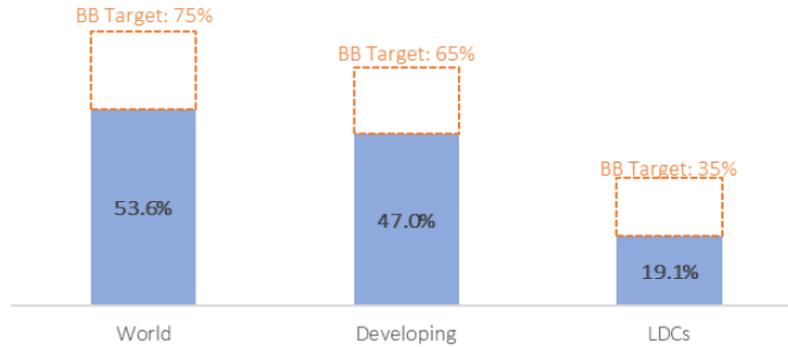


Tietoliikenneverkkojen kehittyminen avaruustoiminnassa: Kohti 6G:tä

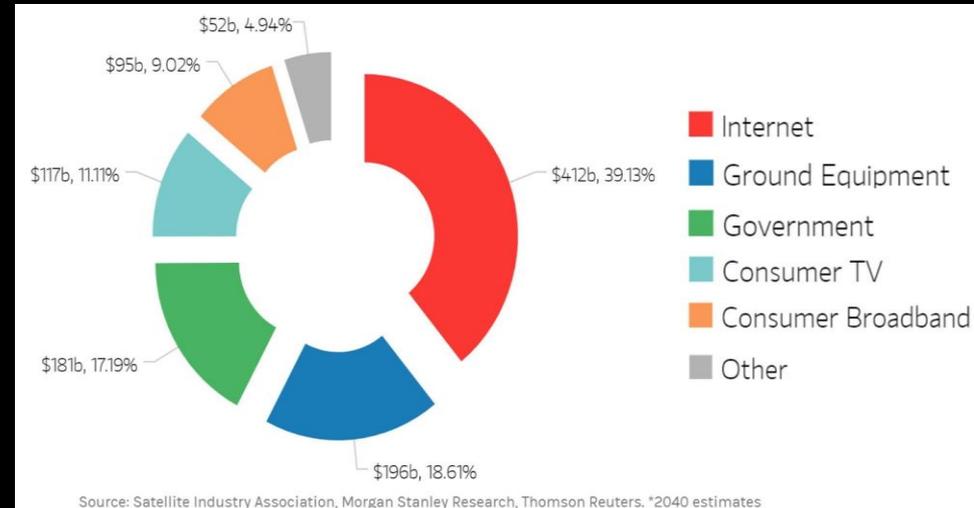
Marko Höyhtyä
Co-Creation Manager, Adjunct professor
VTT Technical Research Centre of Finland Ltd



Note: For statistical purposes, broadband is defined as "everything greater than or equal to 256 kbit/s". See ITU Handbook for the Collection of Administrative Data on Telecommunications/ICT, 2011: <https://www.itu.int/en/ITU-D/Statistics/Pages/publications/handbook.aspx>.

Vain puolet maailman väestöstä laajakaistapalveluiden piirissä

→ Satelliitit voivat olla osaltaan ratkaisu





Satelliittitieto- liikenteen disruptiot



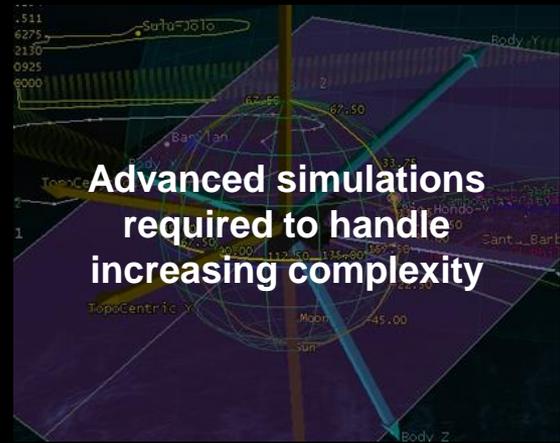
New space attracts
unprecedented investments



5G/6G will integrate
networks



Mega constellations enable
mobile broadband
everywhere



Advanced simulations
required to handle
increasing complexity

Megakonstellaatit (Tyypillinen budjetti \$5-10 B)



VTT

Operator	Frequency band	Altitude	Number launched/ authorised	Mass	User data rate/total capacity	Terminal type	Status
SpaceX Starlink	Ku-band DL: 12 GHz UL: 14 GHz + Ka +V (> 40 GHz)	550 km 350 km (V band)	1677/4408 0/7518 (V band)	270 kg	1/20 Gbps currently providing max. 100 Mbps DL for users	VSAT, ESIM	Beta services available, commercial in 2022
OneWeb	Ku-band DL: 12 GHz UL: 14 GHz + Ka	1200 km	182/648	150 kg	10 Gbps per satellite	VSAT, ESIM	Arctic area coverage in 2022
Telesat Lightspeed	Ka-band DL: 20 GHz UL: 29 GHz	1015 km / 78 satellites 1325 km / 220 satellites	2/292 both test satellites deorbited	700 kg	up to 7.5 Gbps for a single terminal, 20 Gbps for hotspot	VSAT, ESIM	Plan to have commercial service 2023
Amazon Kuiper	Ka-band DL: 20 GHz UL: 29 GHz	590-630 km	-/3236	-	400 Mbps user data rates in terminal tests	VSAT, ESIM	First launches booked
CASIC/CASC GW	Ka/Ku bands	1145 km / 508-600 km	-/12992	-	-	VSAT, ESIM	Chinese state-sponsored activity
AST Space Mobile	Terrestrial frequencies < 2 GHz	-	168	1500 kg	-	Commercial cellular handheld	\$462 M out of required \$1.7 B raised
Lynk	Terrestrial frequencies < 2 GHz	500 km	Plan up to 5000	-	-	Commercial cellular handheld	FCC license files for up to 10 small satellites in May 2021
European Constellation plan	Not defined yet	Multiorbital LEO+MEO +GEO	-	-	-	-	Feasibility study ongoing. Potential new EU flagship
Iridium Next	1.6 GHz (TDD)	780 km	75/66	680 kg	Call 2400 bits/s. A satellite supports up to 1100 simultaneous calls.	Proprietary handheld	Operational, 9 in-orbit spare satellites
ViaSat-2	Ka	GEO	1	6400 kg	260 Gbps total, up to 100 Mbps for user	VSAT, ESIM	Operational

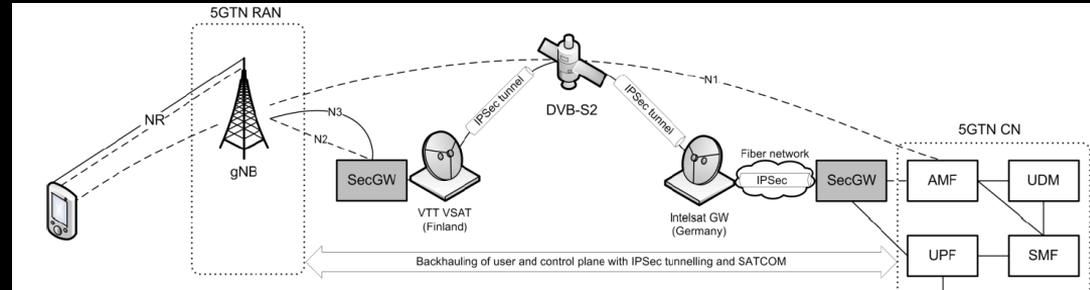
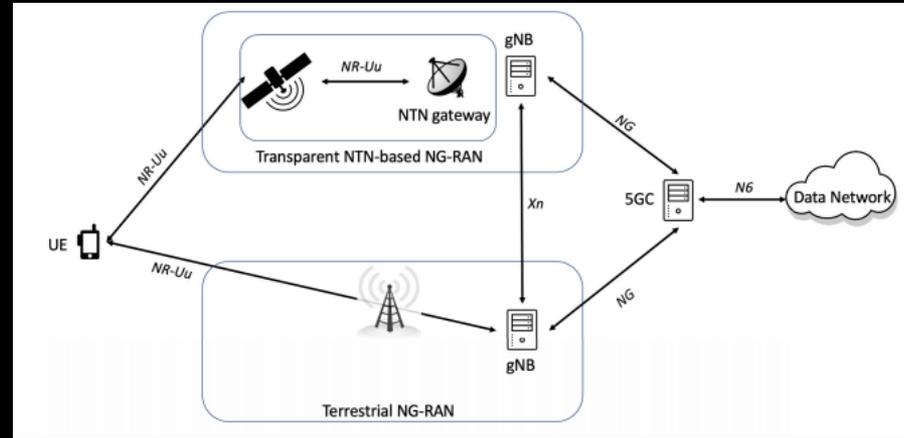
Miksi satelliitit osaksi 5G- ja 6G-verkkoja?

- Läsnaolo kaikkialla, globaali kattavuus; myös resilienssiä ja backup-ratkaisuja
- Mobiliteetin tuki ja yhteydet niin merellä, maalla kuin ilmassa
- Lähetykset (broadcast) laajoille alueille yhtäaikaaisesti



Integrointitapoja

- *Suora yhteys /Direct access:* Pääteleite voi olla 5G-yhteydellä suoraan kiinni satelliitissa
- *Epäsuora yhteys/Indirect access (AKA backhaul):* Pääteleite on yhteydessä radioverkkoon käyttämällä 3GPP tai non-3GPP teknologiaa. Radioverkko liittyy 5G core-verkkoon satelliitin kautta.



6G-järjestelmän vaatimuksia ja tavoitteita

- Extremely high data rates per device,
- Extremely low latency,
- Ultra-high reliable connectivity,
- Very large number of connected devices,
- Very low energy consumption with battery-free Internet of Things (IoT) devices,
- Global connectivity, and
- Connected intelligence with machine learning capability.

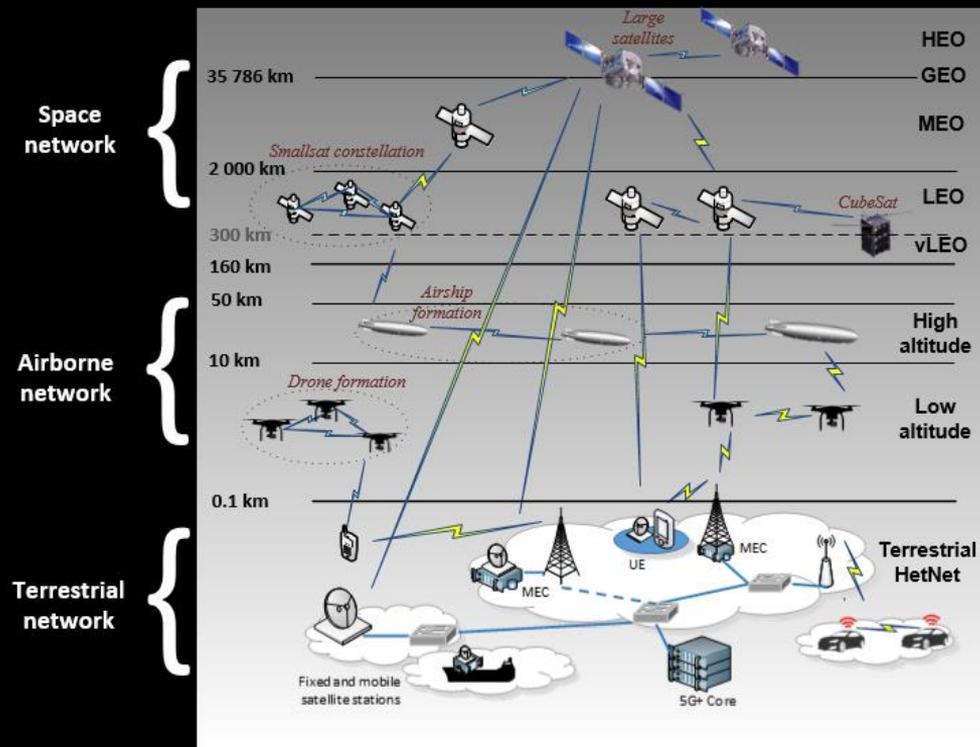
Parameter	4G	5G	6G
Peak data rate	1 Gbps	10 Gbps	1 Tbps
Max spectral efficiency	15 bps/Hz	30 bps/Hz	100 bps/Hz
Mobility support	up to 350 km/h	up to 500 km/h	up to 1000 km/h
End-to-end latency	100 ms	10 ms	1 ms
Network architecture	Horizontal	Horizontal + NTN component studied	Three-dimensional (3D) with vertical
Positioning accuracy	Tens of meters in 2D	10 cm on 2D	1 cm with 3D

Kohti 6G:tä, integroidut 3D-verkot



VTT

- LEO-konstellaatiot voivat tarjota globaalisti korkean kapasiteetin ja matalan latenssin ratkaisuja
- Monikerroksinen arkkitehtuuri tarpeen, integroituu yhteen
- Dynaaminen ympäristö, jossa häiriön ja resurssien hallinta haastavaa
- Tukee monenlaisia käyttötapauksia eri ympäristöissä



Joint vision paper: M. Höyhty, M. Corici, S. Covaci and M. Guta, "5G and Beyond for New Space: Vision and Research Challenges," in *Proc. ICSSC*, Oct. 2019.

Kehityspolut 6G SatCom –järjestelmiä kohti

- 1) The networks will become multi-layered ones; role of small satellites in LEO orbits are essential.
- 2) Payloads need to be flexible and software-defined to allow e.g. dynamic adaptation of beams, power and frequency allocations and even update of latest 3GPP release features.
- 3) From the spectrum point of view, millimetre wave technology allowing very high rate datalinks, optical communications and spectrum sharing techniques to reduce interference are required in the future.
- 4) Reconfigurable phase array antennas and multi-beam architectures are needed to reduce power consumption and improve spectrum efficiency.
- 5) End-to-end cybersecurity need to be taken into account early in the design phase to cover all interfaces, handovers, and the whole platform. Quantum technologies including post-quantum cryptography will be used for secure connectivity.

6G_Sat haastattelujen avulla identifioidut käyttötapaukset

Autonomous systems/
comms on the move



Digitalization of
maritime



Arctic areas and
sustainability



Space safety



Public safety



GovSatCom and secure
connectivity



Military use



Direct handheld
connections



IoT services over satellite



Broadcasting services



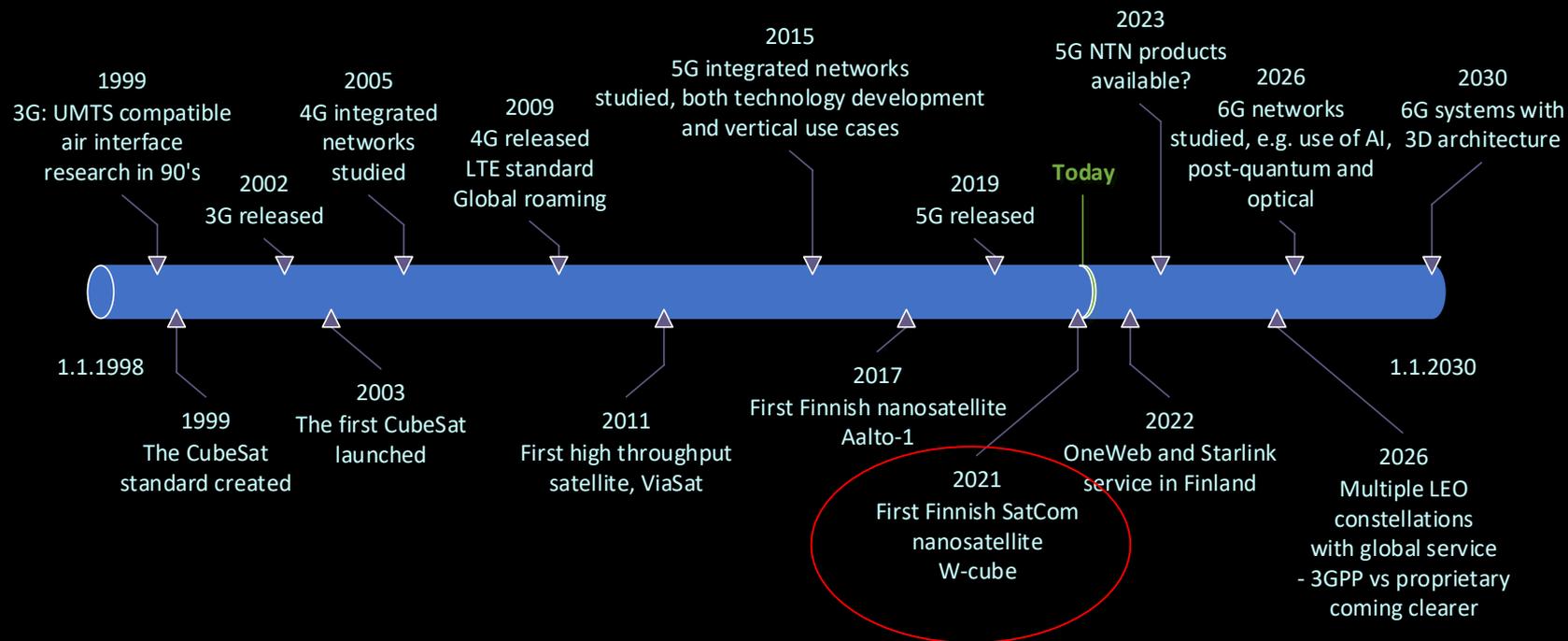
Broadband and Internet



Satellites as a service
/programmability

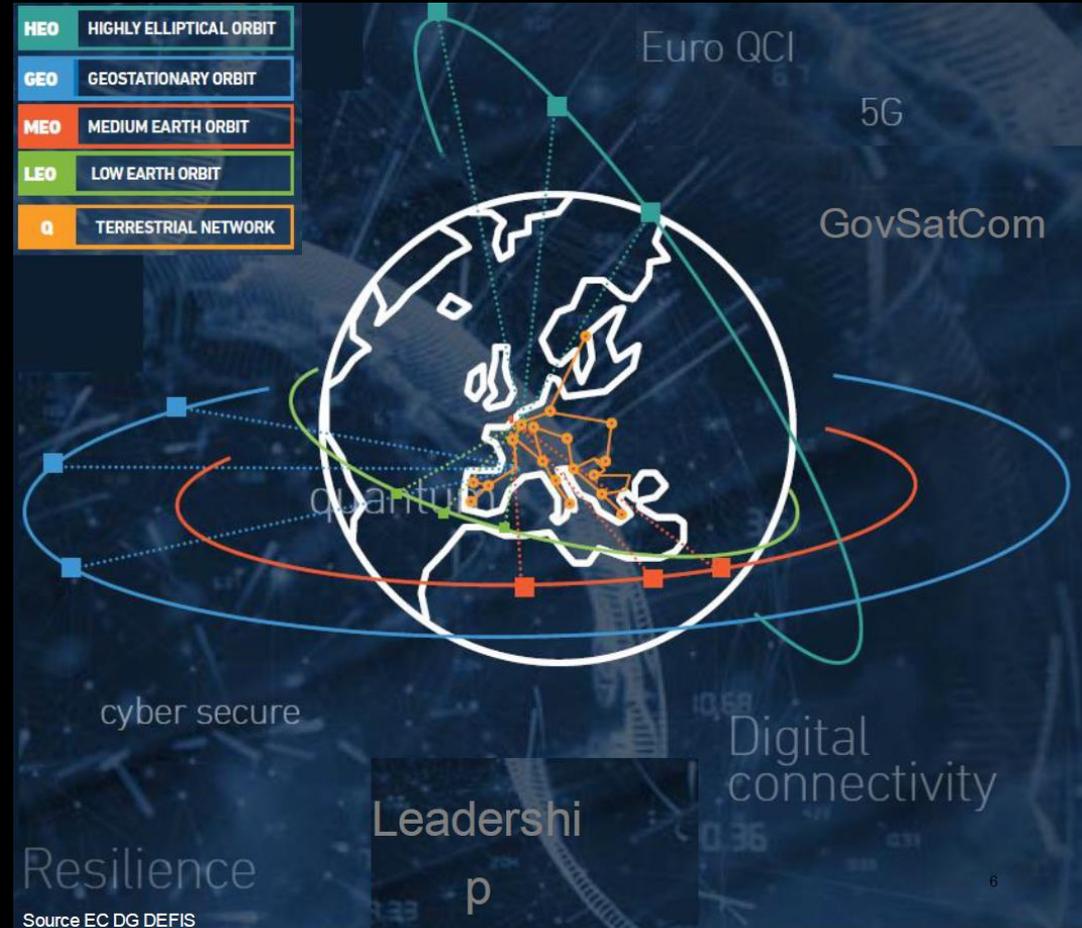


Aikajana 2030 asti



Eurooppalainen konstellaatio: Potentiaalinen flagship

- European sovereign space-based connectivity system (ESSCS)
- Has been proposed by European Commission, feasibility study led by Airbus ongoing until 12/2021
- European strategic autonomy, resilience and technological sovereignty
- Fuel innovative and competitive European industrial ecosystem
- Multi-layer architecture, 5G and broadband connectivity



Kiitos!

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