




SKYFive®
Connecting the skies

Connecting the skies

Welcome to the Gigabit age in aviation! At SkyFive, we believe that it is time for airlines to take the next step in their digitization journey and bring real broadband connectivity to every aircraft as a crucial enabler of operational efficiency, passenger experience, and ancillary revenue generation.

Based on a decade of research, we leverage standardized 4G and 5G technologies to connect aircraft from the ground rather than from space, to boost performance and cut costs at the same time.

This booklet will introduce our approach and solution to you. Please also follow us on LinkedIn ([skyfive.world](https://www.linkedin.com/company/skyfive-world)) and Twitter ([SkyFiveW](https://twitter.com/SkyFiveW)) for further views and updates. Finally, don't forget to check our webpage <https://skyfive.world> for latest information on fairs and conferences that you can meet us at.

Many happy landings!



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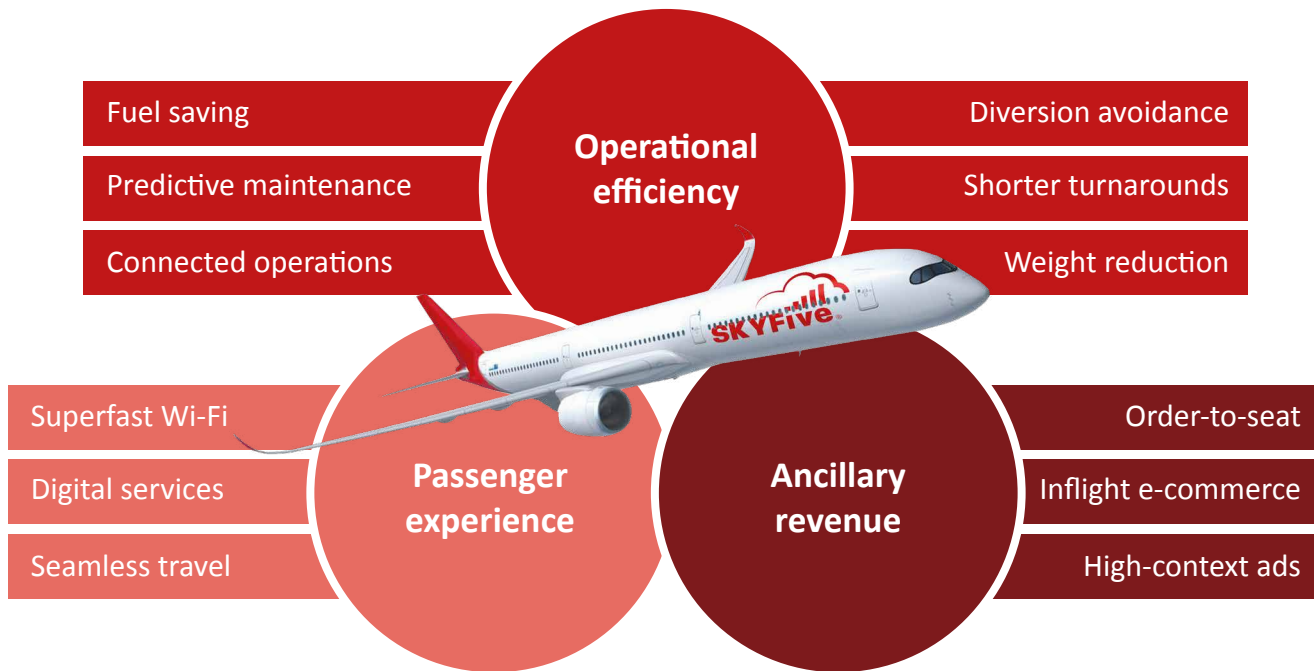
Sky is the limit – or is it?

Over the past 30 years, the yearly amount of airline passengers has more than quadrupled, despite unprecedented events like 9/11, SARS, and now recently COVID-19. As more countries will be rising to prosperity, airline traffic is deemed to double again over the next 2 to 3 decades.

At the same time, the pressure on airlines to operate profitably, reduce their carbon footprint, and improve the passenger experience keeps increasing. Profound digitization offers solutions to these challenges but requires ubiquitous broadband connectivity for aircraft and passengers as an enabler.

Albeit respectable progress has been made since the early days of ACARS, connectivity in the skies is largely inadequate to support the bandwidth demands of modern aircraft flying in dense airspaces. In fact, with more aircraft taking off and more data being generated per aircraft, the gap is just widening.

It is time to catapult the aviation industry into the Gigabit age.

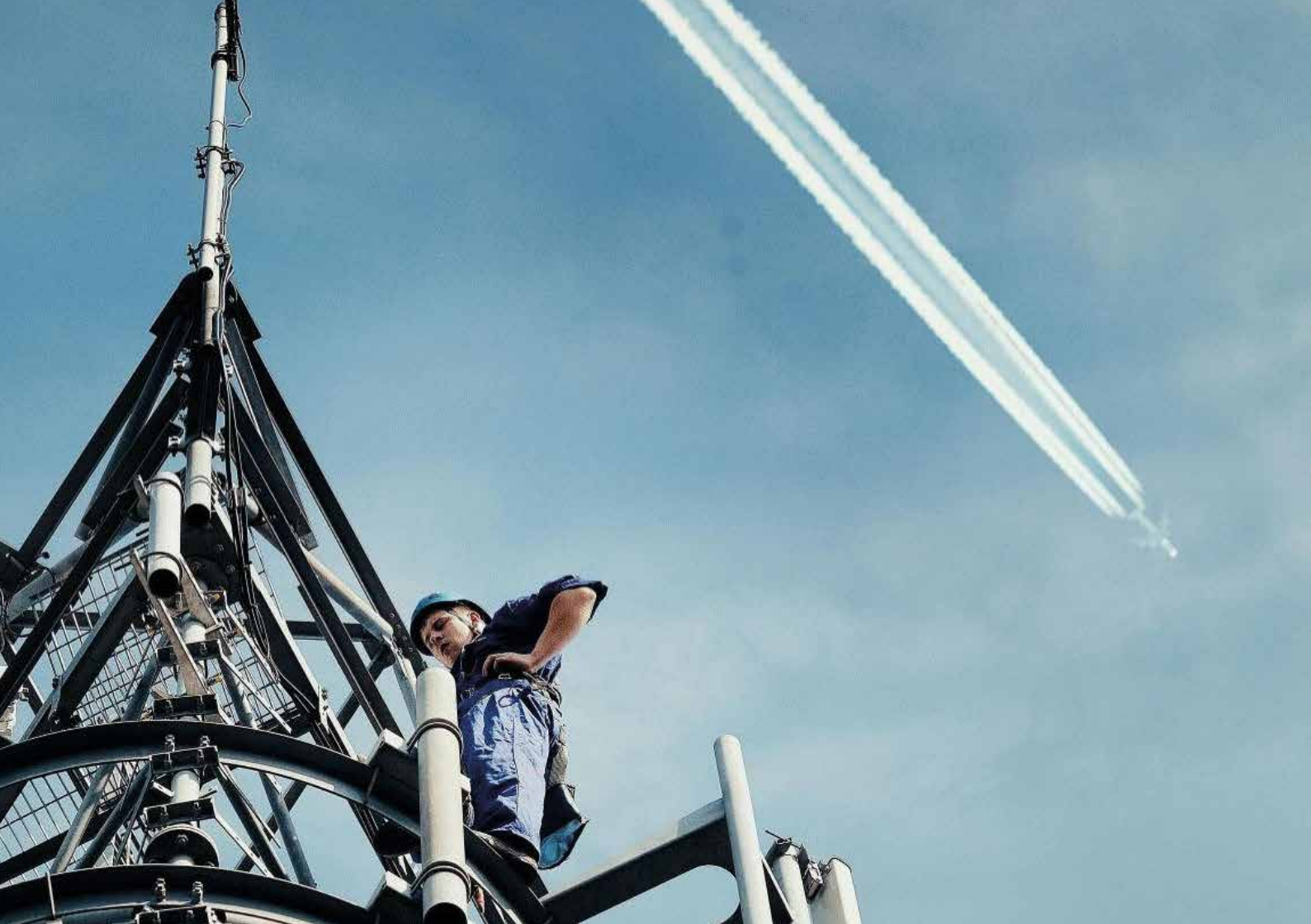


The connected aircraft

Connectivity is a key enabler of digitization in any industry, including aviation. Analyst firm London School of Economics estimates the value of the connected aircraft for the entire industry to amount to US\$ 45 billion by 2035. Value is created in 3 key areas:

- **Operational efficiency:** Direct cost can be reduced in fuel consumption, maintenance, and integrated processes like turnarounds. At the same time, connectivity helps airlines achieving their sustainability objectives.
- **Passenger experience:** Free and fast Wi-Fi in the cabin is a strong service differentiator and loyalty driver for airlines. Connectivity also helps airlines to deliver personalized services and enable a seamless journey end-to-end.
- **Ancillary revenue generation:** With everyone in the cabin connected, advertising and e-commerce become impactful and can generate sizeable revenue beyond standard ticket fees.

Airlines can capture this value only with real broadband connectivity, implemented for the entire fleet at minimal cost.



Air-to-Ground: real broadband in the sky

SkyFive's approach to provide broadband services in the sky radically differs from legacy satellite-based systems. We create a cellular network in the sky, which is dedicated to aviation, and which aircraft can connect to with the help of an ultra-compact terminal mounted under the belly.

SkyFive applies standardized 4G and 5G technologies to leverage the high performance, continuous evolution, low cost, and large economies of scale of the cellular industry. Adhering to standards also assures interoperability between the A2G network and different terminals, and creates the essential choice for airlines.

At SkyFive, our objective is to provide a real broadband connection to every aircraft of the fleet, including regional jets and turboprops; in even the densest airspaces; from gate to gate; all at data rates that encourage consumption instead of penalizing it.



Ground network

The ground network comprises cellular base stations, which get installed on existing towers of our Mobile Operator partners. These base stations are built upon standardized 4G and 5G components and are configured with special sky-pointing antennas, which transmit and receive on a dedicated radio frequency.

Each base station typically produces 3 cells in the sky, with a maximum range of 150 km. The cell size can be decreased around airports and on dense flight routes, to provide the full cell capacity to just one aircraft at a time. The ability to flexibly densify the network is a unique property of the A2G technology.

The base stations are connected to a centralized core network, which contains gateway, traffic management, signaling, authentication, and security functions, all implemented as a set of virtualized network functions running on a redundant pair of servers. Unlike satellite solutions, all data traffic is always kept in-country.



A2G terminal

Our partner Thales was the first to implement an A2G terminal based on the patented SkyFive algorithms. The terminal consists of three components: Baseband Modem Unit, Remote Radio Head, and the palm-sized antenna that is mounted under the aircraft belly.

The total weight of the terminal is only 7.25 kg and does not cause any measurable drag, which allows retrofitting also small aircraft types with it, such as, regional jets and turboprops. A skilled 3-people team can install the terminal in less than 8 hours, as proven in hundreds of retrofits to date.

Inside the aircraft, the A2G terminal provides an Ethernet interface towards the Connectivity Server in the cabin, and an ARINC 429 avionics interface. It is convection-cooled and highly reliable due to no moving parts, resulting in minimum cost for maintenance and spares.

A2G**SATCOM**

Throughput per aircraft in dense airspace	Up to 1 Gbps (spectrum-dependent)	1-5 Mbps
Radio latency	< 1 millisecond	500 milliseconds
Beam size	One base station sector 3.000 - 6.000 km ²	One satellite beam 100.000 - 2 million km ²
Dedicated to aviation	Yes	No
Gate-to-gate connectivity	Yes	Severely limited
Data traffic kept in country	Yes	Depending on location of satellite ground station
Service and terminal unbundled	Yes	No
Time to retrofit aircraft	<8 hours 3-6 mechanics	5-10 days 15-20 mechanics
Structural aircraft changes	No	Yes
Weight of terminal	7.25 kg	Approx. 200 kg

Comparing Air-to-Ground and Satellite Communications

An Air-to-Ground (A2G) system outperforms a Satellite Communications (SATCOM) system in almost every dimension, as illustrated on the adjoining page.

- **Performance:** The throughput of a data connection is the product of both its capacity and latency. An A2G network delivers between 100 Mbps and 1 Gbps per aircraft (spectrum-dependent) with less than 1 millisecond of radio latency.
- **Density:** An A2G network provides its capacity exclusively for aviation users, in a much denser grid than any satellite beam. The A2G network can be flexibly densified further wherever needed).
- **Aircraft impact:** Deploying the A2G terminal on an aircraft is a minor change. The terminal weighs only 7.25 kg, induces no measurable drag, causes no structural changes, and can be installed overnight.

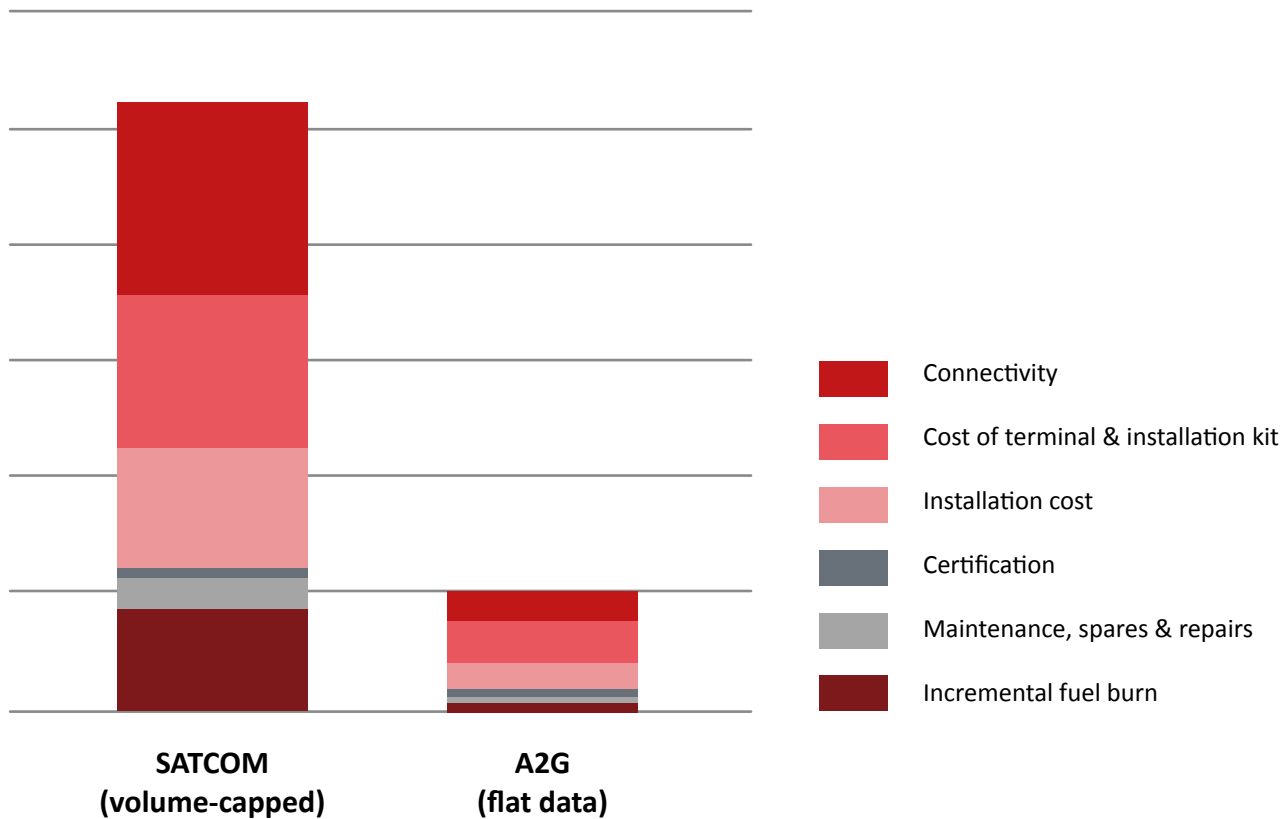
An A2G system can optionally be combined with a SATCOM system, for example, on widebody aircraft that fly oceanic routes where A2G coverage is not available.



Doing it the telco way

At SkyFive, our objective is to provide a broadband connection to every aircraft and every passenger. We achieve that by extending the proven technologies and business principles of the telecommunications industry in the skies:

- **Performance:** A2G is based on standardized 4G and 5G technologies, which feature high throughput and low latency, continuous advancements, a huge ecosystem, and therewith strong investment protection for airlines.
- **Price:** the telecommunications industry is continuously driving down the cost per bit of cellular systems. Airlines fully benefit from this with flat data charges without volume caps. That way data consumption is encouraged, not penalized.
- **Open interfaces:** A2G brings an end to vertically integrated solutions and contractual lock-ins. The A2G terminal and the A2G service subscription are unbundled, such that the aircraft simply connects to its home network, or roams into another.



Lowest Total Cost of Ownership for airlines

With A2G, the cost of broadband connectivity drops to a level that makes it affordable for airlines to equip the entire fleet and fully reap the benefits of digitization.

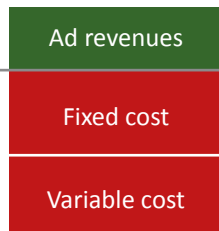
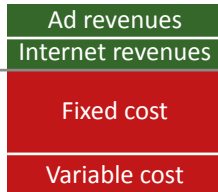
Compared with a SATCOM system, every element of the cost stack is significantly reduced:

- Lower and flat data charges without volume caps
- Lower cost of A2G terminal equipment and installation kit
- Lower installation cost and no loss of revenue due to short ground time
- Lower certification cost due to reduced complexity of aircraft modification
- Lower cost for maintenance and spares due to simplicity and high reliability of A2G terminal
- Lower incremental fuel consumption due to low weight and negligible drag of A2G terminal
- Lower (or no) cost of A2G terminal deinstallation as the terminal is not tied to the provider and could be used also by the next aircraft owner

SATCOM: loss-making for airline

High session price
+ poor performance
= **low take-up**

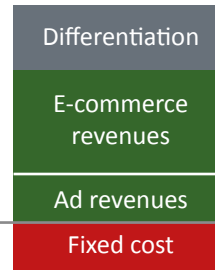
Free Wi-Fi
+ poor performance
= **high take-up**



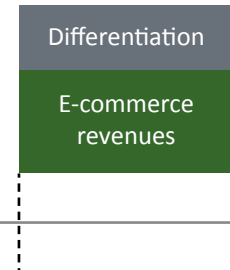
A2G: profitable for airline

Free Wi-Fi
+ great performance
= **high take-up**

Free Wi-Fi
+ great performance
= **high take-up**



Airline funded



SkyFive funded

Generating ancillary revenue with A2G

For long, airlines have been trying to sell Wi-Fi to passengers. However, the combination of high price and poor performance have mostly led to poor adoption. In contrast to that, cheap and fast Wi-Fi yields high take-up rates, even more so if people connect seamlessly through their regular mobile subscriptions.

Once most passengers in the cabin are online during their entire stay in the cabin, the number of eyeballs is large enough to make contextual advertisements impactful. Brands, tourist attractions, and ground transportation companies can target travellers and provide tailored offers, which people can buy and pay online.

If airports are malls with runways, then aircraft should be online stores with wings. The next level of inflight shopping includes refreshments ordered to the seat, duty free items delivered to the gate, and products offered by shops of the arrival airport, where purchases can be picked up after landing.



**Fast & free
onboard Wi-Fi**

**Seamless
travel end-to-end**

**Digital inflight
engagement**

**Real-time
disruption
handling**

**VIP
treatment**

Digitizing the travel experience

Keeping passengers always connected can improve the travel experience at large.

Free & fast Wi-Fi onboard the aircraft is a unique service differentiator and loyalty driver, both for leisure and business travelers. Through a digital travel concierge, airlines can provide additional assistance, such as, a personal moving map, accurate arrival times, and vouchers from ground transportation companies.

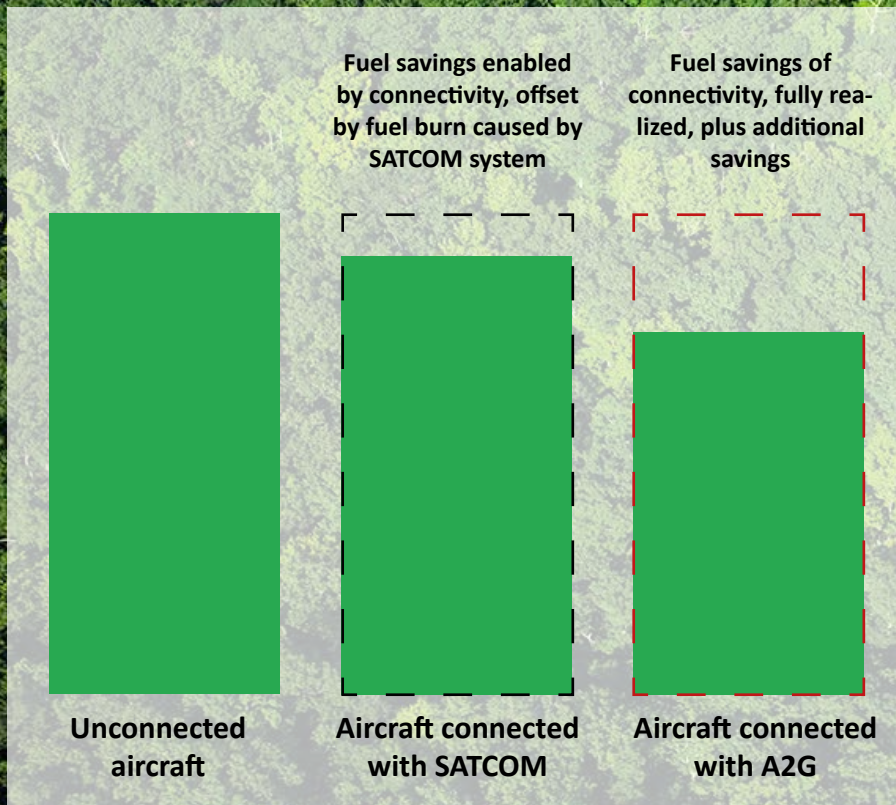
A connected cabin crew can be made aware of status customers and their current travel context, to provide personalized and considerate services. In case of disruptions, airline service desks can reach out to passengers in flight and find solutions on the spot, instead of queuing them at transfer desks upon arrival.

Airports, by relying on real-time data rather than spreadsheets, can proactively staff chronic bottlenecks for the actual amounts of incoming passengers. As a result, airport transfers become predictable, and the journey can be optimized end-to-end across all segments.



Saving cost with A2G

- **Connectivity:** as a quick win, data can be offloaded from existing ACARS and SATCOM services, which typically charge airlines by Kilobyte or Megabyte. When removing the SATCOM system entirely, also significant fixed cost can be reduced.
- **Fuel:** the connected aircraft burns less fuel, as a result of optimizing flight paths based on real time weather and traffic information. Additional fuel can be saved by replacing heavy onboard systems with weightless cloud services.
- **Predictive maintenance:** continuous aircraft health monitoring can reduce the cost of maintenance and minimize disruptions, as a result of improved dispatch reliability, No Fault Found reduction, inventory reduction, and higher productivity.
- **Process efficiency:** bringing the entire fleet online enables connected flight and ground operations in close cooperation with airports, leading to shorter turnaround times.



The green connection

Broadband connectivity for the entire fleet helps airlines in achieving their sustainability objectives. According to consulting firm ICF, the connected aircraft could save airlines globally US\$ 1.7 billion of fuel cost each year, largely as a result of optimizing the flight paths based on real time weather and traffic information.

However, these savings are offset by the significant extra fuel burn caused by SATCOM systems. With a total weight of just 7.25 kg, including a palm-sized antenna that does not cause any measurable drag, an A2G system is the most sustainable way of connecting the entire fleet.

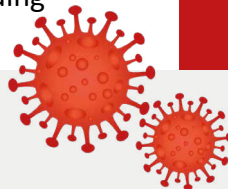
Moreover, the high throughput and low latency characteristics of A2G allow to replace heavy onboard systems with weightless cloud services, for example, streaming services instead of in-flight entertainment systems, online shopping instead of trolley duty-free sales, and cloud storage instead of data recorders.



COVID-19 safety protocol requirements

Digital implementation of requirements

Reduced food and drink service	Online ordering and in-seat delivery
No duty-free sales	Online shopping and gate delivery
Contactless payments	Online payments including validation
Identification and isolation of passengers with COVID-19 symptoms	Inflight diagnosis with connected device and expert on the ground
Immediate information of destination airport about COVID-19 suspects	Inflight transmission of health part of general declaration
Contact tracing	Inflight transmission of Passenger Locator Cards
Coordinated disembarkation	Digital row-by-row notifications
Physical distancing at departure airport	Just-in-time arrival of passengers, based on assigned time slots
Airport transfer without queuing	Crowd management through app-based indoor navigation



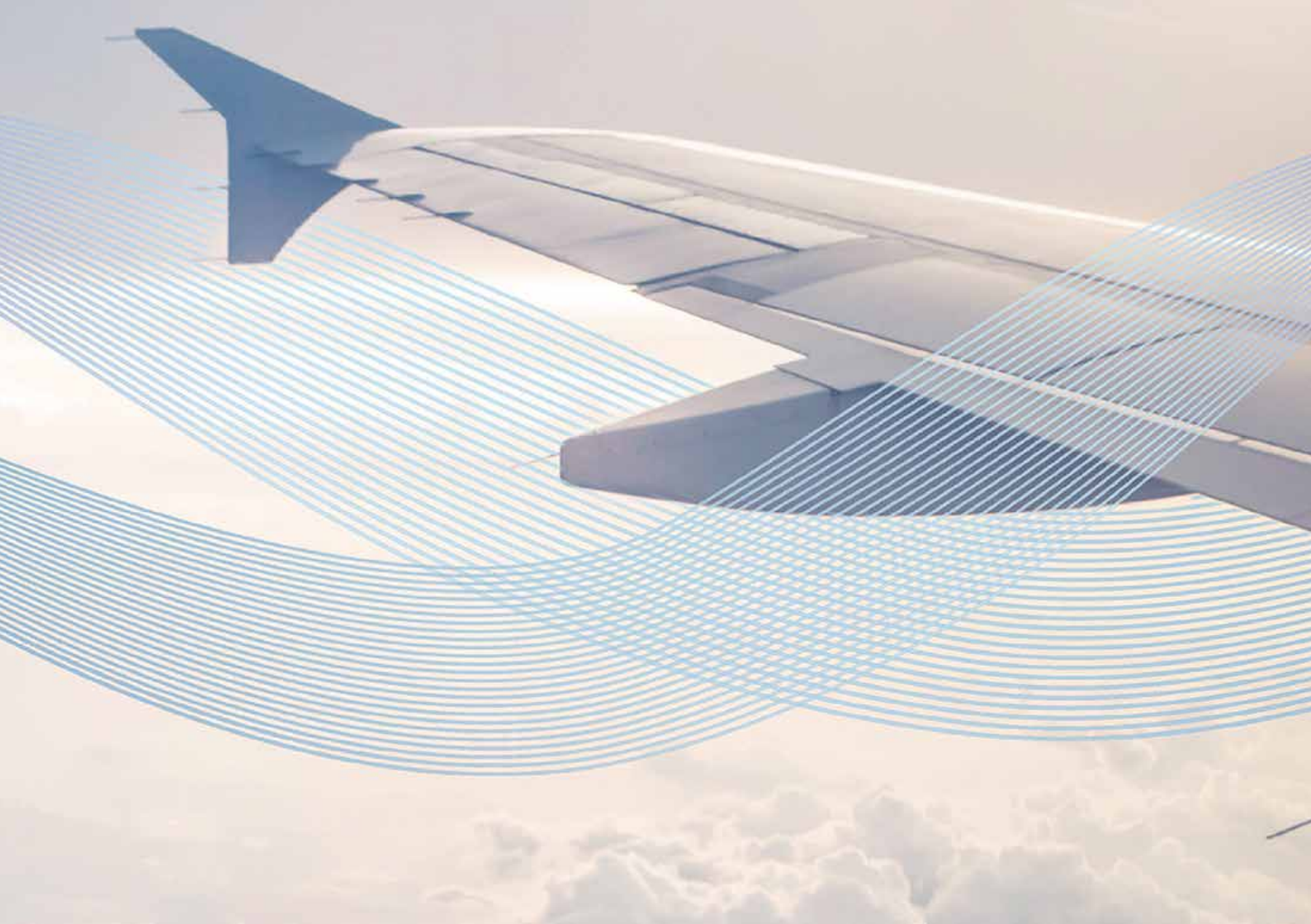
Inflight connectivity in the wake of COVID-19

In the aftermath of the COVID-19 crisis, airlines, like many other industries, consider fast-forwarding their digitization strategy, with ubiquitous broadband connectivity as a key enabler of it. With A2G, airlines can affordably connect every aircraft and every passenger, to reduce operational cost and increase ancillary revenue, as described in previous chapters.

For obvious reasons, these initiatives are more relevant than ever.

A2G can also play a key role in implementing new COVID-19 safety measures, as shown on the opposite page. As these measures make airline travel more pleasant and efficient altogether, many will stay also after the pandemic.

To preserve cash, airlines can purchase the A2G solution in a zero-CAPEX model. The ground time forced by COVID-19 can be used to retrofit the A2G system – in less than 8 hours, which allows equipping an entire fleet within weeks.



The European Aviation Network

The European Aviation Network (EAN) is an integrated network that combines high capacity satellite coverage with a complementary 4G LTE ground network. With around 300 LTE-based sites, the ground network is the first and largest A2G network based on standard 4G technology, to provide high-speed coverage across 35 European countries.

Designed specifically for high traffic flight paths and busy airport hubs, the A2G network delivers over 90Gbps of capacity, a data throughput of up to 100 Mbps per aircraft, and the lowest latency in the market, ensuring a reliable, in-the-air as on-the-ground broadband service, supporting streaming and other high bandwidth requirements.

The European Aviation Network is the result of a partnership between Inmarsat and Deutsche Telekom, who are both recognized experts in connectivity services, and is built upon the SkyFive A2G solution.





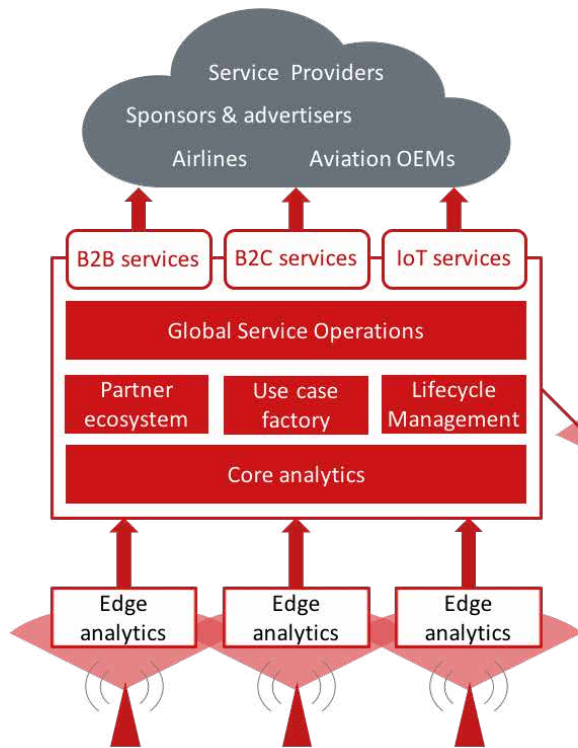
A2G in China

China is well on its way to surpass the United States as the largest airline passenger market worldwide. In its April 2020 edition, the IATA 20-year forecast projects strong growth both in international and domestic travel, also after COVID-19.

Consequently, already in 2018, the State Council decided for the implementation of inflight connectivity. Given the high density of air traffic in the East of China, and the high percentage of single-aisle aircraft serving domestic routes, A2G is the preferred technology for this undertaking.

The A2G network in China will be based on 5G from day 1 onwards. Up to 100 MHz of frequency spectrum are planned to be made available. Compatibility with existing A2G networks is a strong airline requirement.

The SkyFive A2G solution is built upon 4G and 5G standardized technologies. As a result, Chinese aircraft would also be able to connect outside of China, and aircraft from other countries would be able to connect to the Chinese A2G network.



What SkyFive provides

SkyFive provides reliable and high-performance broadband connectivity services in the skies, together with our Mobile Operator partners. Our primary customers are airlines and OEMs, but we also connect the cabin on behalf of advertisers, sponsors, and communication providers.

From our Global Service Operations Centre, we are analysing and optimizing the data performance of aircraft that connect to A2G networks worldwide. All data is always kept in-country, for maximum data protection and to comply with local Internet service regulation.

We take responsibility for the end-to-end solution, including its aviation and telecommunications components, and manage the entire lifecycle of it, including network design, planning, and implementation, as well as aircraft design, certification, retrofit, and Entry-in-Service.



About SkyFive

SkyFive is world's first provider of broadband connectivity services in the skies based on standard 4G and 5G technologies, which we leverage to boost performance, cut latency, and drive down cost per bit. We partner with Mobile Operators to use existing cell towers on the ground, and extend communication services into the aircraft cabin, allowing passengers to seamlessly connect like on the ground.

After years of research and development in Bell Labs, SkyFive was spun off from Nokia 2019 to fully focus on A2G. Our company is home to aviation and telecommunications specialists with over 250 years of cumulative experience, including the key inventors of the technology, the creators of the commercial solution, and the builders of the European Aviation Network.

SkyFive is headquartered on the Ludwig Bölkow Aerospace and Security Campus in Munich, Germany. The R&D Center is located in Stuttgart, Germany.

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