THE STRATOSPHERE

HIGH ALTITUDE, HIGHER AMBITIONS

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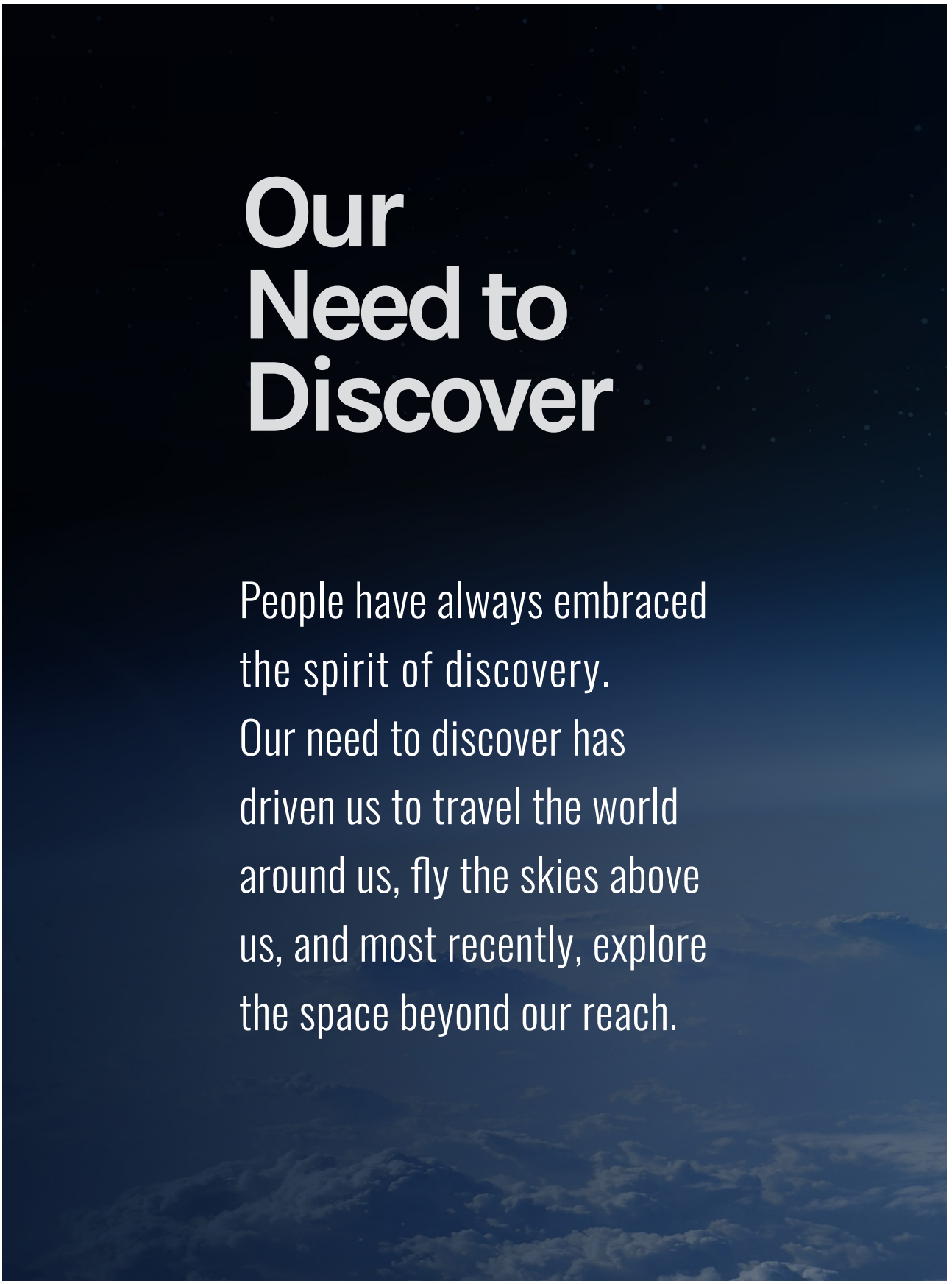

Our Need to Discover

People have always embraced the spirit of discovery. Our need to discover has driven us to travel the world around us, fly the skies above us, and most recently, explore the space beyond our reach.

OVER THE LAST 60 YEARS

We've made monumental achievements in sending vehicles into Earth's orbit—hundreds to tens of thousands of kilometers away from our planet. We've kept satellites in orbit for dozens of years. We've even sent probes billions of kilometers into deep and interstellar space, traveling beyond our solar system.

Notably, one region of near-space remains underutilized, presenting our teeming world with a rare green field: the stratosphere. The stratosphere spans from just above Earth's lower atmosphere to the edge of space—well above air traffic, wildlife and weather events.

TO DATE

The stratosphere hasn't received much attention outside research and academia. That's because for years, the stratosphere was deemed unsuitable for large commercial operations—for good reasons! Pressure and thermal conditions of -65°C, wind speeds exceeding 40 km/hour, gravity waves and solar radiation at 20 km above the earth are harsh conditions for long-duration flights.

It's only in the last decade that advances in solar, battery and artificial intelligence technologies have made it possible to design stratospheric vehicles, also called HAPS (High-Altitude Platform Stations, High-Altitude Pseudo-Satellites or High-Altitude Platforms), that can operate safely in production and at scale.

The Edge of Space

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The Opportunity

Despite the challenges, the stratosphere's close proximity to Earth offers substantial opportunity to advance many industries, including a multi-billion dollar total addressable market spanning telecommunications, high-resolution earth observation and weather prediction and modeling.

TELECOMMUNICATIONS

EARTH OBSERVATION

KEY APPLICATION

TELECOMMUNICATIONS

Over the past few decades, 2.3 billion people have come online, still leaving 3.8B without access to the internet.[1] Terrestrial wireless networks deliver high data rate, low latency connections, and satellites provide broad coverage that can scale globally. However, both systems have limitations. Densely populated urban areas challenge the capacities of satellite infrastructure, while in remote, sparsely populated and hard-to-reach areas, ground-based cell towers aren't cost-effective to deploy. HAPS can help telecom service providers expand coverage to meet the needs of these demanding markets.

HAPS can act as floating cell towers, providing network latency that is comparable to that of terrestrial cell towers but with up to 200 times the geographic coverage from a single vehicle. At an altitude of just 20 km, HAPS can connect directly to mobile handsets, modems and IoT devices using standard 4G LTE and 5G protocols. In addition to expanding telecom coverage into rural and challenging terrains, HAPS operate above the weather and can be moved at will, enabling flexibility in the coverage area and emergency coverage in times of outages and disasters.

> *"As the foundational architects of space-based communications and video broadcast services, Intelsat is continuously exploring new innovations that advance and secure boundless applications for our customers. Ubiquitous communications on a truly global scale that delivers on the growing expectations for low latency and high speed will require the integration of numerous networks and technologies working together in harmony. Intelsat is committed to turning the promise of global communications ubiquity into reality through the advancement of exciting innovations. We view opportunities in the stratosphere as a logical extension to our network designs."*

Greg Ewert
Vice President
Strategy & Business Development
Intelsat

Ultimately, the stratosphere can drive significant growth in the **$3.9T mobile technologies and services business** by bringing millions of people living in unconnected areas online, reconnecting people after disasters, building out the next generation of 5G networks, and connecting the future of Internet of Things (IoT) devices.

[1] ITU, Individuals Using the Internet, 2005-2019. (2019). Retrieved from bit.ly/2G7cqBB

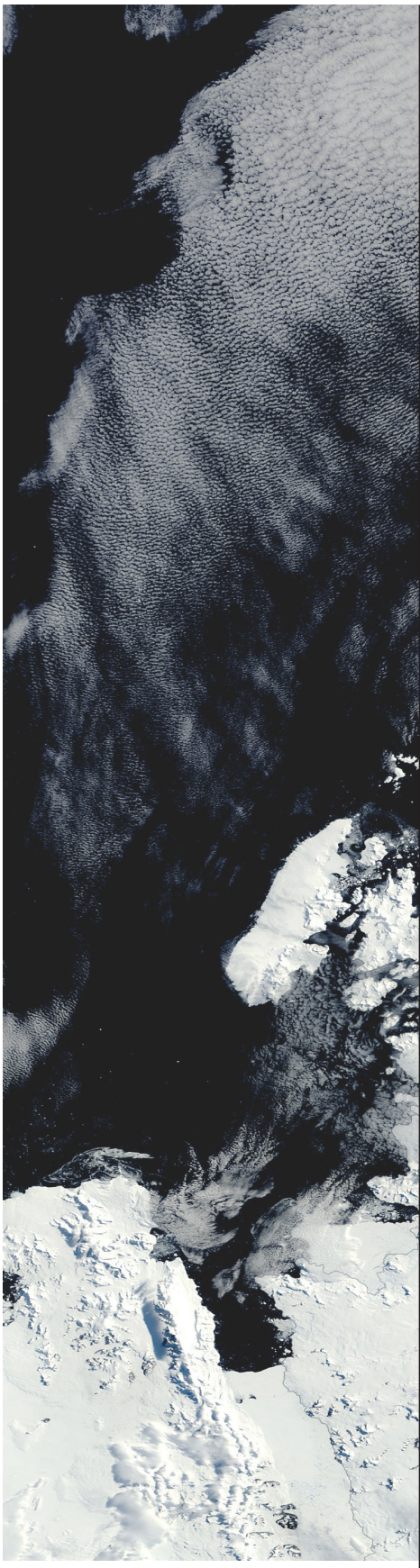
KEY APPLICATION

EARTH OBSERVATION

In addition to connectivity, the stratosphere enables new innovations in Earth observation (EO), a market that is currently commanded by satellites and drone technologies. Less than 1/1,000 of the distance of a geostationary satellite, HAPS can obtain much higher resolution imagery. And, unlike drones, stratospheric vehicles can travel vast distances over long periods of time, toggling between moving and strategically hovering over an area to collect data.

HAPS offer many promising EO advancements, including:

- Gathering data around natural and man-made disasters to enable more effective responses to wildfires, oil spills, floods and more.
- Tracking meteorology to improve weather forecasts.
- Monitoring natural resources, agriculture and infrastructure.
- Watching large stretches of oceans for illegal fishing, pollution and piracy.



> *"HAPS are complementary to satellites, UAVs and manned aircraft providing affordable, persistent, local satellite-like services. They will revolutionise the way we are able to manage environmental and humanitarian earth observation and communications missions around the World."*

Evert Dudok

Executive Vice President
Airbus Defence and Space

The $3B satellite segment of the EO market is growing steadily, as is the $4.4B drone service market.[2,3] As HAPS develop, they will tap into portions of both markets, while stimulating new market demand due to their unique capabilities.

[2] MarketsandMarkets, Drone Service Market. (April, 2019). Retrieved from bit.ly/2v07aNQ

[3] NSR, Satellite-Based Earth Observation (EO), 11th Edition. (September, 2019). Retrieved from bit.ly/38pSgPr

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Driven by Technology

The stratosphere (20 km) offers the benefits of significantly lower launch and recovery costs, longer flight durations and more payload flexibility compared to satellites in geostationary (~36,000 km) or low earth orbit (300-1,200 km), which can be capital intensive, or airplanes (10 km), which are operationally challenging, expensive and offer limited scale.

LAUNCH & RECOVERY COSTS

FLIGHT DURATION

PAYLOAD FLEXIBILITY

REAL-TIME DATA PROCESSING

> *“As stewards of innovation, we are proud to collaborate with Alphabet’s Loon to connect the unconnected. Together, we bring an unparalleled combination of skills, expertise and technology to overcome the challenges associated with high-altitude networking infrastructure. Enhanced LTE wireless networking today, and 5G tomorrow will deliver major economic and societal benefits to communities in remote and challenging environments.”*
>
> Kathrin Buvac
> President
> Nokia Enterprise

LAUNCH & RECOVERY COSTS

HAPS fly at just twice the cruising altitude of commercial airplanes. That’s less than 0.1% the distance of geostationary satellites, and less than 6% that of low-Earth orbiting satellites. This attainable distance allows HAPS to use light gas or solar power to efficiently, sustainably and quietly lift off and power their flight. When a HAPS lands back to Earth, its parts can be effectively collected, analyzed and even repurposed.

FLIGHT DURATION

HAPS, including balloons and fixed-wing vehicles, are being designed to fly for months at a time, using solar energy as their main—or only—source of power.

PAYLOAD

Stratospheric vehicles offer more flexibility of services than typical spacecraft, with the ability to fly modular, tailored payloads for high-resolution earth observation, or emerging standards like 5G or IoT, and swap out these technologies depending on the mission. In fact, HAPS can be refreshed with the latest technology every few months! And the lower altitude enables communications-oriented HAPS to tailor their capacity to more closely match the needs of the service area on the ground.

REAL-TIME DATA PROCESSING

HAPS can be equipped with advanced sensors and edge compute, thanks to development in the IoT sector. As a result, flight data can be aggregated, processed and monitored in real time. This offers potential for improving many use cases, including Earth observation, weather prediction and public safety.

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Emerging & Established Industry

The opportunity in the stratosphere is starting to take off, attracting a variety of companies from many sectors: aviation and space manufacturers, global technology leaders, telecom operators and startups.

THOUGH THE MARKET IS NASCENT, WE'VE SEEN NOTABLE DEVELOPMENTS

Loon has flown thousands of HAPS, with an average flight duration of over 4 months and a 223-day record for longest flight, delivering connectivity to over 300,000 people in partnership with telecom operators.

Airbus completed a 26-day stratospheric flight using a fixed-wing vehicle.

SoftBank Corp.'s HAPSMobile, in partnership with AeroVironment, and Boeing, are developing fixed-wing vehicles spanning approximately 80 m. World View completed a 40+ day balloon flight, and Raven regularly flies balloon missions.

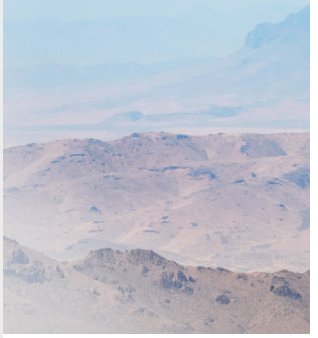
Thales and Sceye are developing high-altitude airships.

In addition to long-lasting stratospheric vehicles, commercial HAPS operations will require a technology stack composed of fleet operations and management software; weather prediction and networking; specialized, stratosphere-hardened payloads and hardware; and more.

High Altitude, Higher Ambitions

People have always embraced the spirit of discovery. But unlocking the stratosphere is more than just a technical challenge and opportunity—it's a humanitarian one.

By enabling ubiquitous coverage, millions of people will get better access to information, communication, education and opportunities. By collecting and analyzing high-resolution Earth imagery, we can build more accurate weather predictions, model climate change, and promote public safety. Tapping into the opportunity in the stratosphere is critical to accelerate the next decade of technological, economic and social development.



"Both SoftBank Corp. and its subsidiary HAPSMobile are working to connect all people and things around the world, and we share Loon's vision of bridging the digital divide by utilizing the stratosphere. HAPS also represents a strong addition to telecommunications infrastructure thanks to its resilience in times of natural disasters and its wide-area connectivity from the sky, which enables drone utilization, IoT applications and 5G deployment.

We're excited to be working with Loon as a strategic partner, and we've already made great progress by jointly developing a communications payload for our unmanned aircraft system. We look forward to continued collaboration with Loon to deploy cutting-edge technologies and to further advance the business potential of HAPS."

Junichi Miyakawa

Representative Dir & CTO
SoftBank Corp.

President & CEO
HAPSMobile Inc.

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About Loon

Loon's mission is to connect people everywhere by inventing and integrating audacious technologies. By effectively carrying cell towers 20 km above Earth, Loon makes it possible to deliver 4G LTE and 5G connectivity in partnership with mobile network operators.

> *"The untapped opportunities of the stratosphere are immense. While just ten years ago it seemed an inhospitable place for almost all activities, technology is now enabling us to harness the unique advantages of the stratosphere for a wide range of commercial operations. It's an exciting time to be on the forefront of this exploration enabled by innovation."*

Alastair Westgarth
CEO
Loon LLC

FLEET AUTOMATION

1M+ HRS
FLIGHT HOURS

40M KM
NAVIGATED

223 DAYS
LONGEST FLIGHT

125 DAYS
AVG DURATION

VEHICLE & PAYLOAD

20+ KG
PAYLOAD CARRY WEIGHT

NETWORK OPTIMIZATION

24 NODES ACROSS 5,000 KM
LARGEST STRATOSPHERIC MESH NETWORK

GROUND & CLOUD

300,000
CONNECTED USERS (PARTNERSHIP WITH AT&T AND TELEFONICA)

IN PRODUCTION & AT SCALE

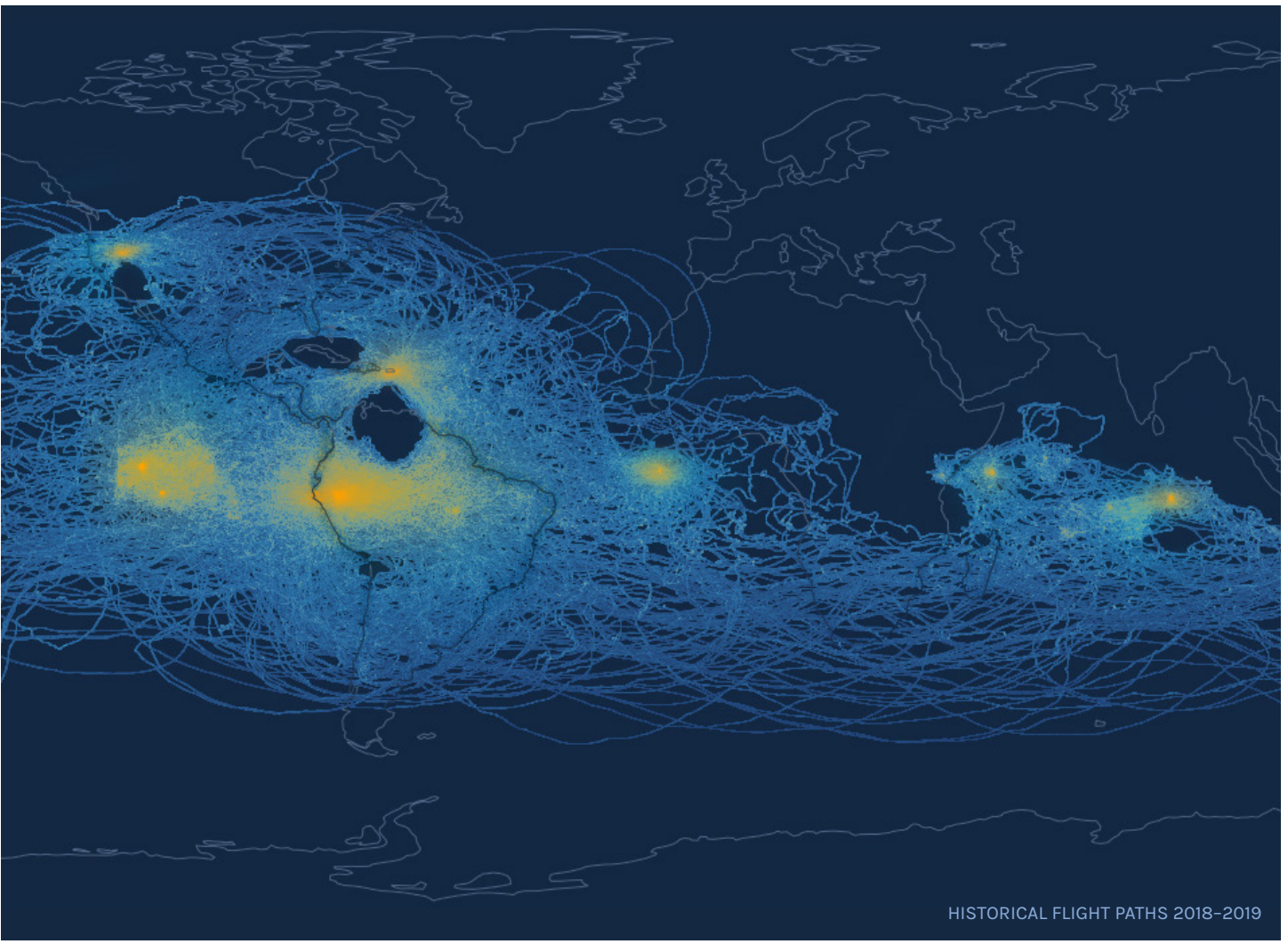
Loon has been a pioneer in the stratosphere for the past seven years, achieving many world firsts. This includes the longest duration navigated stratospheric flight (223 days), average flight durations of 4+ months, and building "self-flying balloons" that leverage machine-learning algorithms based on stratospheric wind datasets spanning 35+ years. Loon safely operates in production and at scale.

Loon is also the first stratospheric connectivity provider to connect real users, including more than 300,000 people in partnership with Telefonica in Peru and AT&T and T-Mobile in Puerto Rico.

As a subsidiary of Alphabet, Loon has also partnered with SoftBank's HAPSMobile, working together to promote the high-altitude platform industry. Loon started deployment efforts to provide service in Kenya in partnership with Telkom Kenya.

WANT TO LEARN MORE?

Get in touch with Loon's experts at press@loon.com



HISTORICAL FLIGHT PATHS 2018-2019