Intelligent Transportation Systems

Connectivity Perspective & Vision

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HISTORY OF INTELLIGENT TRANSPORTATION SYSTEMS

2023 Update

U.S. Department of Transportation

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U.S. DEPARTMENT OF TRANSPORTATION
INTELLIGENT TRANSPORTATION SYSTEMS JOINT PROGRAM OFFICE

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ITS revolution in the next decade (?)

CAV: Connected and Autonomous Vehicles

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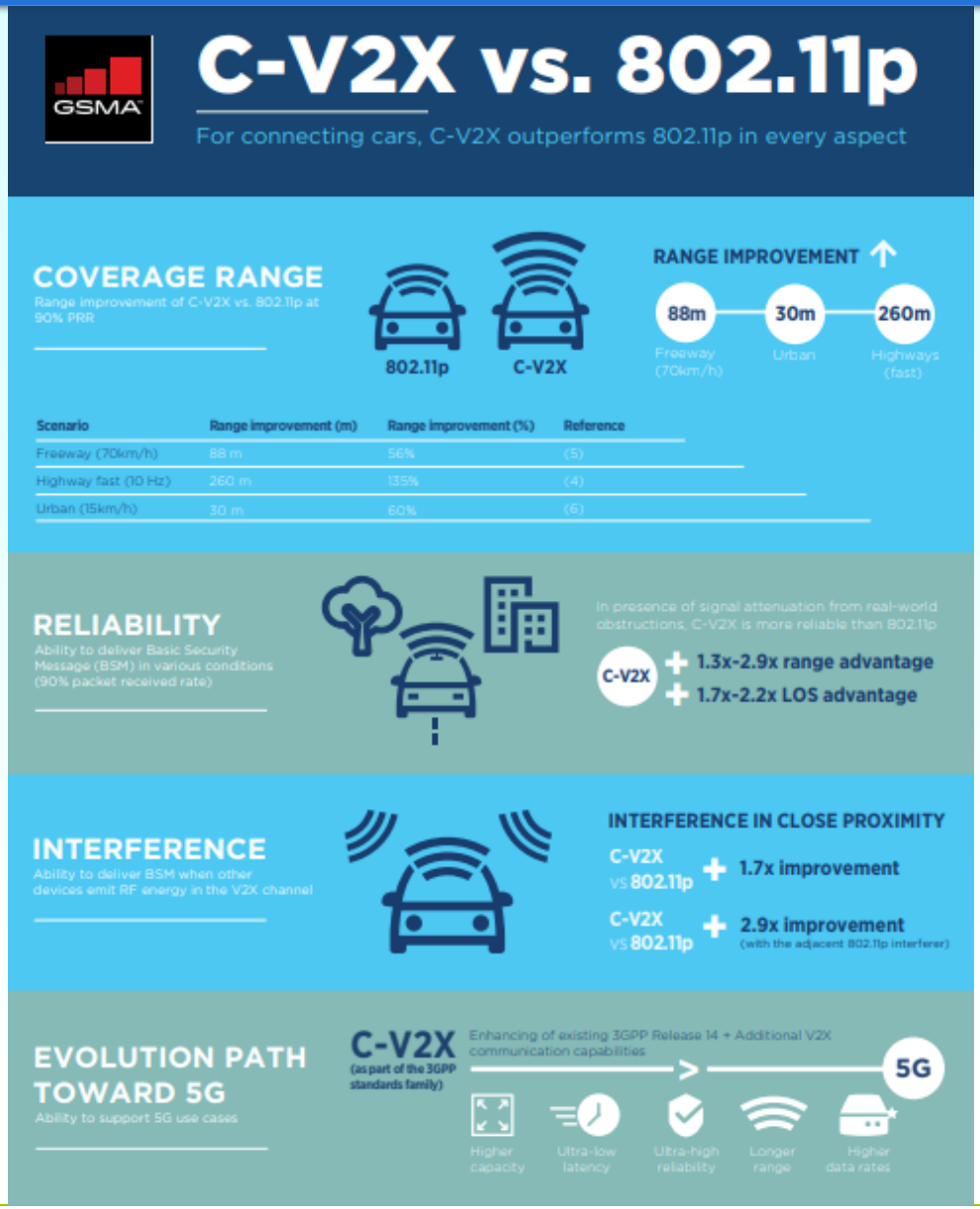

GSMA
C-V2X vs. 802.11p
For connecting cars, C-V2X outperforms 802.11p in every aspect
COVERAGE RANGE
Range improvement of C-V2X vs. 802.11p at 90% PRR
802.11p
C-V2X
RANGE IMPROVEMENT
88m
Freeway (70km/h)
30m
Urban
260m
Highways (fast)
Scenario | Range improvement (m) | Range improvement (%) | Reference
Freeway (70km/h) | 88 m | 56% | (5)
Highway fast (10 Hz) | 260 m | 135% | (4)
Urban (15km/h) | 30 m | 60% | (6)
RELIABILITY
Ability to deliver Basic Security Message (BSM) in various conditions (90% packet received rate)
In presence of signal attenuation from real-world obstructions, C-V2X is more reliable than 802.11p
C-V2X
1.3x-2.9x range advantage
1.7x-2.2x LOS advantage
INTERFERENCE
Ability to deliver BSM when other devices emit RF energy in the V2X channel
INTERFERENCE IN CLOSE PROXIMITY
C-V2X vs 802.11p
1.7x improvement
C-V2X vs 802.11p
2.9x improvement
(with the adjacent 802.11p interferer)
EVOLUTION PATH TOWARD 5G
Ability to support 5G use cases
C-V2X
(as part of the 3GPP standards family)
Enhancing of existing 3GPP Release 14 + Additional V2X communication capabilities
5G
Higher capacity
Ultra-low latency
Ultra-high reliability
Longer range
Higher data rates

Wi-Fi 7 | In-vehicle Access Point

5G and Vertical Industries (2015)

2G → 3G → 4G: rate

4G → 5G: rate, reliability, latency, density

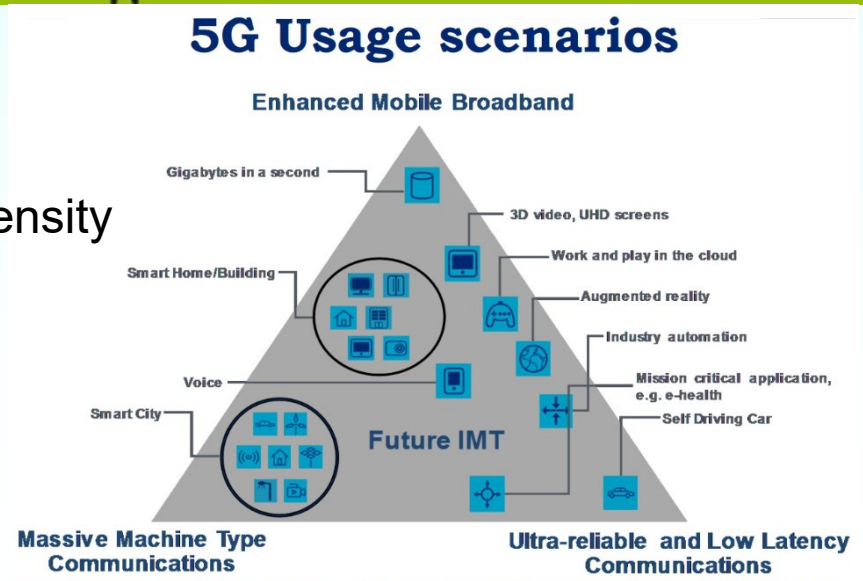


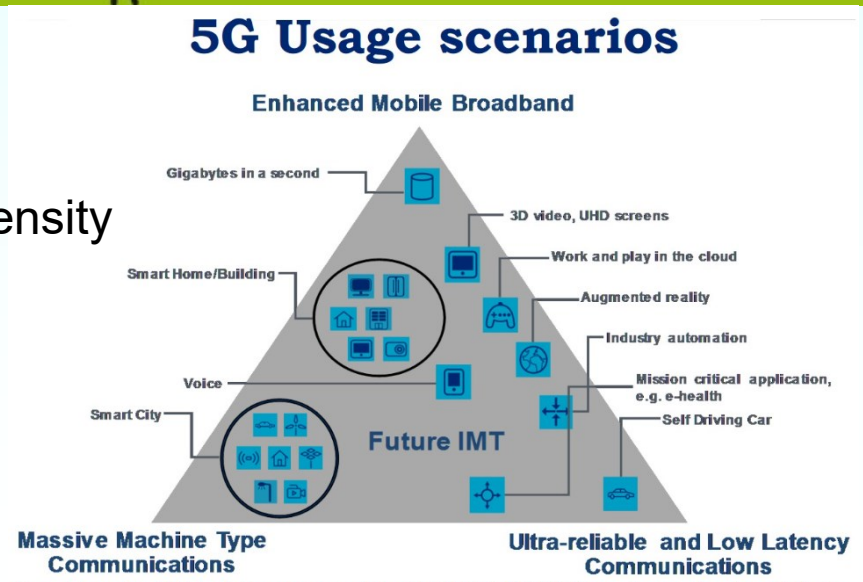
Figure 1. The original 5G triangle, from Recommendation ITU-R M.2083 [ITU-R, IMT Vision—Framework and overall objectives of the future development of IMT for 2020 and beyond]. Recommendation ITU-R M.2083, September 2015, https://www.itu.int/rec/R-REC-M.2083/en]

5G and Vertical Industries (2015)

2G → 3G → 4G: rate

4G → 5G: rate, reliability, latency, density

Failed predictions
- Adoption of vertical paradigms
- Non-ICT related barriers
- Coverage
- Hype



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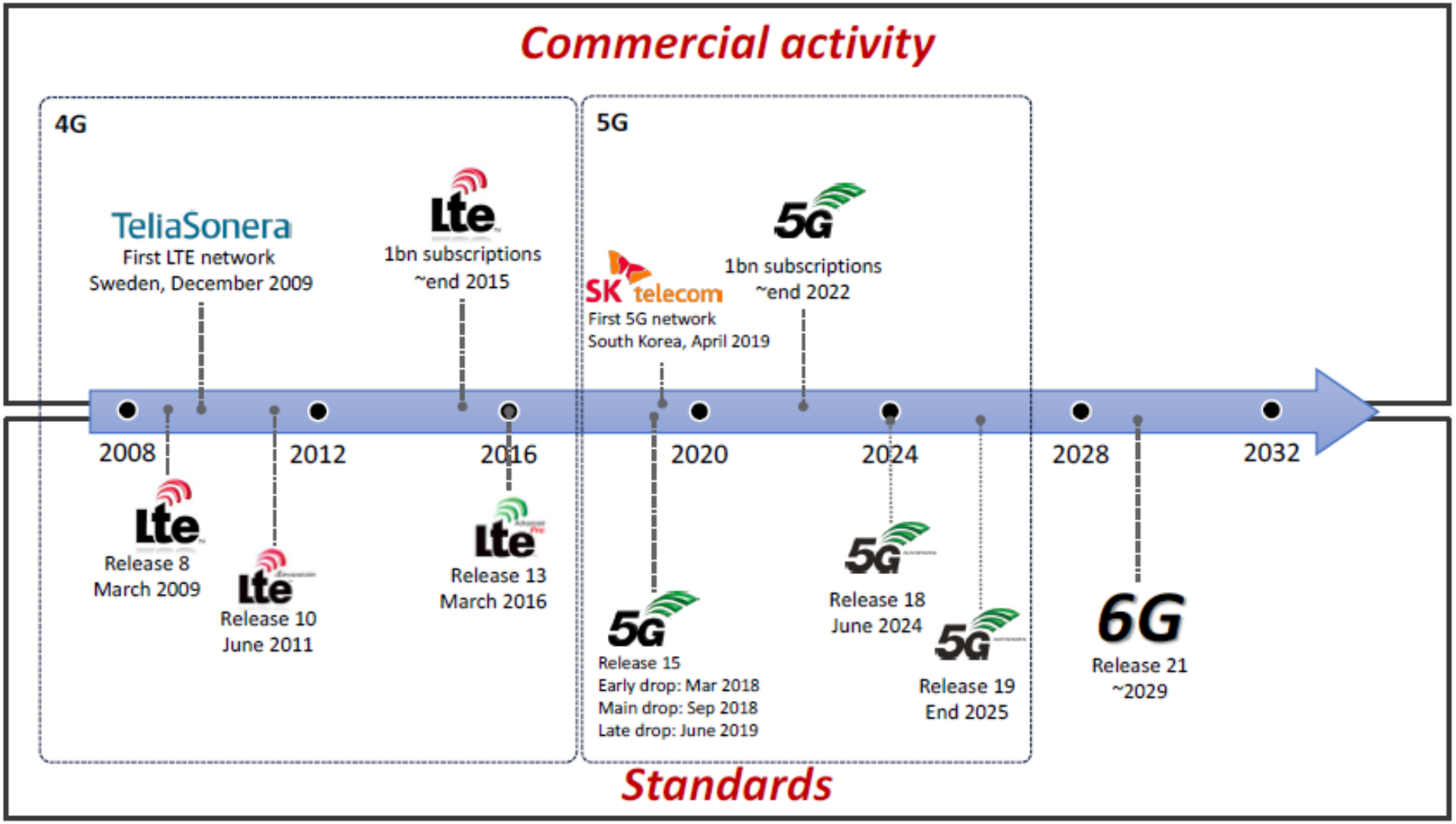
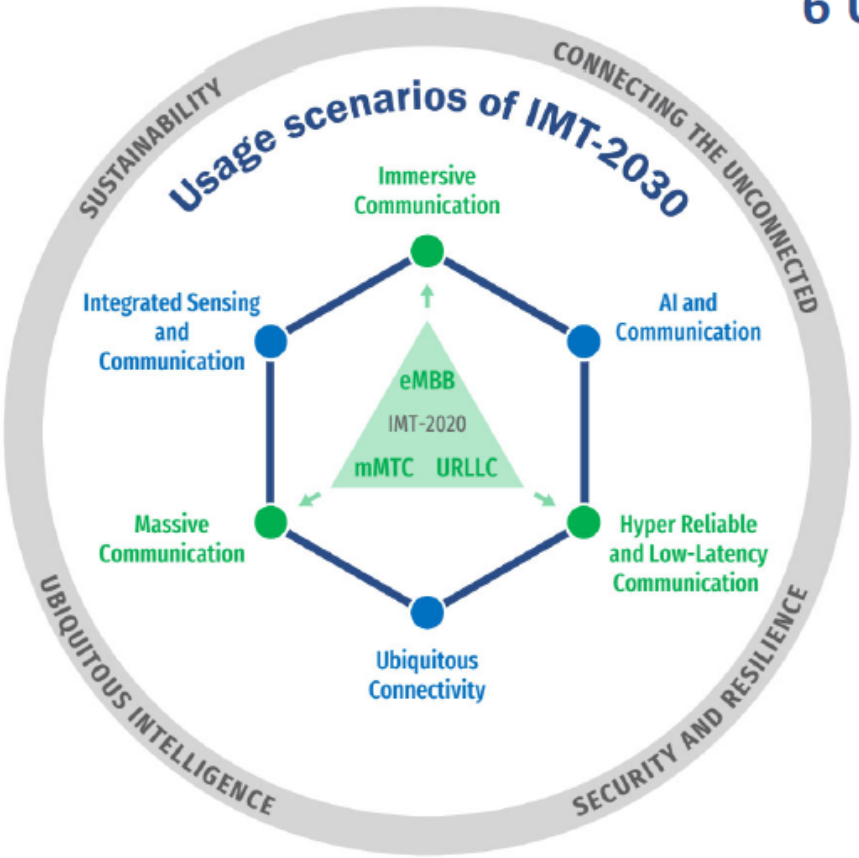
6G Timeline

(Source: ABI Research)



Usage scenarios



So called "Wheel diagram"
Source: Document 5/131 and edited in SG 5

6 Usage scenarios

Extension from IMT-2020 (5G)

- eMBB ➡ Immersive Communication
- mMTC ➡ Massive Communication
- URLLC ➡ HRLLC (Hyper Reliable & Low-Latency Communication)

New

- Ubiquitous Connectivity
- AI and Communication
- Integrated Sensing and Communication

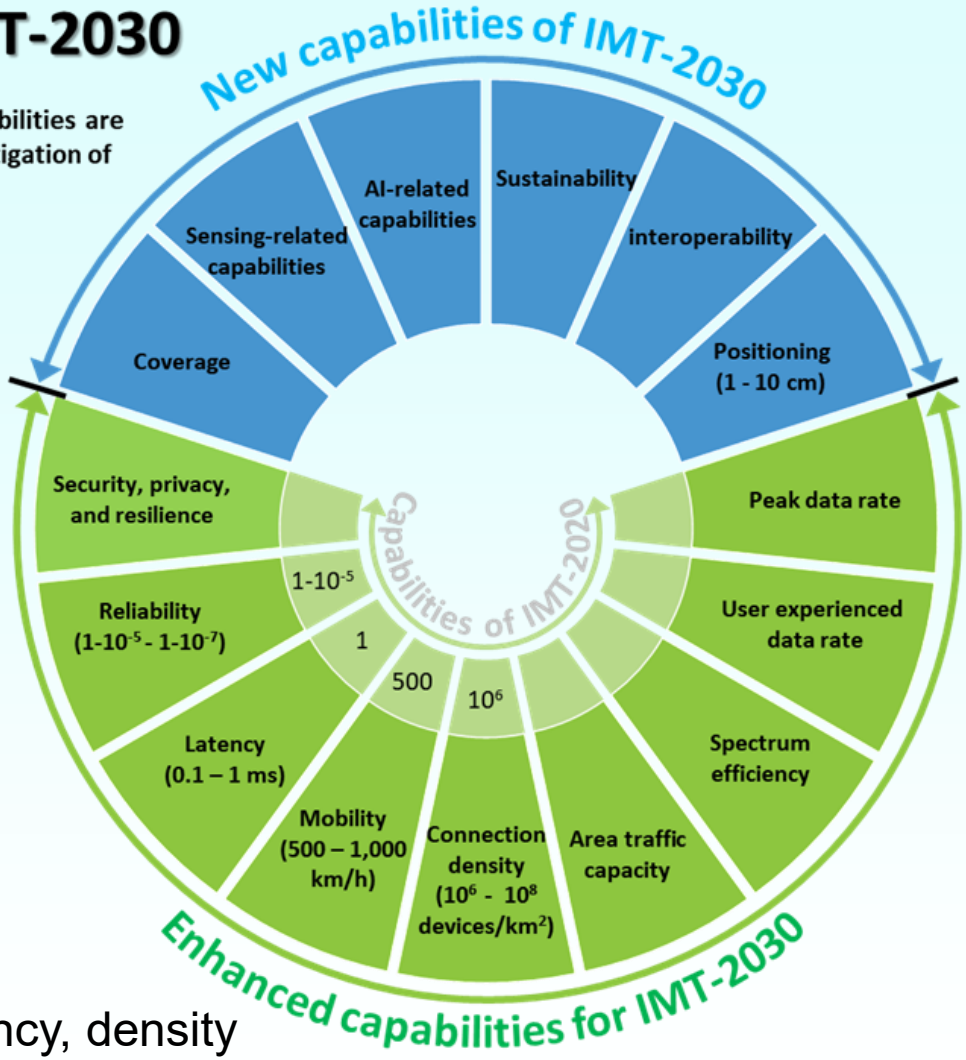
4 Overarching aspects:

act as design principles commonly applicable to all usage scenarios

Sustainability, Connecting the unconnected,
Ubiquitous intelligence, Security/resilience

Capabilities of IMT-2030

NOTE: The range of values given for capabilities are estimated targets for research and investigation of IMT-2030.



2G → 3G → 4G: rate

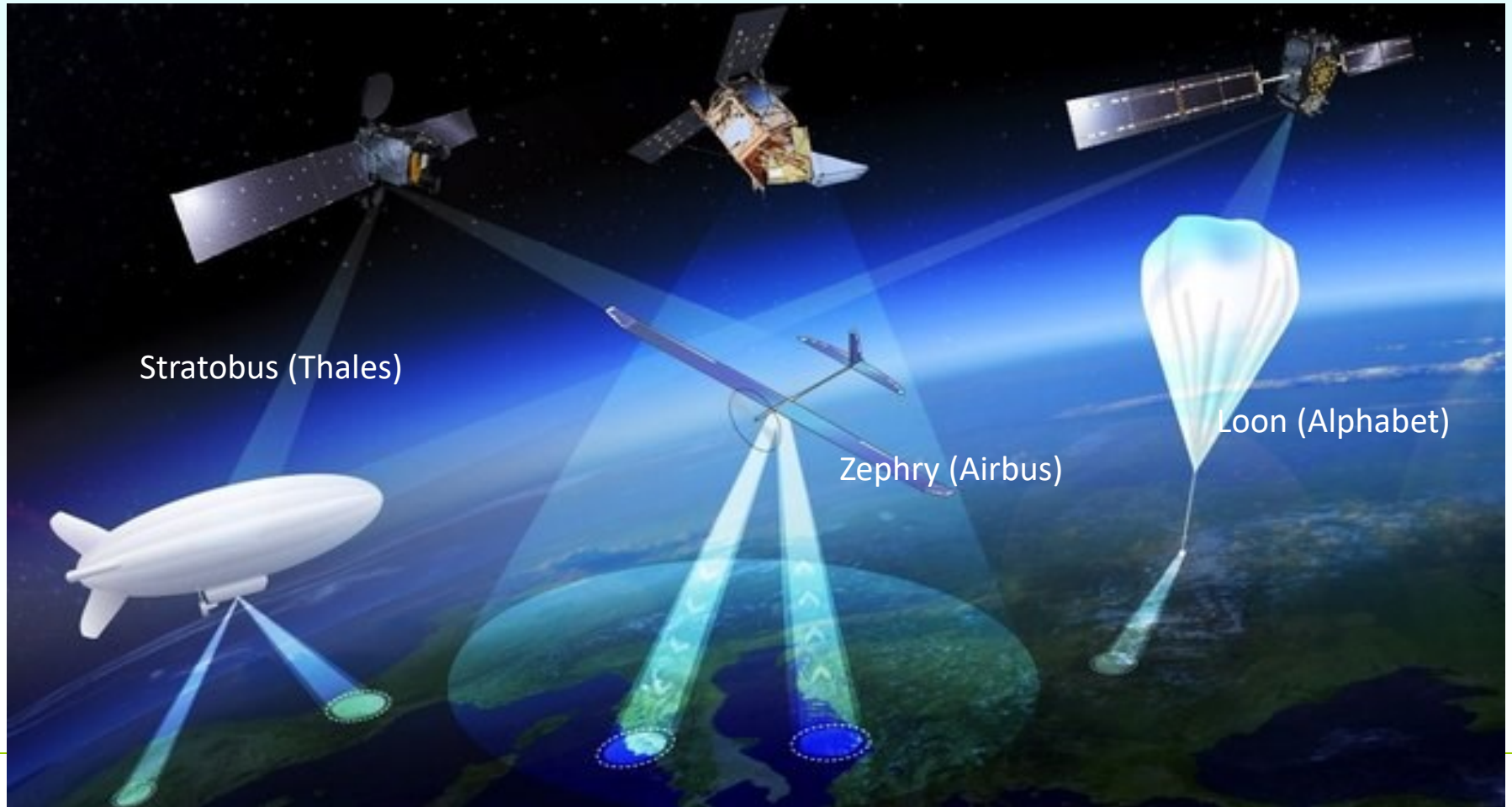
4G → 5G: rate, reliability, latency, density

5G → 6G: rate, reliability, latency, density, coverage (NTN), sensing, AI

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).

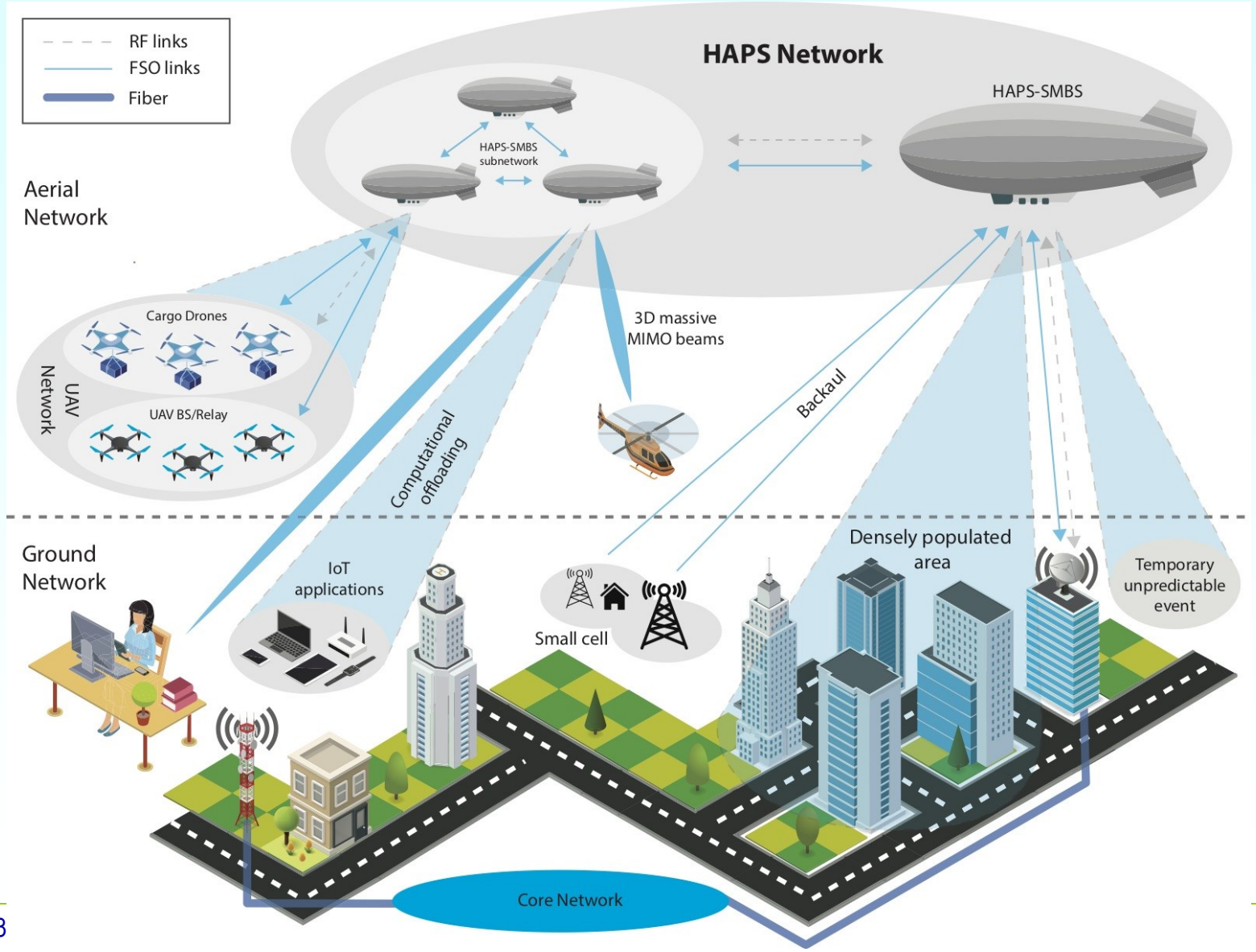
HIBS: HAPS as an IMT (International Mobile Telecommunications) Base Station
HIBS altitude: 18-25 km (WRC-23)



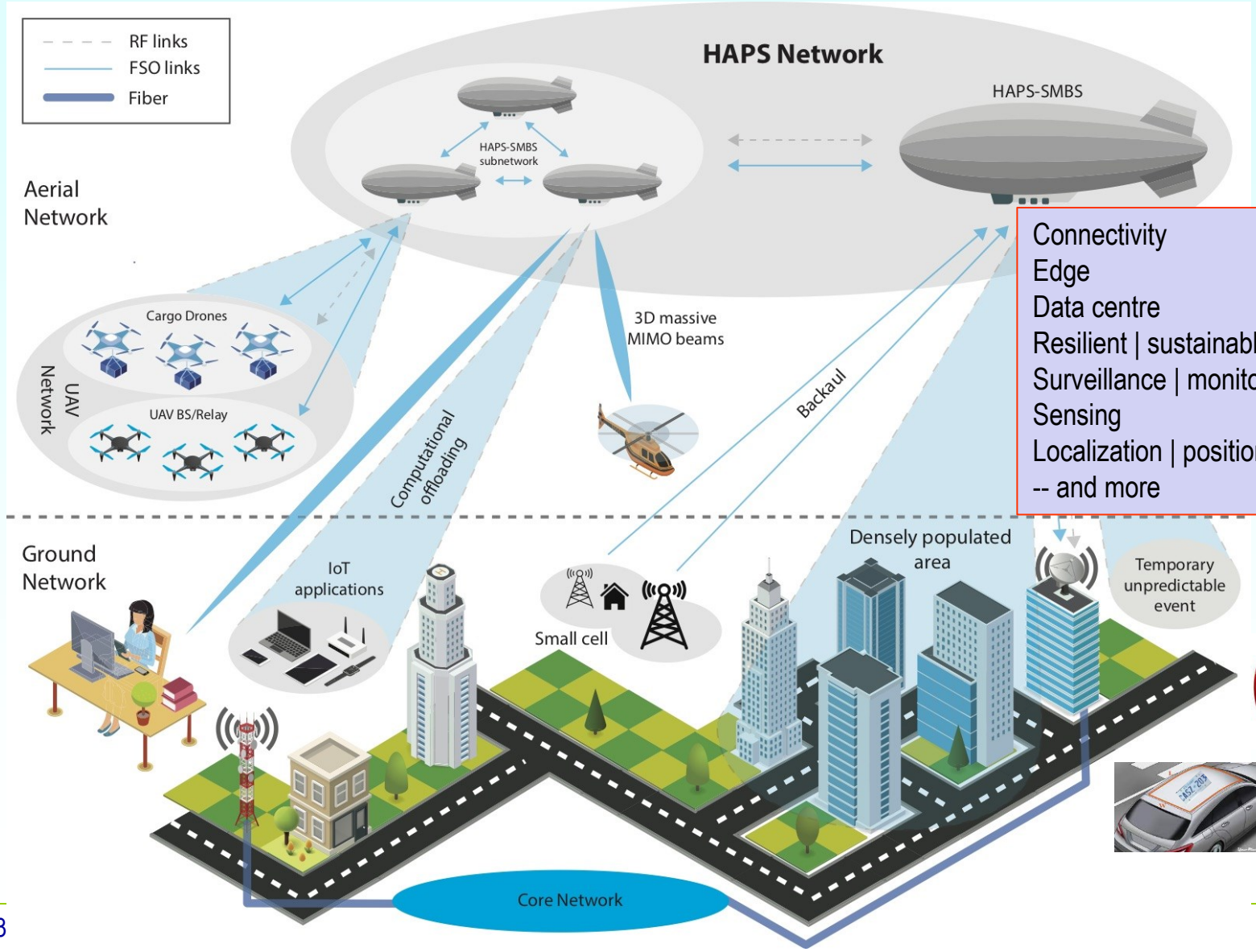
SUMMITS'24

ITS: Connectivity Perspective & Vision

Terrestrial BSs + HAPS BSs in Urban/Suburban Areas



Terrestrial BSs + HAPS BSs in Urban/Suburban Areas

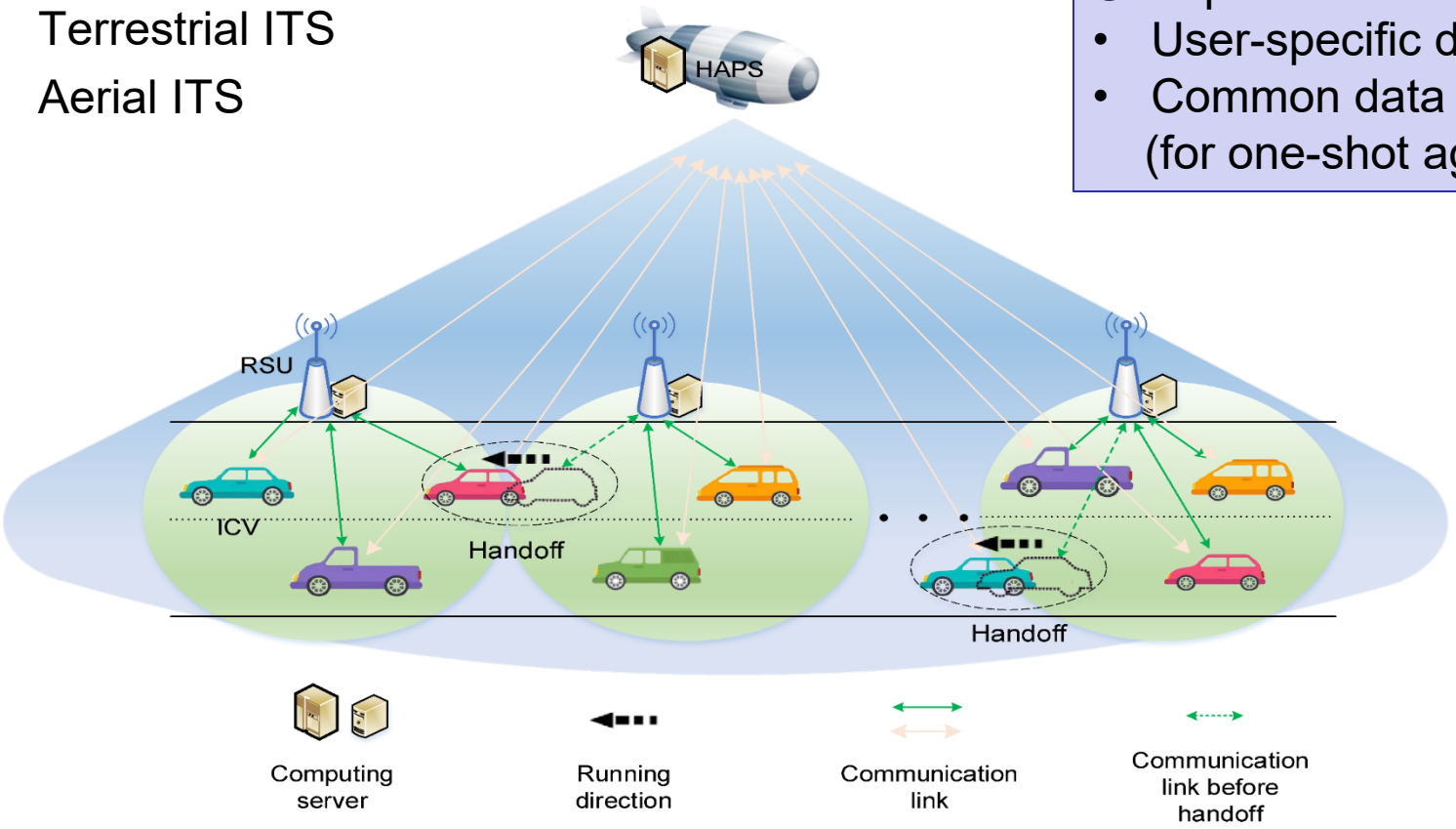


Connectivity
Edge
Data centre
Resilient | sustainable
Surveillance | monitoring
Sensing
Localization | positioning | navigation
-- and more

Edge Computing @ HAPS

- Terrestrial ITS
- Aerial ITS

Control plane → HAPS
User plane
- User-specific data → RSU
- Common data → HAPS (for one-shot aggregation)



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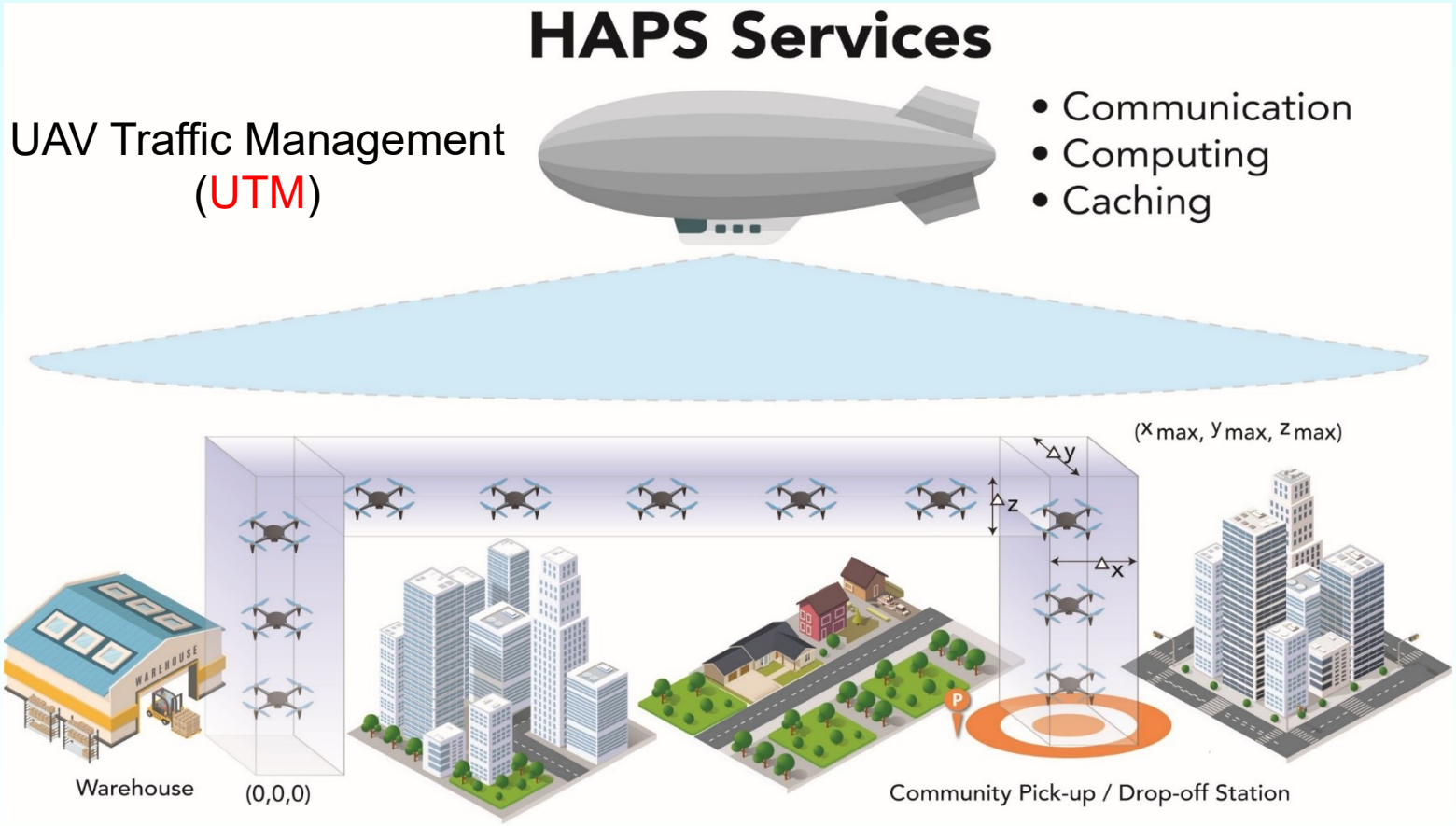
HAPS for 3D Aerial Highways



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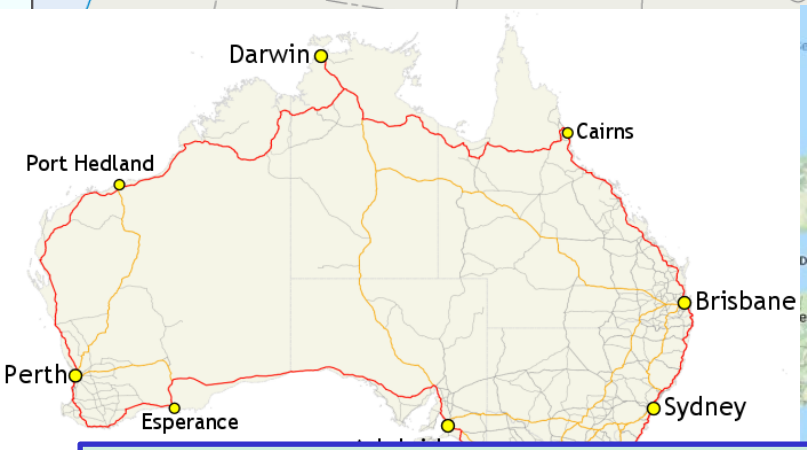
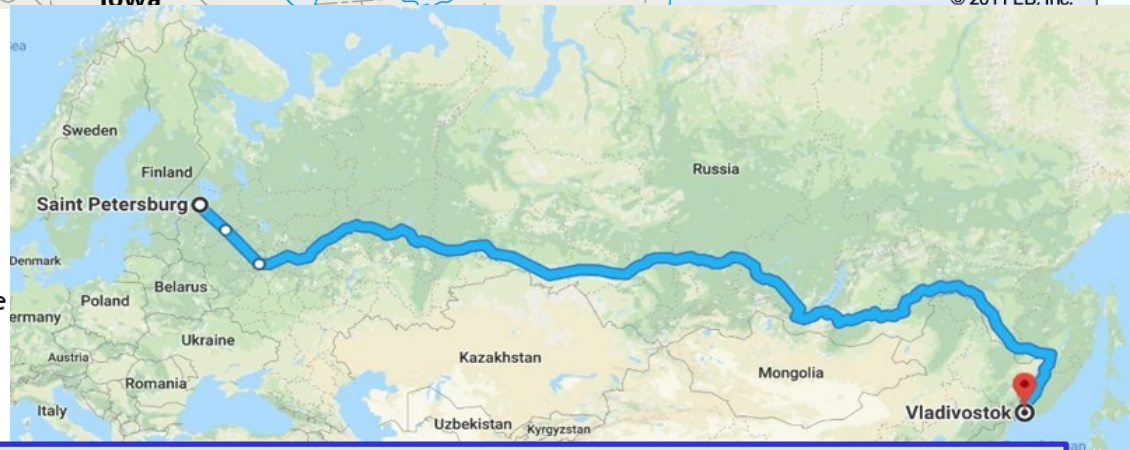
HAPS Constellation for Intelligent Transportation Systems





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NTN (Non-Terrestrial Networks): 6G and Beyond

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15–16 May 2024