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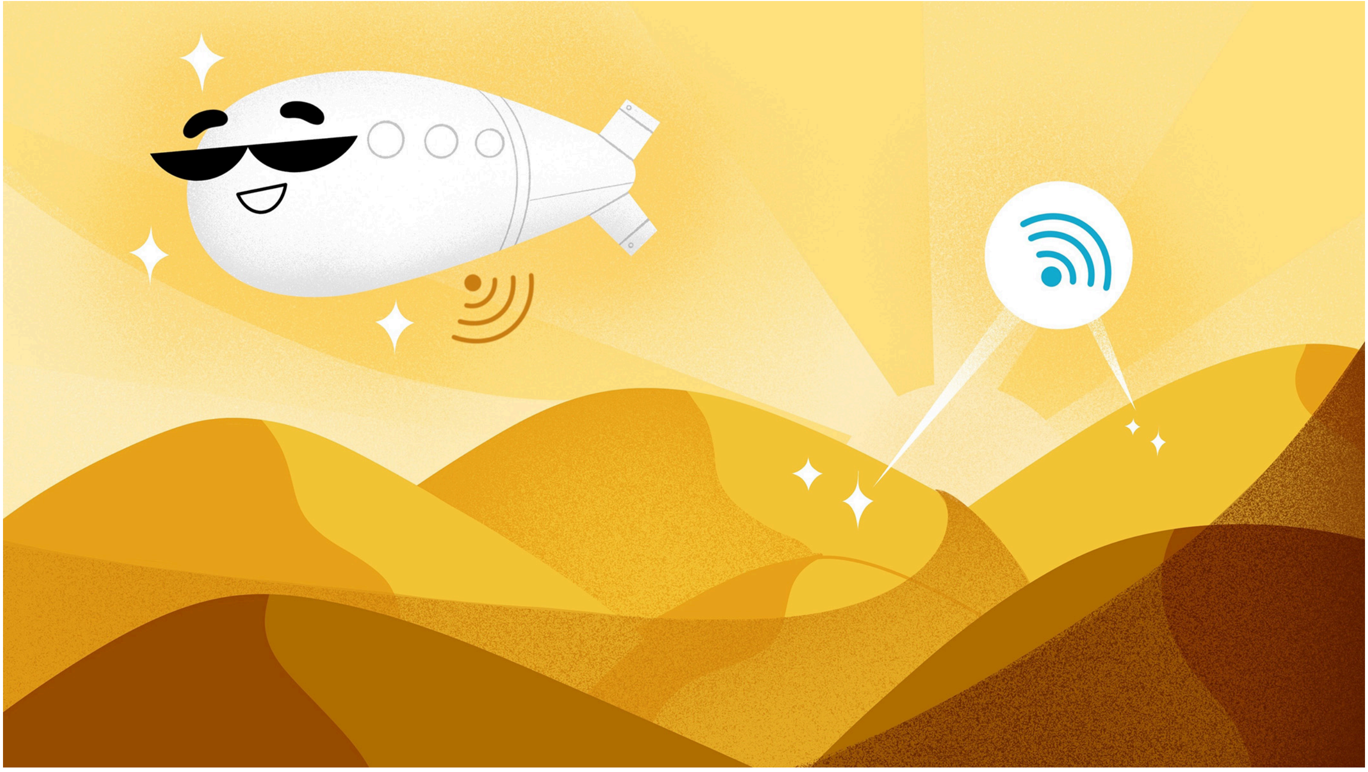

FLYING HIGH TO BRING THE INTERNET EVERYWHERE

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YOUNG REVIEWERS:

LANDON
AGE: 10

High-altitude platform stations (HAPS) are systems that fly about 20 km above Earth to provide internet and monitor the environment. These solar-powered systems can stay in the air for months, bringing fast, reliable internet to remote areas and providing critical communication during emergencies like hurricanes or other natural disasters. HAPS are already being tested to connect communities, track wildfires, and check air quality. They have great potential to bring the internet everywhere, closing the so-called internet divide, but there are challenges. Current rules for airplanes need to be updated to include HAPS, and HAPS must be made tough enough to handle the extreme conditions in Earth's stratosphere. Costs must also come down to make HAPS more affordable for underserved areas. If these challenges can be solved, HAPS could transform how people stay connected.

THE WORLD NEEDS BETTER CONNECTIVITY

Today, having internet access is almost as important as having clean water or electricity. The internet helps people access education, find healthcare and job information, and stay connected with others. However, about one-third of the world's population still does not have internet access. This problem, called the **internet divide**, is especially severe in remote areas like mountains, deserts, or jungles, where **infrastructure** like communication towers is difficult to build and maintain.

The lack of internet is not just about missing out on technology—it also means fewer opportunities. People without internet access often face poverty and inequality in a world that relies on being connected. During the COVID-19 pandemic, the importance of reliable internet became even clearer. Students in unconnected areas struggled to learn online, and many people could not access healthcare information or find jobs that they could do from home.

What if we could bring reliable internet to even the most remote parts of the world, helping to close the internet divide?

EMERGING TECHNOLOGY: HIGH-ALTITUDE PLATFORM STATIONS

High-altitude platform stations (HAPS) are special systems that can operate in the **stratosphere**, about 20 km above the Earth—far above where airplanes fly. These systems can take the form of airships (large, balloon-like vehicles filled with gases lighter than air), or can look more like airplanes, with wings that help them glide through the air. Their high position gives them a big advantage—they can provide connectivity to large areas while avoiding tough terrain like rugged mountains, dense jungles, or vast deserts where it is hard to build infrastructure like cell towers [1, 2].

You might wonder why HAPS are better than satellites, which also provide communication from the sky. Satellites orbit much higher than HAPS—over 35,000 km above Earth. This distance causes a time delay, called **latency**, in communications. For example, you might have experienced latency as a delay during a video call. HAPS, at just 20 km above Earth, have much lower latency, providing faster and more reliable internet. They are also less expensive to set up and easier to upgrade than satellites.

HAPS are adaptable, too. Powered by solar panels, they can stay in the air for months at a time without refueling. HAPS can be deployed quickly for emergencies, like restoring communication after a natural disaster or improving coverage during major events, such as large

INTERNET DIVIDE

The gap between people who have access to the internet and those who do not, often caused by poverty, remote locations, or lack of technology.

INFRASTRUCTURE

The basic systems, like roads, bridges, or communication towers, that help a community or country function.

HIGH-ALTITUDE PLATFORM STATIONS

Platforms that fly up to 20 km above Earth, far above airplanes, to provide internet or monitor the environment. They can stay in the air for months without landing.

STRATOSPHERE

A layer of Earth's atmosphere that starts about 10 km above the ground, where airplanes fly below and HAPS operate above.

LATENCY

A small delay in sending or receiving information over the internet, caused by the distance the signal travels or slow network connections, like when a video game or call freezes briefly.

sports tournaments, music festivals, or international conferences [3]. Advances in materials, solar technologies, and propulsion systems (the mechanisms that help HAPS move and stay in position) have made HAPS more efficient and ready for real-world use.

TECH TO THE RESCUE

HAPS are being tested in exciting ways to show how they can improve connectivity and monitor the environment (Figure 1). These tests are helping to refine the technology and its real-world potential.

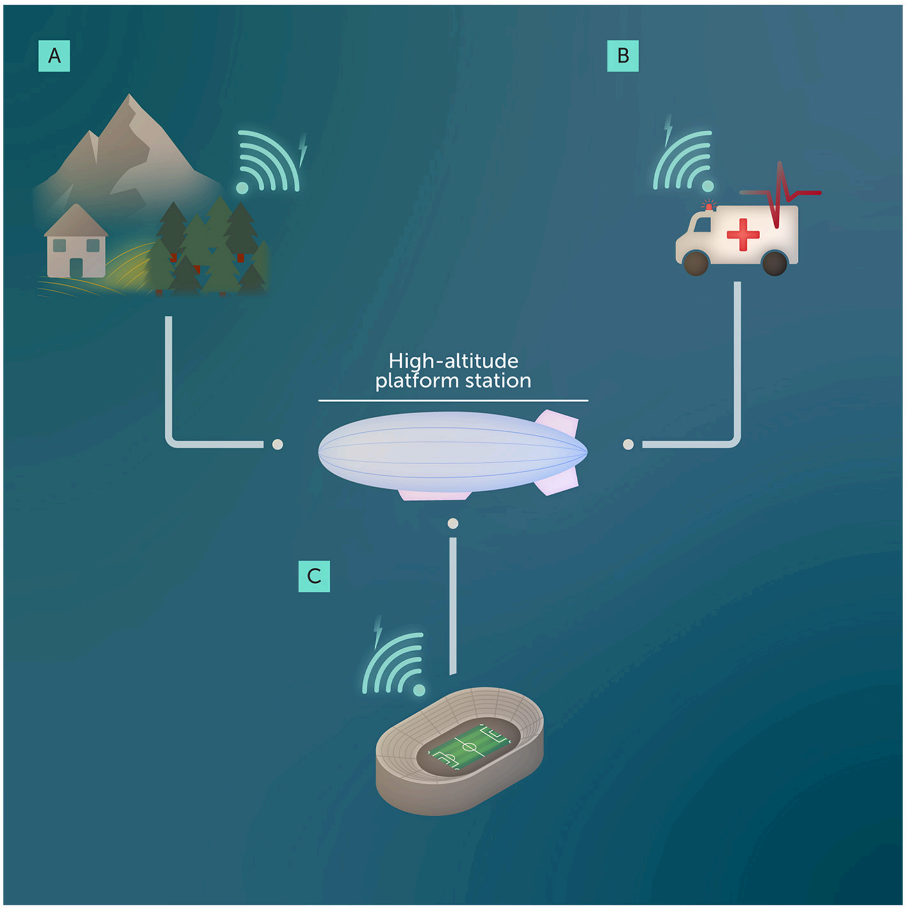

Figure 1

Figure 1

HAPS could improve global connectivity in many situations. **(A)** They can deliver internet to remote locations, like deep mountain regions or isolated islands where installing cables or communications towers would be difficult or impossible. **(B)** During dangerous weather, wildfires, or other emergencies, HAPS could provide real-time data to emergency responders. HAPS could also help to restore connectivity after natural disasters like earthquakes or hurricanes knock out communication networks. **(C)** HAPS could help people stay connected at big events where many people are online at once, overwhelming traditional infrastructure.

One example is Airbus's Zephyr, a solar-powered unmanned aircraft that can stay in the stratosphere for months. The Zephyr has completed several successful test flights, proving that it can deliver internet access and monitor the environment from high altitudes. In one test, it provided continuous coverage over a specific area, demonstrating how it could connect remote places where laying cables or building communication towers would be nearly impossible—like a village deep in the mountains or a small island in the middle of the ocean. A HAPS hovering overhead could deliver high-speed internet, connecting these isolated communities to the world. This connection could allow children to attend online school, families to access telemedicine, and small businesses to reach global markets.

Another project comes from Sceye, a company that works with NASA and the U.S. Geological Survey. Sceye's HAPS platforms have been tested for monitoring wildfires and storms. By observing these events from the edge of space, HAPS can provide real-time data to emergency responders, helping them predict fire behavior or track dangerous weather. From the stratosphere, HAPS can also monitor air quality, deforestation, and wildlife migrations, providing valuable information for tackling environmental challenges like climate change and biodiversity loss. For instance, a HAPS could track pollution levels over a large region, helping governments develop strategies to improve air quality.

HAPS are also being tested to see if they can help restore connectivity after natural disasters like hurricanes, earthquakes, or floods. Imagine a hurricane that knocks out communication networks in a coastal region, leaving communities isolated and delaying rescue efforts. A HAPS could quickly be deployed to provide internet and phone services, reconnecting people with emergency services and loved ones. HAPS could even guide drones delivering medical supplies or share real-time weather updates. These initial tests show how HAPS could be a game-changer in disaster management.

BIG CHALLENGES, BIGGER OPPORTUNITIES

HAPS have exciting potential, but there are still challenges to solve. One big issue is that existing aviation rules were designed for traditional airplanes with pilots and passengers on board, which usually fly for only a few hours at a time. Many of these rules focus on passenger safety. HAPS, however, do not have people on board and can stay in the air for months. New rules are needed to ensure HAPS operate safely, without interfering with other aircraft or satellites. Organizations like the International Civil Aviation Organization are working to create these updated policies [4].

Another challenge is durability. HAPS must be able to handle the harsh conditions in the stratosphere, where temperatures are freezing cold and the air is thin. More research is needed to make sure that HAPS can work reliably in these conditions for long periods. HAPS also need a steady source of power to remain in the stratosphere and to keep their equipment operating. Current solutions being tested include lightweight solar panels and advanced batteries.

Finally, cost is still an issue. Although HAPS cost less than satellites, they are still expensive to build and operate. To truly address the internet divide and bring connectivity to underserved areas, costs must be reduced so HAPS can be deployed affordably, on a large scale.

If researchers and engineers can overcome these challenges, HAPS could transform global connectivity, provide critical support during disasters, and help us learn more about our planet. With the right solutions, HAPS could become an essential part of our global communications infrastructure, ensuring that no one is left offline in an increasingly connected world.

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CONFLICT OF INTEREST: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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LANDON, AGE: 10

Landon, 10 years, is an award-winning member of Davinci Dragon's North Carolina Science Olympiad Team and two-time participant in Kyran Anderson Science Academy. He holds citizenship in two countries and loves to play music, read, swim, and rock climb.

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Mohamed-Slim Alouini was born in Tunis, Tunisia. He earned his Ph.D. from the California Institute of Technology (Caltech) in 1998 before serving as a faculty member at the University of Minnesota and later at Texas A&M University at Qatar. In 2009, he became a founding faculty member at King Abdullah University of Science and Technology (KAUST), where he currently is the Al-Khawarizmi Distinguished Professor of Electrical and Computer Engineering and the holder of the UNESCO Chair on Education to Connect the Unconnected. Dr. Alouini is a Fellow of the IEEE, OPTICA, and SPIE, and his research interests encompass a wide array of research topics in wireless and satellite communications. He is currently focusing on addressing the technical challenges associated with information and communication technologies (ICT) in underserved regions and is committed to bridging the digital divide by tackling issues related to the uneven distribution, access to, and utilization of ICT in rural, low-income, disaster-prone, and hard-to-reach areas. *slim.alouini@kaust.edu.sa

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