

Connecting the Last 2 Billion to the Internet through High-Altitude Platform Stations (HAPS)

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ABSTRACT

Rural and remote communities remain harder to connect than urban areas because sparse populations, difficult terrain, limited power infrastructure, and high maintenance costs make terrestrial networks expensive. Satellite constellations can extend coverage, but their capacity is shared across large regions and require hundreds to thousands of moving platforms [2, 3]. High-altitude platform stations (HAPS) are a better-suited, more targeted solution: they can station-keep above underserved regions, provide wide-area coverage from 20 km above the ground, and reduce dependence on terrestrial infrastructure.

INTRODUCTION

The International Telecommunications Union (ITU), an agency of the UN, estimates that 2.2 billion people remain offline in 2025, most living in rural and remote areas in low-income countries (see Figure 1) [1]. To residents in rural areas, this limits access to e-health, e-banking, emergency information, and government services. Because rural communities are spread across large areas, terrestrial networks need to be installed at multiple sites to serve relatively few users [2]. This poster argues that HAPS are the strongest option to close the connectivity gap over rural areas because they provide targeted, regional coverage without requiring dense ground infrastructure or large constellations of moving satellites.

The urban-rural divide remains wide in regions with low penetration.

Percentage of individuals using the Internet in urban and rural areas, 2025

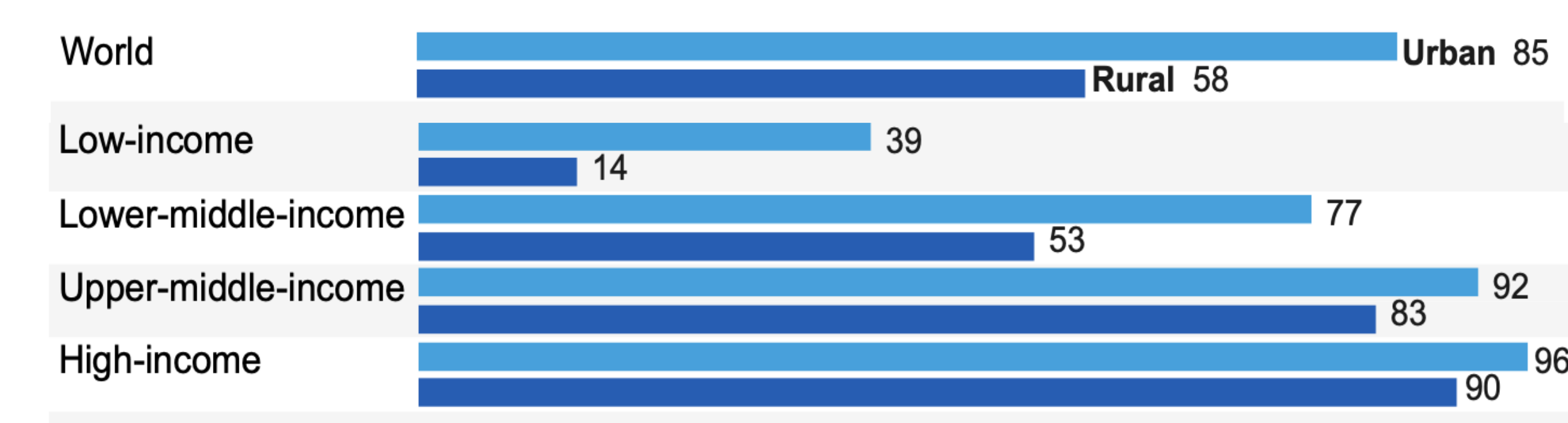


Fig 1. Urban-rural divide around the world, by groups of income [1].

THE PROBLEM WITH TERRESTRIAL NETWORK INFRASTRUCTURE IN REMOTE AND RURAL AREAS

Fibre-optic cable networks and cell towers connect urban areas to the internet today. The same cannot be said for rural and remote communities, which often lie hundreds of kilometres from the nearest urban area by land, or on islands far from populated coasts. A lack of supporting infrastructure such as roads and/or reliable power lines further hinders the maintenance of cable networks and cell towers in these regions [2].

SATELLITES: THE GLOBAL NON-TERRESTRIAL NETWORK INFRASTRUCTURE

Satellite Coverage

Satellites are useful for global coverage, but they are not ideal as the only solution for rural connectivity. A satellite moves quickly over the ground, so continuous service over one region requires a constellation rather than a single platform, which is expensive to scale and an unaffordable service to most rural residents [2].

Satellite Capacity

Satellite capacity is also shared across large coverage areas, creating aggregate capacity limits when many users connect at once [3]. For rural connectivity, satellites are therefore better as a complement to existing terrestrial infrastructure than as a means of closing the very large connectivity gap [2].

HAPS

HAPS Technology

HAPS (High-Altitude Platform Stations, or pseudo-satellites) are long-endurance, solar-powered aircraft designed to station-keep above a region, circling a single point in the sky for weeks or months at a time. Solar panels power the aircraft by day, while batteries store energy for nighttime operation. HAPS fly in the stratosphere: a layer of atmosphere 20 km above the ground, far above regulated airspace and the weather that affects terrestrial infrastructure and passenger aircraft [3]. The only type of HAPS aircraft nearing commercial availability today are fixed-wing, which have ultra-thin airframes that glide over the thin, stratospheric air, like the one in Figure 2.

Engineering Challenges

Two main challenges currently face HAPS before commercial operations begin: limited battery capacity, which hinders persistent network coverage through the night, and flight endurance. To address these issues, developers are turning to higher density battery chemistries such as lithium-sulfur (Li-S), lengthening the flight time HAPS can achieve before they must land [4].

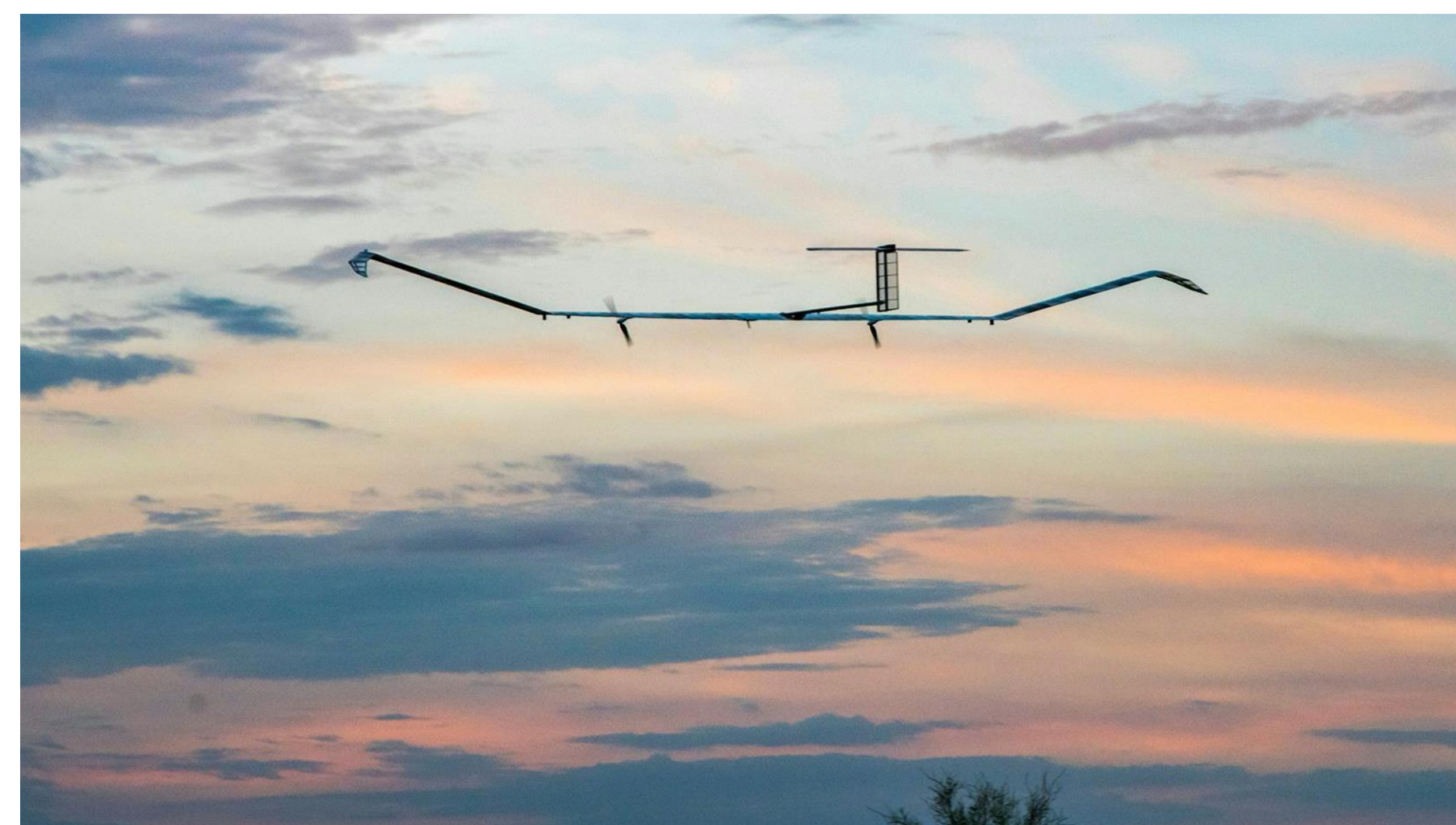


Fig 2. Zephyr, a 75-kg, fixed-wing HAPS manufactured by AALTO, a subsidiary of European aircraft manufacturer Airbus [5].

HAPS'S ADVANTAGE

The ITU has long described HAPS as, "High-Altitude Platform Stations: an opportunity to close the information gap" [6]. The high altitude of HAPS aircraft provides a wide radius of coverage of 100-200 km, allowing them to target remote regions and open a clear line of sight over rugged terrain [3]. In non-terrestrial networks, HAPS functions as relays: lightweight mirrors in the sky that reflects signals from a 4G/LTE ground station carrying the heavy equipment. As a result, HAPS aircraft paired with a ground station can reduce the need for many rural cell sites by providing wide-area coverage from above [3].

Current Applications

In March 2025, NTT Docomo—Japan's largest mobile carrier—collaborated with Airbus subsidiary AALTO to conduct a connection test (Figure 3) between mobile devices and a HAPS at 20 km. At a coverage of 200 km, the test achieved a throughput of 4.66 Mbps—enough to hold a high-definition video call [3, 7]. NTT Docomo will employ this network for commercial operations in 2026, providing coverage to remote, mountainous regions in Japan [5].

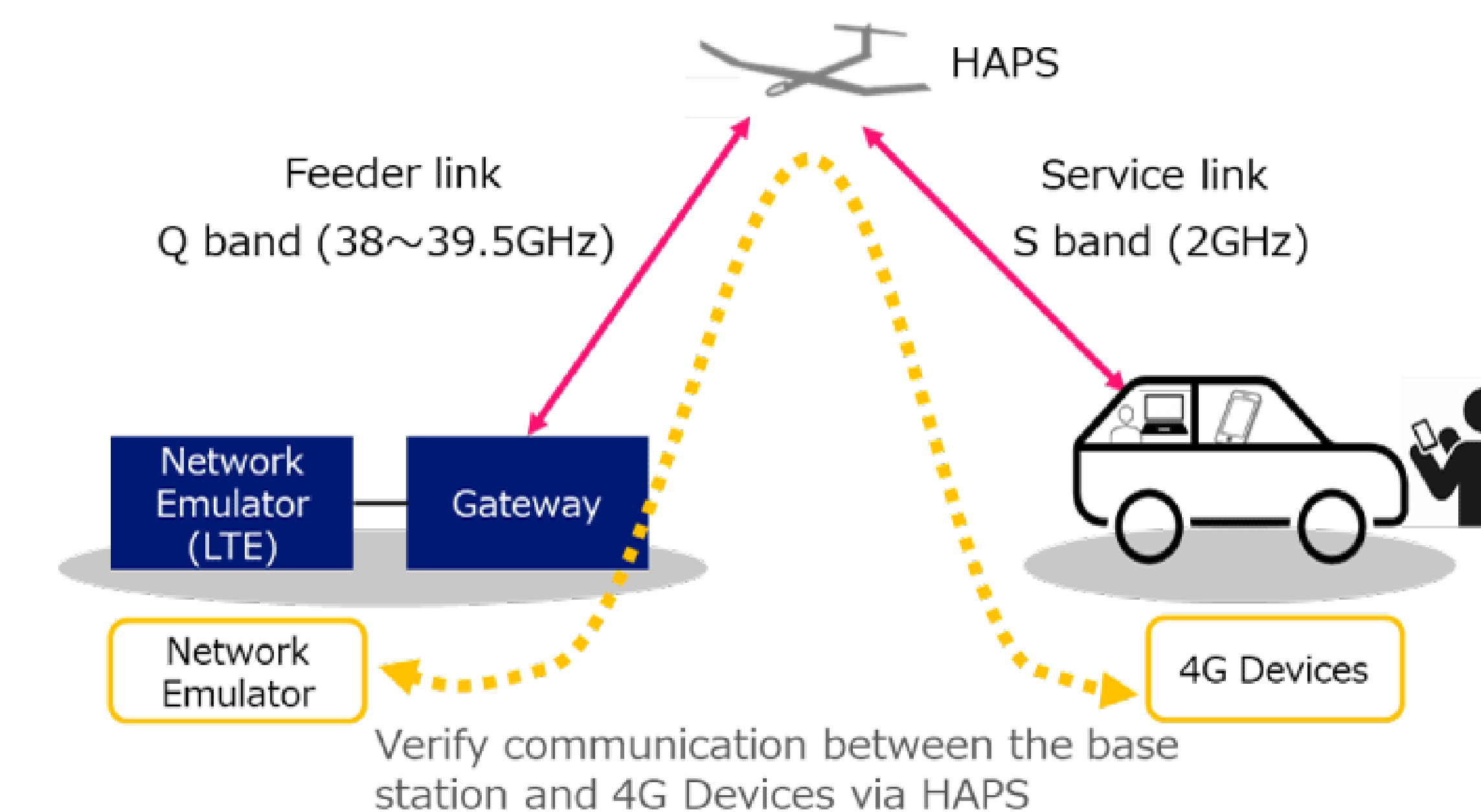


Fig 3. Overview of the 4G/LTE Direct-to-Device communication network used in the demonstration [7].

CONCLUSION

While satellite constellations are a useful complement to existing network infrastructure, HAPS are better suited for targeted rural connectivity because they can station-keep above underserved regions and provide wide-area coverage with less ground infrastructure. As endurance and battery density continue to improve, HAPS are positioned to fill the missing middle layer between cell towers and satellites.

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