



High Altitude Platform Systems (**HAPS**)

The Next NTN Paradigm after LEO Mega-Constellations



Halim Yanikömeroğlu

Chancellor's Professor | Systems and Computer Engineering

Director | **Carleton-NTN** (Non-Terrestrial Networks) **Lab**

Carleton University

Ottawa, Canada



Carleton U's global ranking in telecom engineering: **#28**

BEng in Telecommunications Engineering: **The one and only in Canada**





- Network Capacity of Starlink
 $= 42,000 \text{ LEOs} \times 10 \text{ Tbps/LEO} = \sim 0.5 \text{ Ebps (2035+)}$



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- \$50B for megaconstellation
\$17B for spectrum $\rightarrow$ \$50 B

Total cost of Starlink: $\sim$ \$100B by 2035



What is the Ambition of SpaceX?

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Total cost of Starlink: ~\$100B by 2035
- Connecting the unconnected?
4% uncovered population?
Digital divide?



The Wireless Revolution

1R

1G, 2G, 3G, 4G, 5G

- mobile connectivity
- phone → smartphone → XR



The 2nd Wireless Revolution

1R

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2R

6G, beyond-6G, ...

- ubiquitous hyper-connectivity
- IoE



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Your smart device works everywhere – like your watch



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→ \$T++ business → **global power**



Radosław Sikorski



@sikorskiradek

Follow

Starlinks for Ukraine are paid for by the Polish Digitization Ministry at the cost of about \$50 million per year.

The ethics of threatening the victim of aggression apart, if SpaceX proves to be an unreliable provider we will be forced to look for other suppliers.



Elon Musk @elonmusk · 6h

I literally challenged Putin to one on one physical combat over Ukraine and my Starlink system is the backbone of the Ukrainian army. Their entire front line would collapse if I turned it off. What I am sickened by is years of sl... Show more

12:40 · 09.03.25 · 128K Views

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Musk and Rubio spar with Polish minister over Starlink in Ukraine

10 March 2025

[Share](#) [Save](#)

Rachel Looker
BBC News

Abdujalil Abdurasulov
BBC News

Reporting from Washington

Reporting from Kyiv



Reuters

Starlink provides high-speed internet to remote areas such as war zones



The 2nd Wireless Revolution

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Progress: Fast and unpredictable



Connecting the unconnected | Bridging the digital divide





Connecting the unconnected | Bridging the digital divide





Very Small Aperture Terminal (VSAT)





Connecting the unconnected | Bridging the digital divide (???)



August 2025 | Paris, France
Apartment of Prof. Gunes Karabulut Kurt

Supplementary ???

MNOs (3GPP ecosystem) have been
rather dismissive of SNOs



Best Network.

The truth is out. T-Mobile has the Best Mobile Network in the U.S., according to Ookla® Speedtest®.

Check out our network

Based on analysis by Ookla® of Speedtest Intelligence® data Q4 2024–Q1 2025. Ookla trademarks used under license and reprinted with permission.

Remaining 4% ???

T-Satellite: 23 July 2025
Powered by 657 Starlink
LEOs (3GPP Release 17)

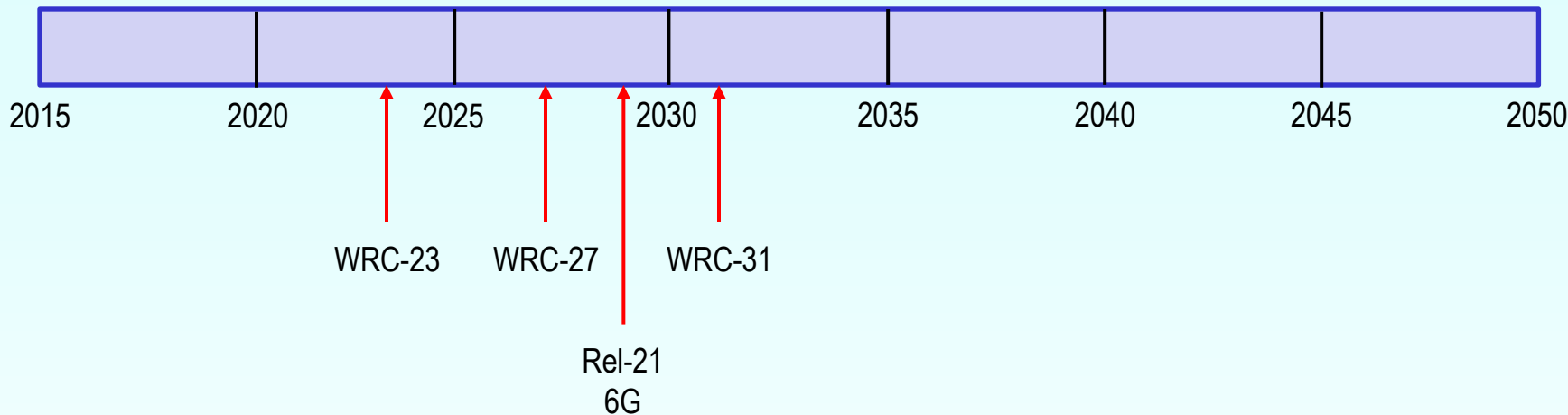
- Beta service: SMS
- Paid service: MMS, picture messaging, short audio clips

T Mobile | STARLINK

EXPERIENCE COVERAGE BEYOND

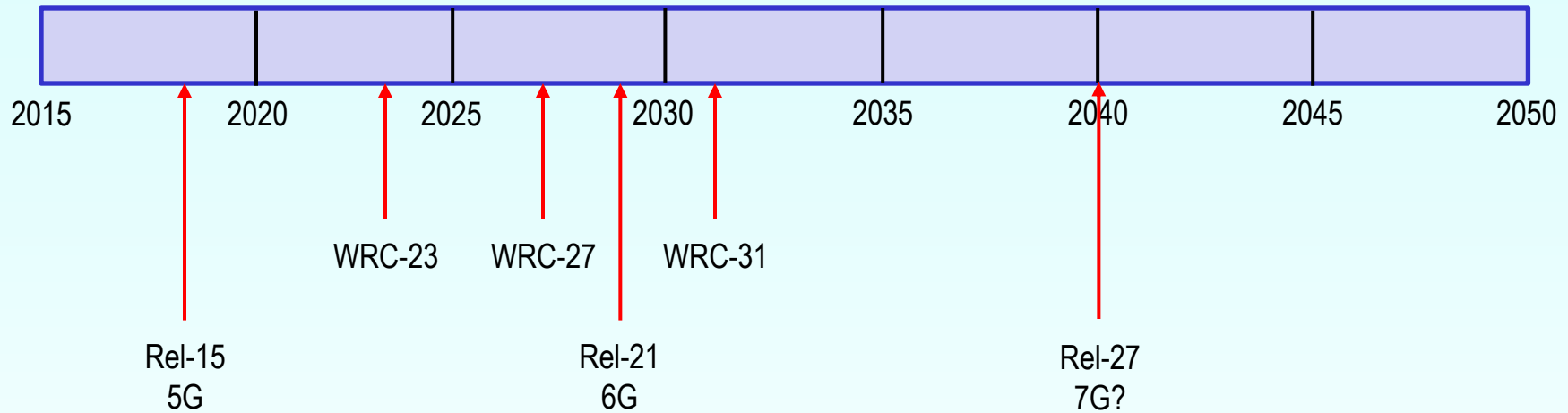


6G and NTN Timelines



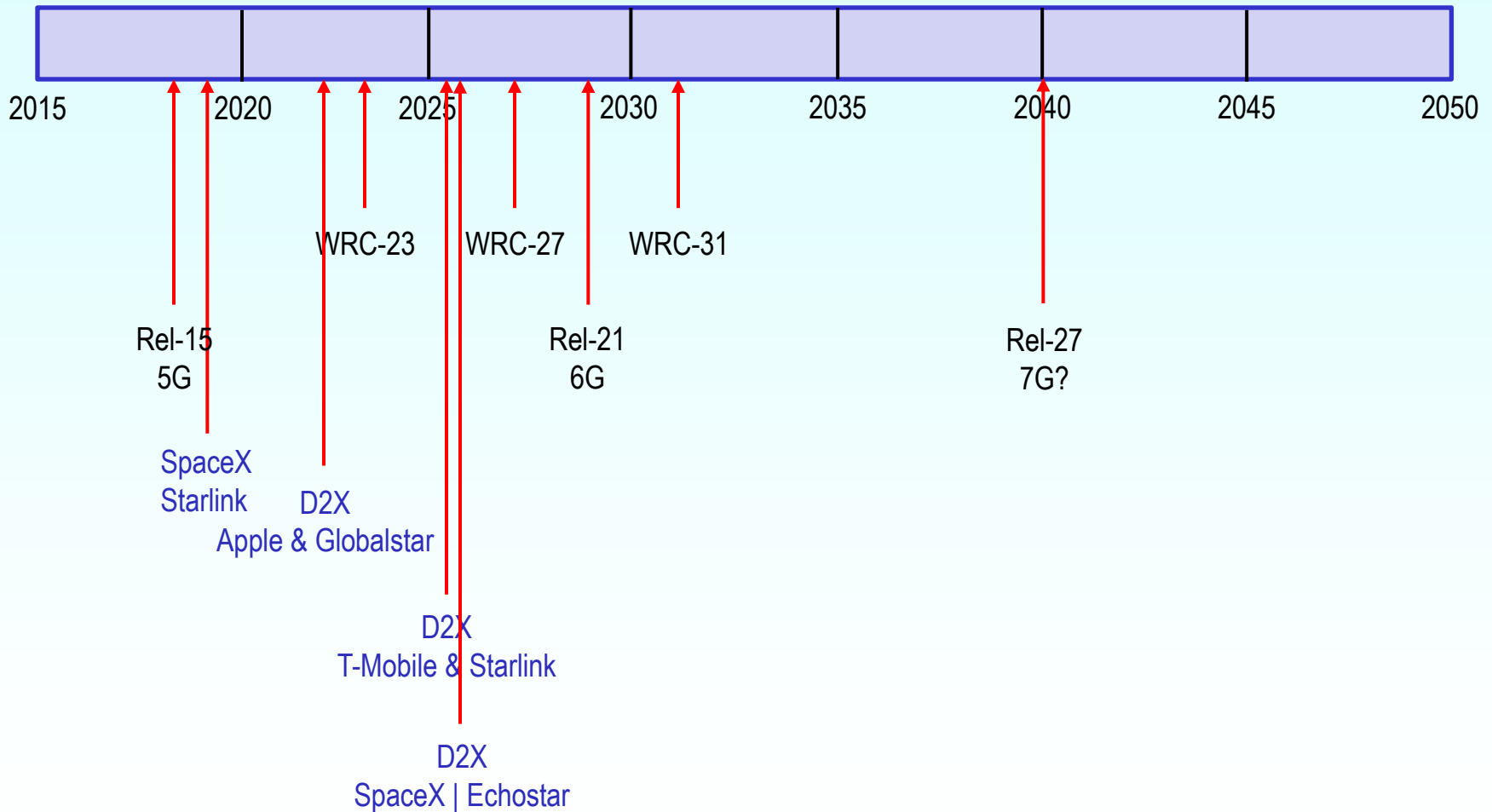


6G and NTN Timelines



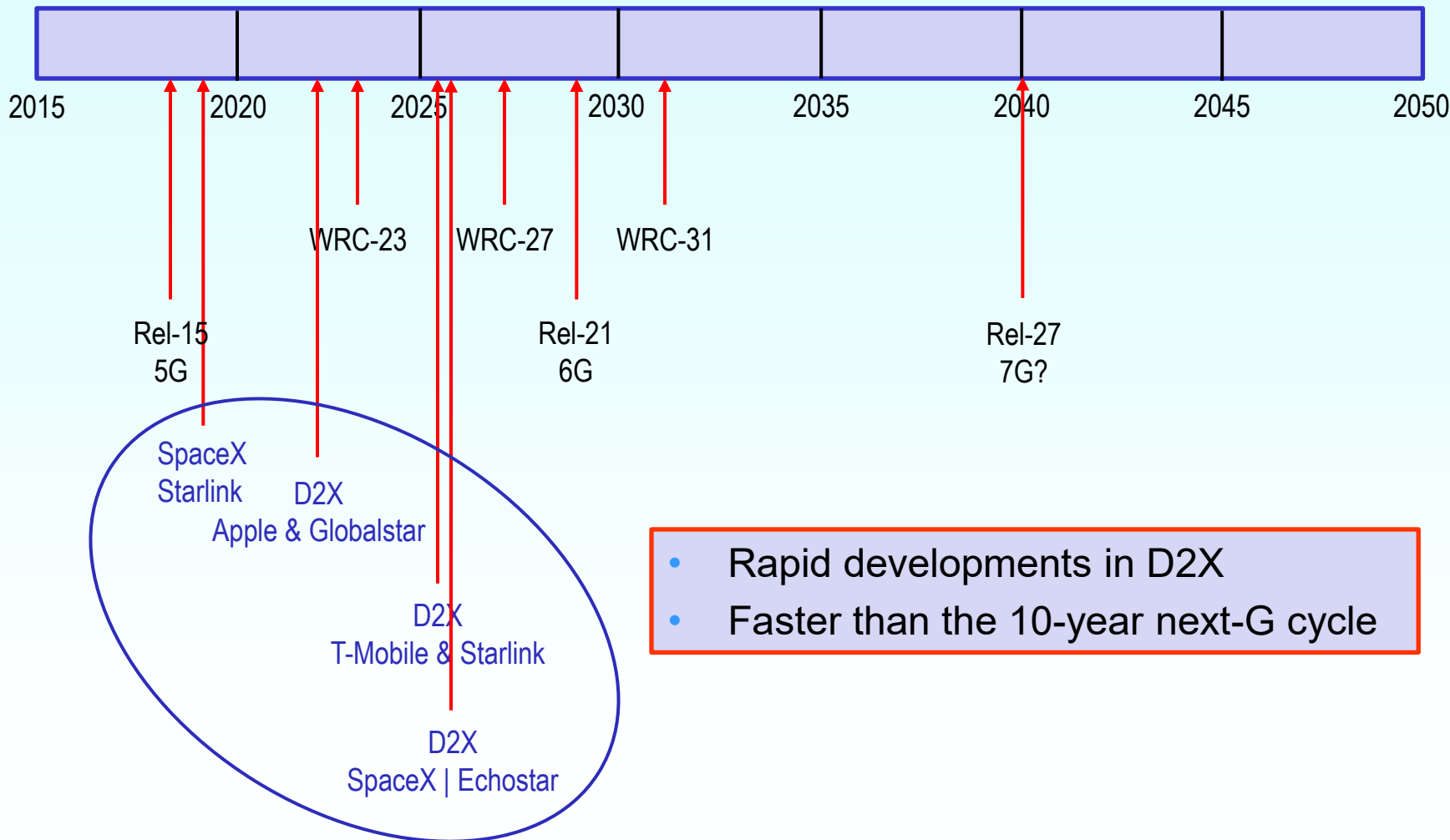


6G and NTN Timelines



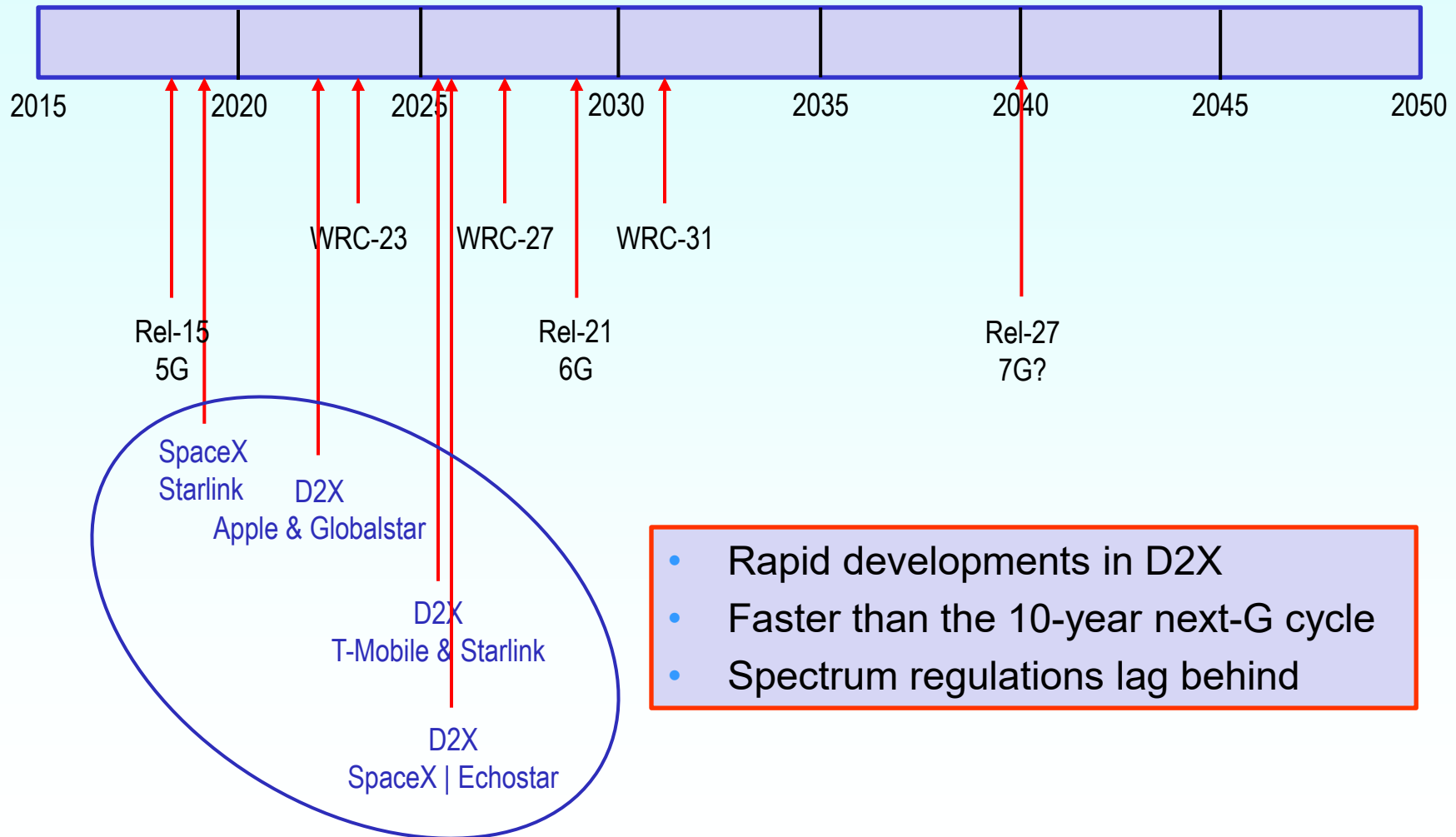


6G and NTN Timelines



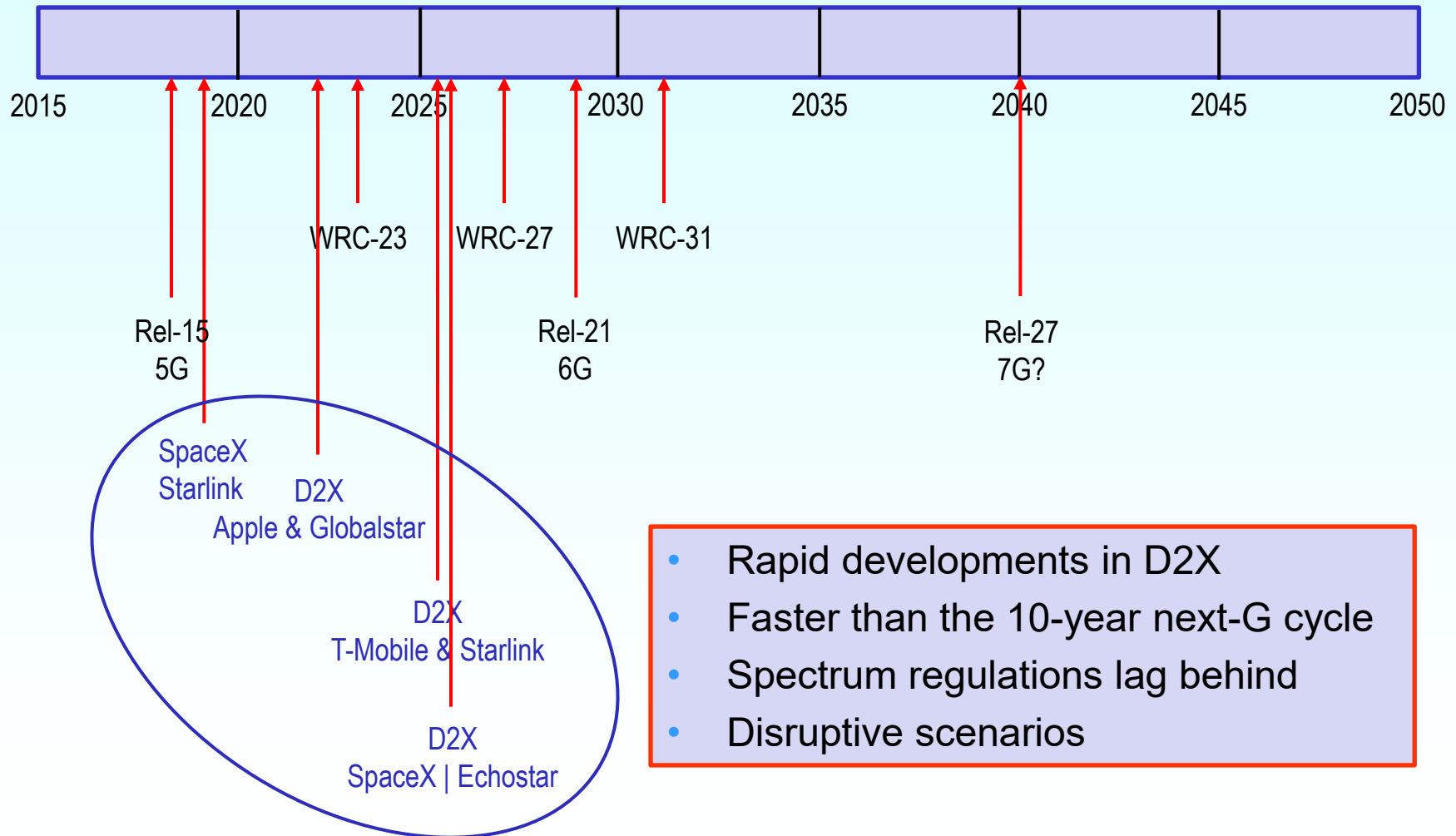


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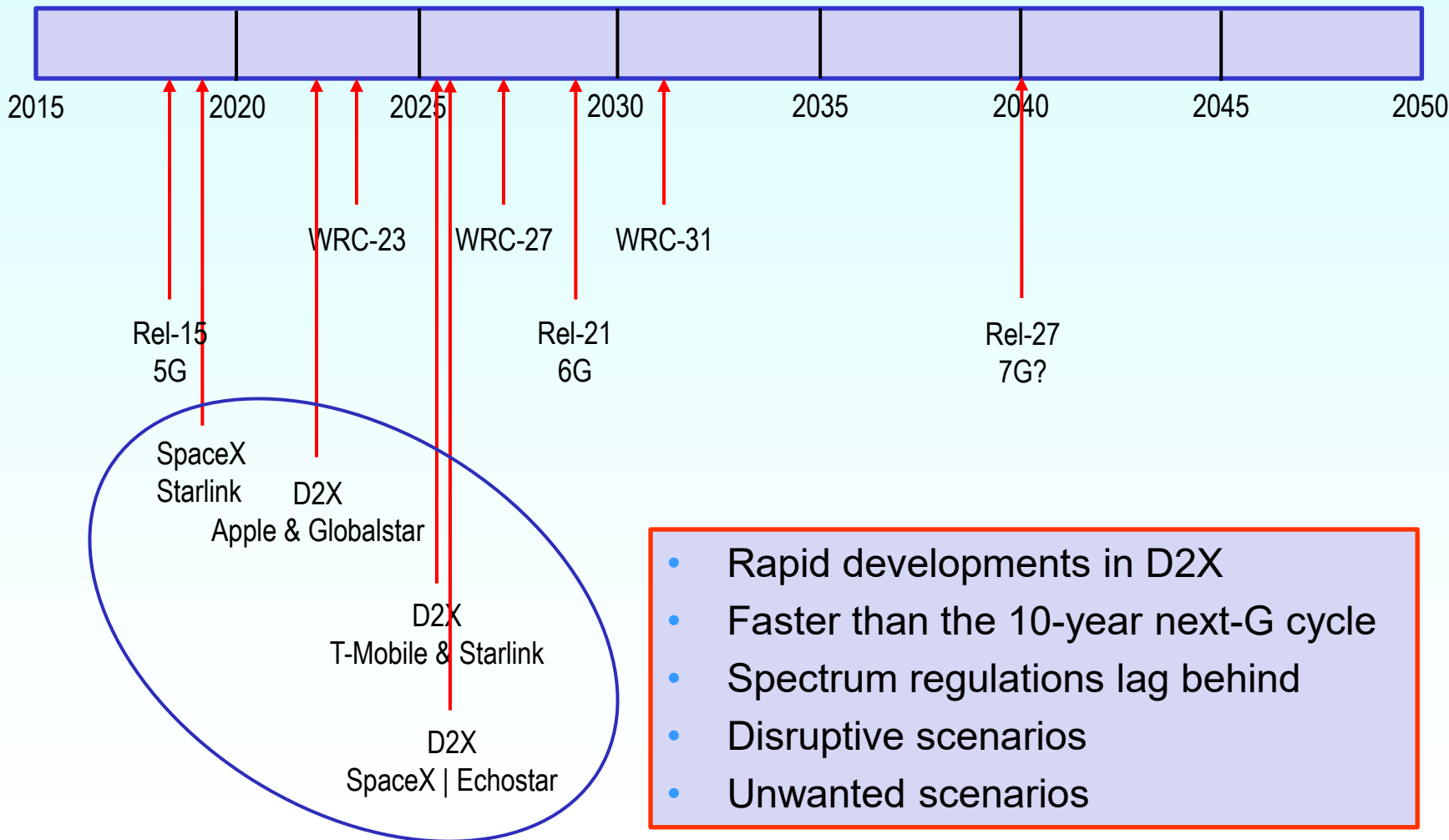


6G and NTN Timelines





6G and NTN Timelines





HAPS: High Altitude Platform Station → HIBS

HAPS: “A station on an object at an altitude of 20 to 50 km and at a specified, nominal, **fixed point relative to the Earth**” (ITU Radio Regulations, Article 1.66A).

HIBS: HAPS as an IMT (International Mobile Telecommunications) Base Station
HIBS altitude: 18-25 km (WRC-23)







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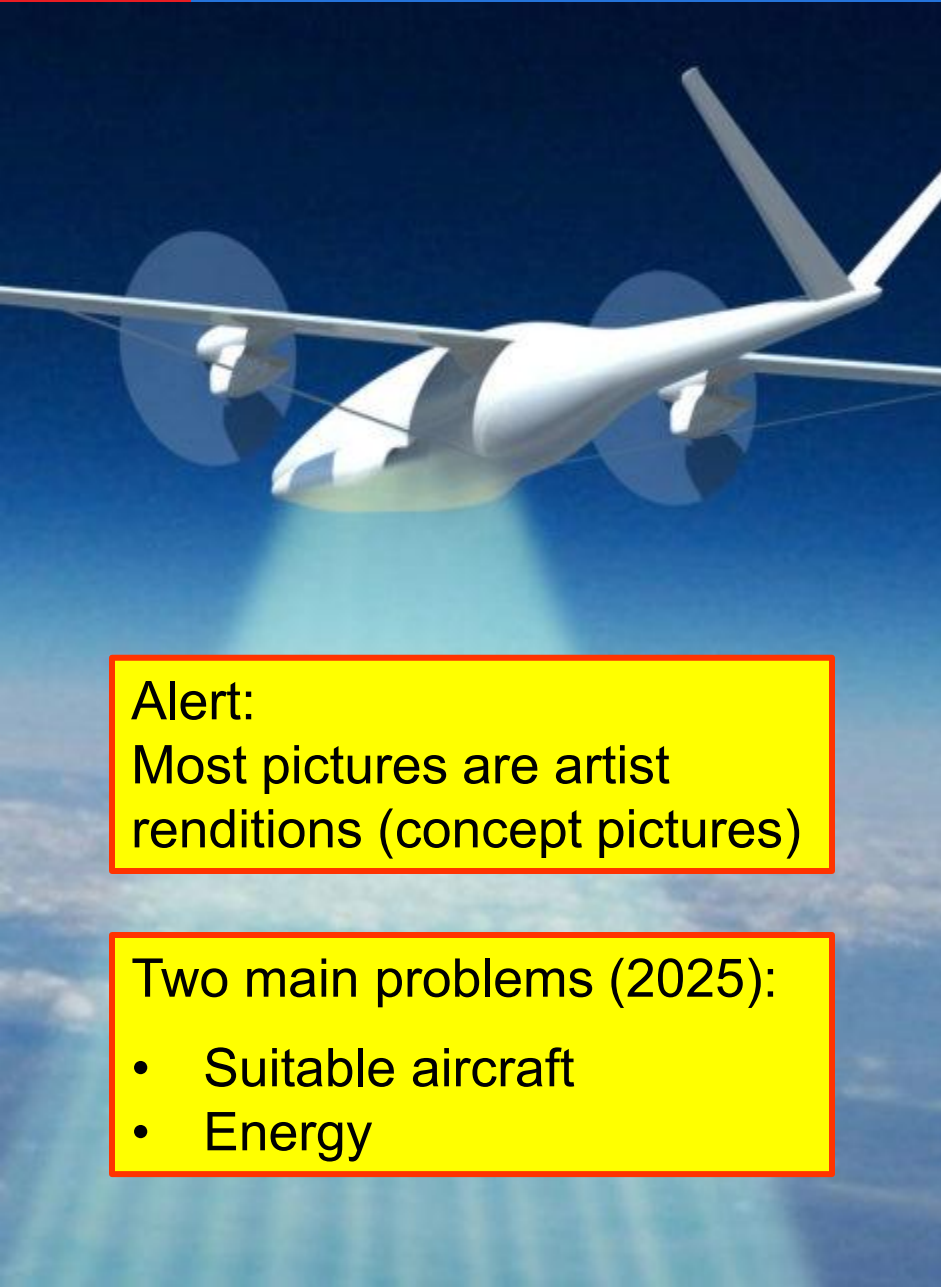








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Alert:
Most pictures are artist
renditions (concept pictures)

Two main problems (2025):

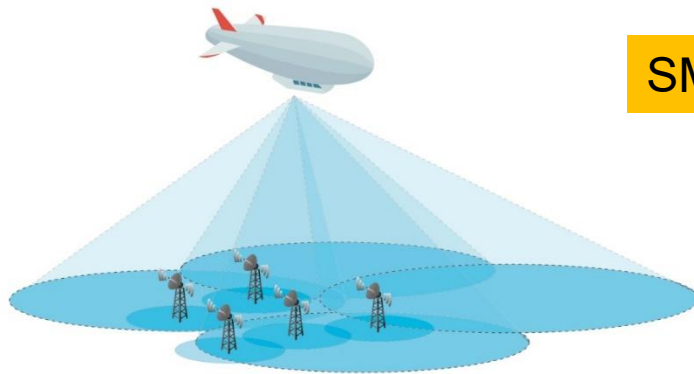
- Suitable aircraft
- Energy





VHetNet: Terrestrial BSs + HAPS BSs in Urban Areas

- ◆ Owned/shared by the legacy operators, part of the 3GPP ecosystem
- ◆ Vertical HetNet (VHetNet): One single network with multiple tiers
super macro BS (SMBS) ← macro BS ← small BS
10-100 km ← few km ← 100 m



SMBS: native



M. Alzenad, H. Yanikomeroglu, “**Coverage and rate analysis for vertical heterogeneous networks (VHetNets)**”, *IEEE Transactions on Wireless Communications*, Dec 2019.

N. Cherif, M. Alzenad, H. Yanikomeroglu, A. Yongacoglu, “**Downlink coverage and rate analysis of an aerial user in vertical heterogeneous networks (VHetNets)**”, *IEEE Transactions on Wireless Communications*, Mar 2021.

G. Kurt, M.G. Khoshkholgh, S. Alfattani, A. Ibrahim, T.S.J. Darwish, Md S. Alam, H. Yanikomeroglu, A. Yongacoglu, “**A vision and framework for the high altitude platform station (HAPS) networks of the future**”, *IEEE Communications Surveys and Tutorials*, Q2 2021.

S. Alam, G. Karabulut Kurt, H. Yanikomeroglu, N.D. Dao, P. Zhu, “**High altitude platform station based super macro base station (HAPS-SMBS) constellations**”, *IEEE Communications Magazine*, Jan 2021.



ITU Publications

International Telecommunication Union
Radiocommunication Sector

World Radiocommunication Conference 2023 (WRC-23)

Provisional Final Acts



ITUWRC
DUBAI2023
20 November - 15 December 2023
Dubai, United Arab Emirates



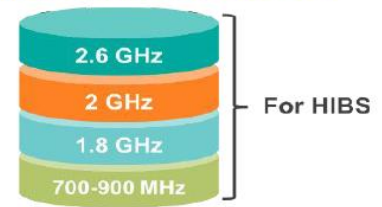
Establishment WRC-23 Agenda Item 1.4 Aiming at expansion of the frequency bands for HIBS

Current Regulation



NO FLEXIBILITY

Candidate bands for WRC-23



FLEXIBILITY

“HAPS industry’s expectation of this agenda item

- Allow to use of more frequency bands that are currently prohibited for HIBS by the RR.
- These frequency ranges (694-960 MHz, 1.7-2.1 GHz and 2.6 GHz) have been assigned to almost all MNOs around world, that enables MNOs to use HIBS with flexible frequency selection.”

Source: WRC-23 Report, SoftBank, 19 Dec 2023



HAPS: High Altitude Platform Station – Urban/Suburban Regions



D2D: no problem
Latency: no problem

$$(\sqrt{2} \times 100)^4 = (20,000)^2$$

Pathloss @ 140 m (w/ PL exp = 4)
= Pathloss @ 20 km (w/ PL exp = 2)

HAPS: Super Macro Base Station in Stratosphere (20 km)

G. Kurt, M.G. Khoshkholgh, S. Alfattani, A. Ibrahim, T.S.J. Darwish, Md S. Alam, H. Yanikomeroglu, A. Yongacoglu, “A vision and framework for the high altitude platform station (HAPS) networks of the future”, *IEEE Communications Surveys and Tutorials*, Q2 2021.

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HAPS: High Altitude Platform Station – Urban/Suburban Regions

non-orbiting

Easy tracking
No handover
Easy deployment
Scalable deployment
Maintenance / upgrade
Relay in LEO-to-smartphone
Data security and sovereignty
Easy integration with TN

close to Earth

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much more than
connectivity



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Imaging for Intelligence, Surveillance, and Reconnaissance (ISR)

Launch Complex 39A (with Polaris Dawn)

A very high resolution satellite image of SpaceX's Launch Complex 39A with the Polaris Dawn Falcon 9 standing vertical on the launch pad.

Date: September 6, 2024

Satellite Provider: [Airbus](#)

Satellite: [Pleiades NEO-4](#)

620 km

Resolution: 30cm/pixel





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- 2025 – Pleiades NEO @ 620 km: 30 cm/pixel (GSD)
- 2025 – Spy satellites @ 160-250 km: 5-10 cm/pixel (GSD)



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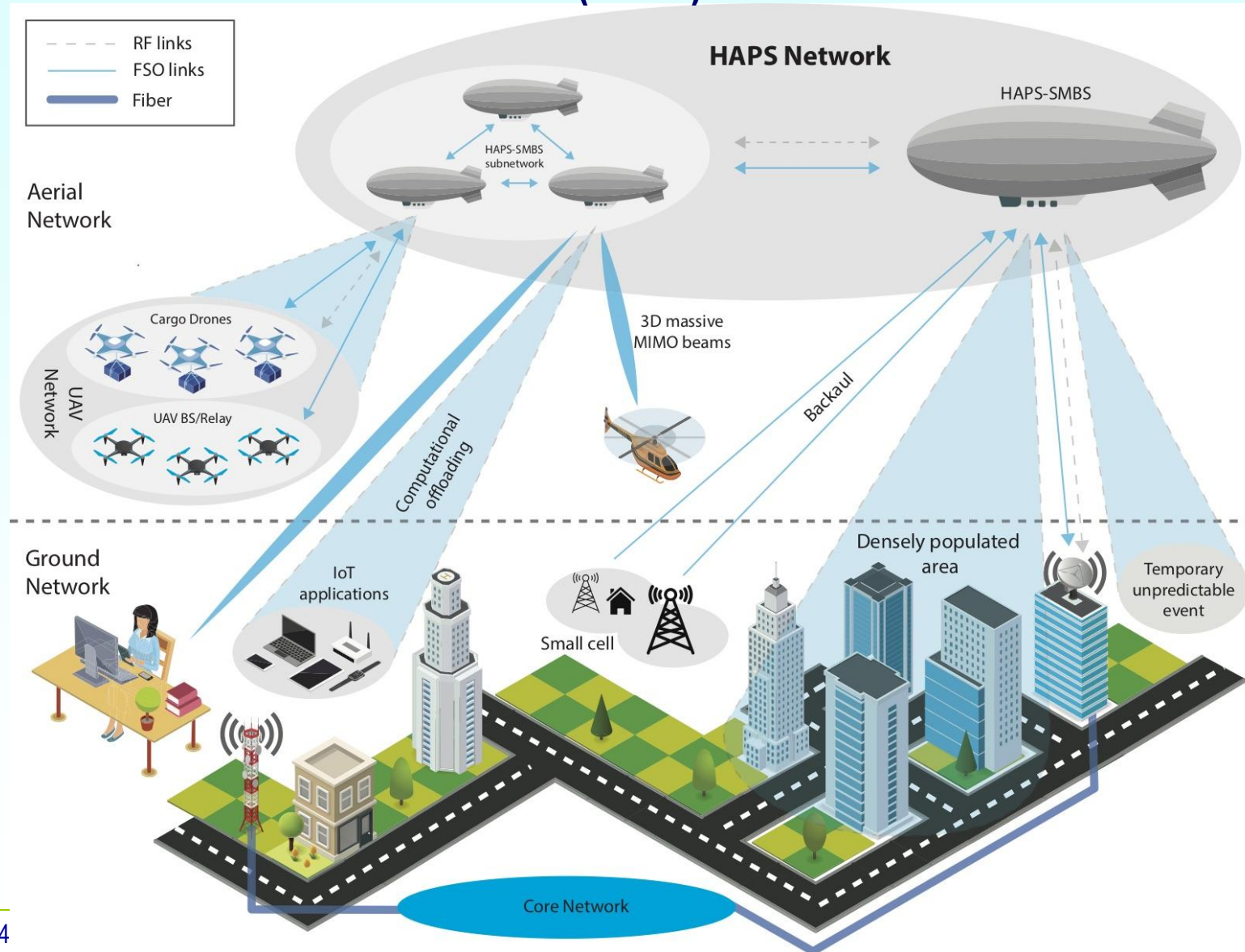
Resolution: 30cm/pixel



- 2025 – Pleiades NEO @ 620 km: 30 cm/pixel (GSD)
- 2025 – Spy satellites @ 160-250 km: 5-10 cm/pixel (GSD)
- 2030s & 2040s – HAPS with bigger, AI-aided, ultra-cameras @ 20 km: few mm/pixel? (GSD)

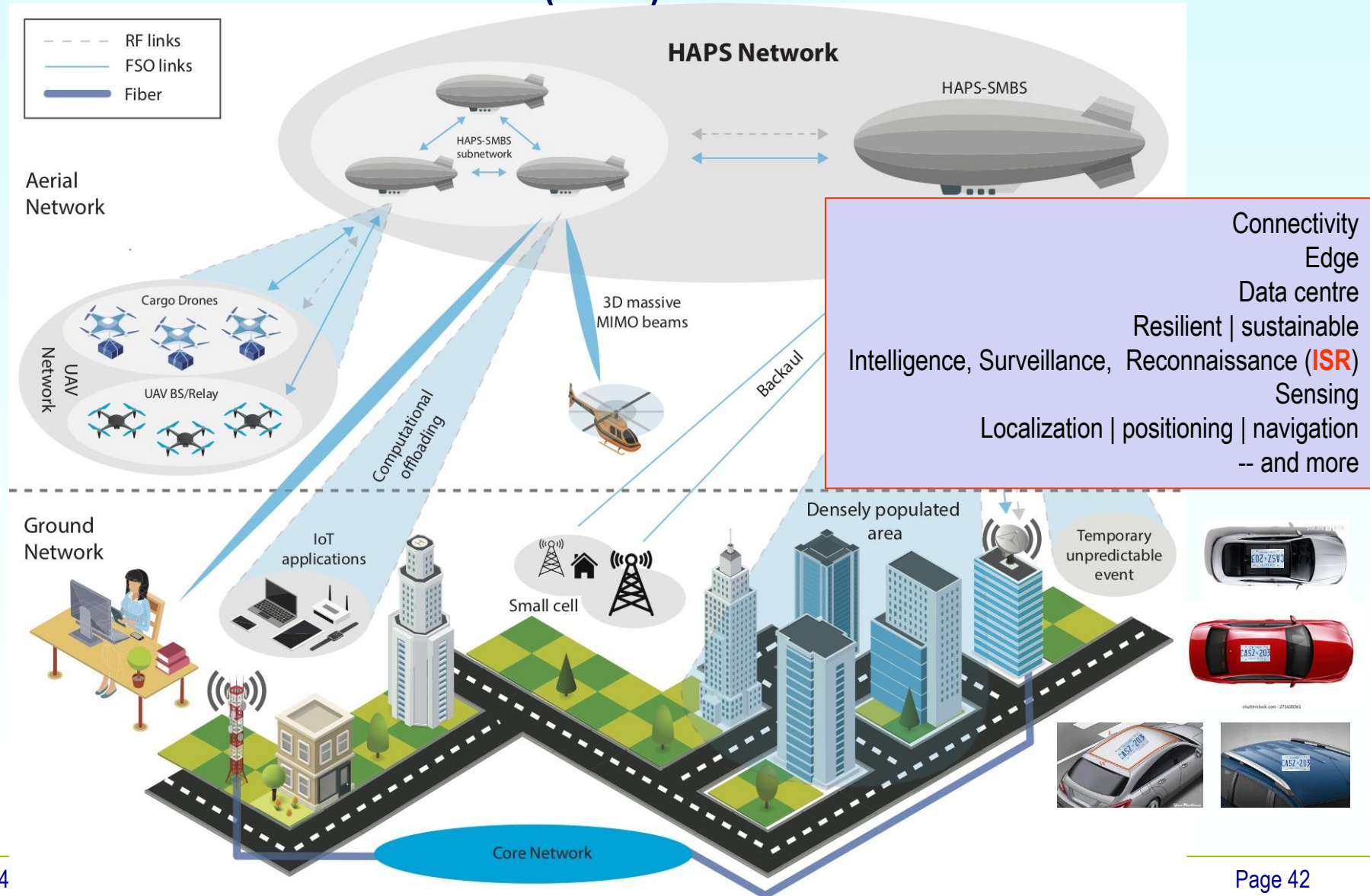


Terrestrial BSs + HAPS BSs (HIBS) in Urban/Suburban Areas



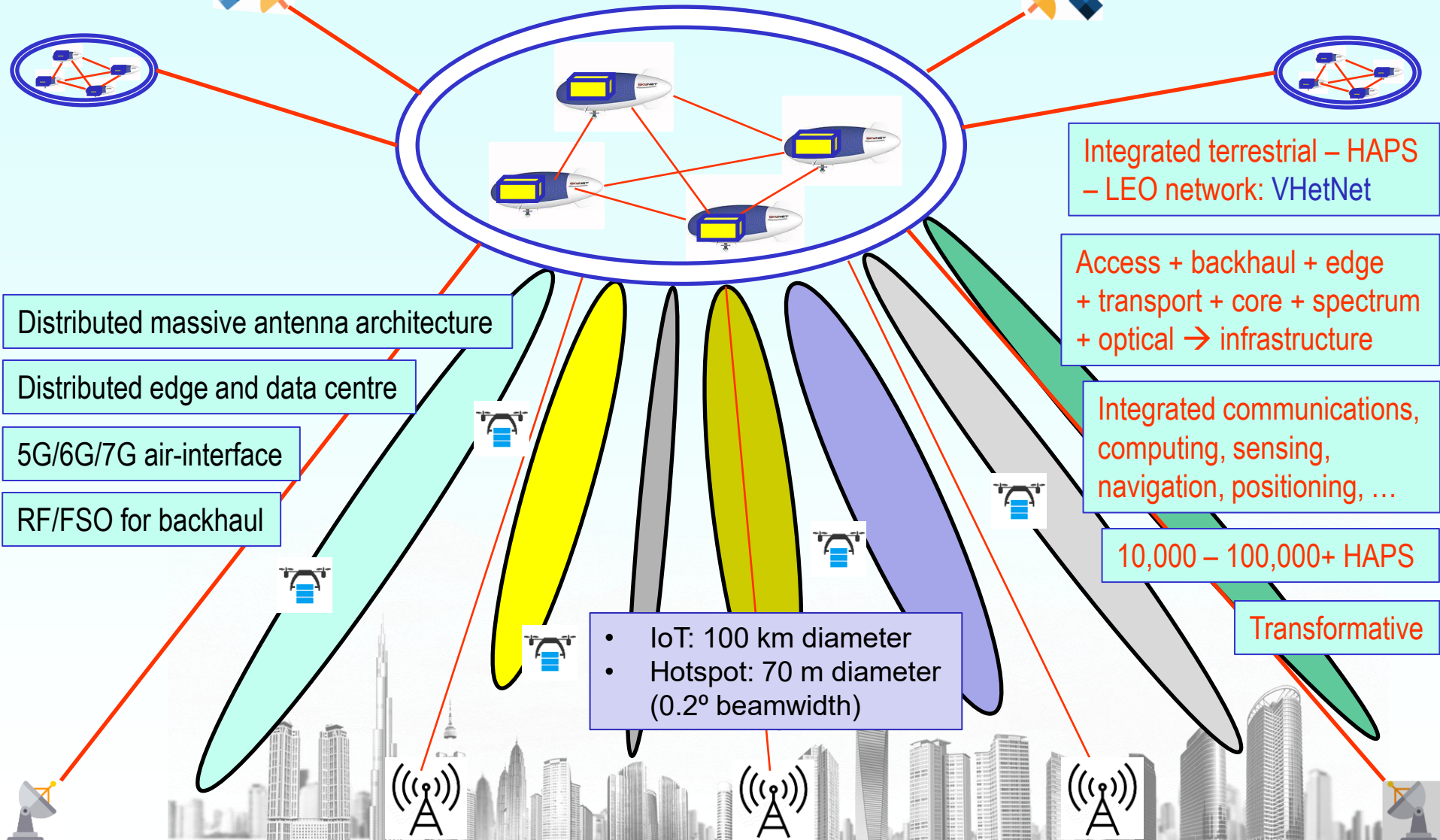


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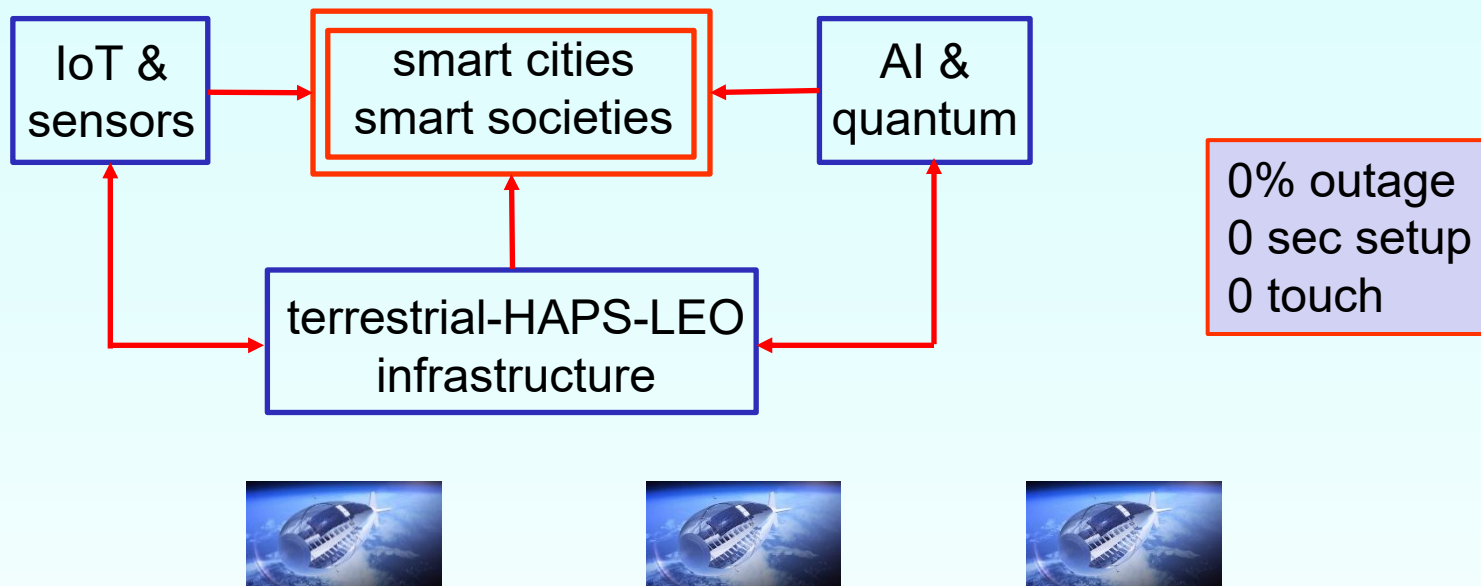


HAPS-enabled Wireless Infrastructure towards 2050





Wireless Infrastructure for Sustainable Smart Cities & Societies





PRESS RELEASE

JUNE 26, 2025

Sceye Receives Investment from SoftBank Corp. to Scale Stratospheric Platform Development and Launch Pre-Commercial HAPS Services in Japan in 2026





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119TH CONGRESS
1ST SESSION

Union Calendar No.

H. R. _____

[Report No. 119-]

To provide for reconciliation pursuant to title II of H. Con. Res. 14.

IN THE HOUSE OF REPRESENTATIVES

MAY --, 2025

Mr. ARRINGTON, from the Committee on the Budget, reported the following bill; which was committed to the Committee of the Whole House on the State of the Union and ordered to be printed

“The Big Beautiful Bill”, July 2025

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130

- 1 (6) \$50,000,000 for the creation of additional
- 2 Defense Innovation Unit OnRamp Hubs;
- 3 (7) \$250,000,000 for the acceleration of Stra-
- 4 tegic Capabilities Office programs;
- 5 (8) \$650,000,000 for the expansion of Mission
- 6 Capabilities office joint prototyping and experimen-
- 7 tation activities for military innovation;
- 8 (9) \$500,000,000 for the accelerated develop-
- 9 ment and integration of advanced 5G/6G tech-
- 10 nologies for military use;
- 11 (10) \$25,000,000 for testing of simultaneous
- 12 transmit and receive technology for military spec-
- 13 trum agility;
- 14 (11) \$50,000,000 for the development, procure-
- 15 ment, and integration of high-altitude stratospheric
- 16 balloons for military use;
- 17 (12) \$120,000,000 for the development, pro-
- 18 curement, and integration of long-endurance un-
- 19 manned aerial systems for surveillance;
- 20 (13) \$40,000,000 for the development, procure-
- 21 ment, and integration of alternative positioning and
- 22 navigation technology to enable military operations
- 23 in contested electromagnetic environments;

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May 15, 2025 (7:46 a.m.)



Federal Communications Commission - Technological Advisory Council
6G Working Group

Federal Communications Commission - Technological Advisory Council
6G Working Group

FCC Technology Advisory Council 6G Working Group Report August 5, 2025

Co-Chairs

Abhimanyu Gosain, Northeastern University
Brian Daly, AT&T

FCC Liaisons

Martin Doczkat, Kamran Etemad

Ethical and Social Impacts of Emerging Applications

1. Brain-Computer Interfaces (BCI) is making notable strides, particularly in healthcare, with promising but still emerging consumer applications. BCIs are primarily used in medical contexts, such as helping people with paralysis communicate or control prosthetic limbs. Industry and academic institutions are advancing implantable and non-invasive BCIs.
2. Holographic communications are progressing from experimental demonstrations toward practical use cases but face technological and infrastructure hurdles before mass adoption. Some companies offer holographic conferencing solutions for niche markets, with demonstrations by tech giants and startups working on holographic telepresence.
3. Both technologies hold transformative potential but require continued R&D, ecosystem development, and regulatory consideration.
4. BCIs and holographic communications hold transformative potential but also pose significant ethical and social challenges. Addressing privacy, equity, consent, and psychological impacts proactively will be key to responsible innovation that benefits society broadly.

Non-Terrestrial Networks (NTN and D2D), UAS, HAPS, and SATCOM

1. Satellite Direct-to-Device (D2D) technology is advancing rapidly with the deployment of large Low Earth Orbit (LEO) satellite constellations by companies like AST SpaceMobile, SpaceX (Starlink), OneWeb, and Amazon (Project Kuiper), offering lower latency and improved signal strength that enhance direct communication to smaller consumer devices.
2. Hybrid network solutions are emerging, integrating satellites with terrestrial cellular coverage through evolving 5G Non-Terrestrial Network (NTN) standards, enabling seamless switching between satellite and cellular signals.
3. **The FCC should evaluate the scope and regulatory implications of non-terrestrial platforms including D2D, NTNs, Unmanned Aerial Systems (UAS), High Altitude Platform Systems (HAPS), and Satellite Communications (SATCOM).**
4. **The FCC should work in coordination with the FAA and other agencies on spectrum and operational frameworks is essential to ensure safe and efficient use of these platforms within 6G ecosystems.**

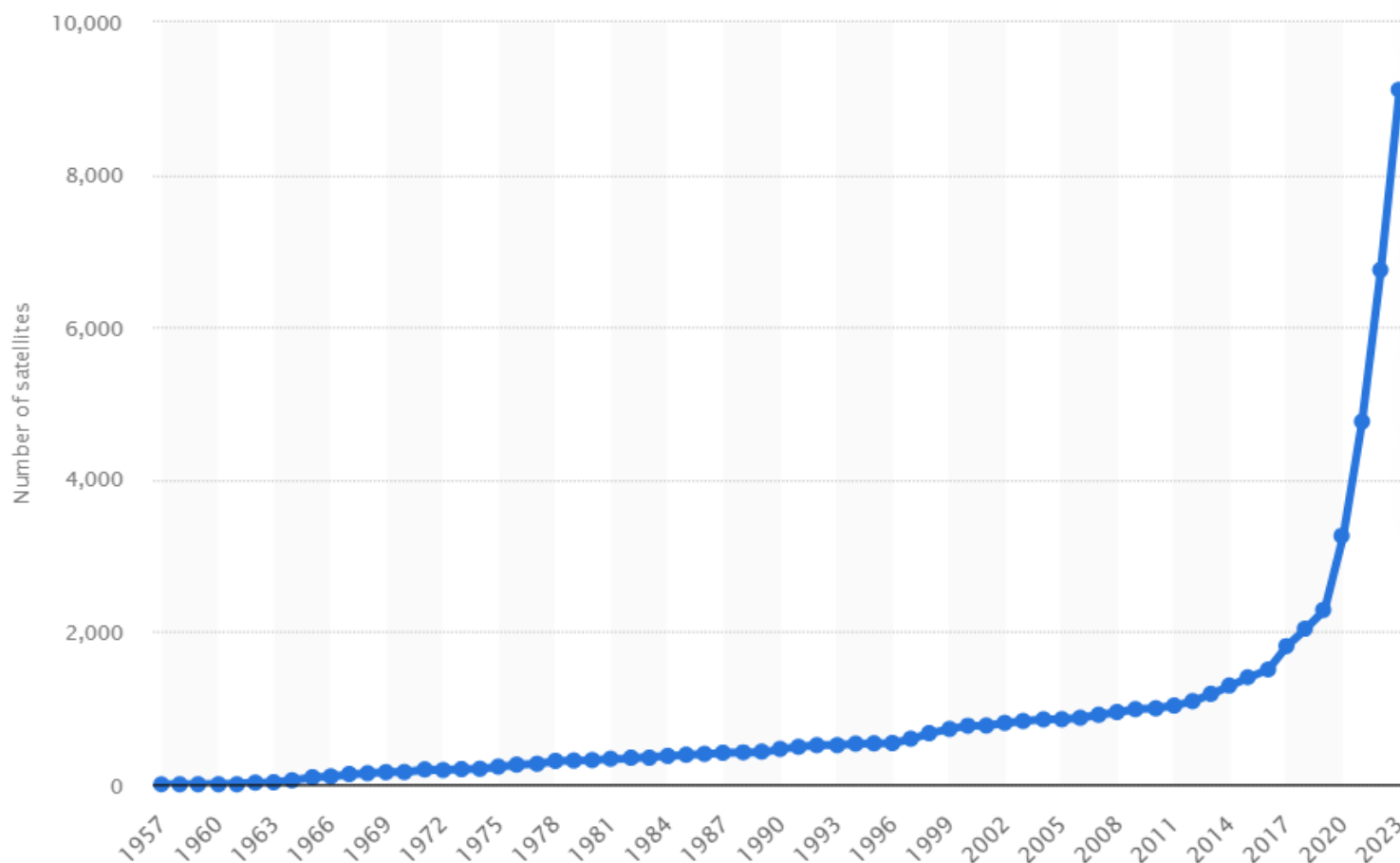
Integration with Non-3GPP Technologies

1. Trends like Multi-Radio Service Support (MRSS) and integrated terrestrial-non-terrestrial networks (TN-NTN) will play a significant role in overall connectivity strategies.
2. Coordinated policy and standardization efforts should align to maximize interoperability and spectrum efficiency.
3. Integrated Wireless Ecosystem includes Non-3GPP Wi-Fi technologies and 3GPP cellular standards (including TN and NTN) and are converging toward integrated networks that leverage the strengths of each.
4. Spectrum Sharing & Offload with MRSS and Wi-Fi offload strategies optimize spectrum use across licensed and unlicensed bands.
5. Wi-Fi 8 and 6G standardization efforts are being aligned to create complementary technologies that deliver seamless, high-performance wireless experiences.
6. TN-NTN integration extends connectivity beyond terrestrial limits, filling gaps with satellite and aerial networks.



Number of active satellites from 1957 to 2023

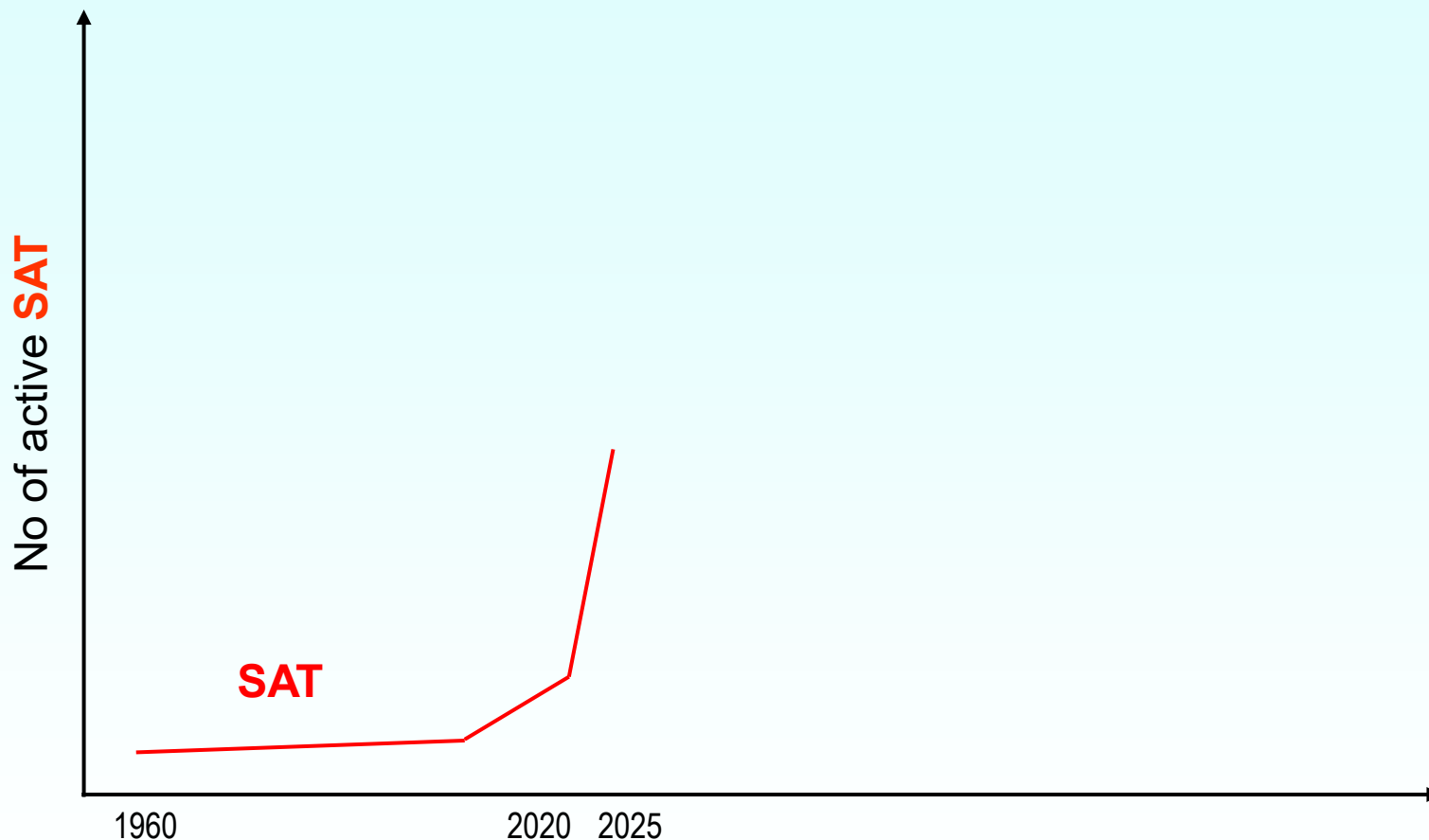
12,149 (04 May 2025)



© Statista 2025

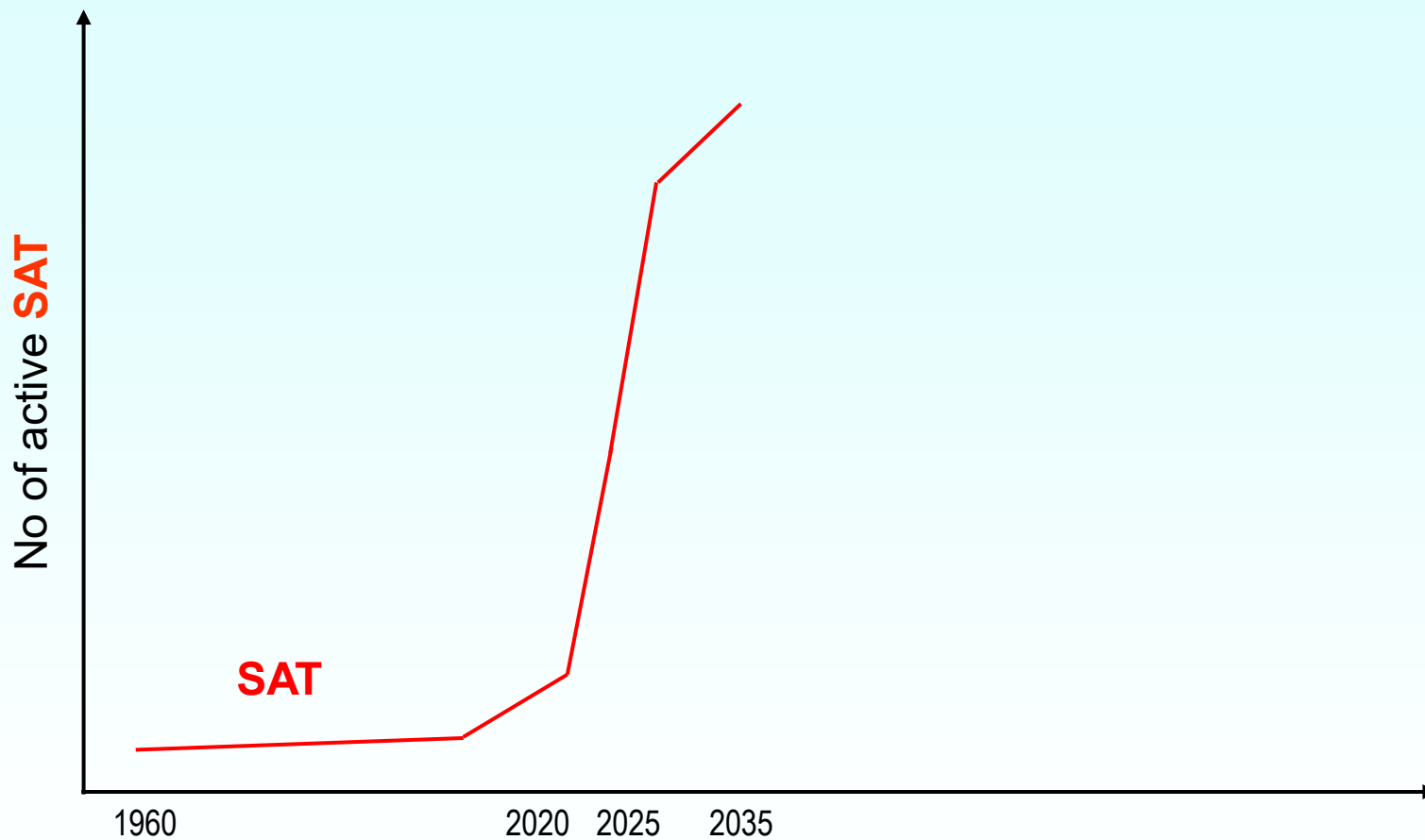


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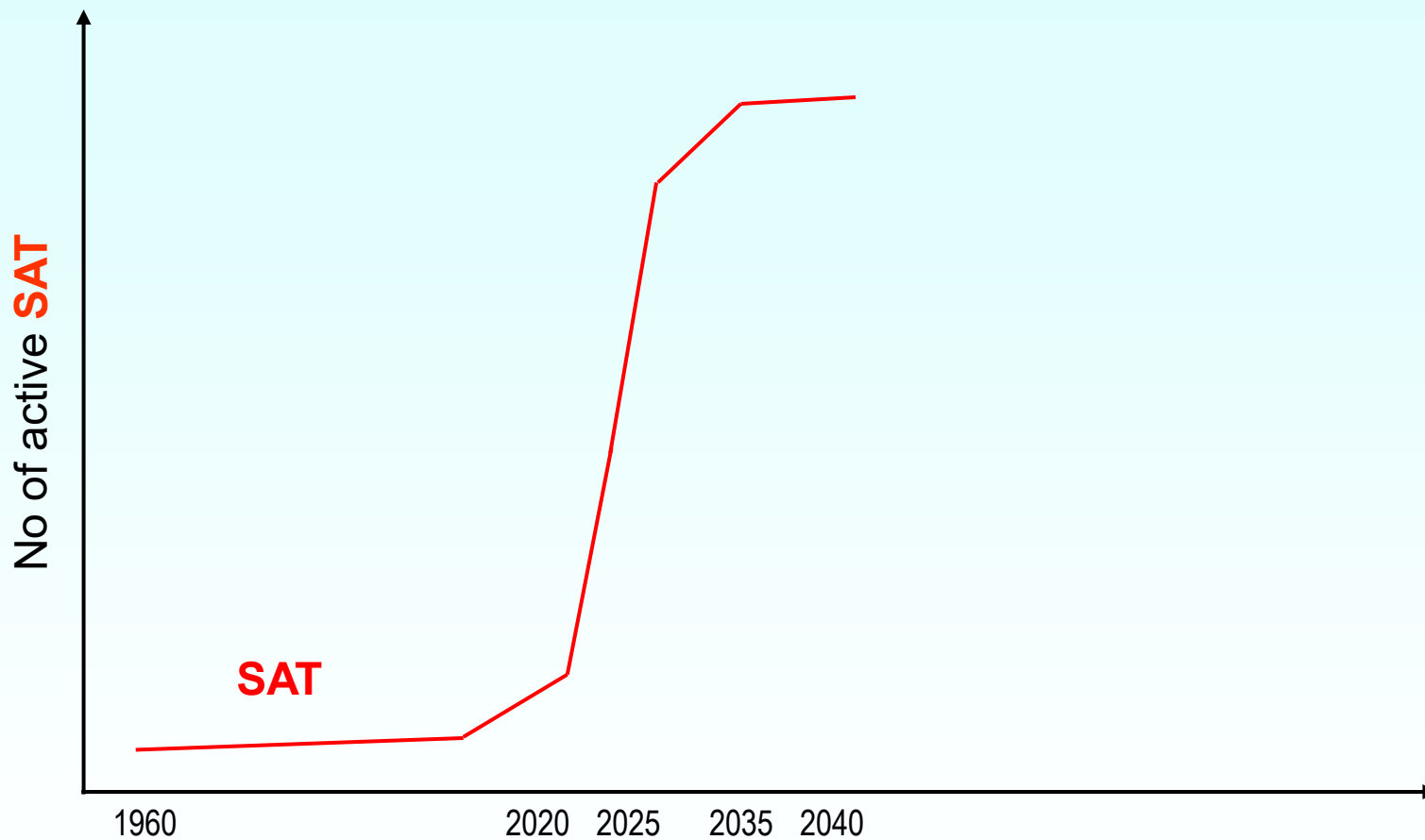


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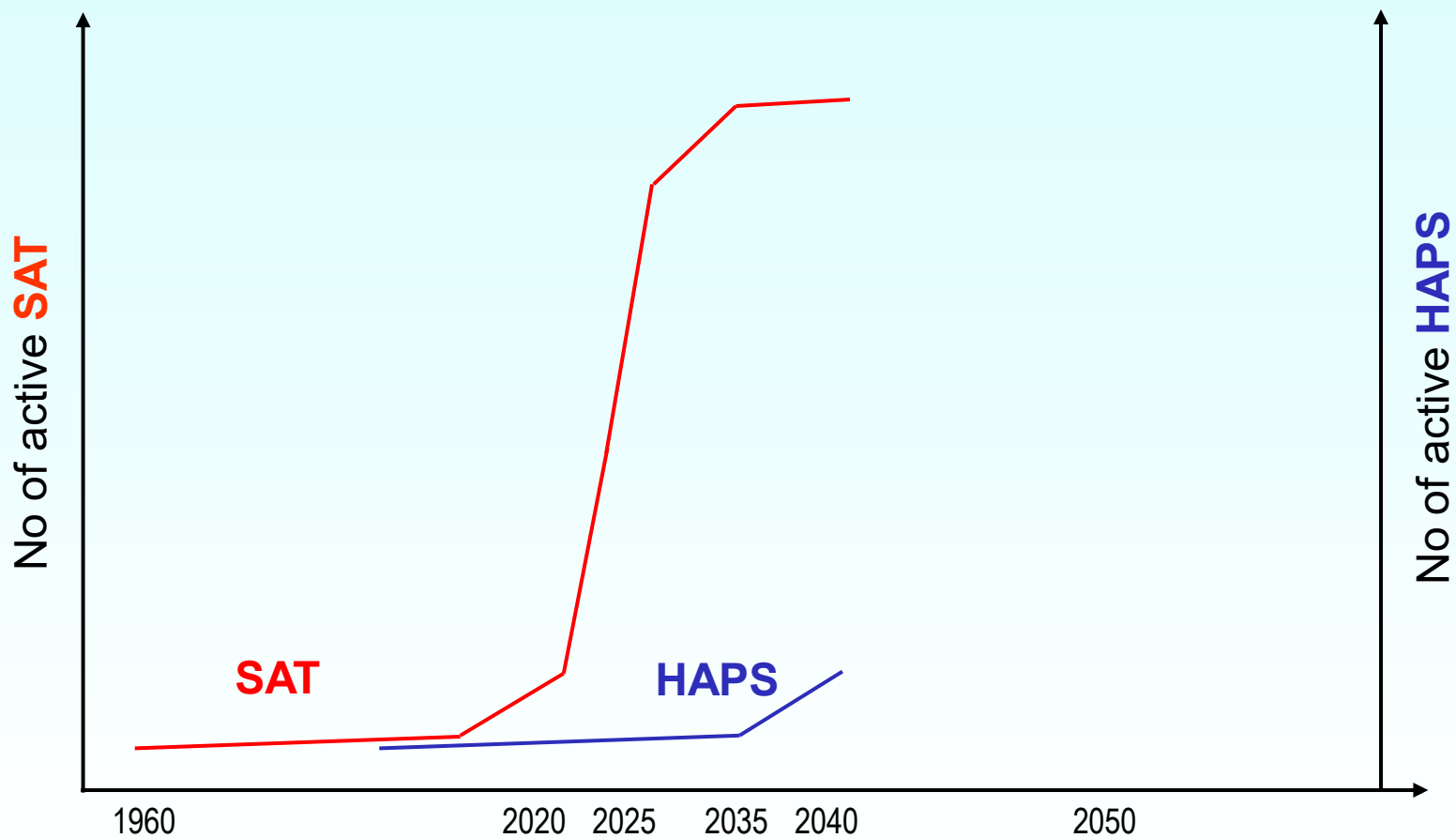


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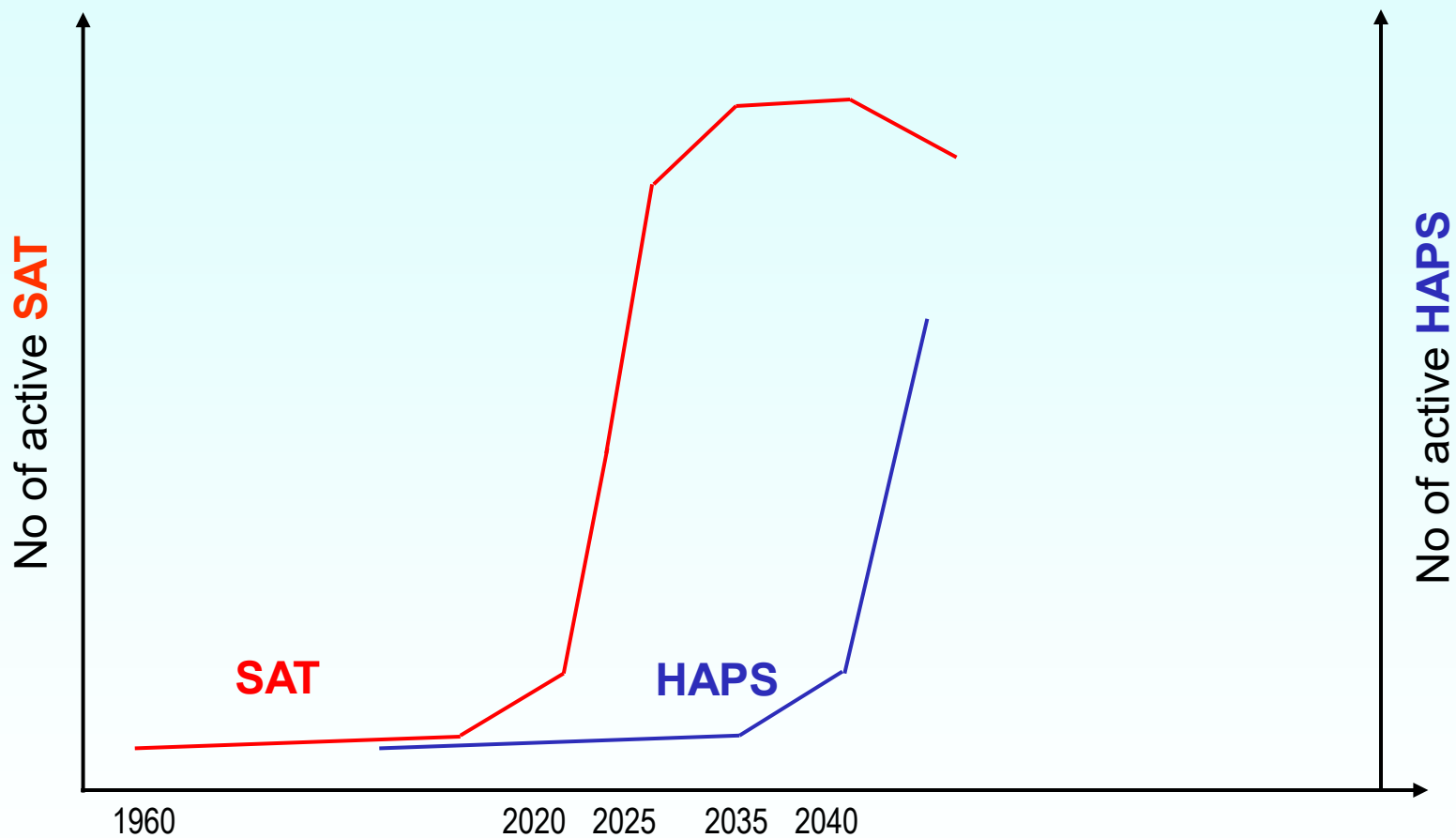


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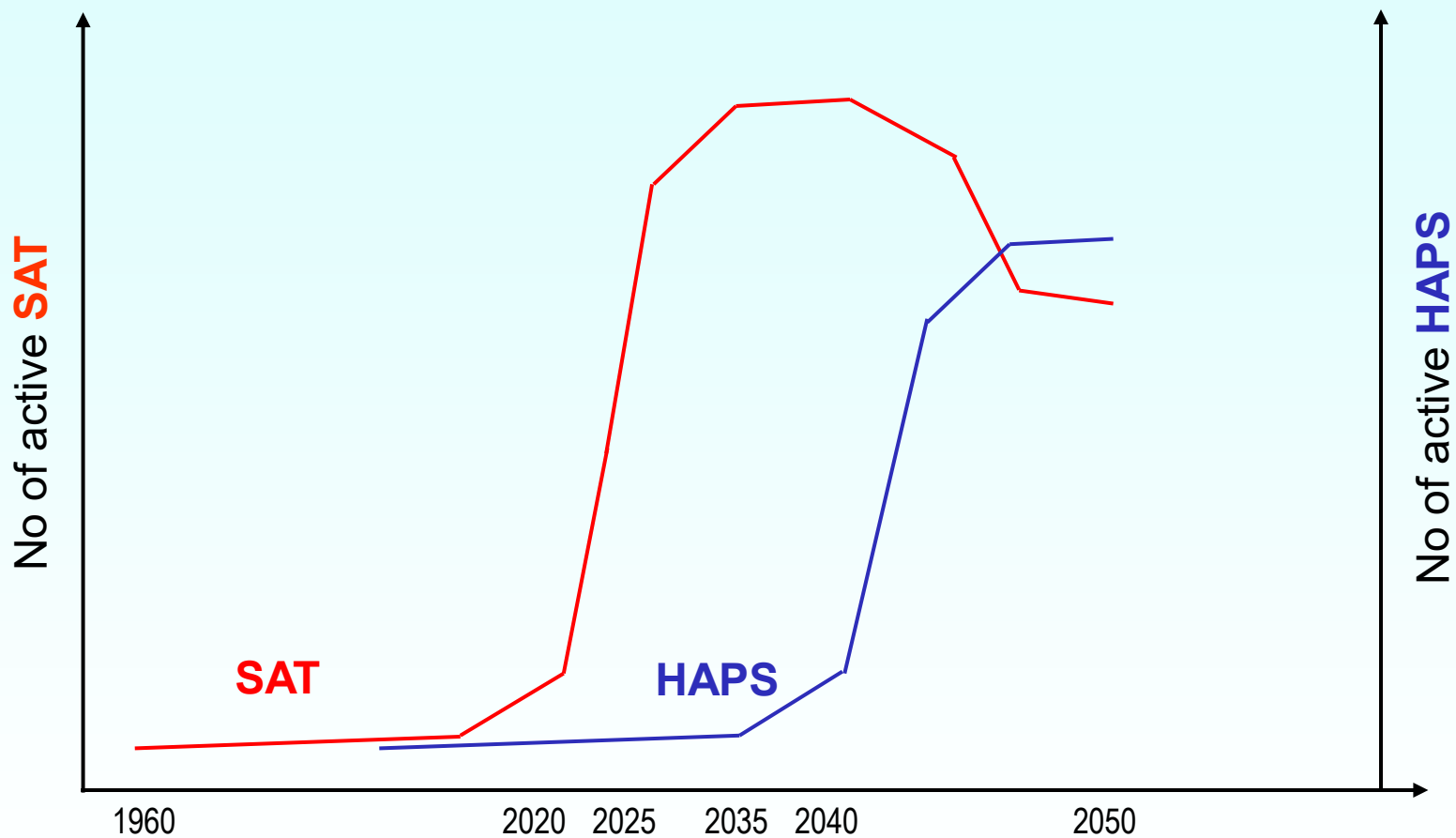


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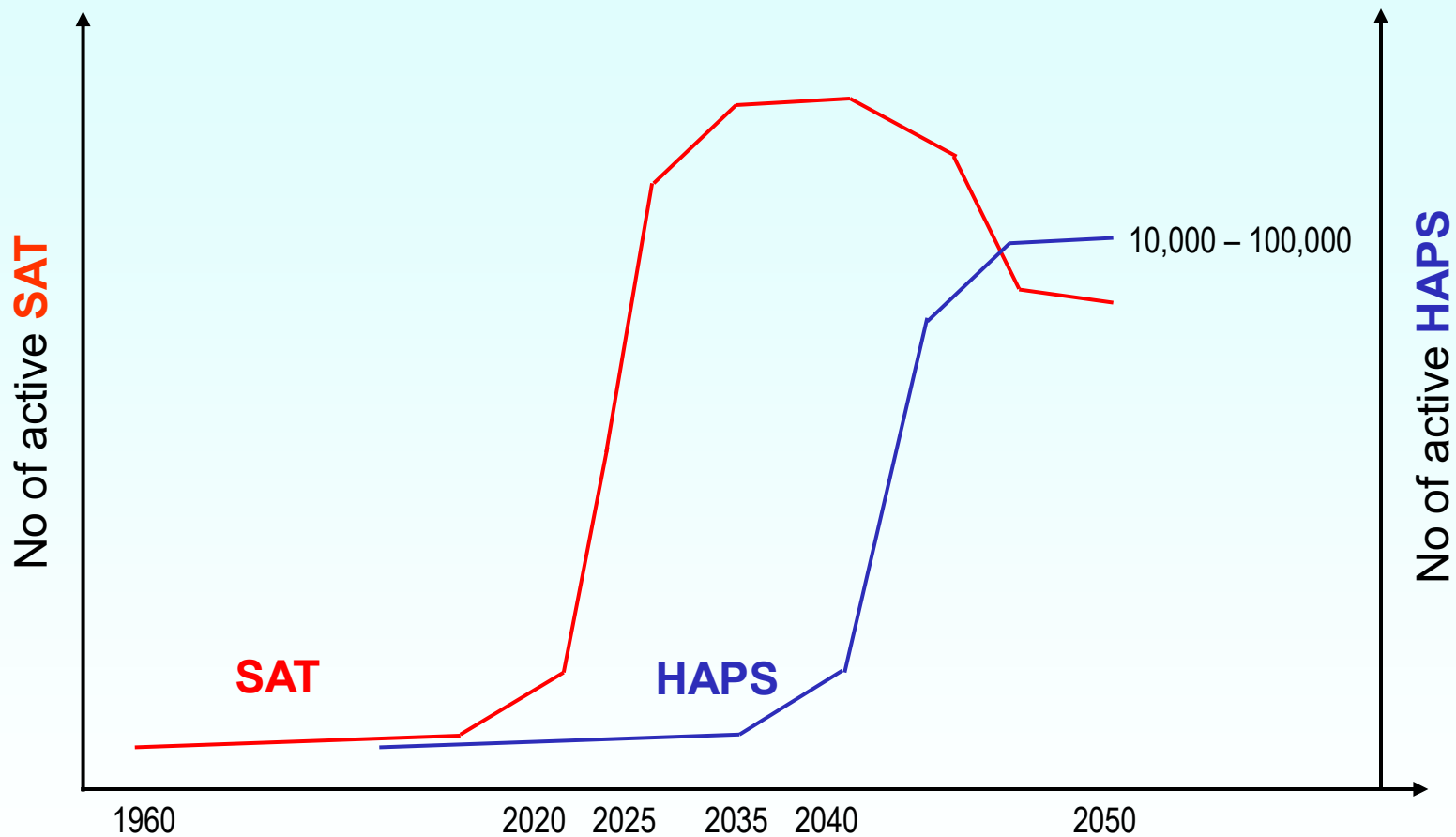


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NTN (Non-Terrestrial Networks)

- NTN is more than satellite constellations.
- Future NTN will include **HAPS** constellations in stratosphere.



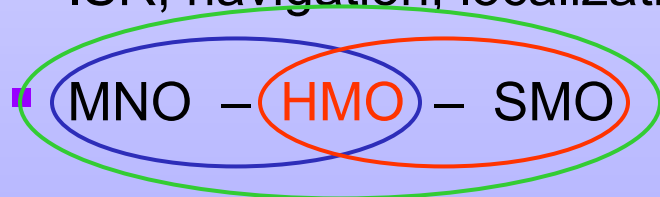
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- Not only for rural & remote coverage; unprecedented potentials in densely populated metro (urban and suburban) areas as well.
- Opportunities are very many: Connectivity, edge, computing, sensing, ISR, navigation, localization, positioning, and more.



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- MNO – **HMO** – SMO
- Multi-trillion-dollar global business.
- Will unfold progressively in the next 2-3 decades.
- **NTN** can be truly **transformative**.



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- **6G NTN**: Big ticket item with high priority.
- **ITU**: Strong, empowered, and rapidly acting.



NTN for Accelerating Canada's Ubiquitous Connectivity and Digital Future (NTN-CAN)

CFI infrastructure fund application: \$13,500,000

Universities | Government | Industry | Non-profits

Carleton
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DESIGN SOFTWARE

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The Canadian
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Engineering



L'Académie
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