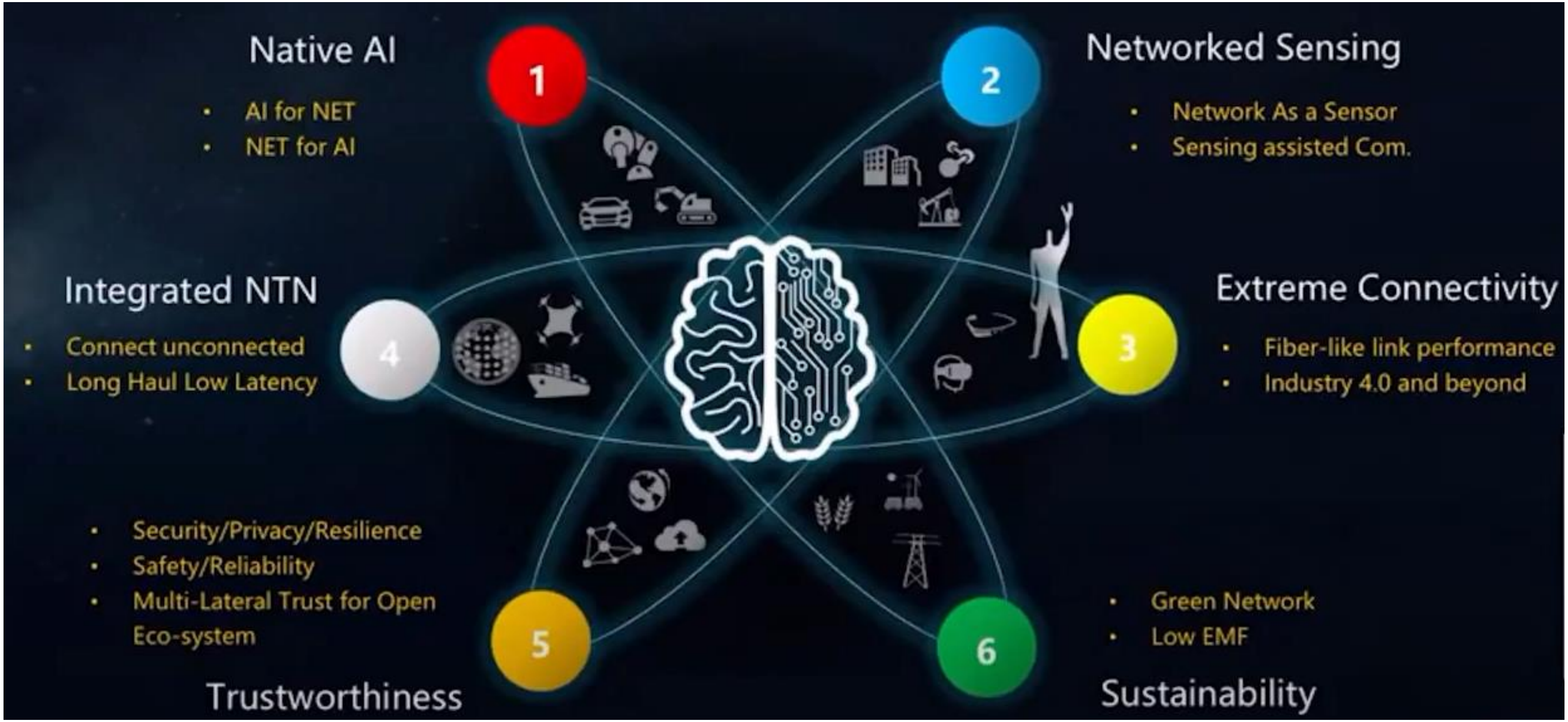


Multi-Layered Space Networks



Source: Michele Zorzi, 2022

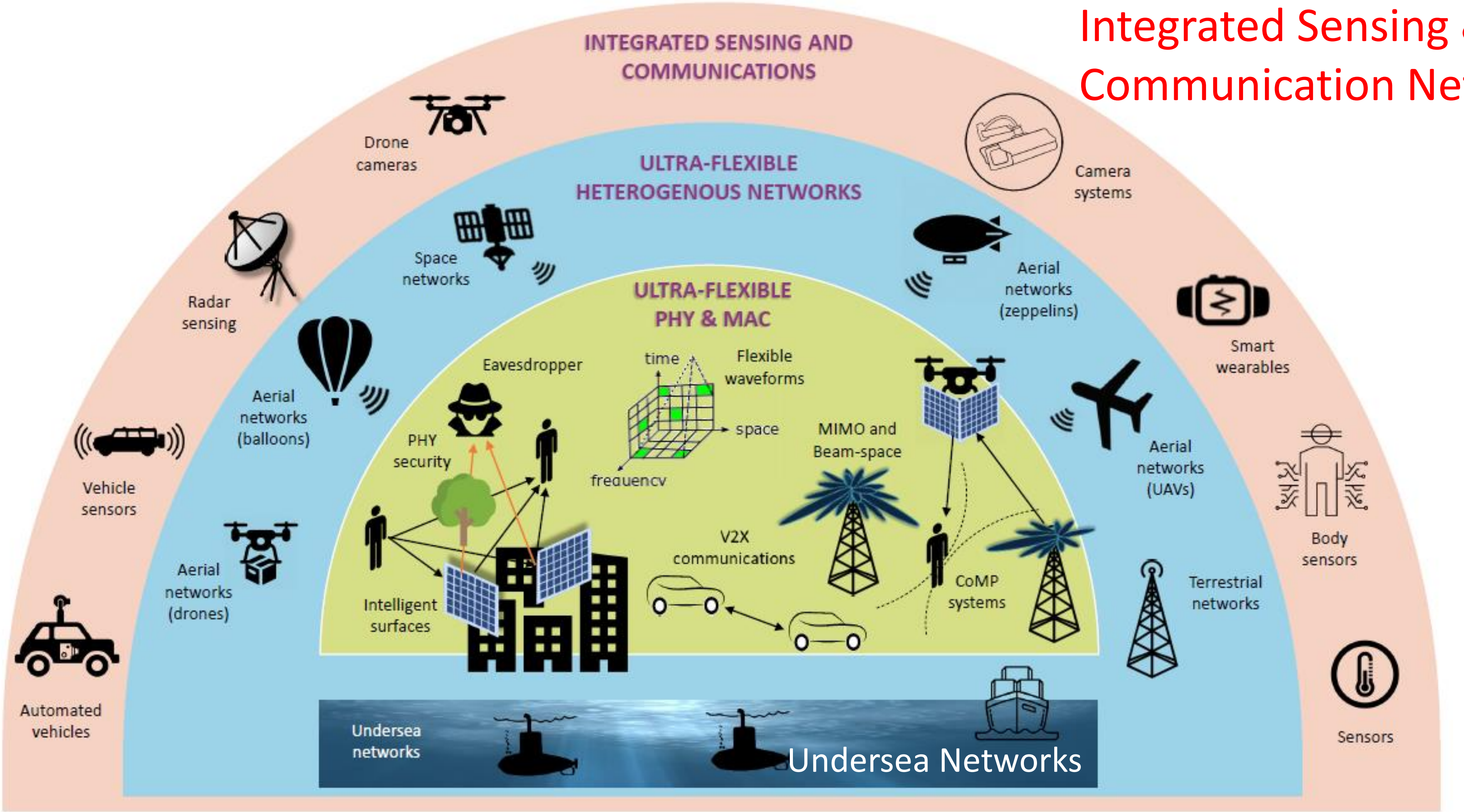
6G Six Key Capabilities AI-Enabled



Source: Huawei, 2022

6G Global Networking Objectives

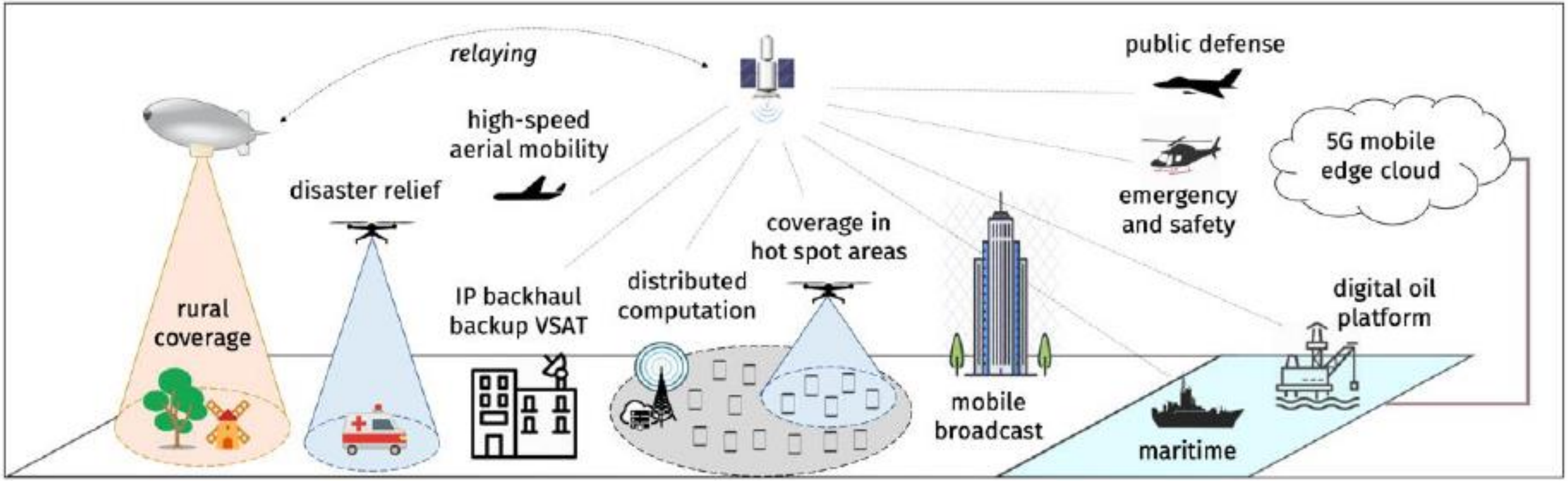
Integrated Sensing & Communication Networks



Source: IEEE Communications Magazine, 2022

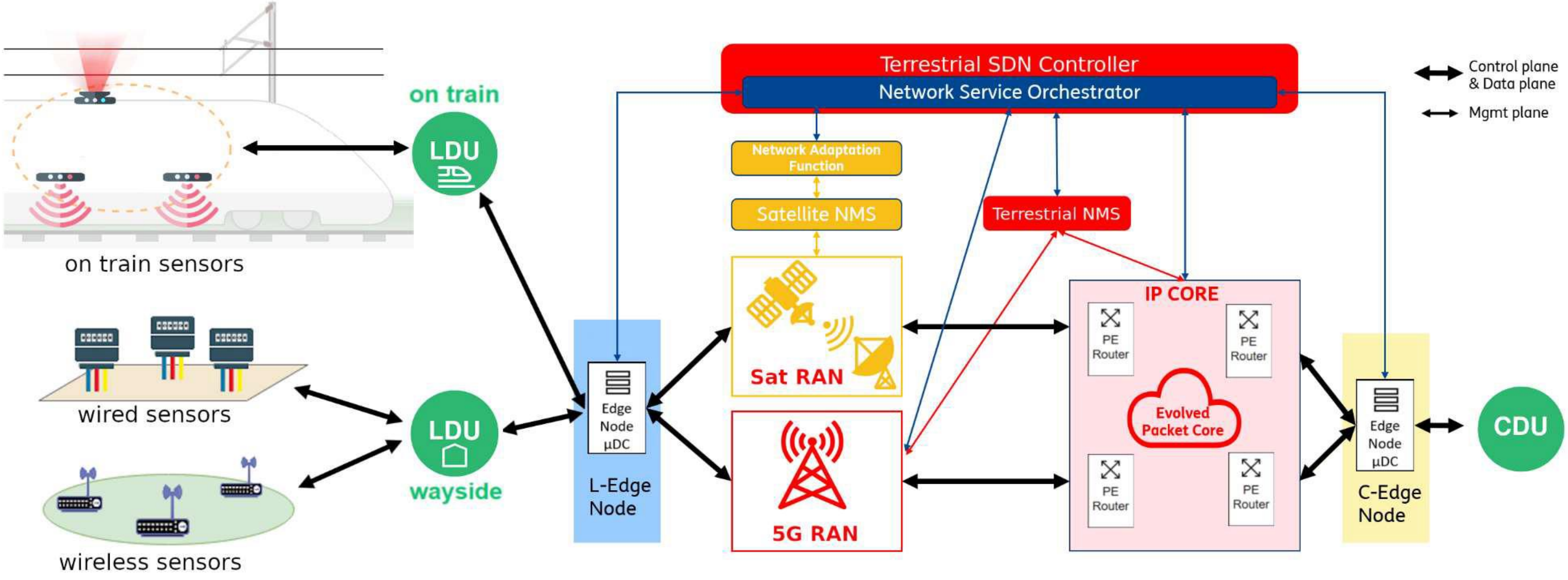
Eterogeneous Networks

6G Research Areas & Applications



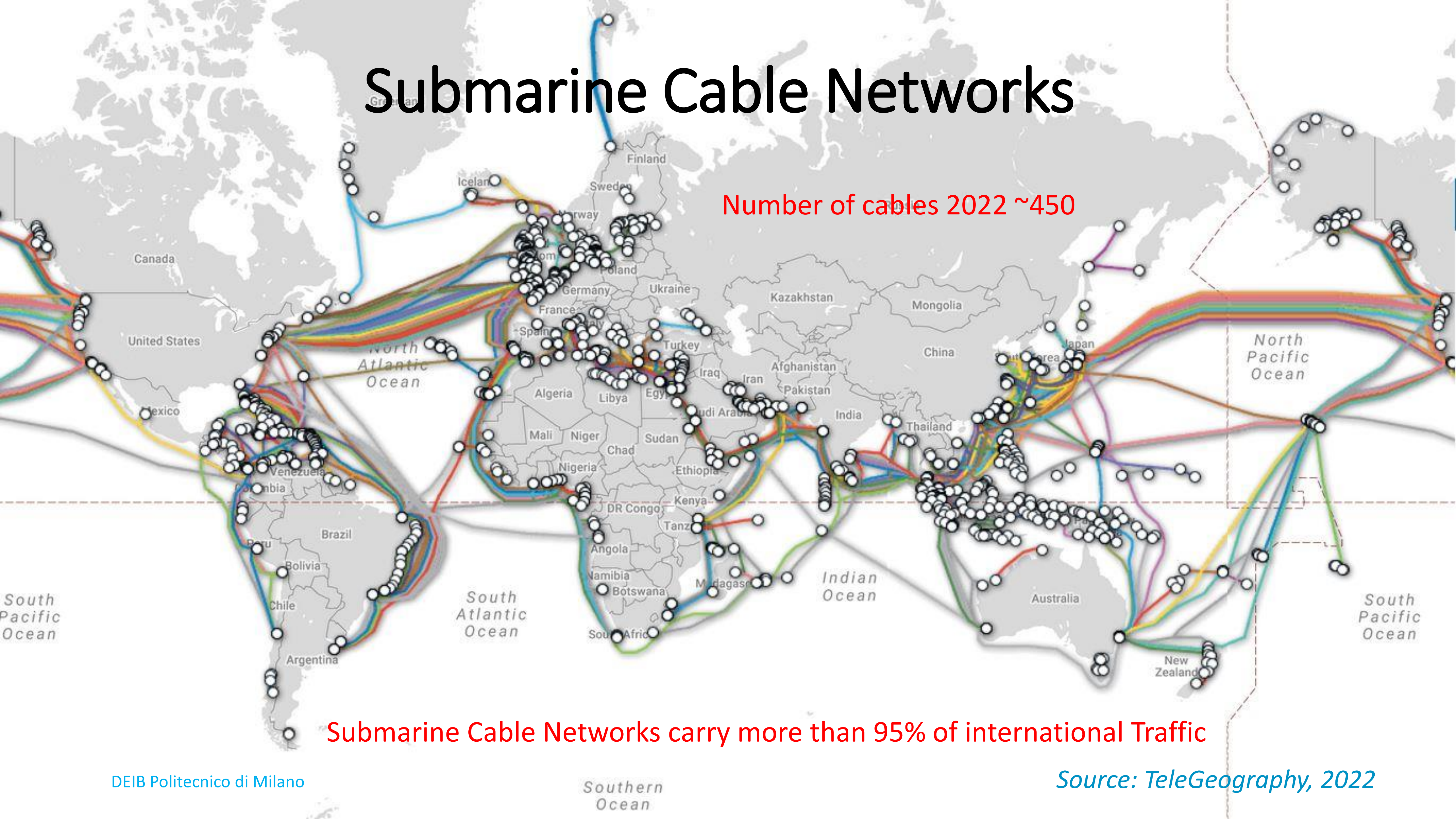
Source: Michele Zorzi, 2022

5G RAN & Sat RAN Integration (DINoS5G)



Source: Telespazio, 2022

Submarine Cable Networks



Number of cables 2022 ~450

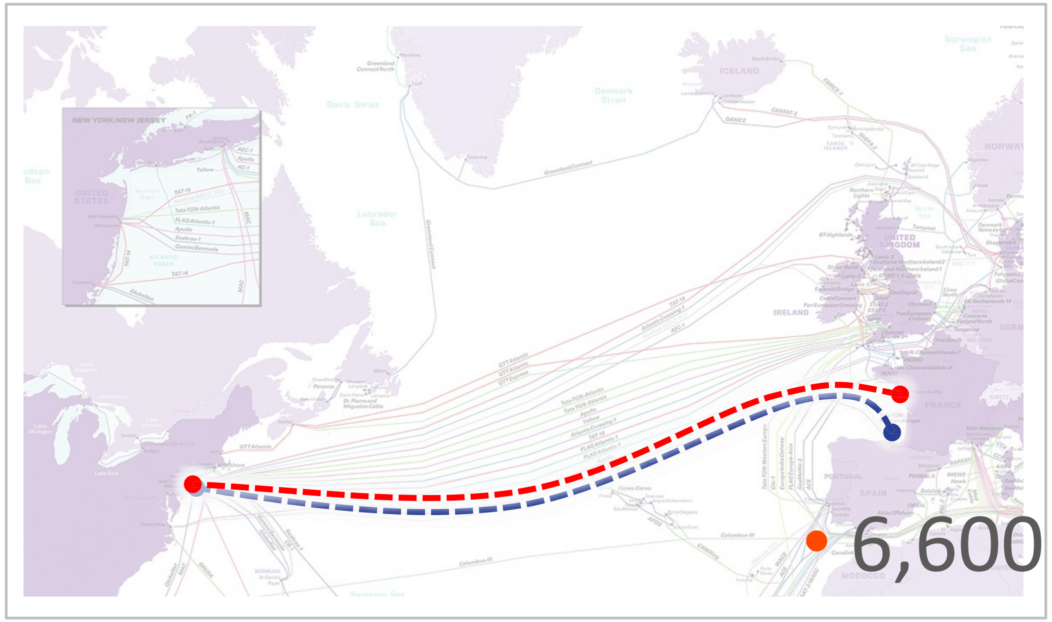
Submarine Cable Networks carry more than 95% of international Traffic

Source: TeleGeography, 2022

Recent Transatlantic Submarine Cables

SDM Roadmap

Future transatlantic cable
40 fiber pairs @ 25Tb/s
DDPetabit scale cable



- MAREA

State of the art
UNCOMPENSATED cable

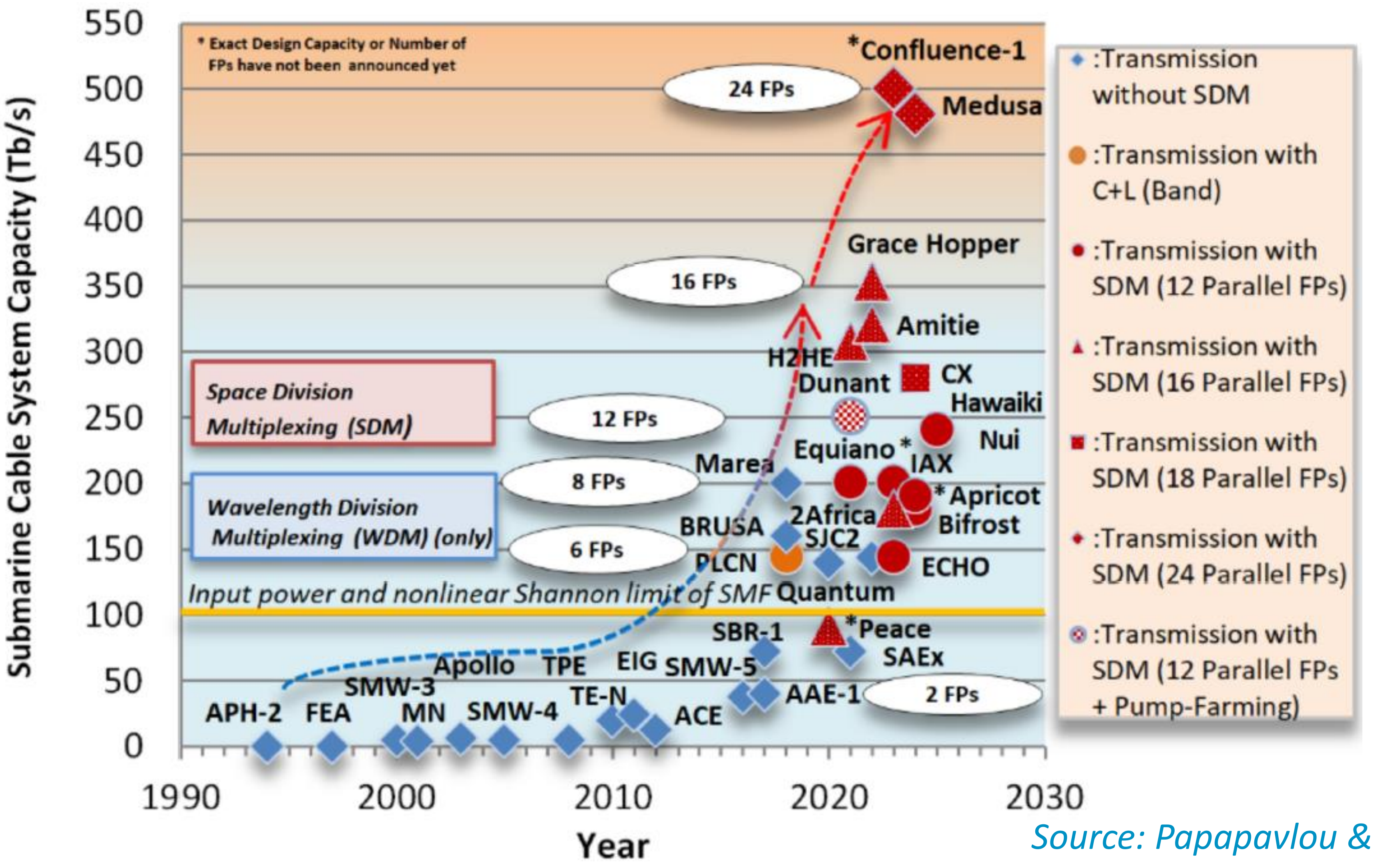
- 6,600 km cable
- 8 fiber pairs
- 24 Tbit/s per fiber pair
- Total capacity **192** Tbit/s

Source: Infinera, 2021

DUNANT

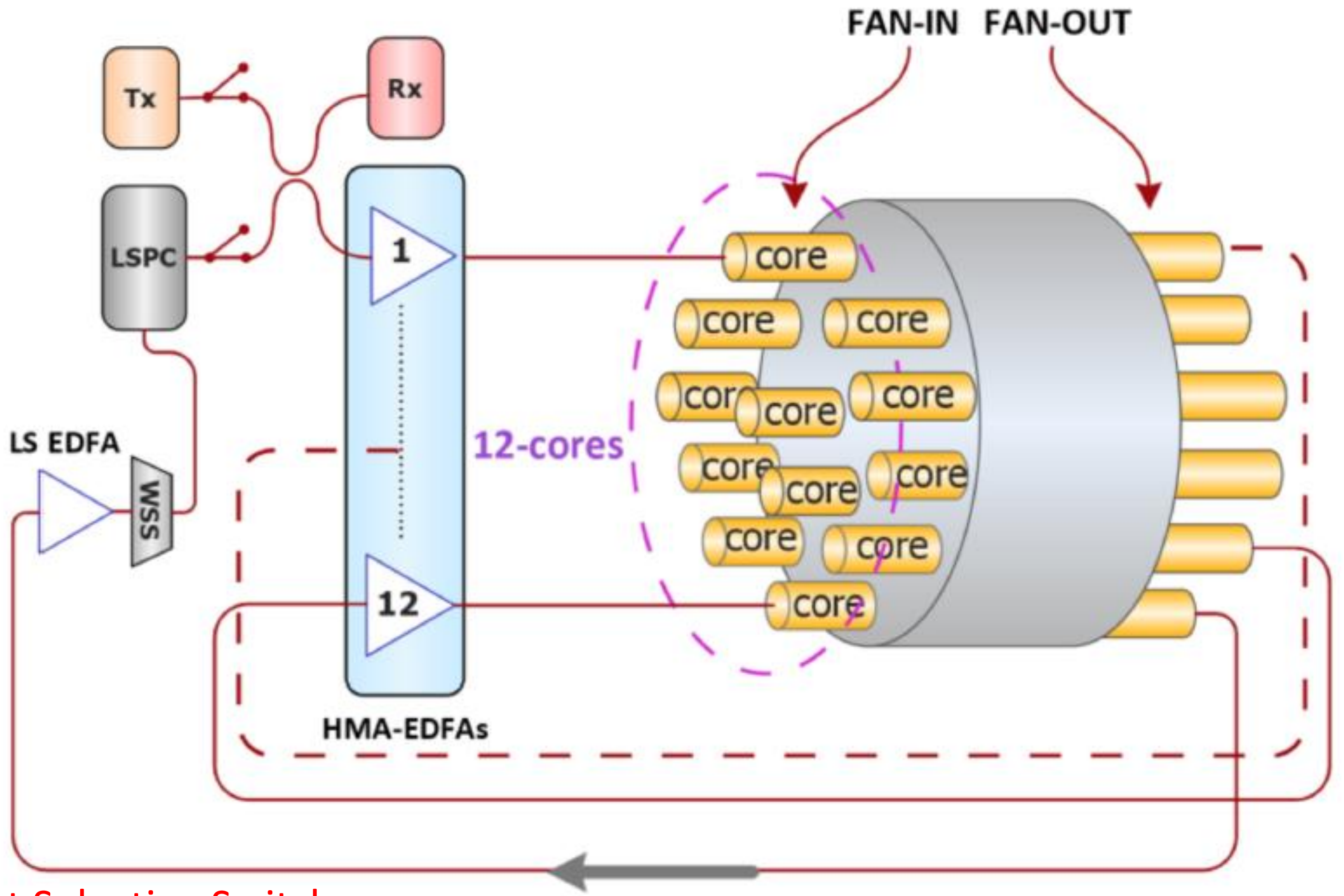
- 6,600 km cable
- 12 fiber pairs
- 25 Tbit/s per fiber pair
- Total capacity **300** Tbit/s

Submarine Cable's Capacity Growth



Source: Papapavlou & Others, 2022

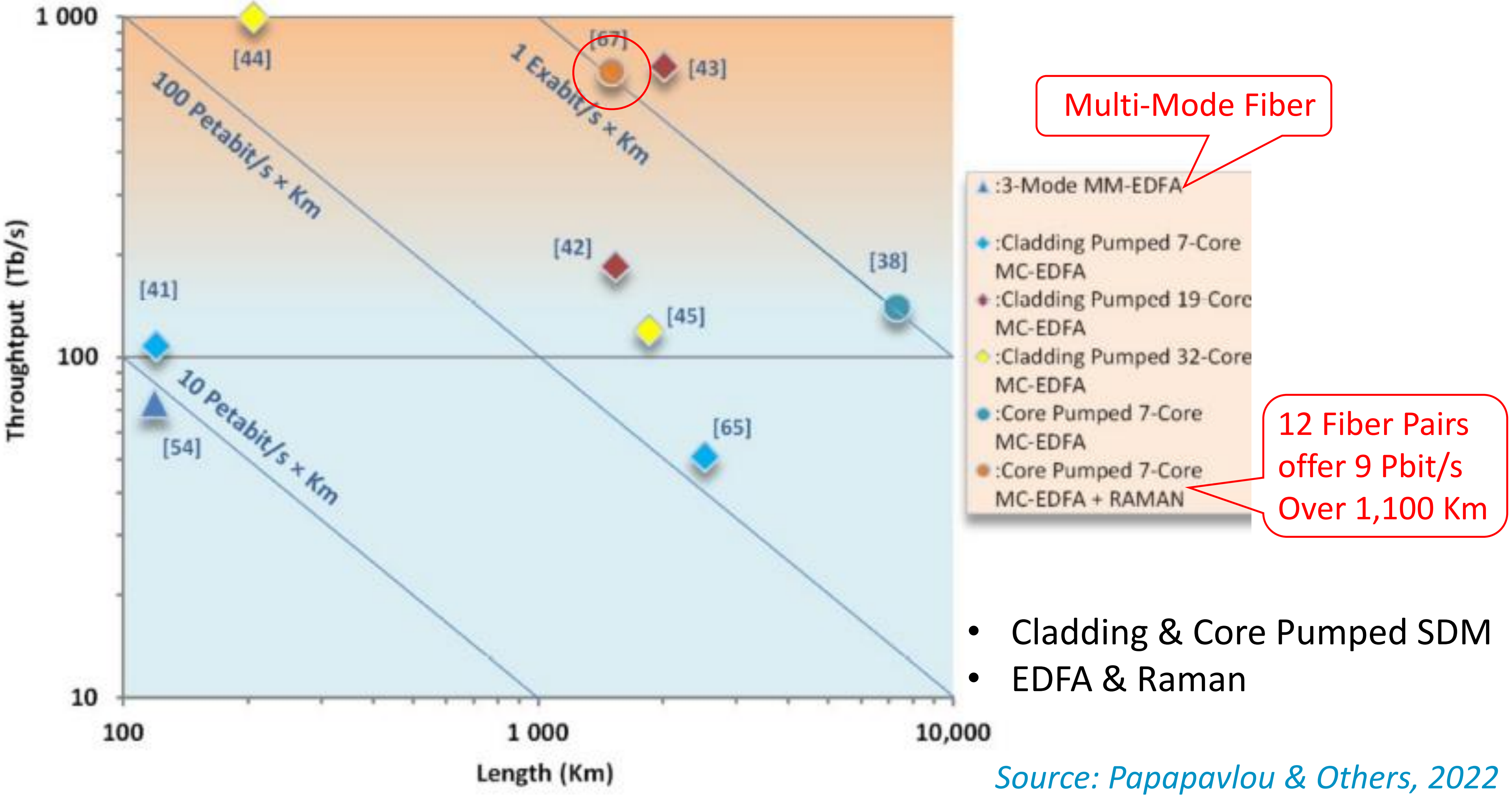
12 Core-Fiber Micro Amplifier Prototype



WSS: Wavelenght Selective Switch
LSPC: Loop Synchronous Polarization Controller
HMA: Hybrid Microassembly Amplifier

Source: Papapavlou & Others, 2022

Single Multi-Core Fiber Experiments

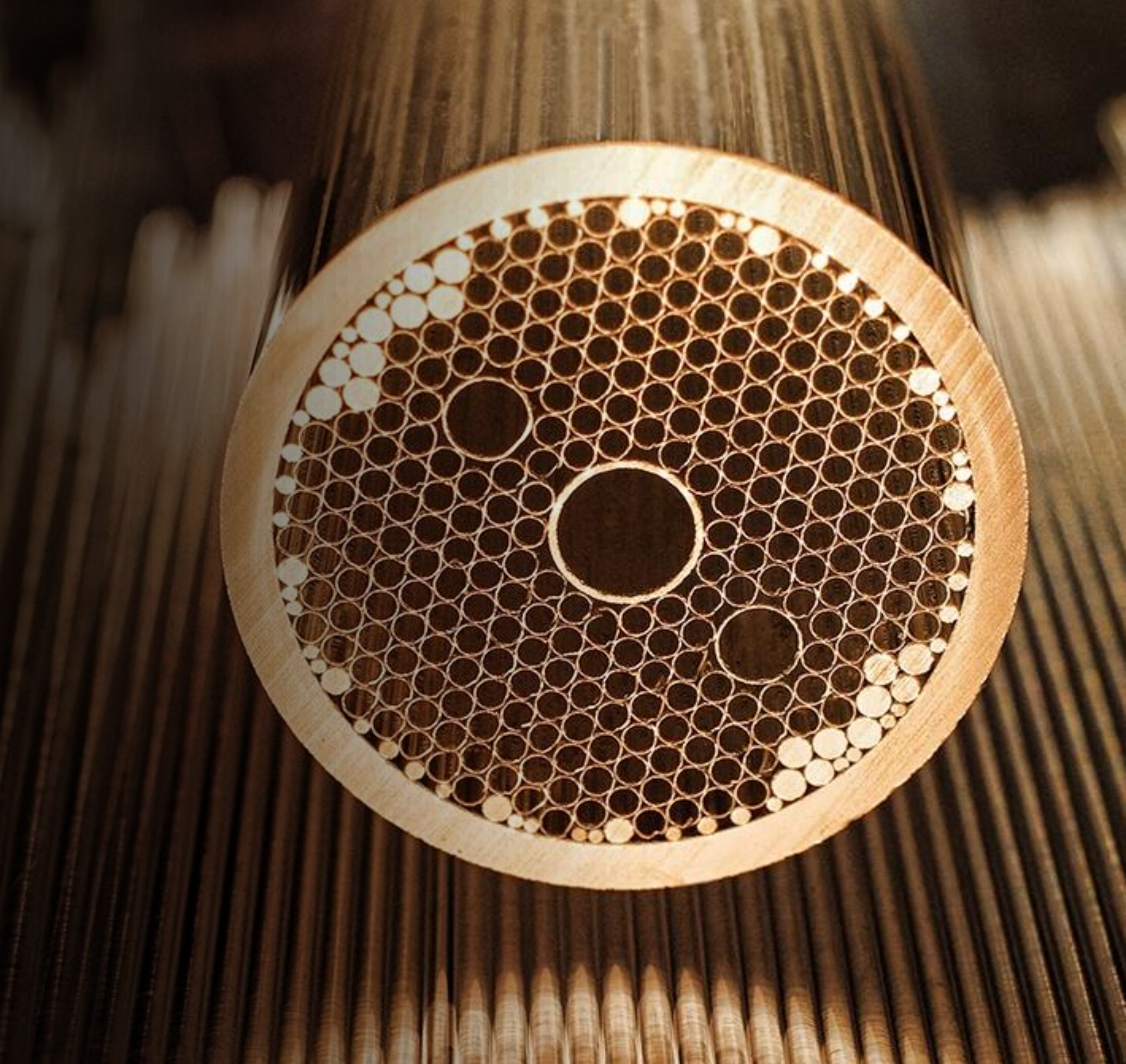


- Cladding & Core Pumped SDM
- EDFA & Raman

Source: Papapavlou & Others, 2022

Hollow Core Fibers

Critical use for deep undersea pressure



Subsea Cables as Sensing Network

REPORT

GEOPHYSICS

Optical polarization–based seismic and water wave sensing on transoceanic cables

Zhongwen Zhan[1*], Mattia Cantono[2], Valey Kamalov[2], Antonio Mecozzi[3], Rafael Müller[2], Shuang Yin[2], Jorge C. Castellanos[1]

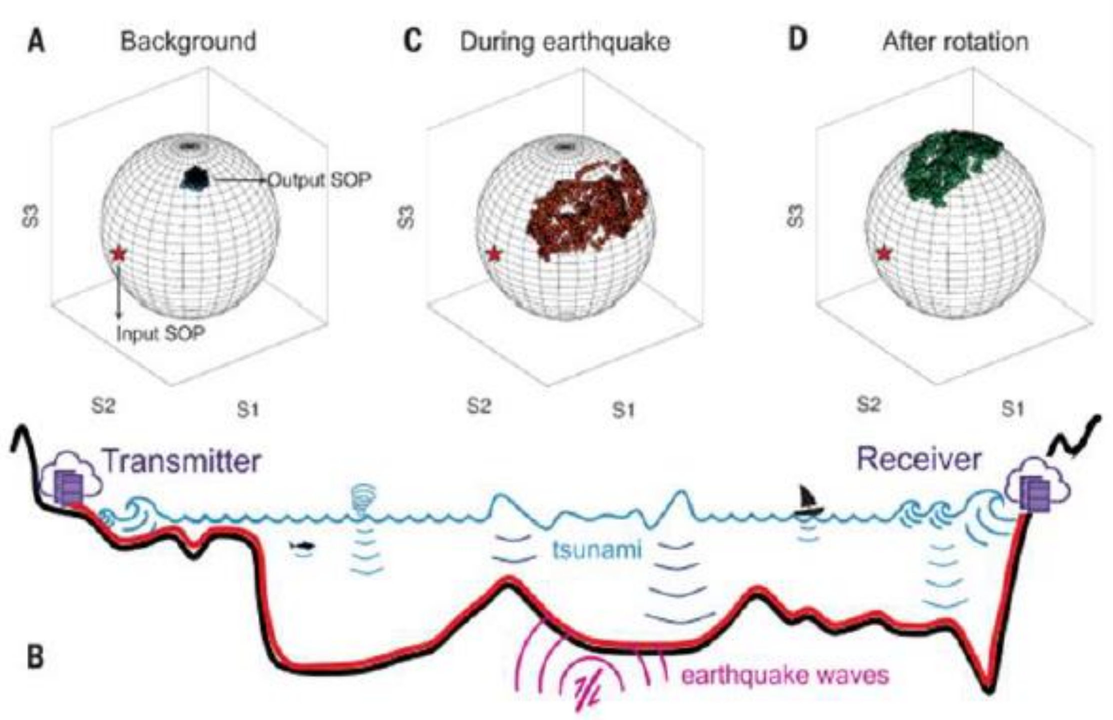


Fig. 2. Principles of polarization-based geophysical sensing. (**A**) The state of polarization (SOP) at the receiver is monitored routinely (blue dots on the Poincaré sphere) while the input SOP stays stable (red star). For the Curie cable, the output SOP is robust, owing to relatively minimal perturbations along most of its path in the deep ocean (**B**). The robustness allows us to detect earthquakes or ocean waves that produce SOP anomalies by shaking or pressuring the cable (**C**). Because the three Stokes parameters are normalized to 1.0, only two are independent. In this study, we rotate the Stokes parameters to the north pole of the Poincaré sphere (9) and focus on analyzing the S1 and S2 parameters after rotation (**D**).

Earthquakes detected by phase/length changes in fiber (ultra-stable laser)

Good correlation with terrestrial seismometers

Potentially low impact on commercial telecoms systems

Source: Science, 2021