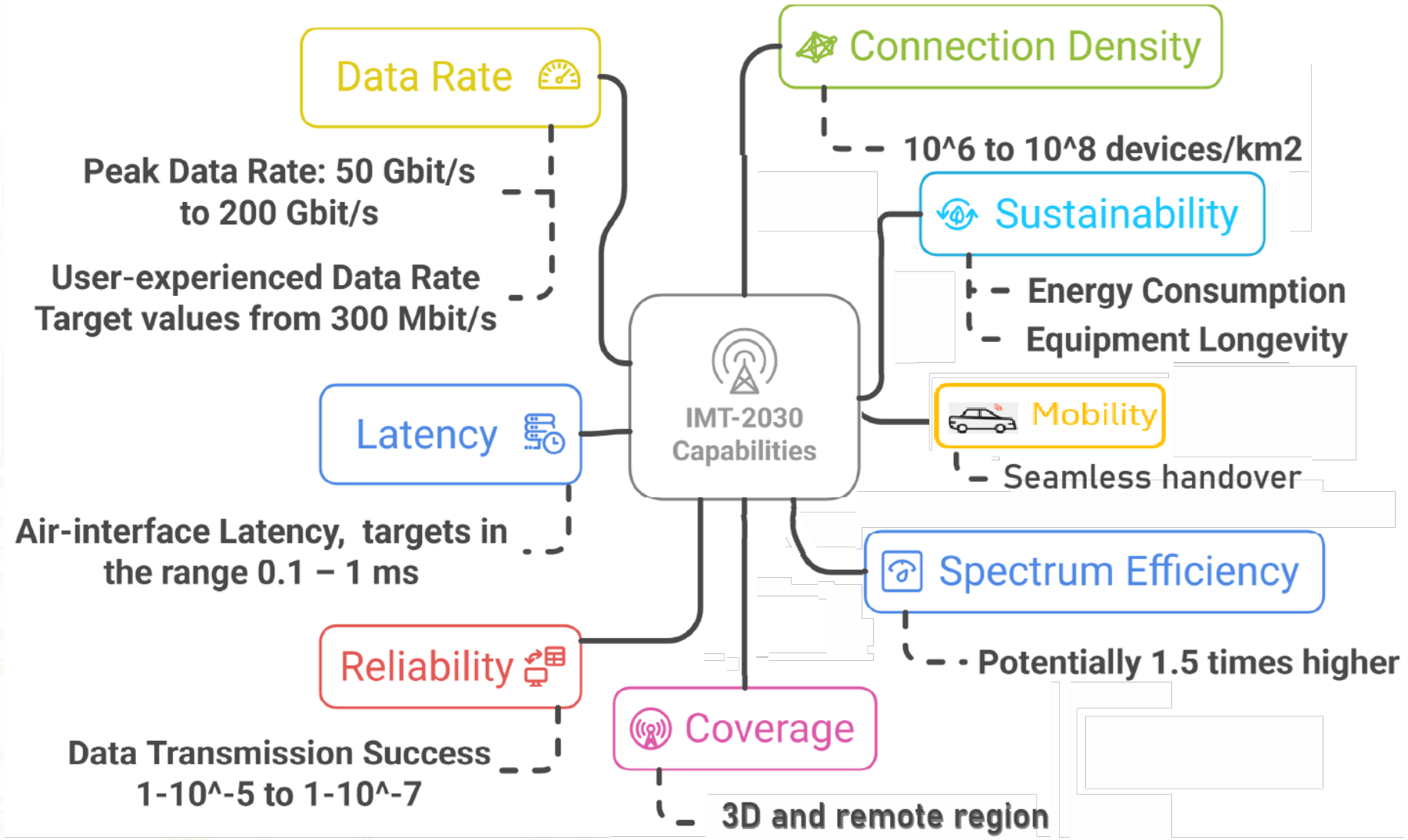
Session #4 - HAPS based connectivity– Technical Feasibility, Trials, and Market Dynamics

HAPS for 6G and Beyond Wireless Networks

by

Animesh Yadav, Ohio University, USA

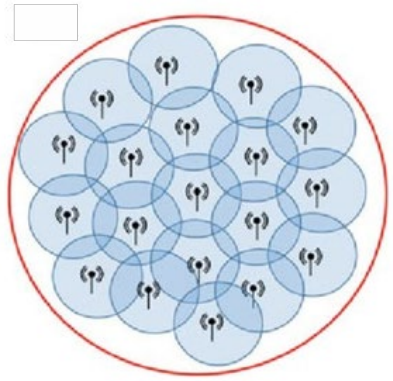
IMT-2030 Framework Key Capabilities



How to Achieve Them?

Expanding network coverage both in the air and remote region

Increasing connection density both in the air and urban region



Terrestrial cell densification

Requires significant investments and resources

The handover may not be seamless

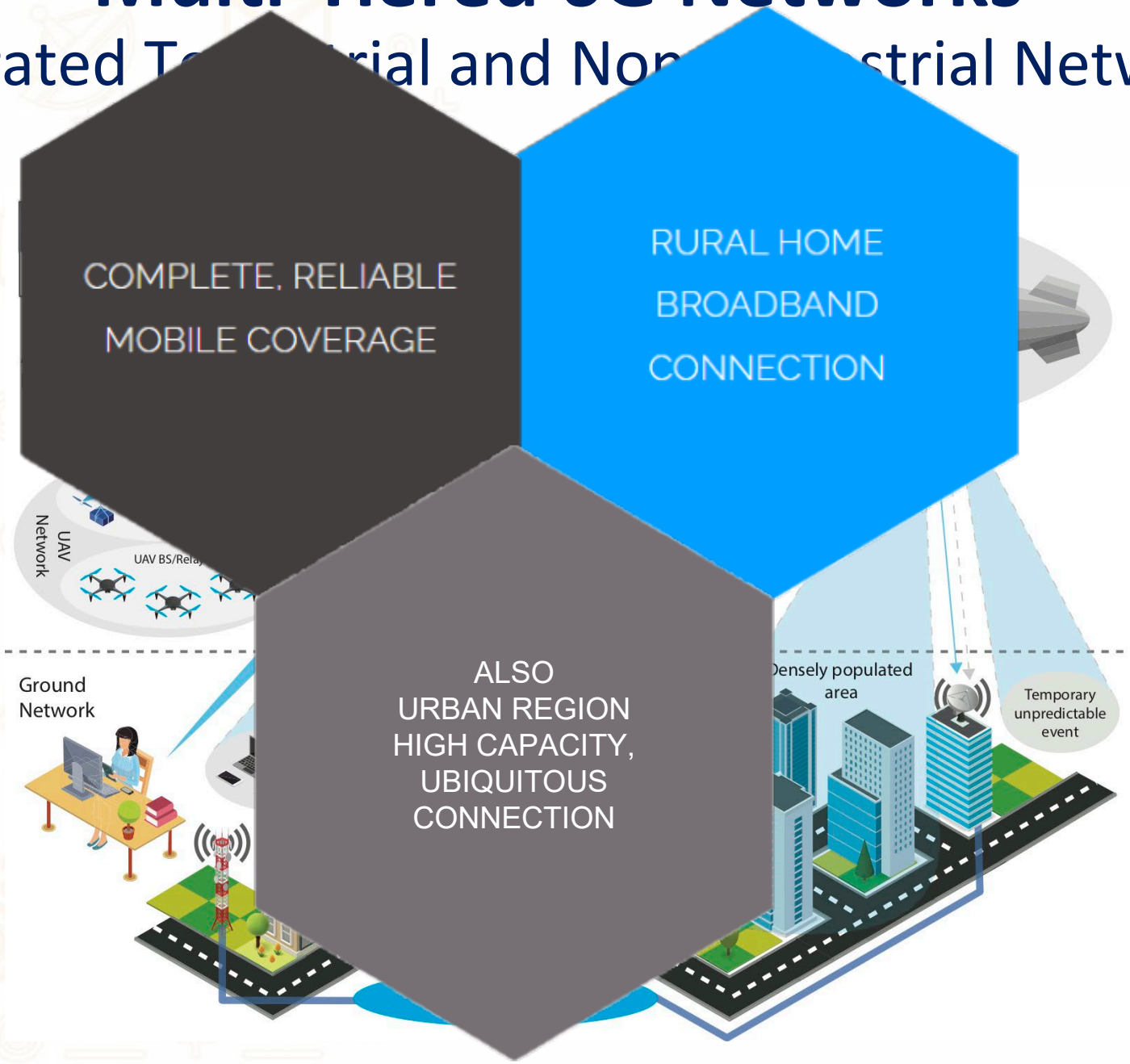
The network's sustainability is uncertain

3D coverage and connectivity are likely to be unreliable

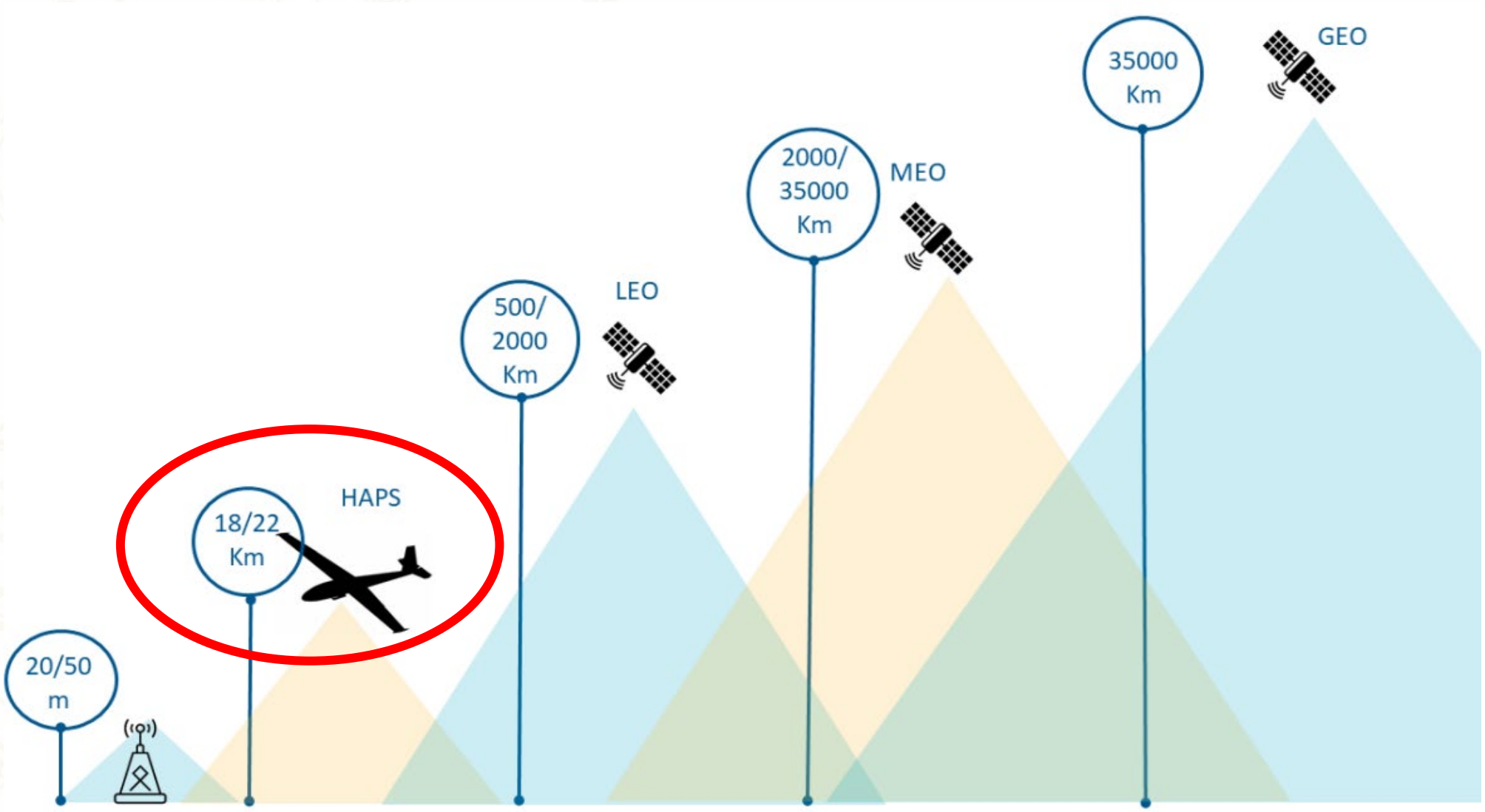
Capacity, coverage, connection, reliability, sustainability and mobility must be addressed together to meet the IMT-2030 key capabilities.

Multi-Tiered 6G Networks

Integrated Terrestrial and Non-Terrestrial Networks



Towers in Skies



HAPS

ITU 6G Definition-2023

Text proposed by WWRF (Wireless World Research Forum) to:

Annex 5.18 to ITU Working Party 5D Chairman's Report

Draft working document towards a preliminary draft new Report ITU-R M.[IMT.FUTURE TECHNOLOGY TRENDS OF TERRESTRIAL IMT SYSTEMS TOWARDS 2030 AND BEYOND]

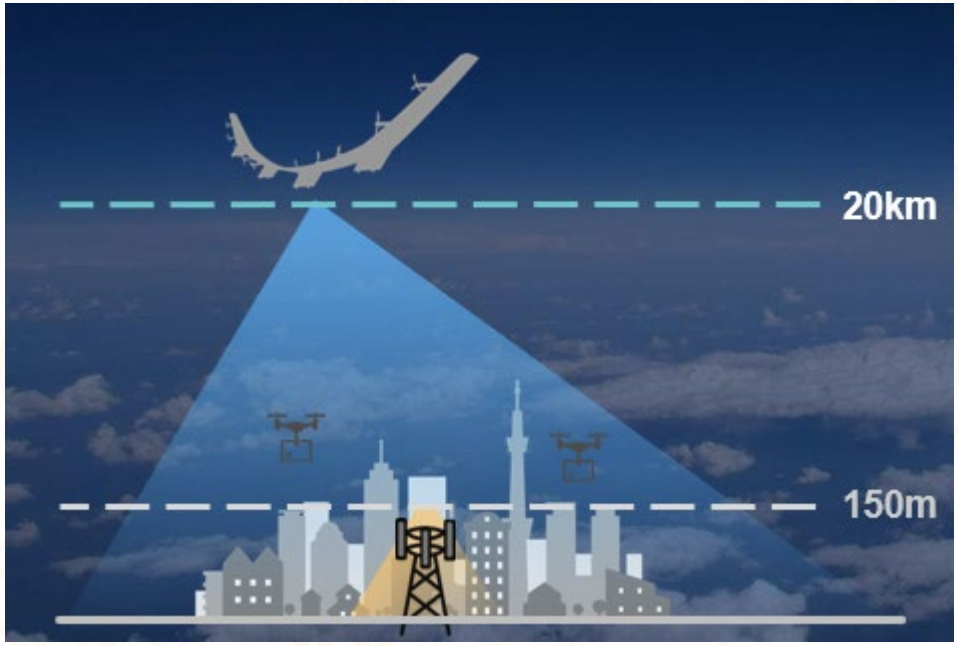
"With its bird's-eye and almost-line-of-sight view of an entire metropolitan area, a **HAPS** is more than a base station in the air; it is a new architecture paradigm with access, transport, and core network functionalities for integrated connectivity, computing, sensing, positioning, and navigation, towards enabling a variety of use-cases in an agile and green manner for smart and sustainable societies of the future."

Key Characteristics of HAPS

- Favorable channel conditions
  - Line-of-Sight link with high probability
  - Path loss same as microcell of radius 2 Kms.
- Almost geostationary positions
  - The position of a HAPS is relatively stationary (no significant Doppler shift)
- Large footprint
  - Cover almost an area of radius 200 Kms
- Large platform
  - Suitable for mMIMO and full-duplex transceiver with significantly reduced self-interference
- Low latency
- Hybrid connectivity
  - Cellular band and FSO

HAPS/HIBS Connectivity

Network coverage from the stratosphere



Connect the unconnected

High-speed Low latency

Power resilient

Direct connection with devices

Cost reduction

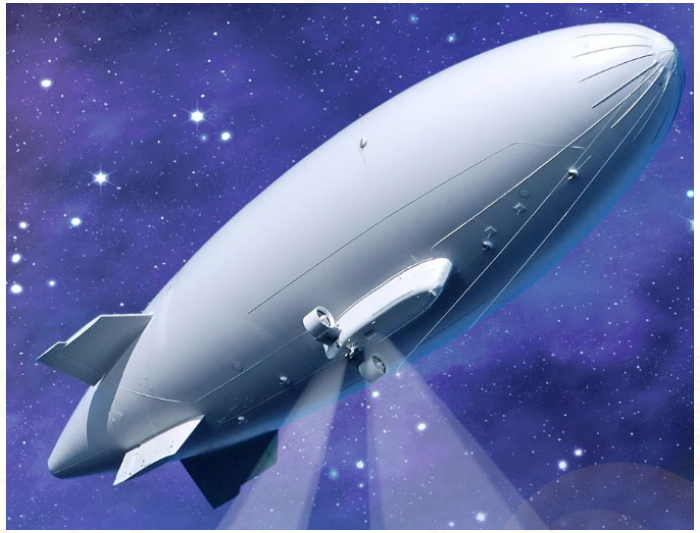
Weather resilient

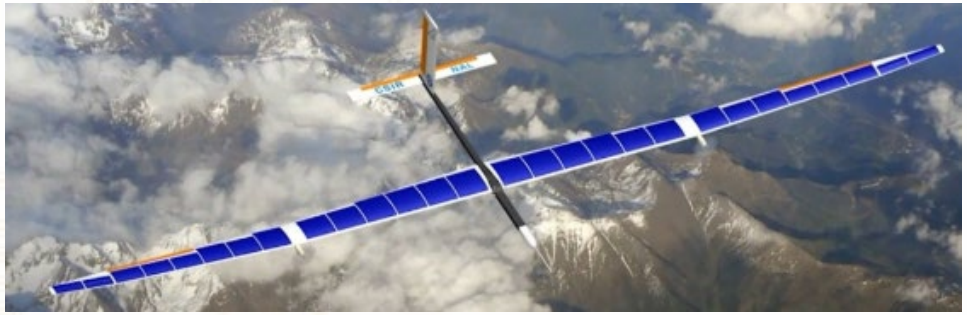
IoT connectivity

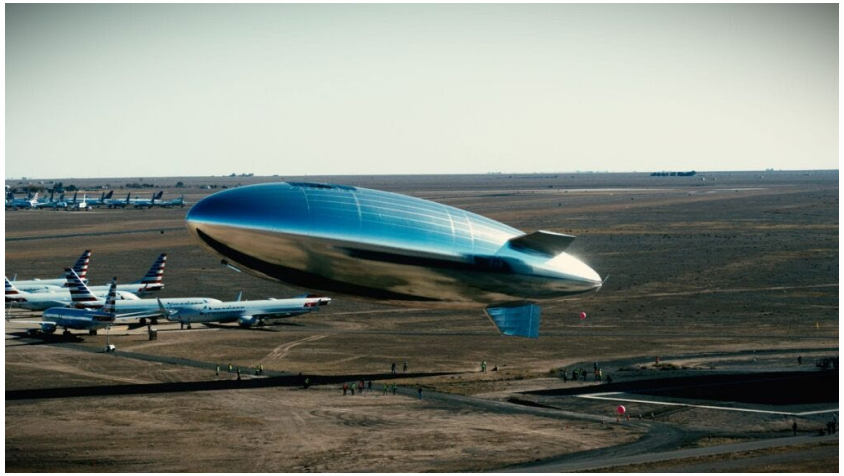
Disaster recovery

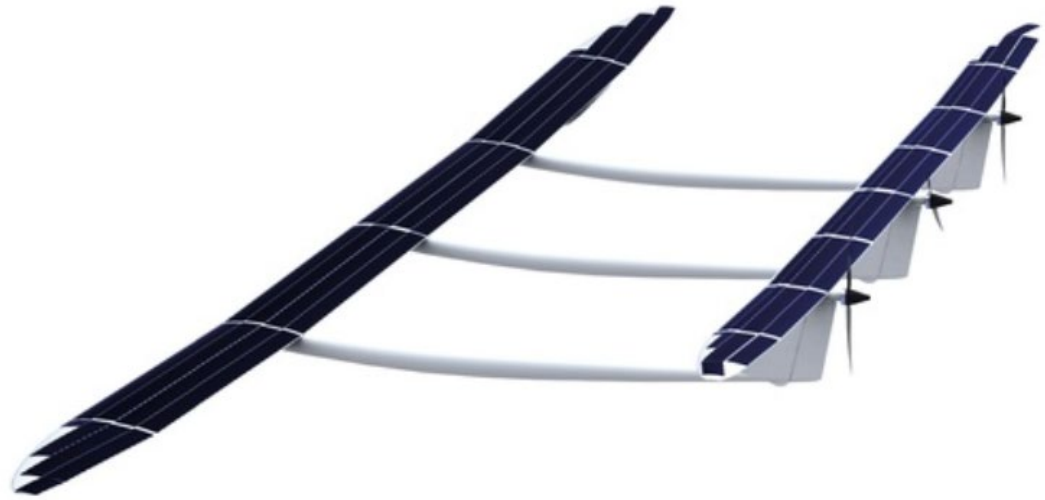
Flexible Fast activation

Shapes and Sizes of HAPS

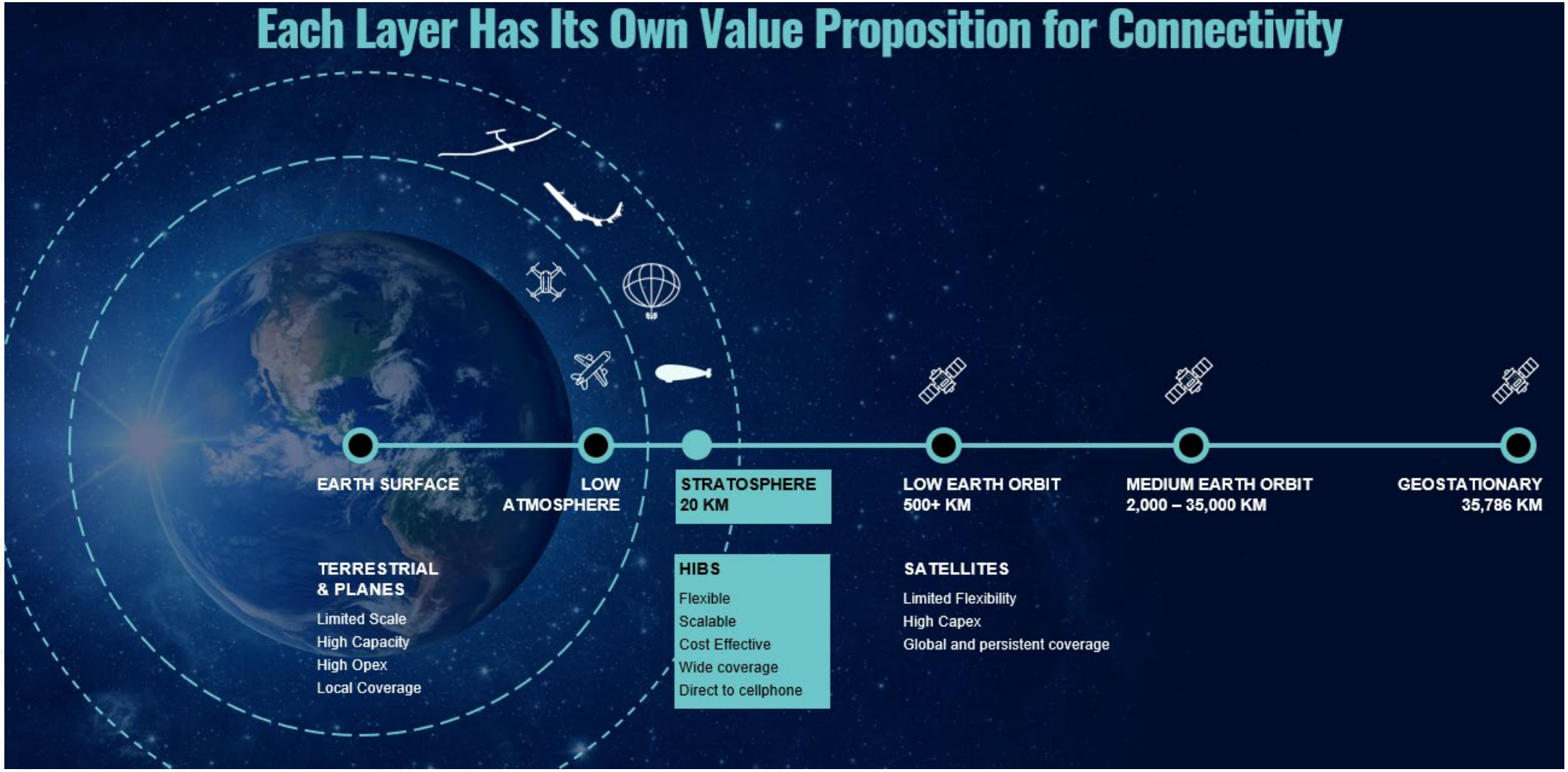




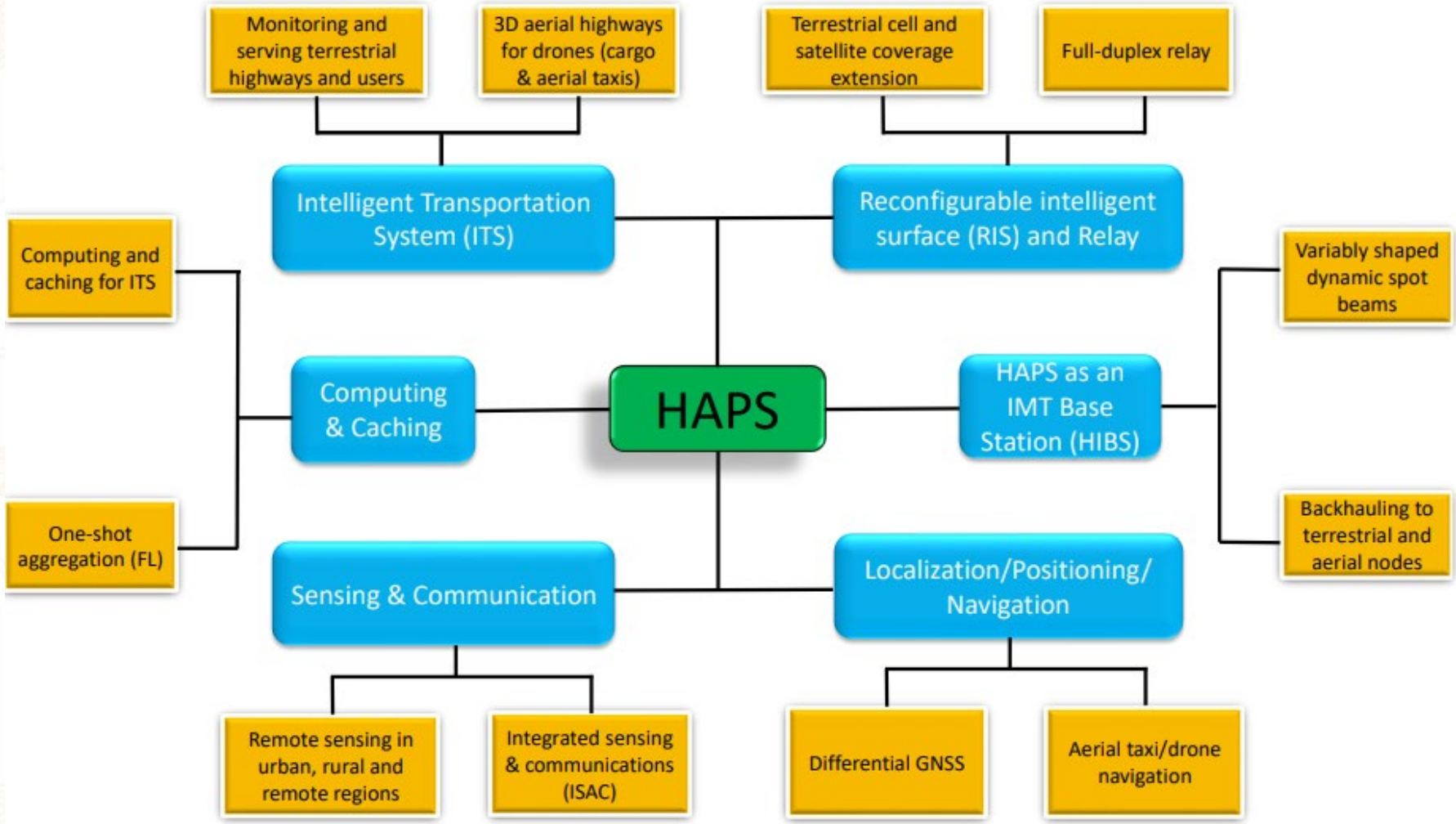




HAPS: Complementing not Competing

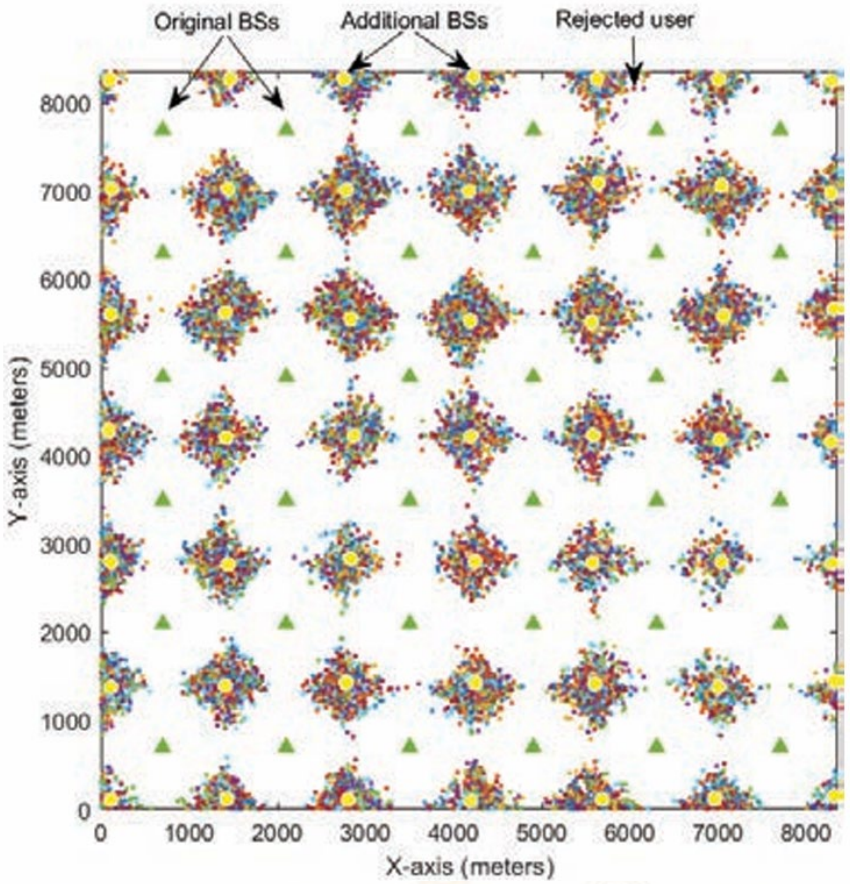


Opportunities within HAPS for 6GB Networks



[1] O. Abbasi, **A. Yadav**, H. Yanikomeroglu, N. D. Dao, G. Senarath, and P. Zhu, "HAPS for 6G Networks: Potential Use Cases, Open Challenges, and Possible Solutions", IEEE Wireless Communication, no. 3, vol. 31, June 2024

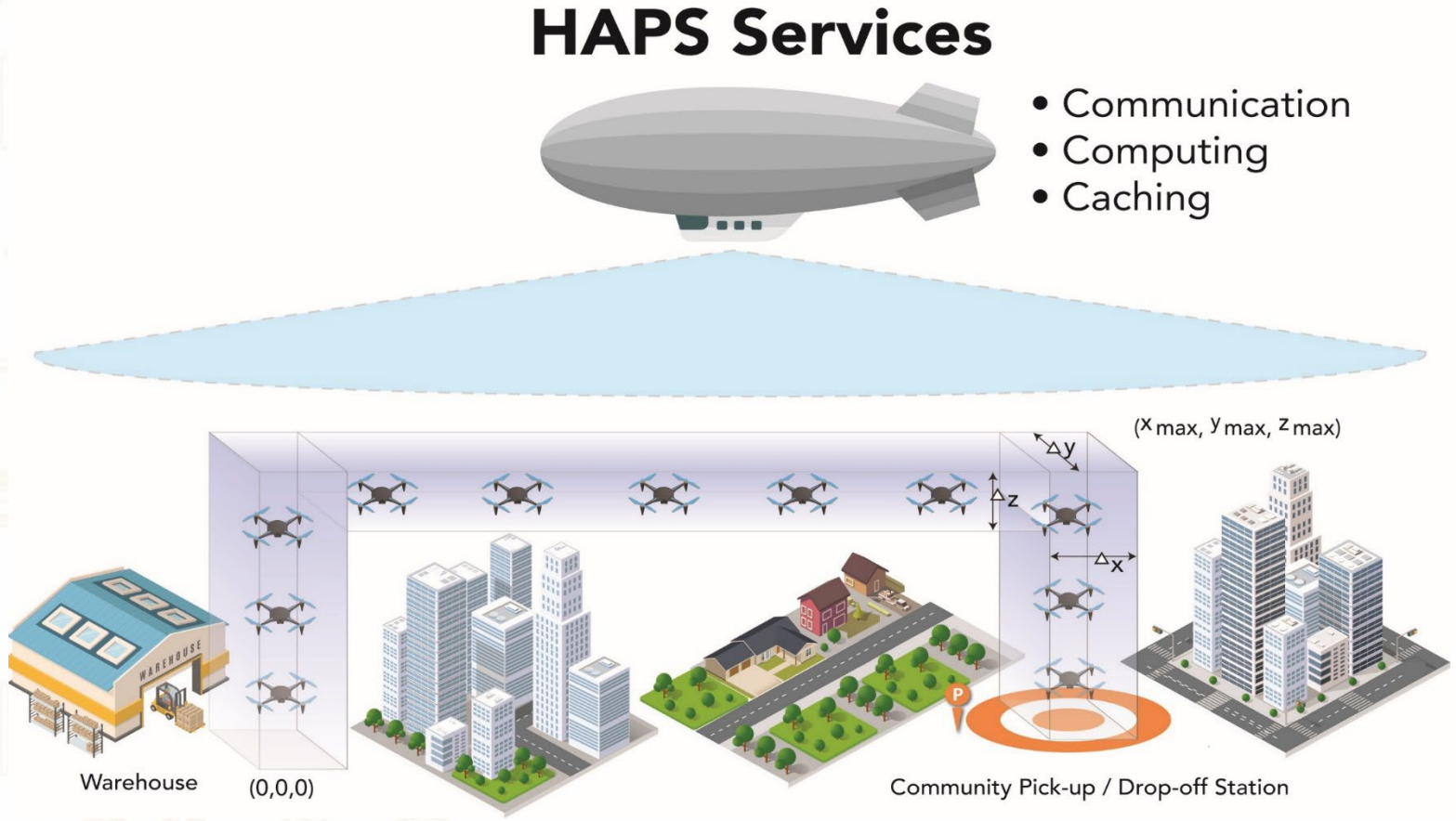
Sustainable Networks with HAPS



Feature	HAPS-assisted Network	Densified Terrestrial Network
Available Capacity	38 Gb/s (36 Gb/s terrestrial + 2 Gb/s HAPS)	85 Gb/s
Proportion of Users Served	100%	100%
Capacity Utilization	71.2%	31.3%
Network Power Consumption	140.6 kW	314.5 kW

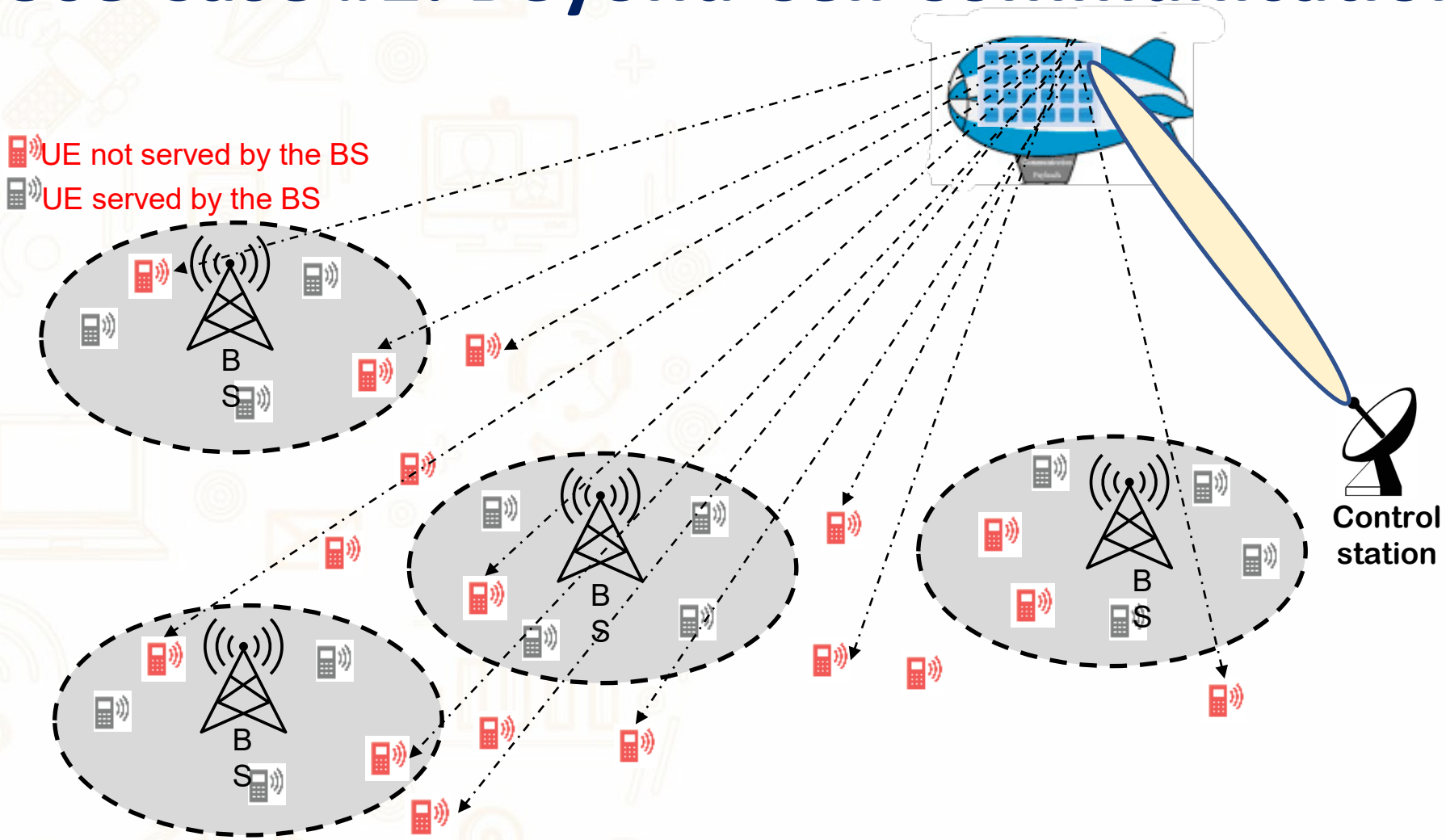
[2] C.E. Kement, F. Kara, W. Jaafar, H. Yanikomeroglu, N. D. Dao, G. Senarath, and P. Zhu, "Sustaining Dynamic Traffic in Dense Urban Areas with High Altitude Platform Stations (HAPS)", IEEE Communications Magazine, no.73, vol. 61, July 2023

Use Case #1: HAPS for 3D Aerial Highways



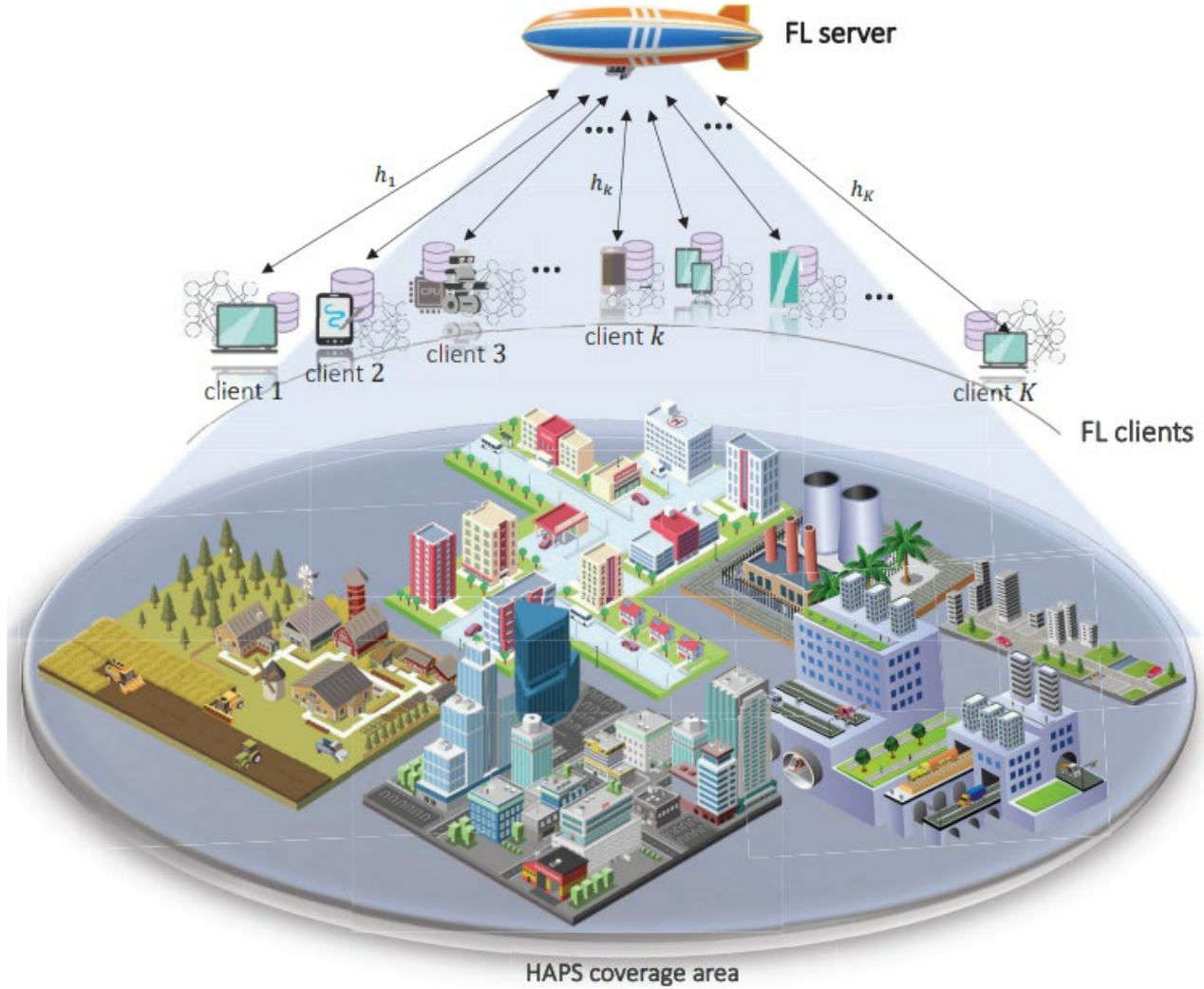
[3] N. Cherif, W. Jaafar, H. Yanikomeroglu, and A. Yongacoglu, "3D Aerial Highway: The Key Enabler of the Retail Industry Transformation", IEEE Communications Magazine, vol. 59, no. 9, pp. 65-71, Sep. 2021.

Use Case #2: Beyond Cell Communications



[4] S. Alfattani, **A. Yadav**, H. Yanikomeroglu, and A. Yongacoglu, "Resource-efficient HAPS-RIS enabled beyond-cell communications", IEEE Wireless Commun. Lett., vol. 12, no. 4, pp. 679-683, Jan. 2023.
[5] S. Alfattani, **A. Yadav**, H. Yanikomeroglu, and A. Yongacoglu, "Beyond-Cell Communications via HAPS-RIS", in Proc. of IEEE Globecom 2022, Rio de Janeiro, Brazil, 4–8, December 2022.

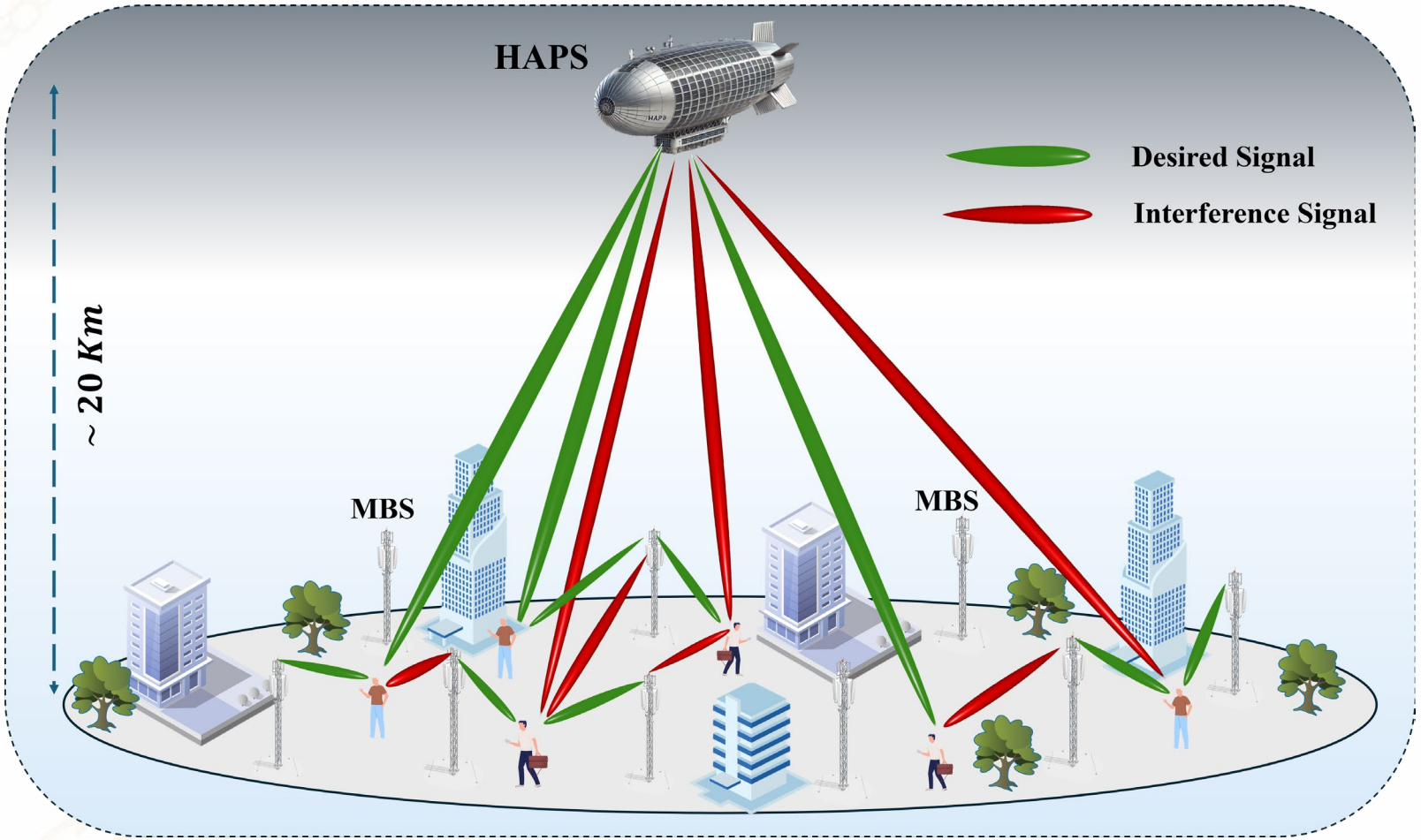
Use Case #3: Federated Learning in Stratosphere



[6] A. Farajadeh, **A. Yadav**, O. Abbasi, W. Jaffar and H. Yanikomeroglu, "FLSTRA: Federated learning in stratosphere", IEEE Transactions on Wireless Communications, no. 2, vol. 23 Feb. 2024.

Use Case #4: Handling Interference

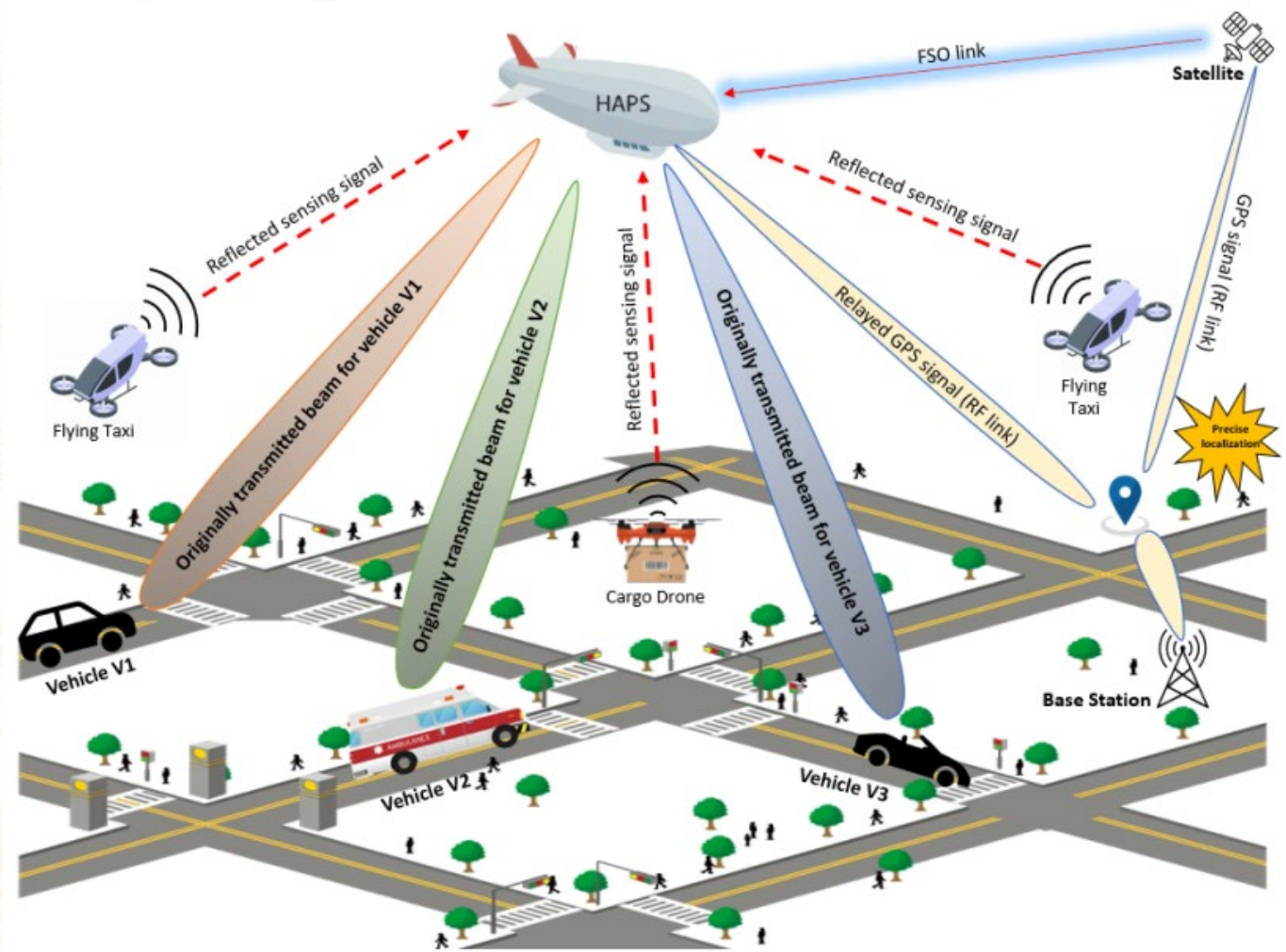
Large-scale Networks



[7] A. A. Shamsabadi, **A Yadav**, and H. Yanikomeroglu, "Two-Level Distributed Interference Management for Large-Scale HAPS-Empowered vHetNets", IEEE Transactions on Wireless Commun. June 2026 **(Accepted)**

Research in Pipeline

Integrated Sensing and Communications



Thank You