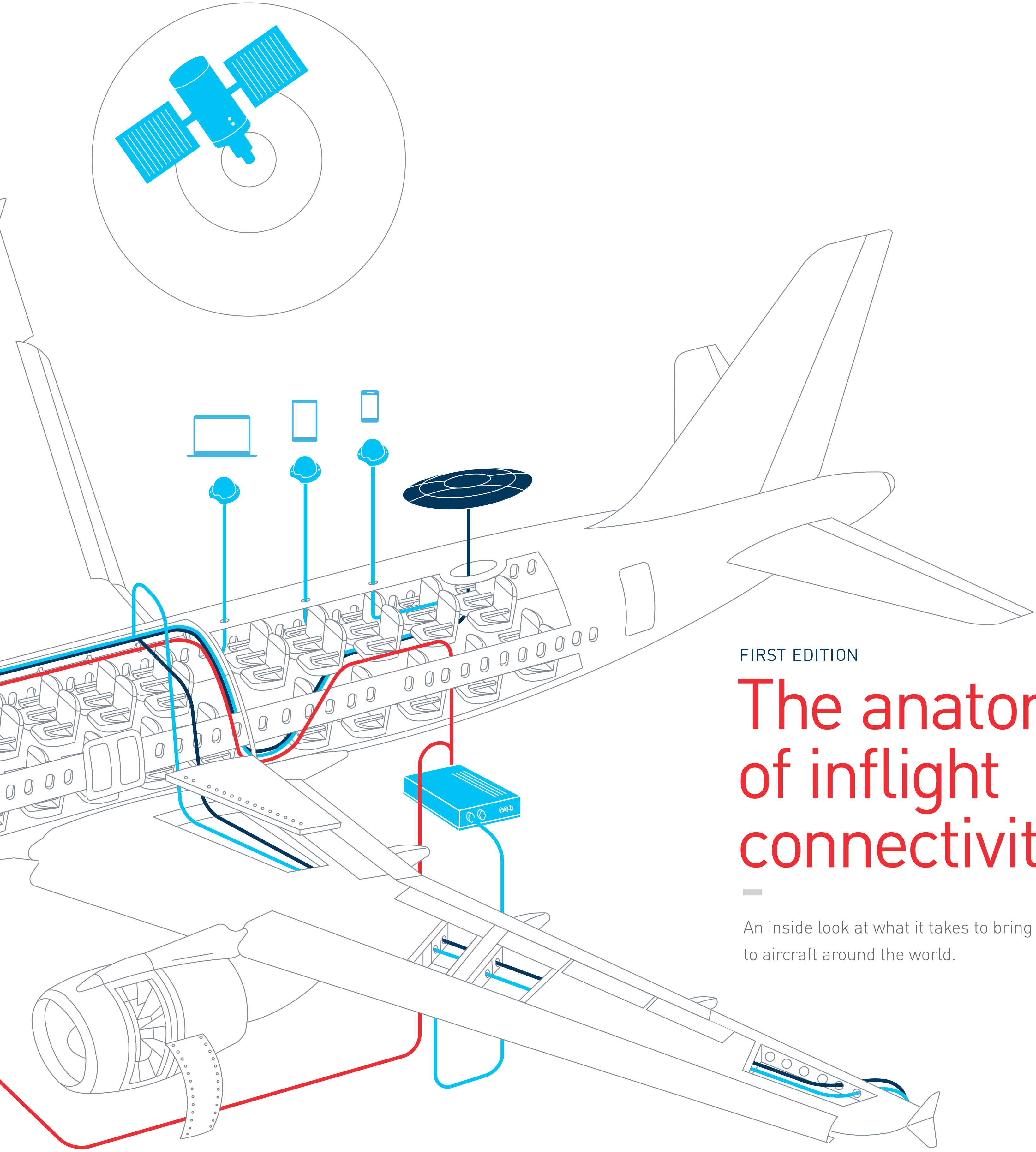


FIRST EDITION

The anatomy of inflight connectivity

An inside look at what it takes to bring connectivity to aircraft around the world.

Table of contents

Preface

Inflight connectivity (IFC) is a fast-moving and complex industry. Just as aircraft operators around the world have begun to appreciate that connectivity is increasingly essential to their operation, the market is becoming crowded with different technologies and connectivity-based services. This has created a landscape that is increasingly difficult to navigate. The purpose of this book is to take a step back from the competitive claims and bring some clarity back to the conversation.

Inside, we'll take a behind-the-scenes look at everything that goes into providing reliable communications services for global aviation. From securing certifications and regulatory approvals, to providing real-time in-air customer care and network management, this overview will show that making IFC work involves more than getting an aircraft online. It's also about making the most of the bandwidth, and making that bandwidth work for your bottom line.

It is our hope that this guide provides useful information to business and commercial aircraft operators around the world. It should help them make informed decisions about how to connect their fleets, and determine the models that best fit the unique needs of their business.

We believe that understanding what goes into providing inflight connectivity will help airlines make informed decisions for connecting their fleets, which ultimately will enable them to operate at maximum efficiency. And in an industry where seconds are compounded, flight after flight, across the breadth of fleets, this efficiency can make all the difference.

01

Inflight connectivity at a glance

To get an idea of how inflight connectivity works, it's useful to first review the basics of how the internet works on the ground. To do that, we'll follow the path that information takes to complete a basic request.

1.1

How the internet works

USER MAKES A REQUEST

The process begins when a user makes a request – to send an email, to post a picture, to visit a website, to make a purchase, etc. This request goes to the router, which sends the request along to the modem.

REQUEST IS SENT TO ISP

The modem sends the request to the internet service provider (typically referred to as an ISP). The service provider's server then determines where to send the request.

REQUEST IS ROUTED TO DATA CENTER

For this example, let's imagine the request is to visit a particular website. In this case, the website request is routed to a data center. The data center forwards the request to the destination server, which is where the website is hosted.

REQUEST IS EXECUTED

The host server then springs into action, executing the request. This is done by sending the packets of information (html code, for example) to the user's connected device. If things go as they should, this is when the user's browser begins to receive the packets of information. These packets of information are then rendered into the web page that the user can see and interact with.

That's the general path of information for a basic internet request. There's a good deal of hardware involved to facilitate this process. In addition to routers and servers, there can also be satellites, cellular towers, fiber-optic cables, radios, nodes, and other devices that work together to create a network upon which the packets of data can travel. This core hardware works together to create the backbone of the internet.

All of this hardware, along with the clients (the computers, smartphones, and other devices that we interact with at the end of these network lines), are subject to internet protocols. Protocols are the rules that all the computers working within the network must adhere to in order for data transmission to be successful. In other words, protocols form the common language that computers use to communicate with one another.

1.2

Staying connected in flight

Providing inflight connectivity is considerably more complex than providing Wi-Fi in a stationary locale, such as in a coffee shop or airport lounge.

Both of these examples are fixed locations, which can be hard-wired for connectivity. To provide a global, wireless network that can keep thousands of aircraft connected simultaneously, there are additional considerations.

BANDWIDTH MANAGEMENT

One of the key differences between an aero-communications network and a fixed-location network is that the available bandwidth for a given aircraft is inherently more limited – and this limited amount of bandwidth must be shared among all the connected devices onboard. This bandwidth must be managed to deliver an equitable experience to everyone connected to the network. These networks are also subject to capacity lags in terms of spectrum and efficiency, as well as the inherent latency that comes with routing data over the vast distances between orbiting satellites and/or terrestrial cellular towers and the users onboard the connected aircraft.

TAKING CONNECTIVITY WORLDWIDE

When a network is global, there are additional challenges to navigate – the first of which are regulatory complexities. Regulatory policies and compliance frameworks vary by region and country, so the service providers are responsible for securing the appropriate approvals and licensing on a country by country basis. Once licensing is secured, the service provider has ongoing compliance responsibility.

Gogo fast facts

To create a consistent and equitable connectivity experience in flight, Gogo uses traffic compression, image compression, video optimization, traffic shaping, and content filtering to maximize bandwidth efficiency.

Gogo uses "fair play" network policies. This prevents a few extreme users from controlling an inordinate amount of connectivity resources through the use of high-bandwidth activities. Gogo manages the network both for maximum availability and to ensure a good user experience.

Gogo manages a mobile network in the sky for 9,000+ aircraft worldwide.

SUPPLY AND DEMAND

Unmanaged networks inevitably lead to poor user experiences. Because all networks have finite capacity, and demand almost invariably exceeds supply, the available bandwidth must be managed appropriately for the mobile network to remain viable. Given the continued proliferation of personal electronic devices and the increase in demand for online video streaming, it's unlikely that this relationship will reverse in the foreseeable future.

Staying connected in the sky

Bringing connectivity to the sky takes this complexity one step further. Delivering data can be envisioned as connecting a beam of light with the utmost precision to an aircraft at cruise. And that's just one aircraft. This precision over distance must happen continuously, thousands of times per day, to maintain constant communications with all the aircraft connected to the inflight network at any given time.

1.3

Key considerations for airlines

Airlines have much to consider when determining the right inflight connectivity solution for their fleets, route structures, customer bases, and overall business needs.

Of course there's the cost of connectivity equipment and service, but that's only the beginning. There's also installation, maintenance, network management, and fuel burn – all of which must be factored into making the right decision. Only when all of these aspects are assessed together can an airline begin to properly evaluate the inflight connectivity options the market has to offer.

Key equipment

CABIN SERVER

The onboard server that acts as the hub between the cabin's wireless network and the data moving on and off the aircraft via the antenna.

ANTENNA

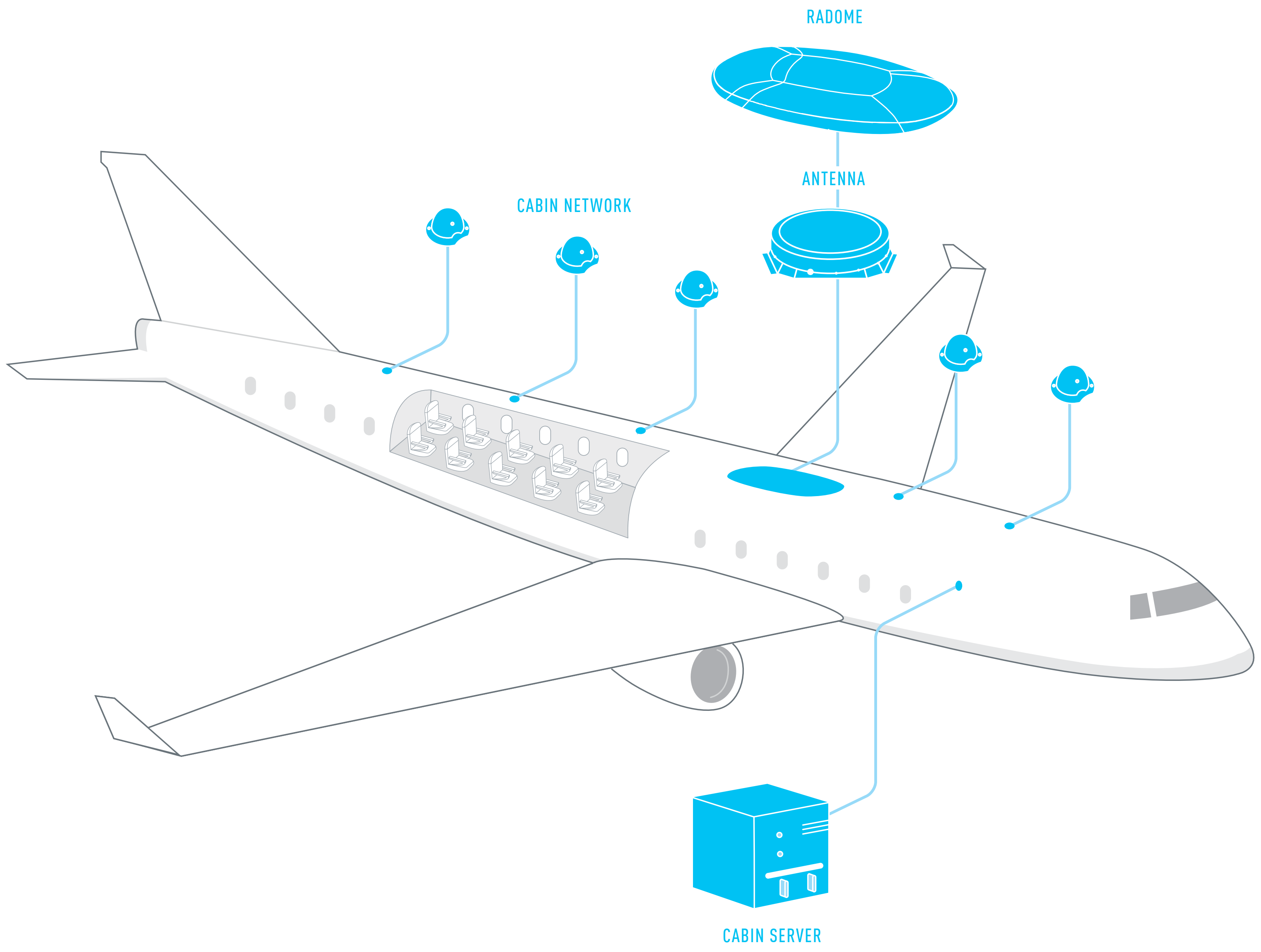
Mounted to the exterior of the plane to send and receive data.

RADOME

Aerodynamic housing that covers and protects a satcom antenna.

CABIN NETWORK

Interior equipment (e.g. wireless access points, radio frequency converters, etc.) that creates the Wi-Fi network within the cabin.



Installation

LABOR

As with any aircraft modification, the process must be scheduled and qualified labor must be assigned to the task.

DOWNTIME

Any time an aircraft spends in the hangar and not in revenue-generating service represents a cost, making downtime a key consideration for retro-fit installations.

LINE-FIT

On many new aircraft, inflight connectivity hardware can be installed to specifications before the airline takes delivery, which eliminates downtime altogether.

What creates fuel burn?

WEIGHT

The total weight of all equipment installed on the aircraft to perform inflight connectivity operations. This includes not only the antenna, but the equipment that comprises the in-cabin network and all necessary wiring.

DRAG

This physical force impacts the aircraft payload, range, and amount of fuel required to complete its mission. The antenna and its radome cover are designed to minimize the impact of drag.

FIGURE 1.1
Connectivity hardware ready for installation

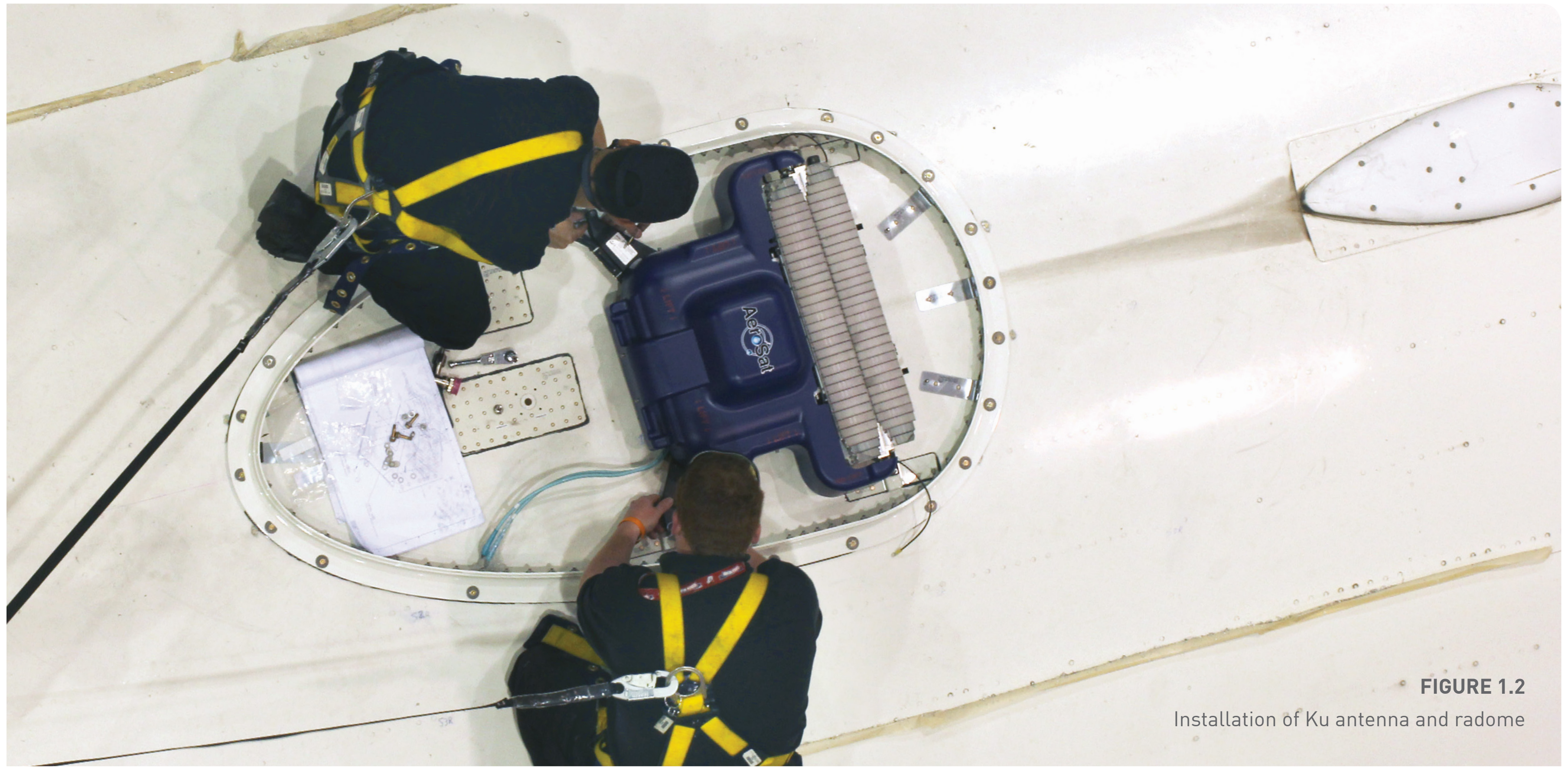


FIGURE 1.2
Installation of Ku antenna and radome

Maintenance

LABOR

As with installations, there are scheduling and labor costs associated with maintaining the aircraft's inflight connectivity equipment.

SPARE COMPONENTS

It's important to consider how quickly inflight connectivity equipment can be replaced if necessary. An aero-communications service provider should have strategically positioned depots for supplies and maintenance as part of a plan for quickly replacing any equipment that does not meet performance standards.

DOWNTIME

Once again, aircraft downtime can add up to lost revenue. Having a schedule for ongoing maintenance and updates that coordinates with your route structure can go a long way toward mitigating these opportunity costs.

Network

SATELLITE BANDWIDTH COSTS

These will vary by satellite technology (e.g. Ku-band vs. Ka-band; wide beam vs. spot beam) and by the cost structure offered by the satellite network owner/operator.

OPERATIONS CENTER

This is where the complexities of the network are managed, including including network health assessments, bandwidth management, and signal hand-offs, as well as identifying and responding to operations issues.

DATA CENTERS

Data moving to and from aircraft is routed and stored through these centers. These centers generally include redundancies and backup power supplies, as well as added security to protect the data in transit. **See fig. 1.4**

Gogo fast facts

The Gogo Network Operations Center (NOC) is an around-the-clock organization that monitors ATG and satellite networks for more than 9,000 aircraft. The NOC team is responsible for continuous network triage. They work in close coordination with satellite partners and provide real-time notifications to internal support teams as part of their network health-monitoring and troubleshooting efforts. More than 10,000 systems feed into the Gogo NOC. **See fig. 1.3**

Gogo's network is designed with redundancy to ensure reliability and operational excellence. All traffic and data from the NOC, Customer Care Center, and AAA server (Authentication, Authorization and Accounting) is replicated in real-time between two data centers separated by 1,000 km.

FIGURE 1.4 Data center

FIGURE 1.3 The Gogo Network Operations Center (NOC)

1.4

Business model considerations

It goes without saying that inflight connectivity comes at a price. Equipment and service can be offset through revenue that the service generates, but there are business model considerations to be made to determine the best approach – and this may vary based on an airline's unique needs.

In reality, airlines that provide inflight connectivity are finding that a positive ROI is not necessarily one of the benefits of offering the service. While there is certainly the opportunity for a revenue-based model, such as the retail model, to help offset the costs, ultimately inflight connectivity is better viewed as a necessary amenity – not unlike inflight entertainment.

Paid or sponsored models

There are two primary ways to offer inflight connectivity: airlines can charge passengers for the service, or the service can be offered through sponsorship. Here's a brief overview of these options:

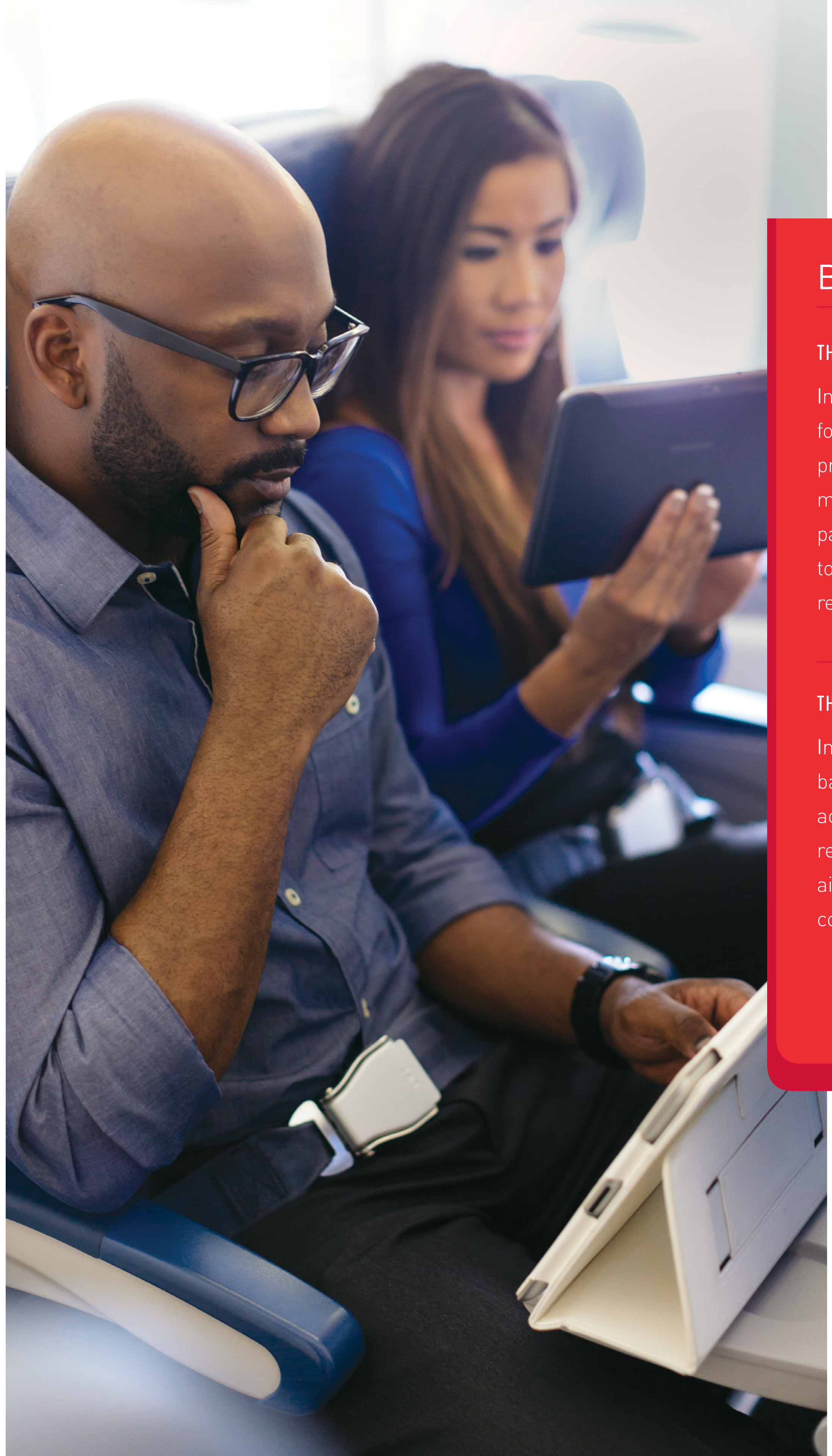
CHARGING PASSENGERS

This option is a clear form of ancillary revenue for the airline, which can help offset the cost of IFC equipment and service. Options for pricing include time-based pricing, per-flight pricing, subscriptions, tiered-bandwidth pricing, and data-based (megabytes used) pricing.

SPONSORED SERVICE

This option also includes opportunities for generating ancillary revenue, such as engaging with third parties who want to reach a captive audience. Such sponsorship partners may be willing to pay to provide complimentary internet for passengers in exchange for the opportunity to gain brand impressions or serve a promotional message.

Airlines also have the opportunity to pay for connectivity themselves and offer complimentary service to high-value customers (such as elite frequent flyers or premium class passengers), or to offer the service to all passengers as part of their amenity package.



Business models

THE RETAIL MODEL

In this model, the service provider sets the prices for passenger connectivity. This allows the service provider to manage the customer experience and maximize revenue. The service provider collects the passenger revenues and delivers a monthly payment to the airline in the amount of the agreed-upon revenue share.

THE AIRLINE-DIRECTED/WHOLESALE MODEL

In this model, the airline selects specific passenger bandwidth levels for each aircraft and sets pricing accordingly. The airline collects 100% of passenger revenues, and the service provider charges the airline for the amount of bandwidth used by all connected aircraft.

1.5

Wrap-up

01

Managing a global wireless network in the sky is significantly more complex than managing a fixed-position wireless network on the ground.

02

In the sky, demand for bandwidth almost invariably exceeds the supply.

03

Bandwidth must be managed for a consistent and equitable inflight connectivity experience.

04

Regulatory policies and compliance frameworks vary by region and country, so a multitude of regulatory approvals must be secured in order to operate globally.

05

Connectivity offers a point of difference that can drive loyalty among valuable customers.

06

The revenue that inflight connectivity generates can help offset the costs of investment.

07

There are several business models for offering inflight connectivity – the right choice for any given airline likely depends on their unique needs and customer profiles.

02

Evolution of inflight connectivity

–

We can learn a lot about where the industry is going by taking a look at where it has been.

Generally speaking, as technology improves over time, the cost per megabyte of moving data on and off aircraft decreases. There's no ceiling to this progression, but innovation and deployment do take time.

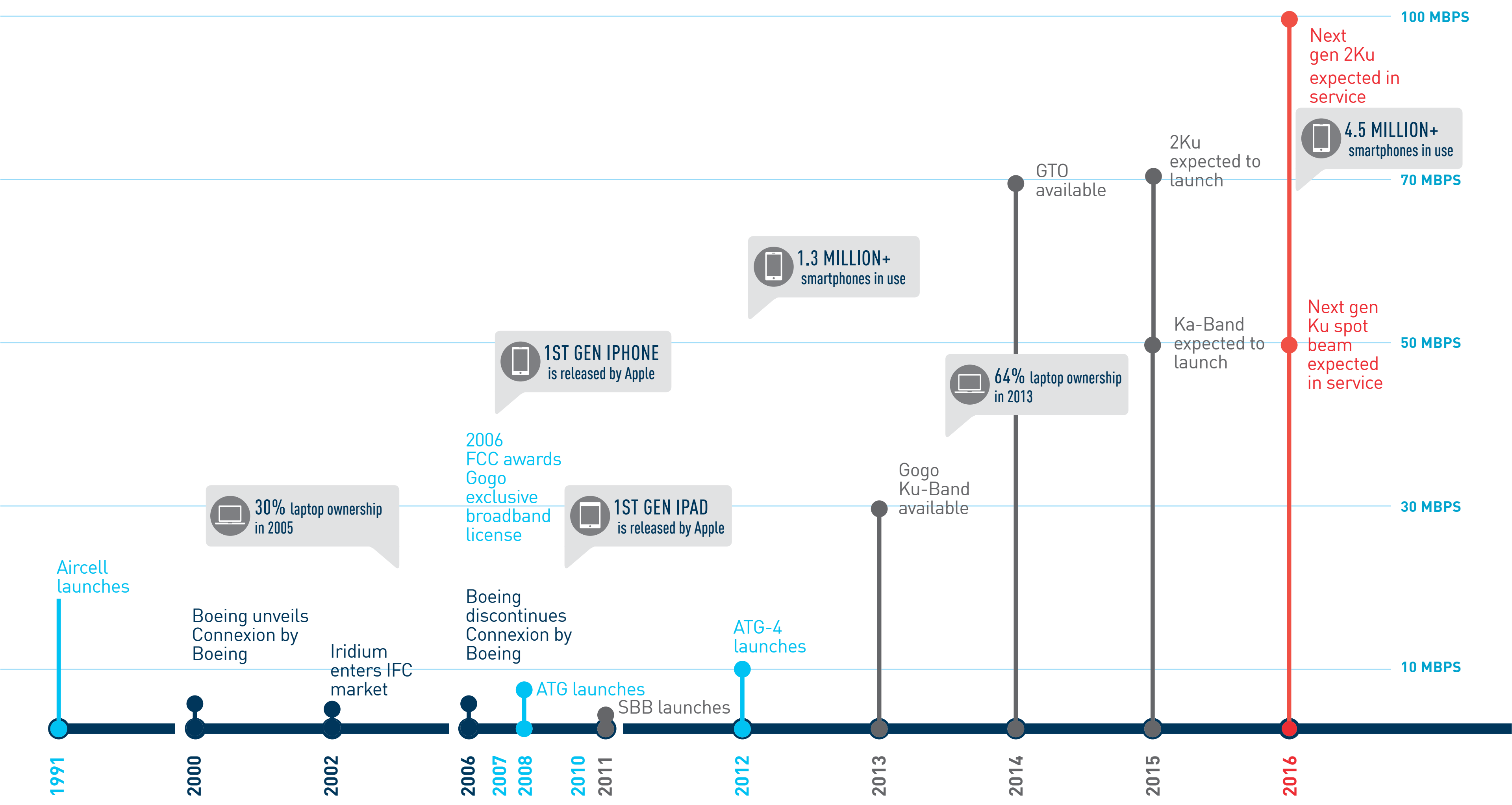
The good news is that the relationship isn't simply a linear one, with a steady increase in speed over time. Data speeds are increasing at an exponential rate – just as they are on the ground. That continued growth is a given, as is the insatiable demand for more bandwidth. The role of an aero-communications service provider is to ensure that this technology performs reliably, consistently, and as specified. And because there is no one-solution-fits-all approach, service providers must evolve to find the best technology to enable their partners and meet passenger demands.

In the beginning

Inflight connectivity has come a long way since broadband was first made available to commercial aircraft. In 2000-2001, Connexion by Boeing® was unveiled, which relied on satellite technology to bring data onboard.

Unfortunately, the cost of this technology at the time was higher than customer demand allowed. At the time, air travelers (and the public in general) had not yet adopted Wi-Fi enabled laptop computers and other personal electronic devices to the extent that they would a decade later. Additionally, the required onboard hardware weighed nearly 1,000 pounds, which made operating costs unfeasible. In short, the system could not deliver sufficient bandwidth to the aircraft to warrant the cost of operation. That led Boeing to discontinue its Connexion service in 2006.

In 2002, Iridium entered the inflight connectivity market when it introduced a service that offered inflight voice and data communication – as well as cockpit communication services – with speeds up to 134 kbps.



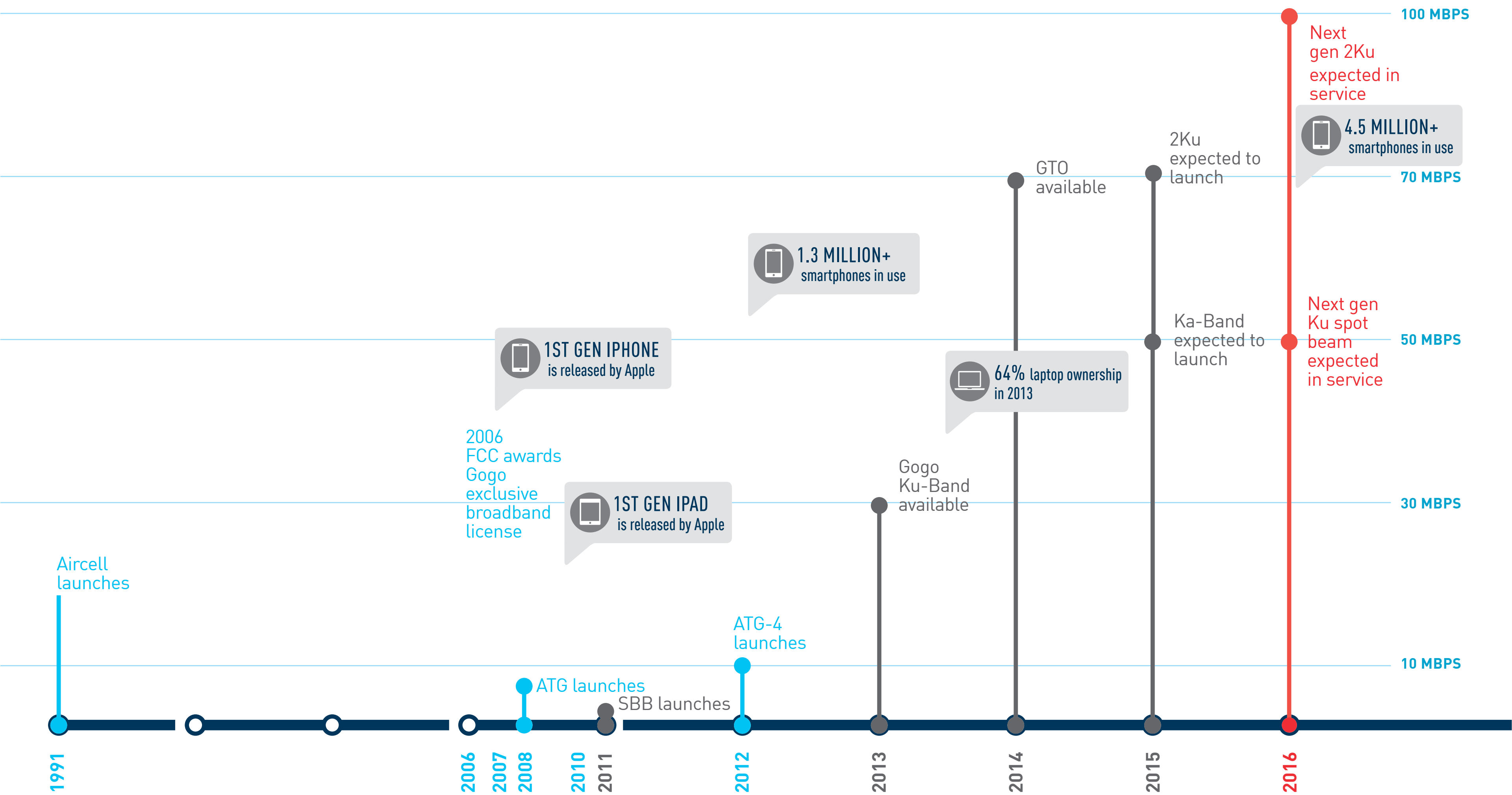
A viable solution emerges

In 1991, ten years before Boeing announced its Connexion service, Gogo (operating as Aircell) was providing analog-based voice communications on private aircraft in North America, and by the late '90s, had successfully leveraged a satellite-based system to offer voice communication on overseas flights.

Leveraging our own inflight communications experience, Gogo recognized an opportunity to provide affordable broadband connectivity to commercial aircraft. Instead of relying on the heavy equipment necessary for satellite-based connectivity, Gogo would create a network of cellular towers in North America to provide a lightweight, cost-effective solution. In 2006, the Federal Communications Commission (FCC) in the United States awarded Gogo an exclusive broadband frequency license to operate their Air-To-Ground (ATG) network. And in 2008, Gogo made its debut on commercial aircraft.

In 2012, Gogo announced ATG-4, an enhanced version of its ATG service. ATG-4 is backwards-compatible, which allows for upgrades to existing ATG systems through low-cost retrofits. ATG-4 delivers peak speeds from current performances of up to 9.8 Mbps per aircraft – a threefold increase of the peak speeds delivered via standard ATG.

While ATG and ATG-4 technology is geographically limited, it continues be a viable and cost-effective IFC solution. Together, these two solutions have been adopted on 2,000+ commercial aircraft to date in North America.

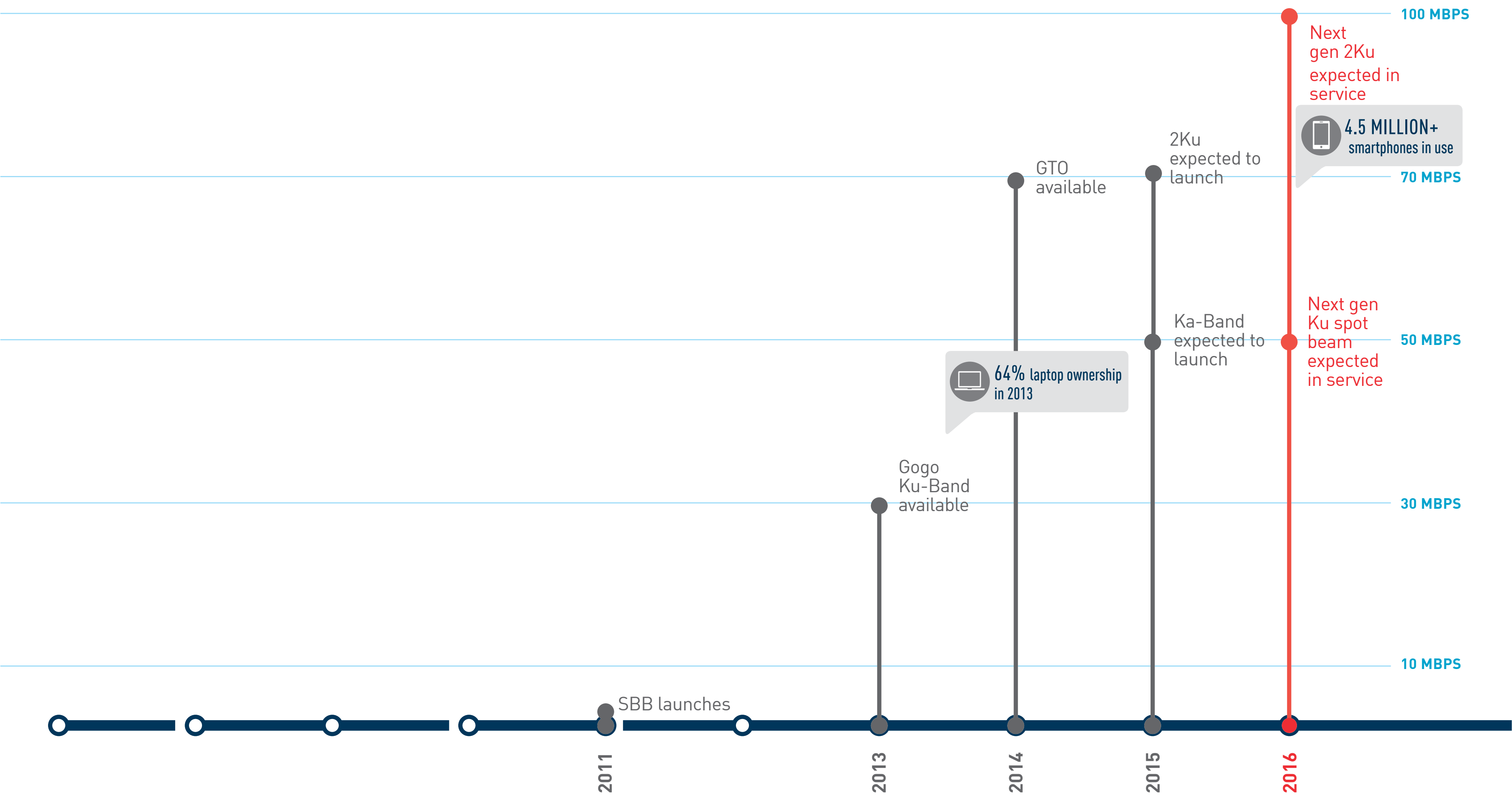


Satellite technology takes off

While Gogo built out its ATG network, we were also working on developing cost-effective satellite solutions to support the global aviation market.

In recent years, Ku-band satellite technology has become a viable solution for certain aircraft operating on certain routes. Solutions using this technology are available from several providers and re-sellers throughout the world, including Panasonic Avionics, Row 44, and Gogo.

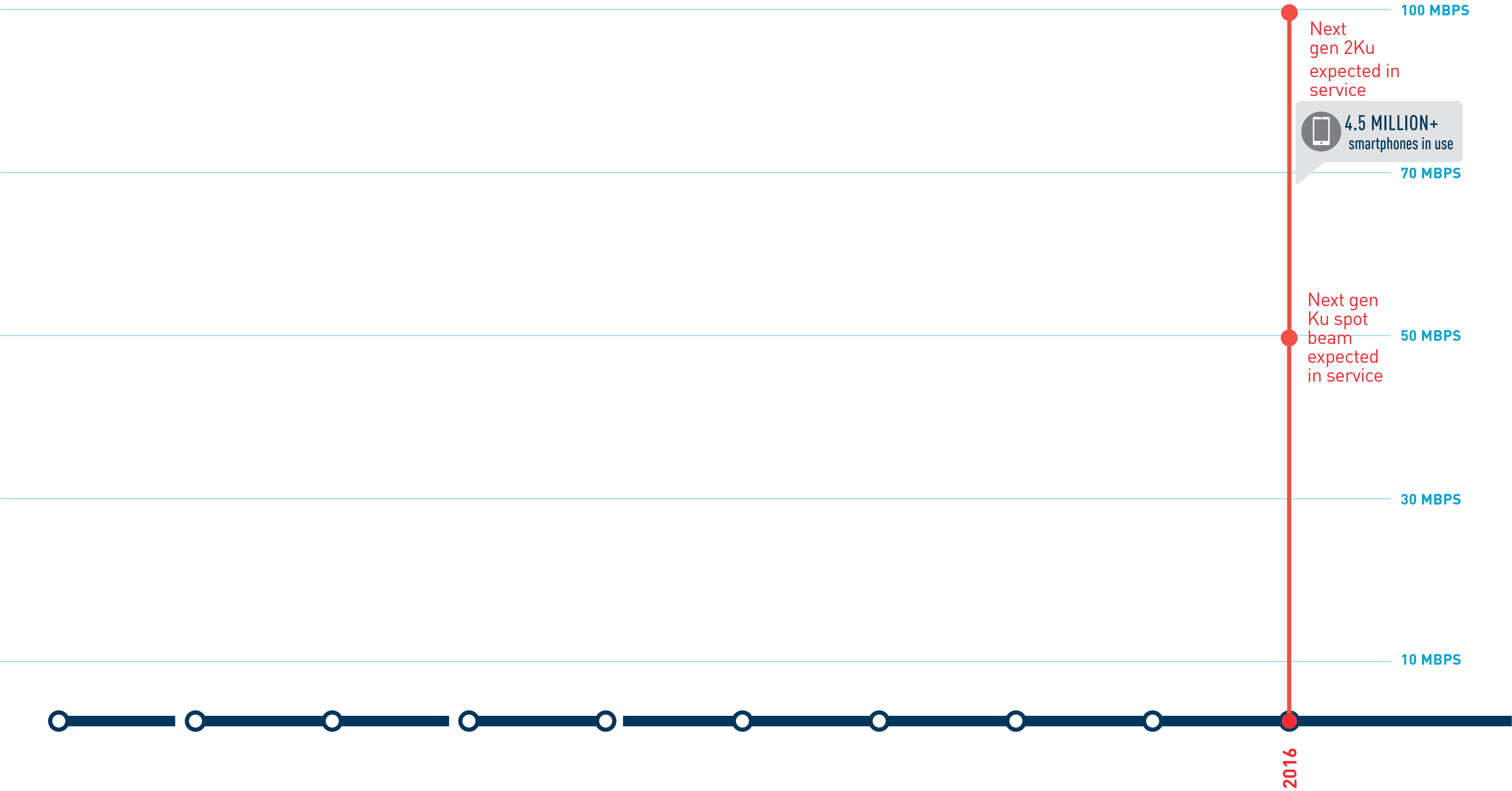
There are also some Ka-band solutions available today, which offer higher speeds but limited coverage. Like all IFC technologies, Ku- and Ka-band solutions have their benefits and limitations, which we'll outline later.



Next-generation global solutions

Just as the latest computer technology or mobile device is always on the horizon, new-and-improved inflight connectivity solutions are always in the works. But like mobile technology, IFC solutions are only as good as the service providers and networks that support them.

With Gogo, the latest development is 2Ku, which delivers global coverage and incorporates an antenna capable of speeds up to 70 Mbps.



03

Making inflight connectivity work

Providing reliable inflight connectivity takes more than offering a connectivity solution or two. But what, exactly, does it take?

In this chapter, we'll give you an understanding of the various aspects of service and support required to deliver connectivity. This knowledge will help you understand some of the industry terminology as well as some of the key systems that make inflight connectivity possible.

Making an evaluation

To deliver global inflight connectivity effectively, a service provider should offer these elements, which can serve as indicators of capability and credibility:

RELIABILITY

The aviation industry demands experienced providers that have demonstrated their reliability on any aircraft, from small Cessnas® to B747s, operating virtually anywhere.

GLOBAL INFRASTRUCTURE

A worldwide network and the technology and staff to support it are required to deliver consistent performance.

COMPLETE SOLUTIONS

Products and services supported by flexible commercial models and branding control help meet the unique business needs of each airline.

SCALE & INVESTMENT

These aspects aid in growing, operationalizing, and improving network and technology, because airlines expect performance and longevity from their IFC investments, all while minimizing costs.

AN EXPERIENCED TEAM

Key support groups should be dedicated to operational excellence and full-time support, because the complexities of IFC are best navigated alongside a trusted partner.

Making it work

To manage connectivity and transmit data to and from aircraft, a sophisticated ecosystem must work in harmony to deliver consistent, reliable service for crew and passengers.

Regardless of aircraft type or geographic location, a viable inflight connectivity network must offer a high level of reliability. Only then can airlines operate with the assurance that their connected fleets will perform for their passengers and crews.

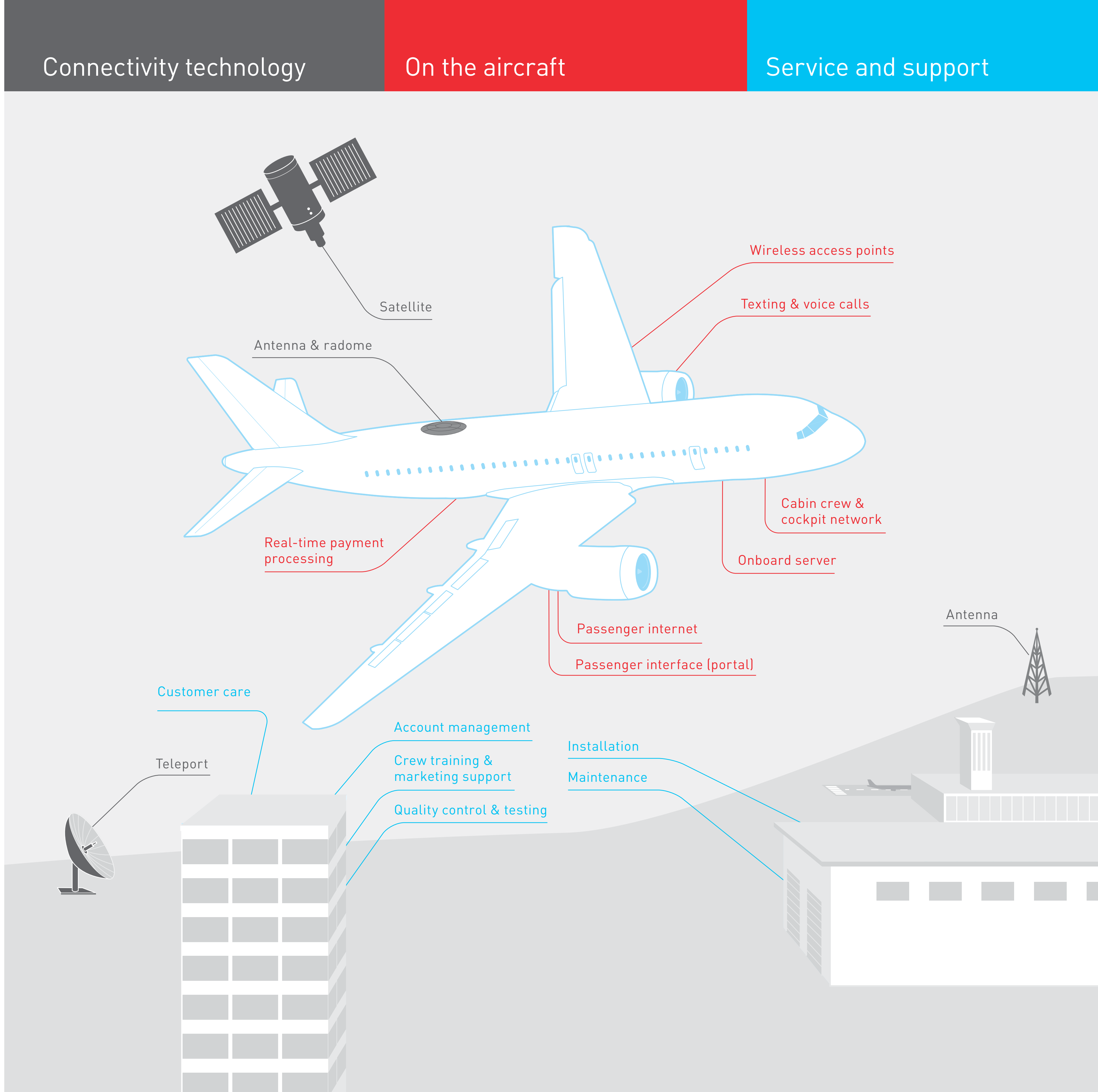
Gogo fast facts

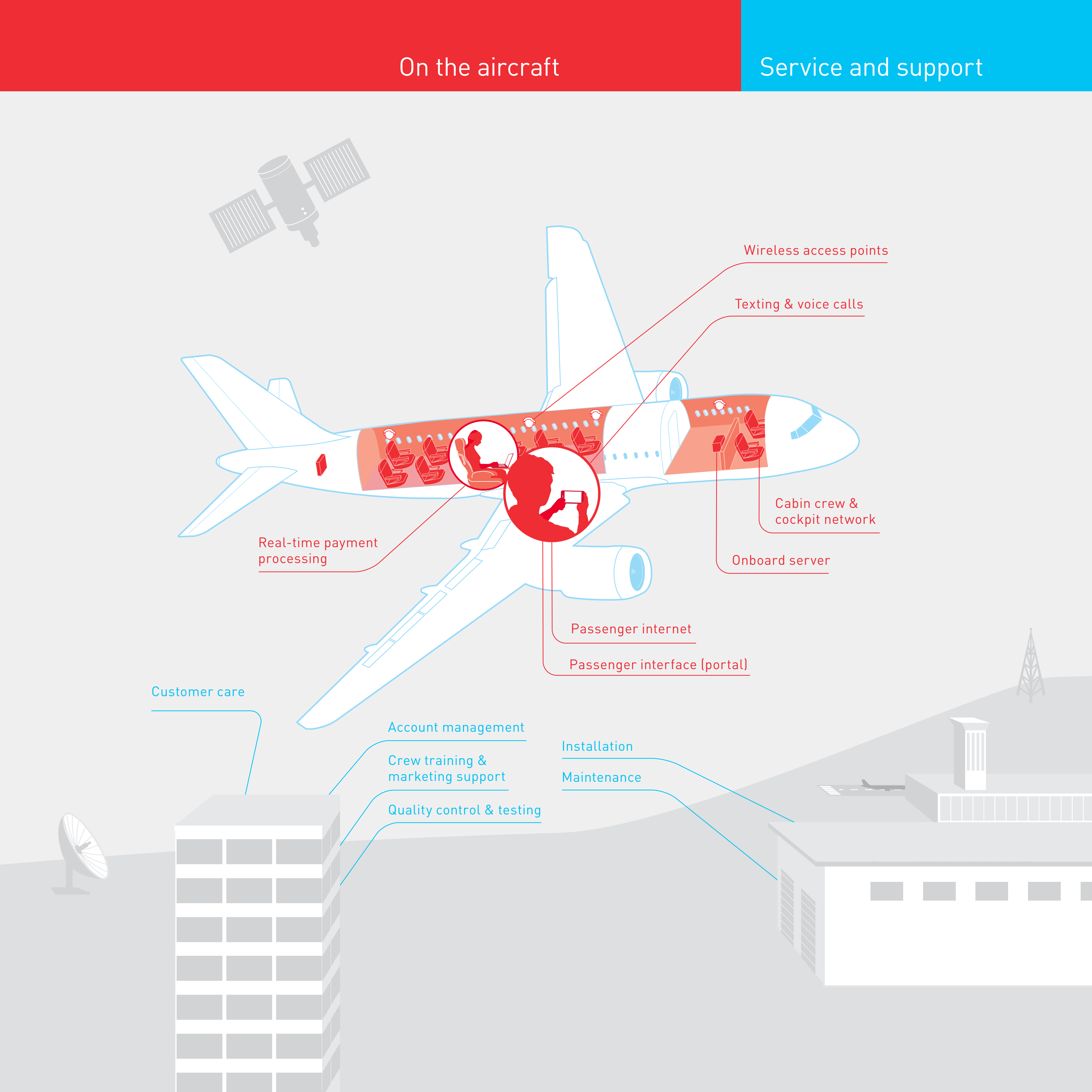
Over the past 6 years and 55+ million inflight internet sessions, Gogo has optimized a global network for its aviation partners.

3.2

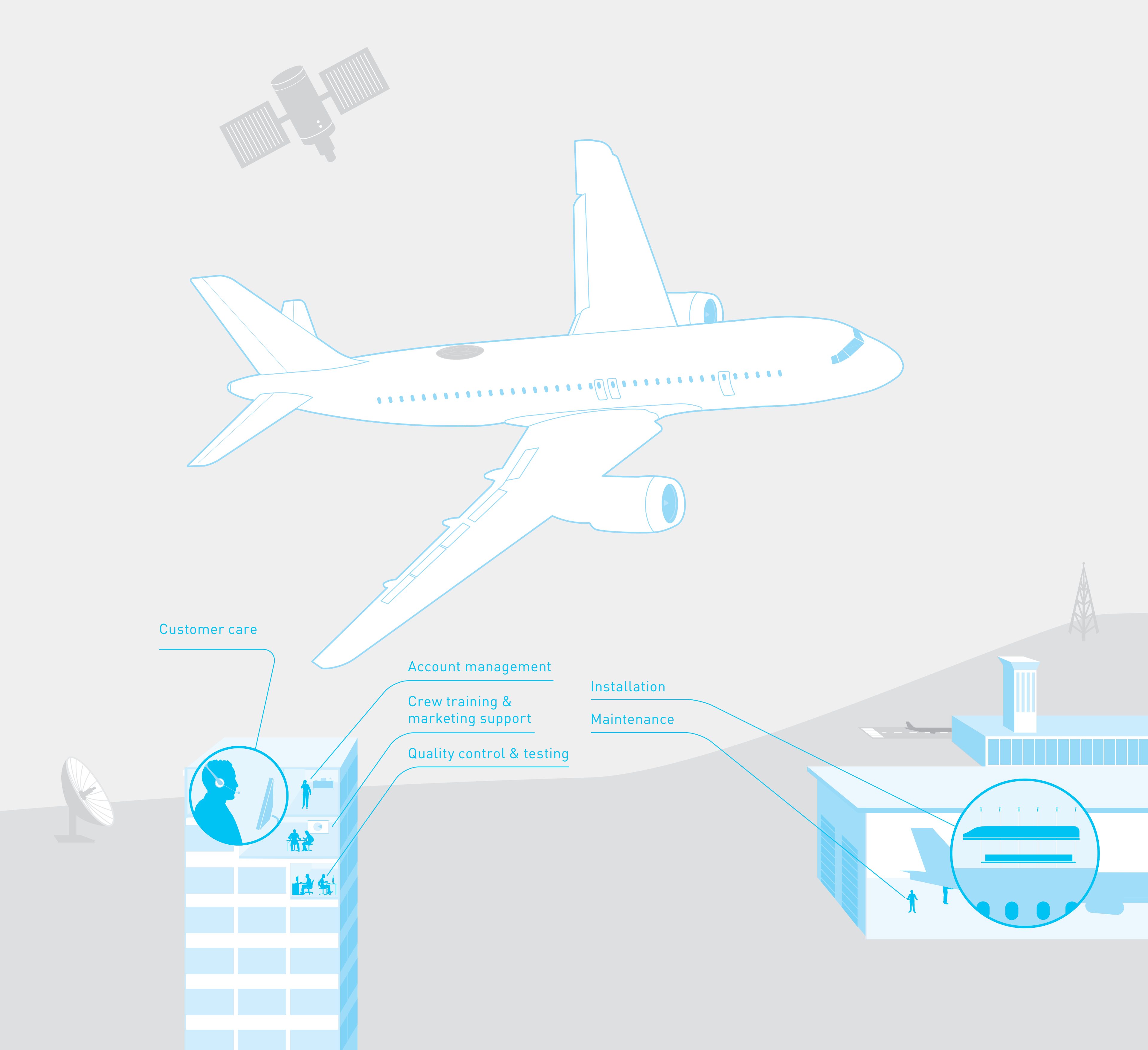
The aero-communications ecosystem

To understand the inflight connectivity ecosystem, it can be helpful to divide the components into three categories: the technology itself, the hardware onboard the aircraft, and the accompanying service and support work that takes place on the ground.





On the aircraft
Service and support
Wireless access points
Texting & voice calls
Cabin crew & cockpit network
Onboard server
Real-time payment processing
Passenger internet
Passenger interface (portal)
Customer care
Account management
Crew training & marketing support
Quality control & testing
Installation
Maintenance



Customer care
Account management
Crew training &
marketing support
Quality control & testing
Installation
Maintenance

3.3

Service and support

Connecting the aircraft is only the beginning.

Whether it's securing regulatory compliance, providing ongoing technical assistance and maintenance, or coordinating with partners to manage current service offerings and plan for the future, connectivity service providers can play a broader support role in implementing the service to ensure the smoothest performance possible.

CERTIFICATIONS AND REGULATORY APPROVAL

In order to operate a network for inflight connectivity, the service provider must work with all relevant aviation bureaus (e.g. CAAC, CAAS, EASA, FAA, etc.) to secure the necessary Supplemental Type Certificates (STCs), which enable installations of connectivity equipment on the specific aircraft in a given airline's fleet.

A regulatory team must also develop and execute a regulatory compliance plan based upon an airline's global route network and launch timing, as well as the regulatory requirements in the airline's home country and abroad.

INSTALLATION AND MAINTENANCE

With partner authorization, a service provider can manage the equipment and system installation across all fleet types. To minimize aircraft downtime, installations and certifications can be performed in phases. After install, any connectivity-related issues on the aircraft must be addressed, so preparations should be made ahead of time. This includes taking airline hub locations into account to handle regular maintenance and equipment upgrades with maximum efficiency.

QUALITY CONTROL & TESTING

Quality control and testing on all offerings should be conducted before launch, including simulating the passenger experience, testing across devices and operating systems, and overseeing inflight testing to ensure launch-ready performance. **See fig 3.1**

FIGURE 3.1 Gogo's test lab

CREW TRAINING AND MARKETING SUPPORT

Because airport staff and flight attendants help drive awareness of connectivity and entertainment onboard, a service provider should work with their partners to give crews a working knowledge of the service. This can help crews answer any questions customers may have in flight. Similarly, to build awareness among passengers and offer easy-to-follow instructions in relevant languages, digital assets, seatback cards, and other marketing materials should be planned for, created, and distributed in the appropriate places.

ACCOUNT MANAGEMENT

Connectivity providers should offer dedicated account and program management teams to support and champion each partner's objectives. The account team collaborates with partners to drive awareness, increase take rates, and provide regular reporting of system performance and service statistics.

3.4

On the aircraft

The hardware on and within the plane creates an in-cabin network, which delivers connectivity for passengers and crew.

This technology also allows for the integration of voice and/or text capabilities and inflight entertainment services (such as streaming movies and TV).

ANTENNAS & RADOMES

Antennas are installed on the exterior of the aircraft to send and receive signals to and from the source. When cellular towers are the source, small antennas are mounted on the bottom and side of the aircraft. When satellites are the source, antennas are mounted on top of the aircraft and housed beneath a cover known as a radome. Satellites then relay signals to the ground. For satellite connectivity, an adapter plate and fairing may also be used in the installation process.

MODEMS

Modems are the devices responsible for connecting computers over communications lines. They consist of modulators that convert computer signals into radio frequency signals and demodulators to handle the reverse of these conversions.

WI-FI ANTENNAS

These convert electric power into Wi-Fi radio waves. The number required for inflight connectivity depends on technology used and aircraft type.

WIRELESS ACCESS POINTS (WAPS)

Cabin wireless access points and Wi-Fi antennas provide the Wi-Fi signal to devices within the cabin. The number of WAPs required for the in-cabin network varies based on aircraft type.

ONBOARD SERVER

The onboard server hosts airborne applications (such as video files that can be made available for inflight streaming) and caches a version of the inflight portal – the gateway by which passengers connect.

Together, these components make the following possible:

PASSENGER INTERNET

WIRELESS INFLIGHT ENTERTAINMENT

TEXTING & VOICE

LIVE CUSTOMER CARE
for any assistance passengers may need inflight

REAL-TIME PAYMENT PROCESSING
and account management & billing for passengers

PASSENGER INTERFACE (PORTAL)
providing the passenger gateway to connectivity

CABIN CREW & COCKPIT NETWORK

Gogo fast fact

Gogo's latest onboard server houses a 4G wireless terrestrial modem to support operations and a storage capacity of 2.56 terabytes.

3.5

Connectivity technology

We've gone into detail about inflight connectivity, but what is a connected aircraft connected to, actually?

The only viable methods thus far connect aircraft via satellites in orbit or cellular towers on the ground. These deliver the bandwidth to aircraft, allowing passengers to connect to the internet.

SATELLITES

Satellites have the potential, when networked, to provide global coverage to support any aircraft mission. Ku-band satellites are the most prominent today, while more Ka-band satellites are expected to be deployed in the near future. L-band satellites are also in use, though these deliver considerably lower levels of bandwidth to aircraft.

CELLULAR TOWERS

Cellular towers provide connectivity (over land, where an uninterrupted network of towers can be established) for aircraft operating within the coverage area. Gogo's ATG network in the U.S. and portions of Canada is the only such example in operation as of 2014. However, other internet providers have announced plans for additional ATG solutions in Australia, China, Europe, and North America.

HYBRID SOLUTIONS

As mentioned at the end of Chapter 2, hybrid solutions are emerging as well. These combine cellular tower technology with satellite technology to create new connectivity solutions that may offer advantages in terms of coverage and/or bandwidth.

3.6

Wrap-up

01

In today's market, reliable inflight connectivity requires an experienced team, operational scale, a global infrastructure, and a commitment to investing in the future.

02

In the inflight connectivity ecosystem, the aircraft is only part of the picture. Technology on the ground and in orbit, along with established infrastructure and dedicated teams, are required to ensure reliable performance.

03

On the aircraft, multiple pieces of hardware coordinate to form what's known as the in-cabin network.

04

In order to provide inflight connectivity, the service provider must secure regulatory approvals not only in the country where an airline is based, but in every country where the airline's connected fleet operates as well.

05

Crew training, marketing support, and customer care all play critical roles in raising awareness among air travelers and assisting them with the service.

04

The science behind inflight connectivity

Now that we've covered the basics of inflight connectivity, there are a few more technical topics that warrant a closer look.

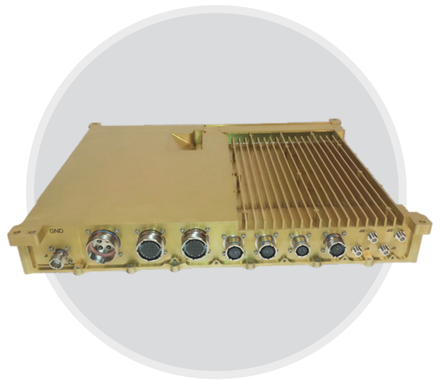
Understanding these complexities will offer better perspective regarding how they affect the inflight experience and what they mean for airline operations.

4.1

Satellite-specific onboard hardware

Satellite-connected aircraft require specialized equipment.

While knowing the specifics of every component of the connectivity system may not be essential to making the right connectivity decisions for a fleet, introducing these components here should aid in the understanding of some of the concepts and explanations that follow.



KU/KA-BAND AIRCRAFT NETWORKING DATA UNIT (KANDU)

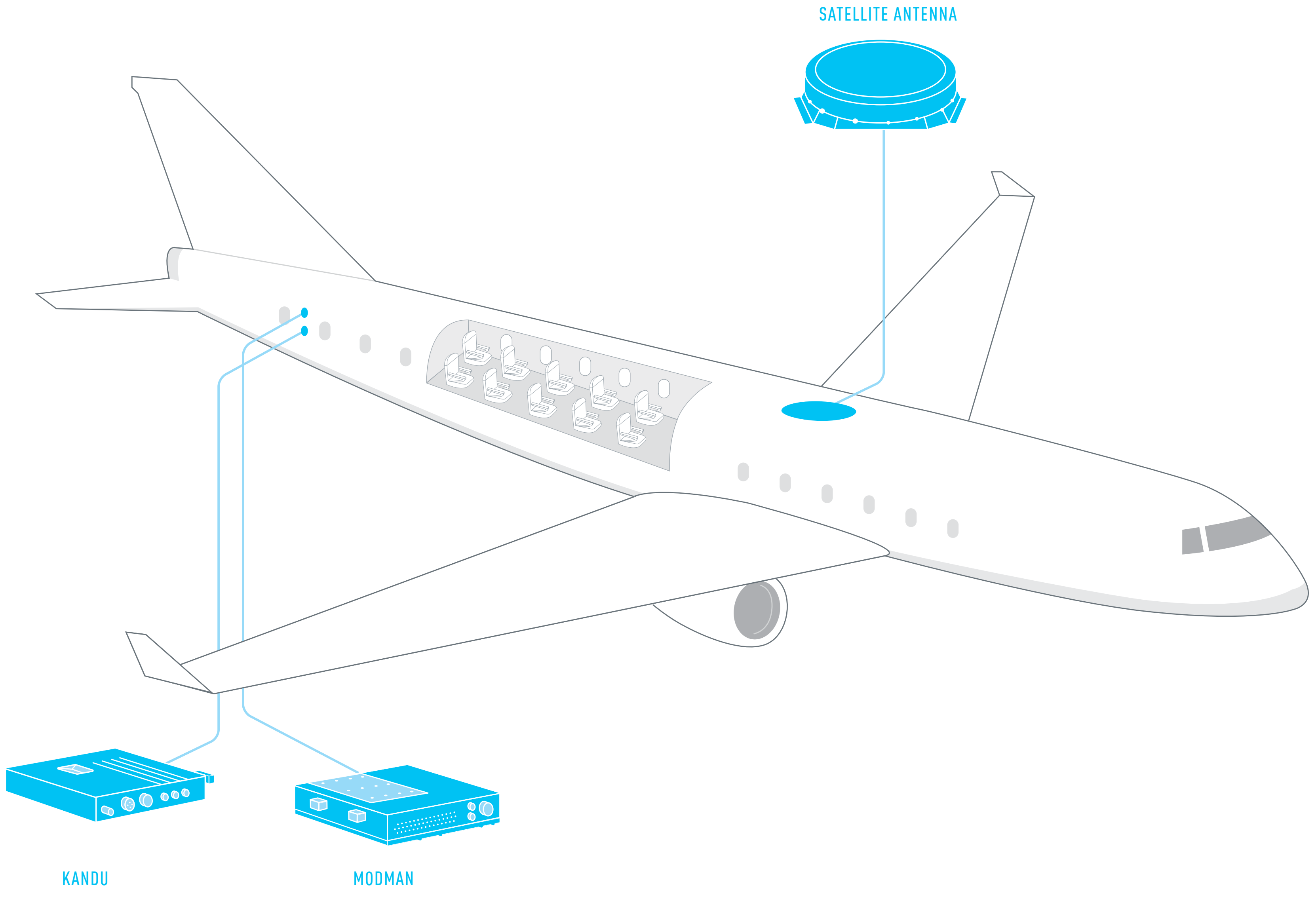
The KANDU provides power to the satellite antenna and uses aircraft navigational data to control its movement.

KU/KA-BAND RADIO FREQUENCY UNIT (KRFU)

The KRFU converts L-band to Ku- or Ka-band frequencies from the modem to prepare for transmission to the satellite. It also amplifies the Ku- or Ka-band signal for this transmission. The KRFU governs this process in reverse as well, converting the Ku- or Ka-band transmissions received from the satellite back to L-band frequencies.

MODEM AND MANAGER (MODMAN)

The MODMAN hosts the modem, which modulates and demodulates L-band signals to and from baseband.



4.2

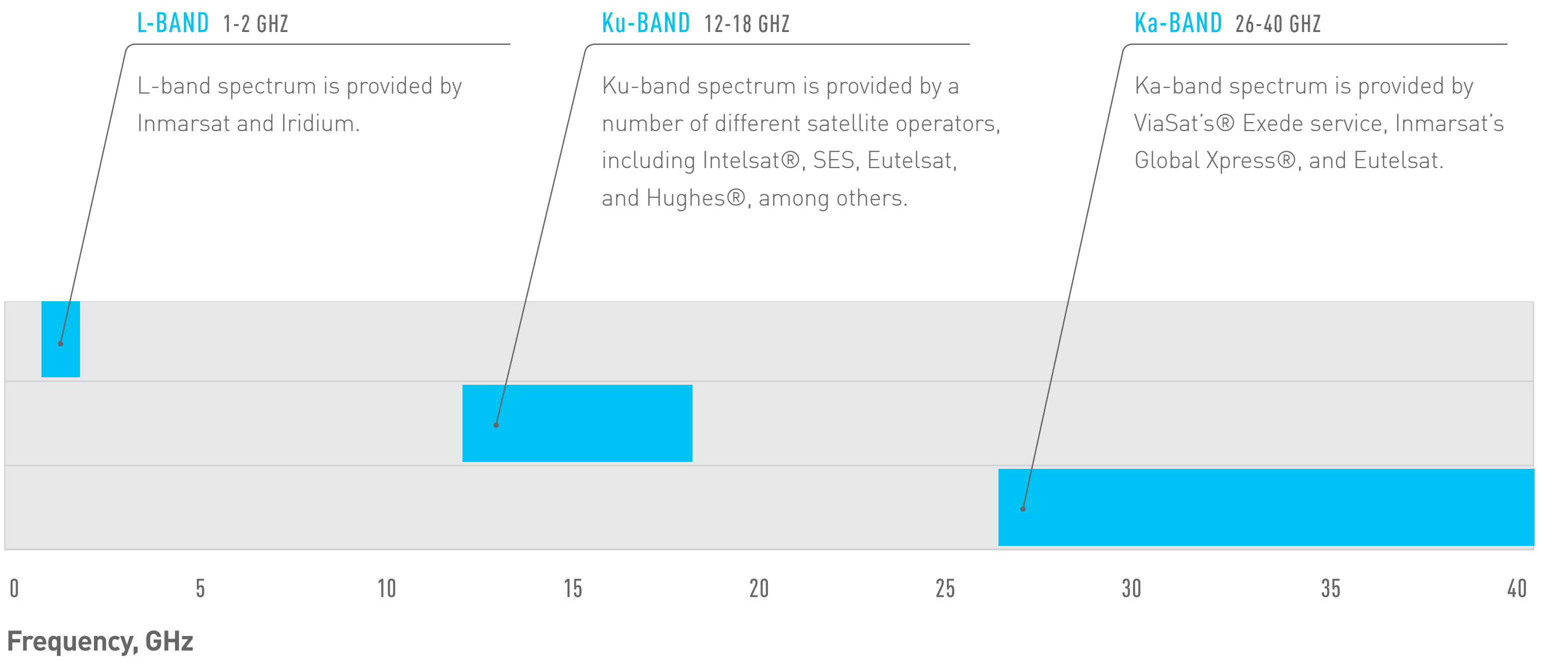
Frequency band overview

Frequency bands are specific ranges of frequency within a portion of the electromagnetic spectrum.

There are three frequency bands over which satellite-based inflight connectivity currently operates. All three of these fall within the microwave portion of the electromagnetic spectrum.

Gogo fast fact

Gogo ATG and ATG-4 technologies transmit data in the 800 MHz range, which is within the UHF portion of the electromagnetic spectrum.



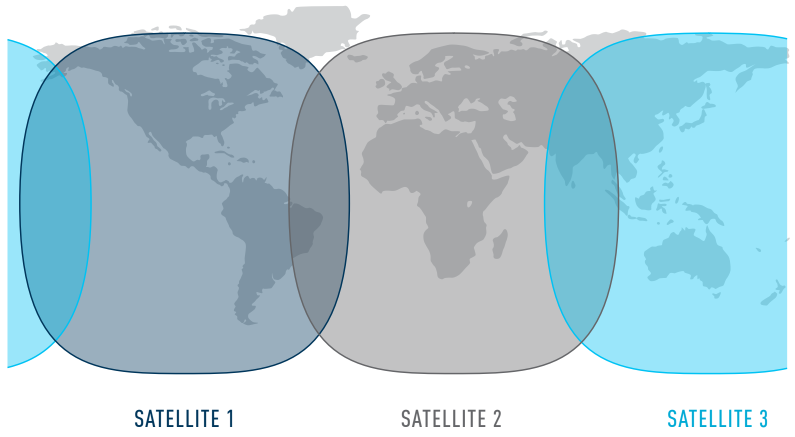
4.3

Satellite signals & handoffs

In order for connectivity to remain uninterrupted on a satellite-connected aircraft, the antenna must maintain its orientation toward the desired orbiting satellite.

As the aircraft progresses along its flight path, eventually it will move beyond the range of the satellite at the other end of the connection. When this occurs, the connection must physically transition from one satellite to another. This is known as a "handoff."

This process is not instantaneous. The modem onboard the aircraft must register the handoff, reorient the antenna, reacquire the signal, and reestablish the data link to the servers on the ground.



Because satellite coverage tends to overlap, multiple satellite options are often available. The onboard hardware (the MODMAN, in this case) constantly monitors the aircraft position and uses an onboard service map that specifies the best satellite to use in a given location.

Overall, the handoff process typically takes about 1-2 minutes. On a typical long-haul flight, the satellite antenna usually requires at least one satellite beam handoff. Minimizing handoff time is vital to ensure a seamless passenger experience.

4.4

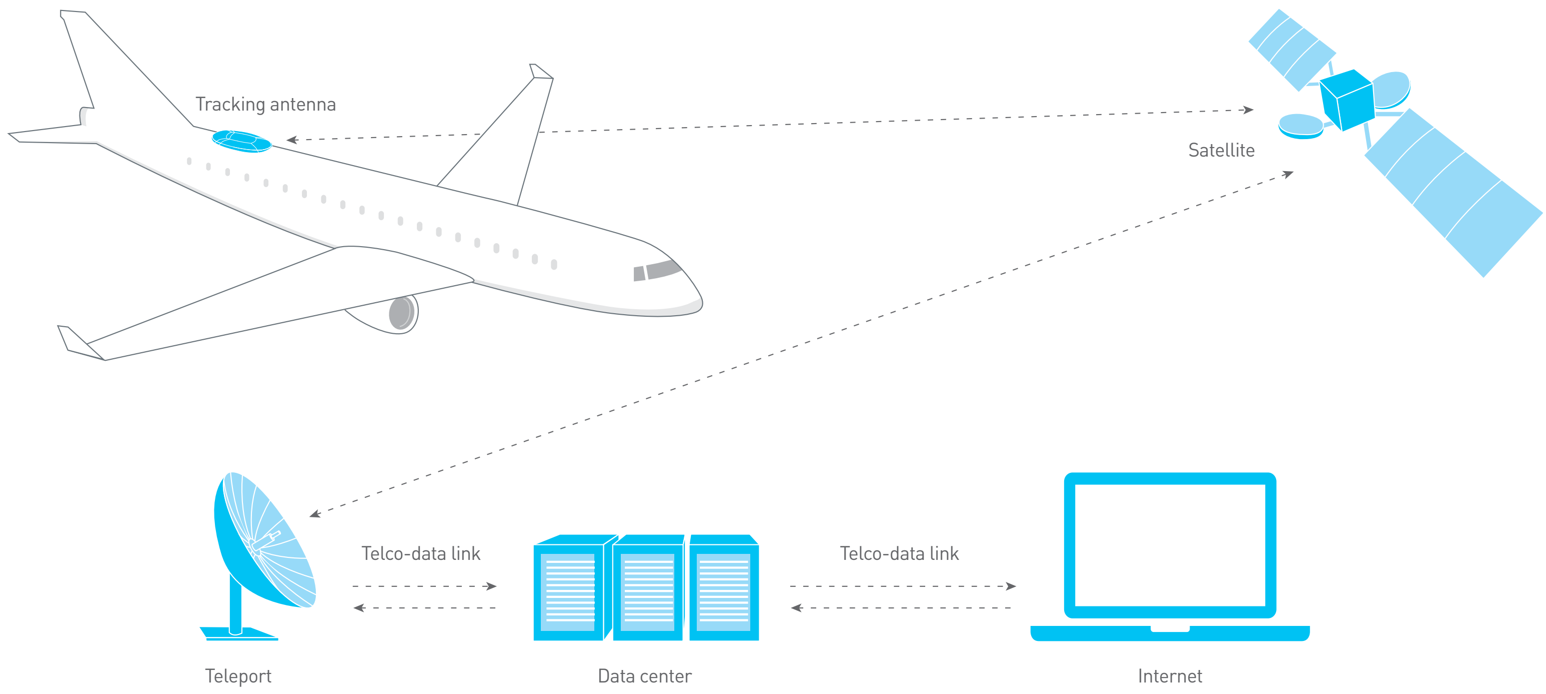
Latency

Latency refers to the amount of time it takes for a packet of data to move from one point to another over an internet connection.

While latency is inherent in all communications, the degree of latency varies.

When someone on a satellite-connected aircraft makes a data request, it must travel from the aircraft's antenna to the satellite – a distance of approximately 35,000 km (22,000 miles). The request then travels from the satellite to a teleport on the earth's surface, then along to a data center, before reaching its destination on the internet. The response then travels this path in reverse, back through the aircraft's antenna, over the in-cabin network, and ultimately to the device where the request originated.

With satellite-based connectivity, the latency is higher compared to Air-To-Ground connectivity, as the path data must follow is much longer when routed through orbiting satellites.



4.5

Antennas, radomes & fuel burn

The size and shape of the antenna on the aircraft determines the size and shape of the radome that covers the antenna.

Engineers consider the aerodynamics of the given size and shape as they design the radomes to best minimize drag and fuel burn.

As for the antennas themselves, there are two designs worth reviewing: traditional gimbaled antennas and new mechanically-phased-array antennas. The key difference is that a gimbaled antenna rotates to direct the beam, whereas a mechanically-phased-array antenna synthesizes a beam and sends it in the desired direction.

TRADITIONAL GIMBALED ANTENNAS

Gimbaled antennas are asymmetric in design, which results in an asymmetric beam shape. Airborne antennas have typically adopted this design due to aerodynamic considerations. These antennas rotate on two axes to maintain orientation toward the target satellite regardless of aircraft location or altitude.

MECHANICALLY-PHASED-ARRAY ANTENNAS

Mechanically-phased-array antennas represent the next-generation of airborne antenna design. Rather than physically pointing toward the target satellite, these antennas create a beam in the desired direction by mechanically rotating a series of internal plates with carefully designed resonance characteristics. These antennas are symmetric in design, which results in a symmetric beam shape. Compared to gimbaled antennas, they are even lower in profile and more aerodynamic, effectively reducing the amount of drag.

4.6

Satellite beam types

Satellite beams can be classified into two main types: wide beams and spot beams.

When connecting to the antenna on an aircraft, wide-beam satellites (such as those used in today's Ku network) project a beam with a broad width. These are sometimes called "regional beams" because a single wide-beam satellite can provide coverage to a large region of the globe.

Spot-beam satellites have much narrower beams, which are specifically concentrated in power to provide coverage to precise geographic areas. Only antennas in these focused reception areas are able to receive the spot-beam signal. These function similarly to cellular networks, in that many spot beams are used to provide coverage over larger areas. A satellite using spot beams can transmit multiple data signals by reusing the same frequency over different geographic locations, ultimately delivering more bandwidth at greater efficiency.

Inmarsat's Global Xpress will use spot-beams when available in 2015. Next-generation Ku satellites will also use spot-beams; Intelsat's Epic^{NG} is expected to debut in 2016.

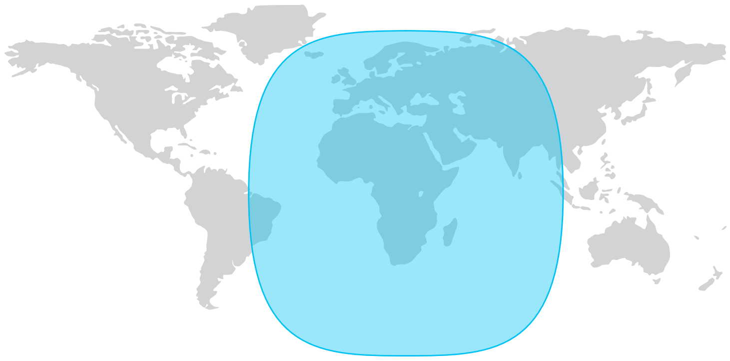


FIGURE 4.1 wide-beam

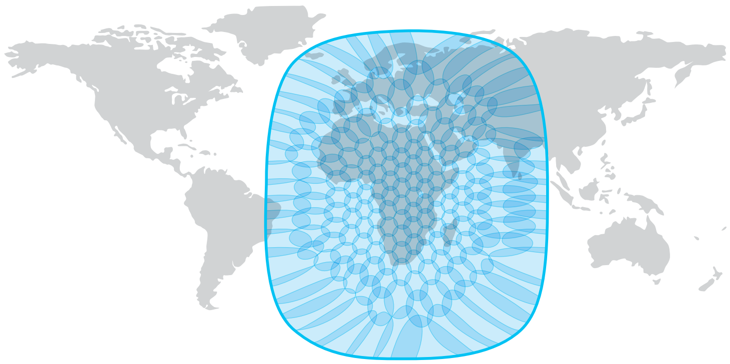


FIGURE 4.2 spot-beam

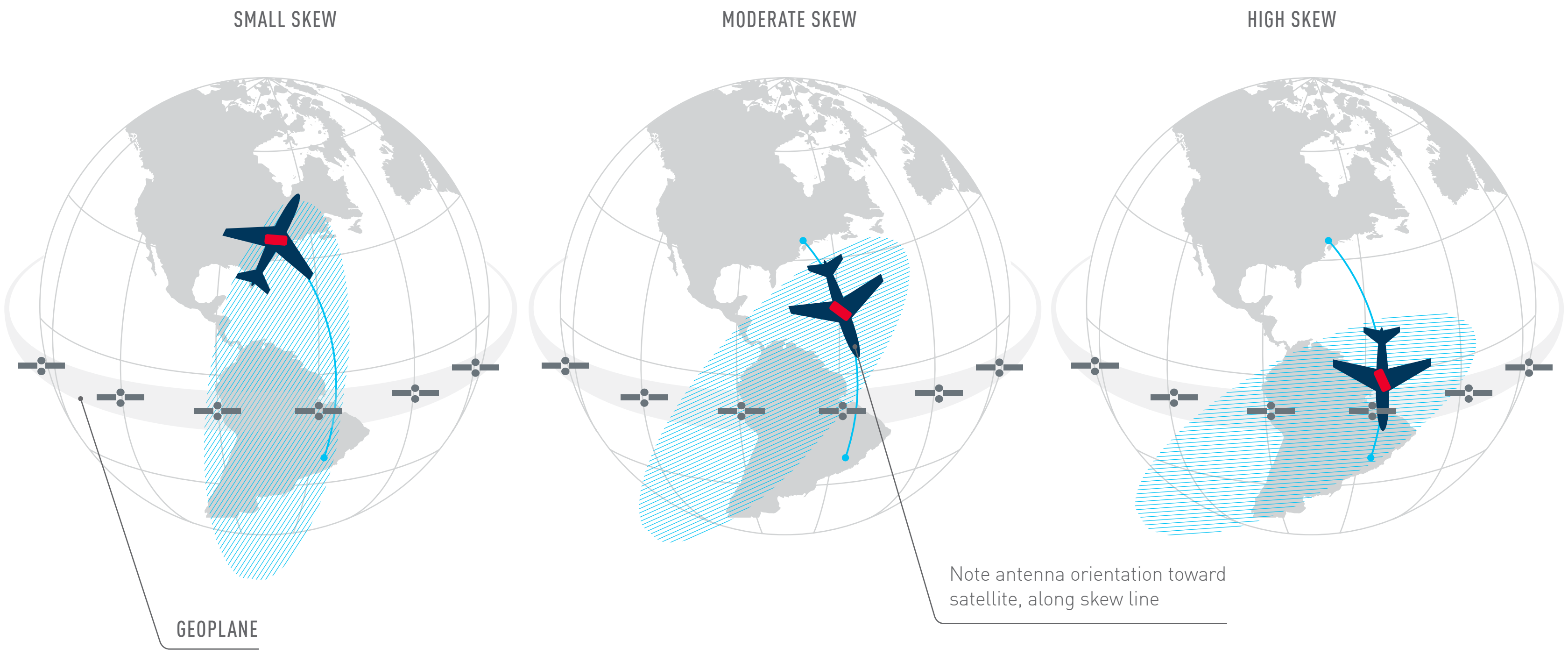
4.7

Skew angles and coverage in tropical regions

Understanding the challenges associated with operating an asymmetric antenna first requires some familiarity with the idea of the "geoplane."

The geoplane is an imaginary line that runs through all the geostationary satellites in the sky, which align along the equator.

Asymmetric antennas produce oval-shaped beams, which can lead to interference that results in decreased performance both to and from the aircraft when flying in tropical regions. This interference occurs because as the aircraft moves toward the equator, the wider cross-section of the beam begins to align with the geoplane, causing undesired signals from adjacent satellites to be received along with the signal from the target satellite. The degree to which the beam is twisted



into the geoplane – and hence, the severity of the interference – is characterized by the "skew angle."

Symmetric-aperture antennas can avoid these interference issues in most operational scenarios by projecting symmetric beams toward the geoplane – even at high skew angles – and provide excellent performance on flights that cross the equator.

Asymmetric antennas must compensate for interference at high skew angles by lowering power, which results in significantly decreased data speeds (known as "throughput") to and from the aircraft.

Skew angle review

01

Traditional gimbaled antennas are asymmetric in design.

02

Asymmetric antennas create asymmetric beams.

03

Asymmetric beams result in effective beamwidth that varies with geographic location.

04

Effective beamwidth determines how much interference with other satellites occurs.

05

How severely interference degrades performance is determined by the skew angle to the serving satellite.

06

Adjacent satellite interference degrades link efficiency, which equates directly to degradation of economic performance.

4.8

Wrap-up

01

In addition to the antenna and radome on top of the aircraft, satellite-specific hardware such as the KANDU, KRFU, and MODMAN are installed to provide Ku- or Ka-band connectivity.

02

On a typical long-haul flight, a satellite signal must be handed off from one satellite to the next – a process that can take 1-2 minutes.

03

Latency is the time required for a packet of data to complete its path from the point of request to the delivery of the response. Latency is higher for connectivity solutions that rely on satellites.

04

Antenna and radome designs are key drivers of operational expenses associated with fuel burn.

05

Satellite beams classified as wide beams are generally lower in power and provide coverage to broad areas, while spot beams are much higher in power and provide coverage to narrowly focused areas.

06

The challenge of skew angle must be considered by any airline serving routes near or within tropical regions.

07

The portion of the electromagnetic spectrum used to send and receive data varies based on which type of connectivity technology is deployed.

05

Connectivity technologies

–

One thing to keep in mind while considering inflight connectivity options is that there is no one-solution-fits-all approach.

Ultimately, the right service provider for an airline is the one that can provide the best technology to meet the current and unique demands of their fleet, passengers, and route structure.

The right service provider will also be able to anticipate and accommodate changing needs, offer new technologies as they become available, and implement them on the airline's timeline: that is, when it makes the best business sense.

Because in the end, it's not just about the technology, it's how the bandwidth to and from the aircraft is managed that can make all the difference. Individual technologies matter most when evaluating the best option for an individual aircraft. This factors in aircraft type, mission, route structure, and the demands of the passengers onboard. This overview of the technologies available today should provide insight into how such decisions, on a plane-by-plane and airline-by-airline basis, are best approached.

Why multiple solutions are a must

Each inflight connectivity solution has practical limitations, if not physical ones. Just as certain routes are better served by certain aircraft types, the technology that's ideal for one aircraft may not be the best option for another. A narrow-body jet, for example, could fly long-haul, trans-oceanic routes, but a wide-body jet is better suited for such a mission.

Similarly, a global Ku-band solution could be installed on a regional jet serving short-haul, overland routes. However, the costs of the equipment, data, and fuel burn coupled with the projected revenue for such short flights suggest that other connectivity solutions may be more suitable.

That's why it's essential that an aero-communications service provider offer a suite of technologies. Depending on the type of aircraft and where it operates, a service provider with a full portfolio can provide the recommendations and the solutions to best serve an airline and its customers.

Comparing IFC technologies

Data based on Gogo and its technology partners

Technology	Coverage	Relative cost	Average installation	Latency	Peak capacity	Aircraft types	Availability
SwiftBroadband	global	$$$$	2 days	high	332 kbps	BRNW	now
ATG	N. America [1]	$	under 8 hrs	low	3.1 Mbps	BRNW	now
ATG-4	N. America [1]	$	under 10 hrs	low	9.8 Mbps	BRNW	now
Ku	global	$$$	3-7 days	high	30 Mbps	NW	now
Ka [2]	global	$$$	TBD	high	50 Mbps	BNW	~2015
GTO	N. America [1]	$$	TBD	medium	70+ Mbps [4]	NW	~2014
2Ku	global [3]	$$	TBD	high	70+ Mbps [4]	NW	~2015

[1] Continental US, Alaska, parts of Canada
[2] Via Global Xpress
[3] Enhanced performance at equitorial regions
[4] 100 Mbps with next generation Ku spot beam satellites

B = business
R = regional jets
N = narrow
W = widebody

5.1

SwiftBroadband

Data based on Gogo and its technology partners

FREQUENCY
1-2 GHZ

PEAK DATA SPEEDS
332 KBPS

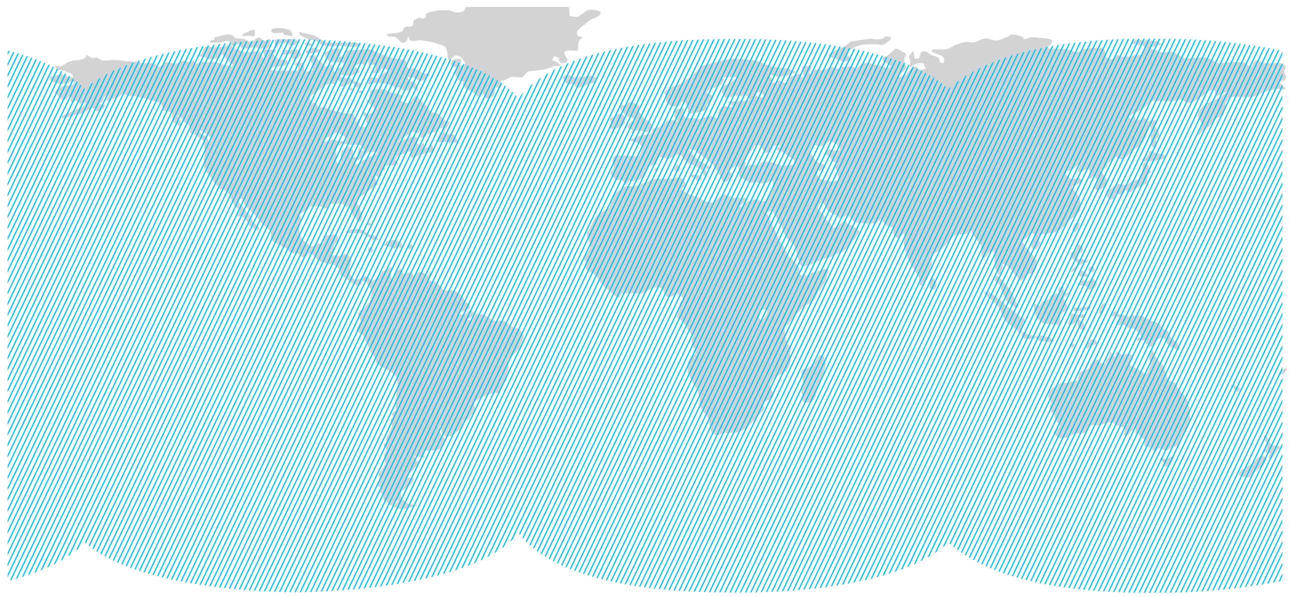
NUMBER OF AIRCRAFT
40 equipped

OWNER/OPERATOR
Inmarsat, offered through I-4 global satellites

LATENCY
High

AVAILABILITY
Available now

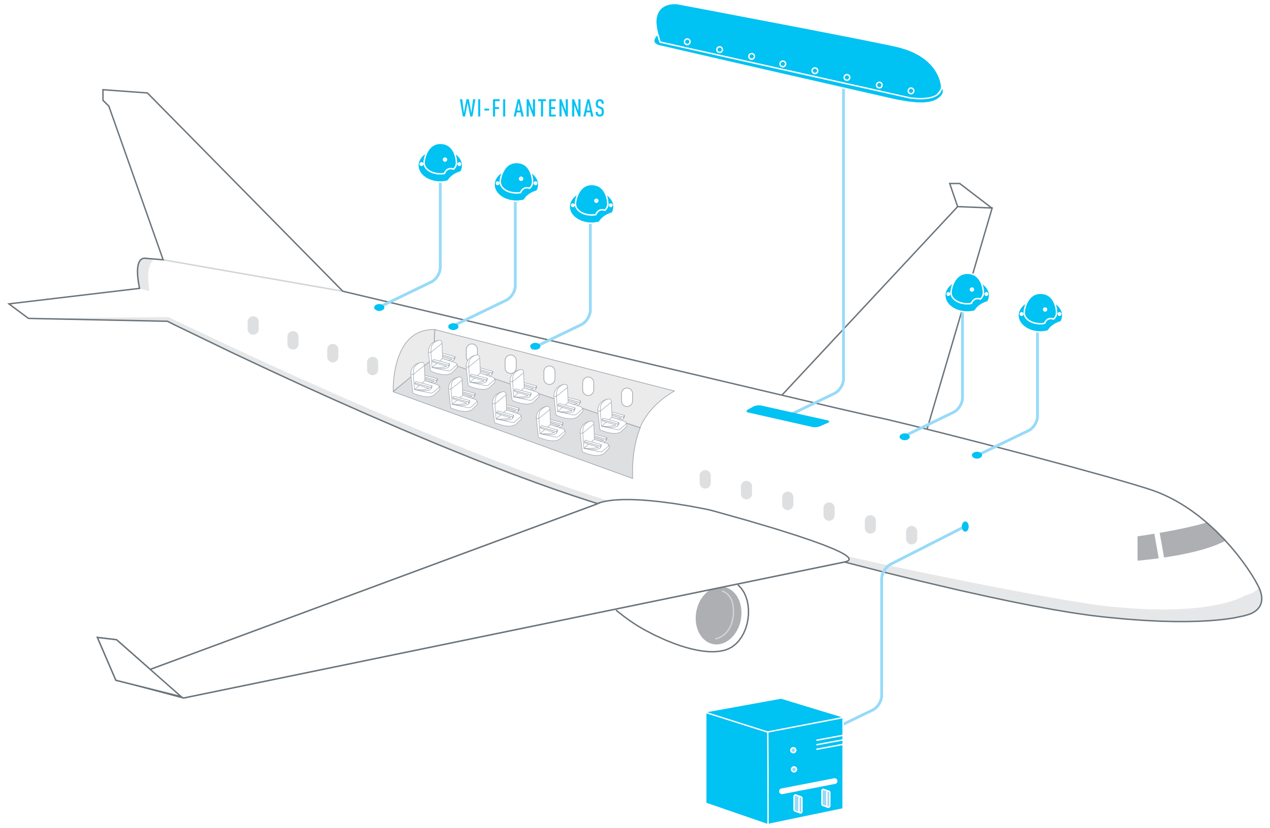
APPROXIMATE COVERAGE



PERFORMANCE HIGHLIGHTS

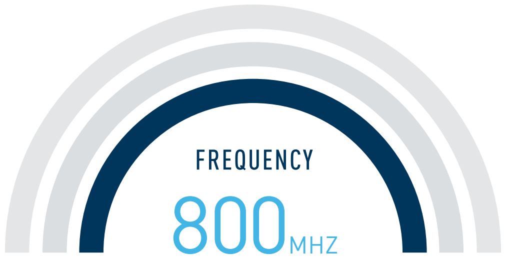
Ideal for light internet applications such as email and SMS texting.

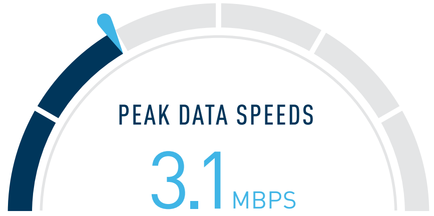
KEY EQUIPMENT



5.2

ATG





NUMBER OF AIRCRAFT

1,500+ commercial aircraft equipped

2,000+ business aircraft equipped

OWNER/OPERATOR

Gogo, offered through a network of more than 200 cellular towers in North America

LATENCY

Low

AVAILABILITY

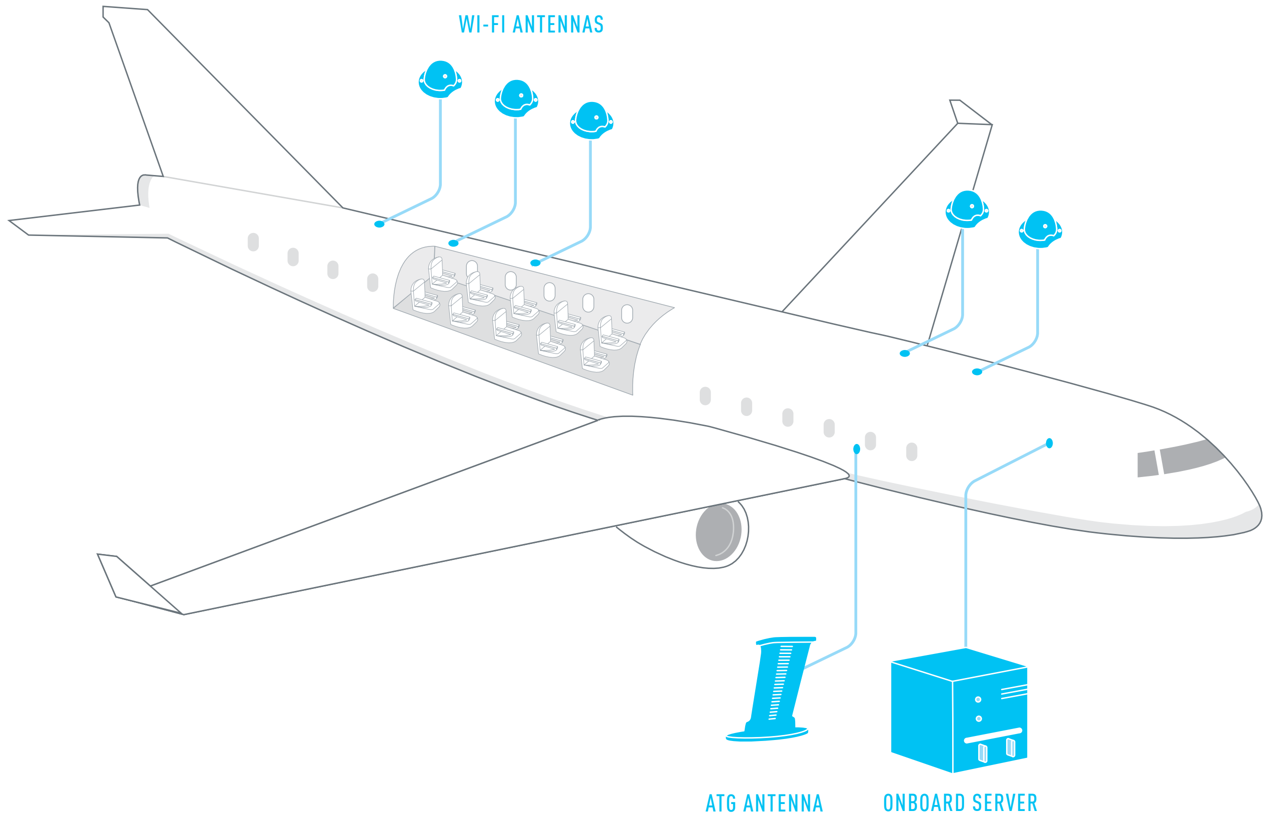
Available now

APPROXIMATE COVERAGE

PERFORMANCE HIGHLIGHTS

The smallest, lightest, most economical connectivity solution; overnight installation.

KEY EQUIPMENT



5.3

ATG-4

FREQUENCY

800 MHZ

PEAK DATA SPEEDS

9.8 MBPS

NUMBER OF AIRCRAFT

500+ equipped

OWNER/OPERATOR

Gogo, offered through a network of more than 200 cellular towers in North America

LATENCY

Low

AVAILABILITY

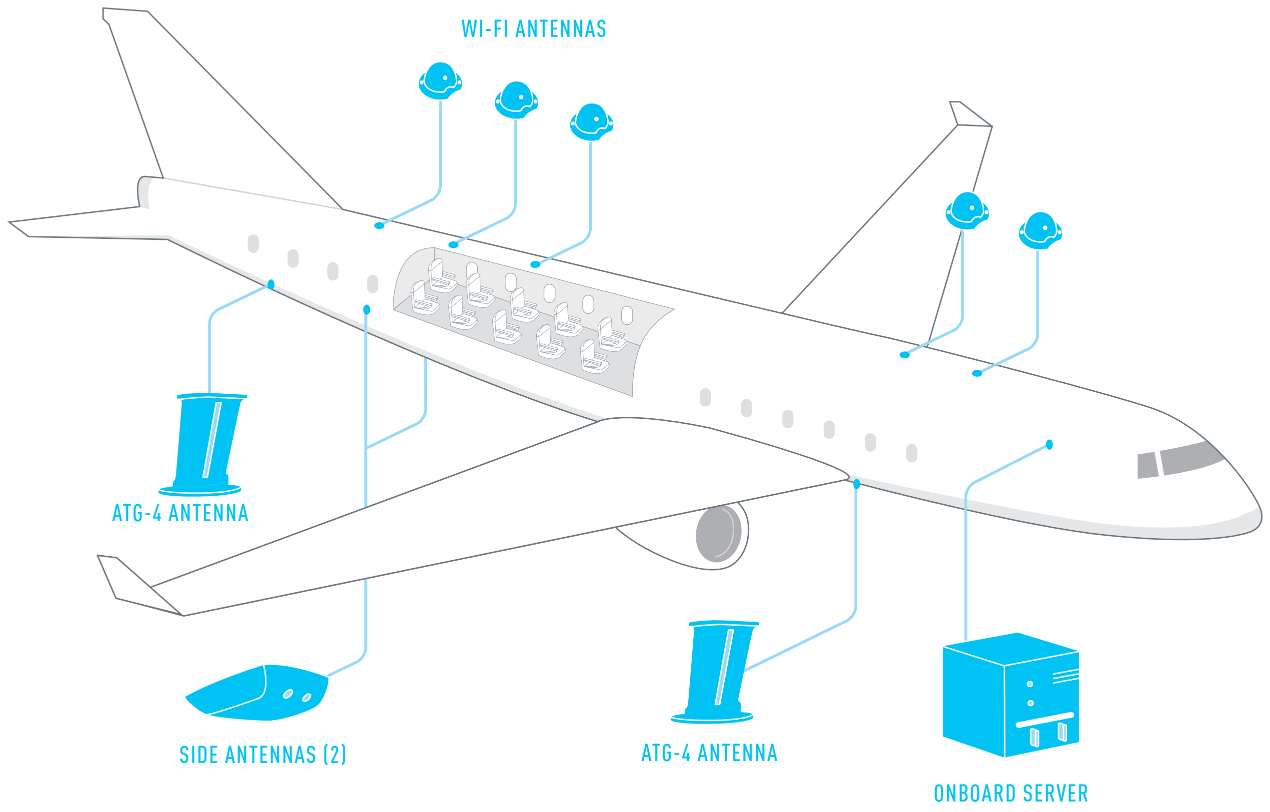
Available now

APPROXIMATE COVERAGE

PERFORMANCE HIGHLIGHTS

Next-generation ATG technology, using dual modems to effectively triple the data speeds compared to basic ATG technology.

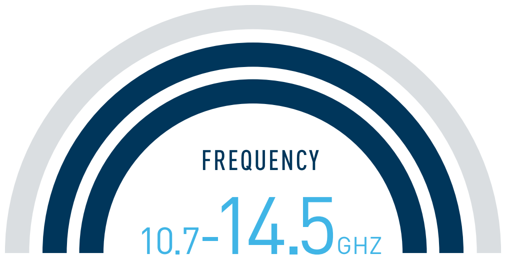
KEY EQUIPMENT

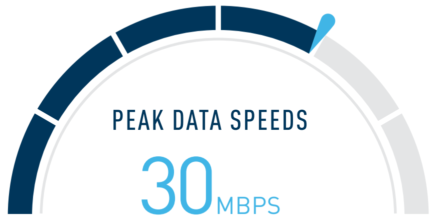


5.4

Data based on Gogo and its technology partners

Ku





NUMBER OF AIRCRAFT

20 equipped

300+ committed

OWNER/OPERATOR

Intelsat and SES

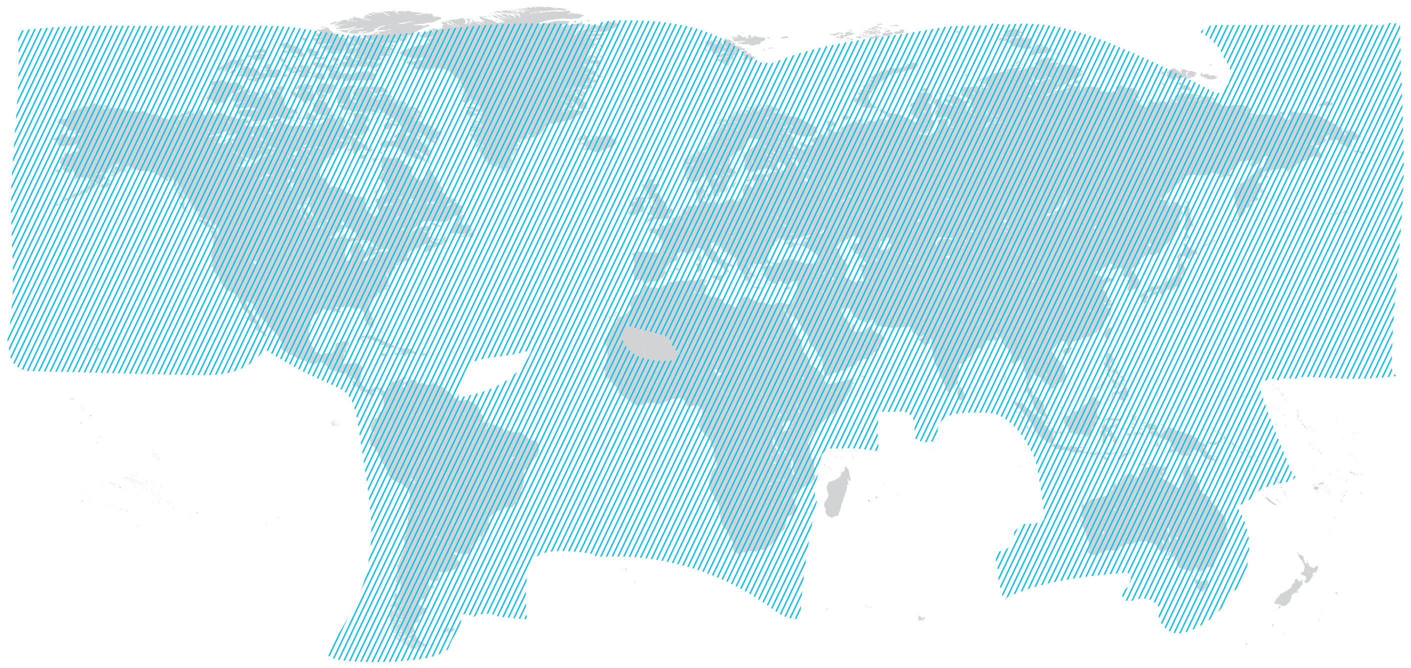
LATENCY

High

AVAILABILITY

Available now

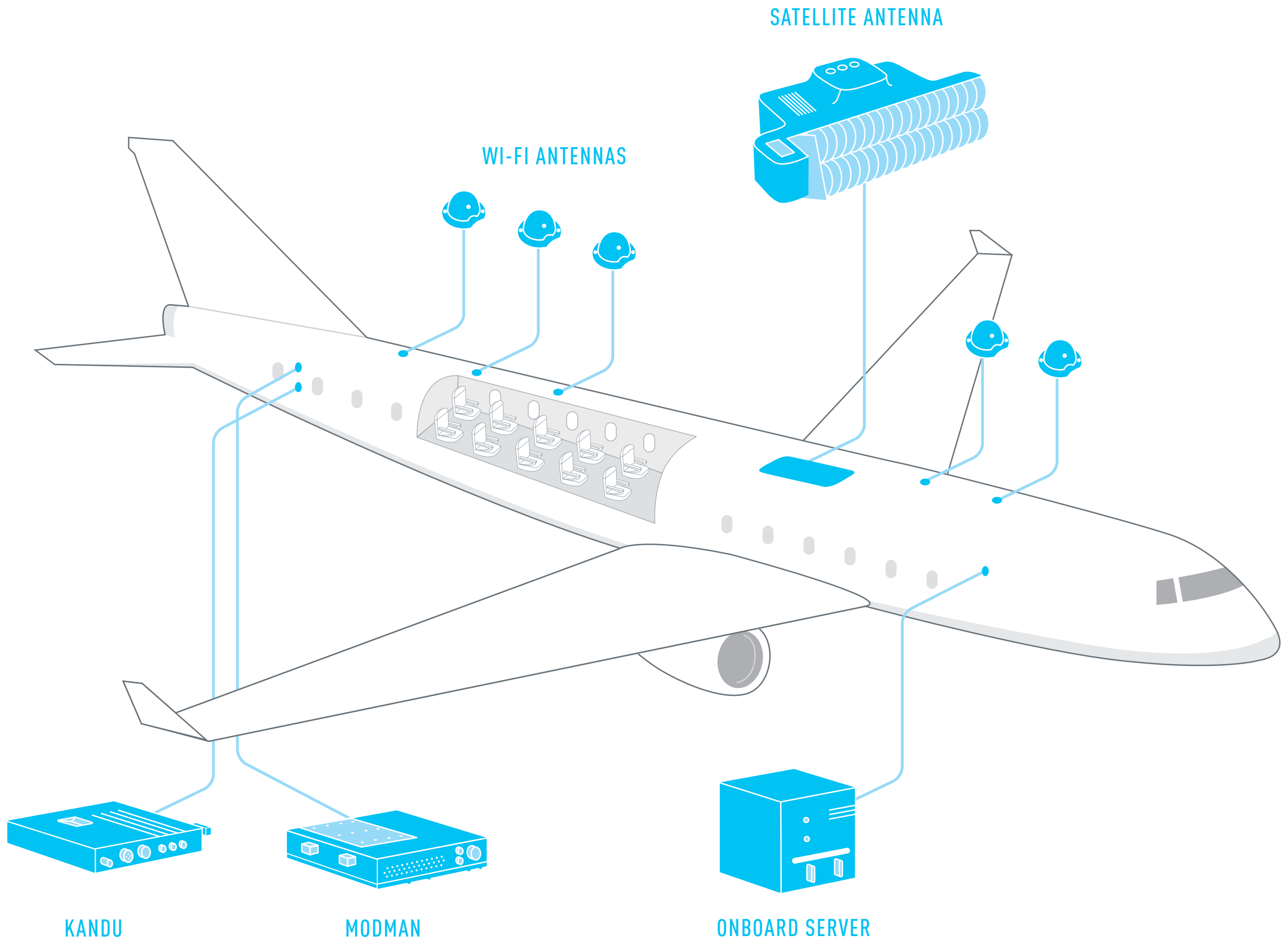
APPROXIMATE COVERAGE



PERFORMANCE HIGHLIGHTS

Next-generation spot-beam satellites, projected for 2016, will offer higher speeds.

KEY EQUIPMENT



5.5

Data based on Gogo and its technology partners

Ka

FREQUENCY
12-18 GHZ

PEAK DATA SPEEDS
50 MBPS

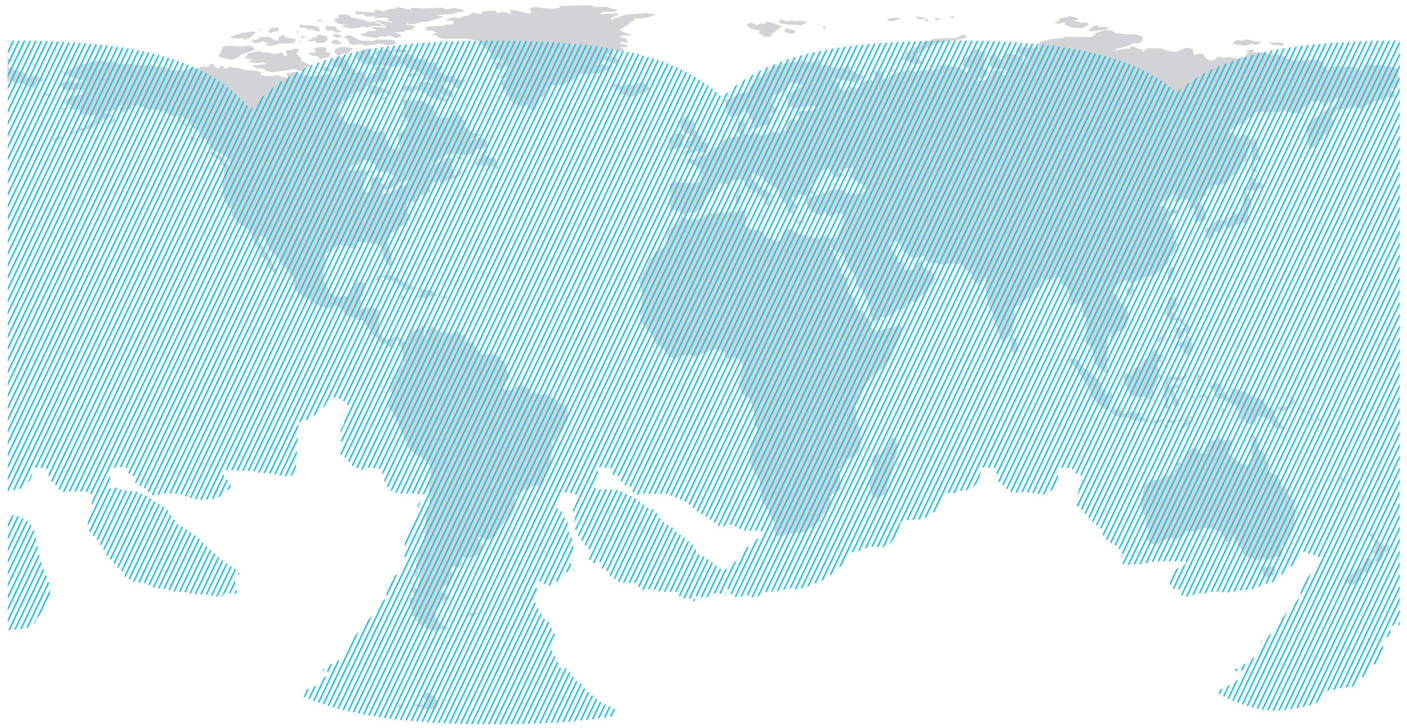
NUMBER OF AIRCRAFT
1 trial announced

OWNER/OPERATOR
Inmarsat Global Xpress

LATENCY
High

AVAILABILITY
Estimated 2015

APPROXIMATE COVERAGE



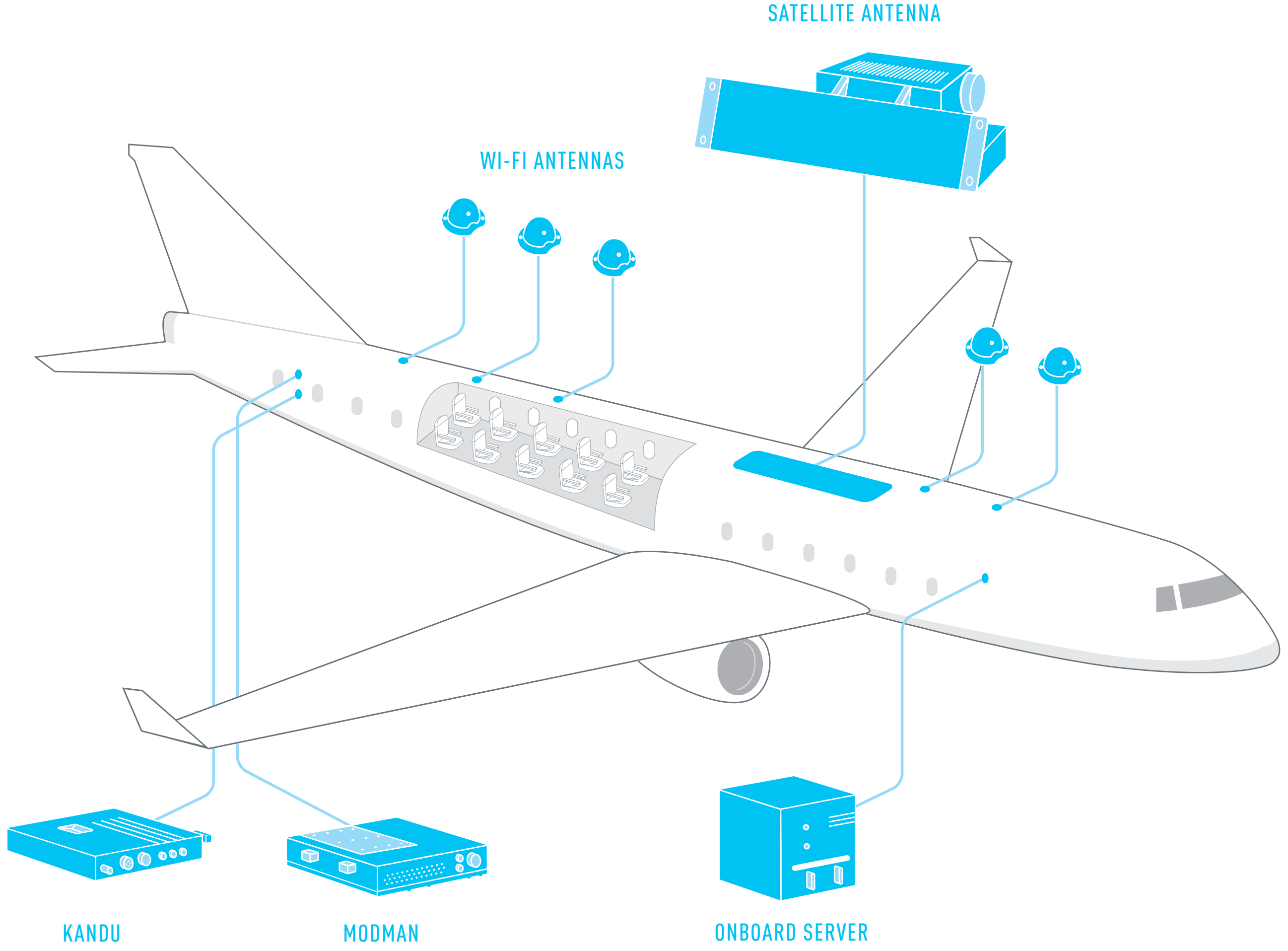
PERFORMANCE HIGHLIGHTS

Delivers consistent, global high-speed broadband connectivity through steerable spot beams, providing capacity when and where it's needed.

Flexible bandwidth meets the needs of passengers and crew.

Ideal for inflight entertainment.

KEY EQUIPMENT



5.6

Ground-to-Orbit (GTO)

FREQUENCY
800 MHZ (ATG)
10.7-12.75 (Ku receive)

PEAK DATA SPEEDS
70 MBPS

NUMBER OF AIRCRAFT
N/A

OWNER/OPERATOR

Gogo, offered by combining Ku satellite technology with its proprietary network of over 200 cellular towers in North America

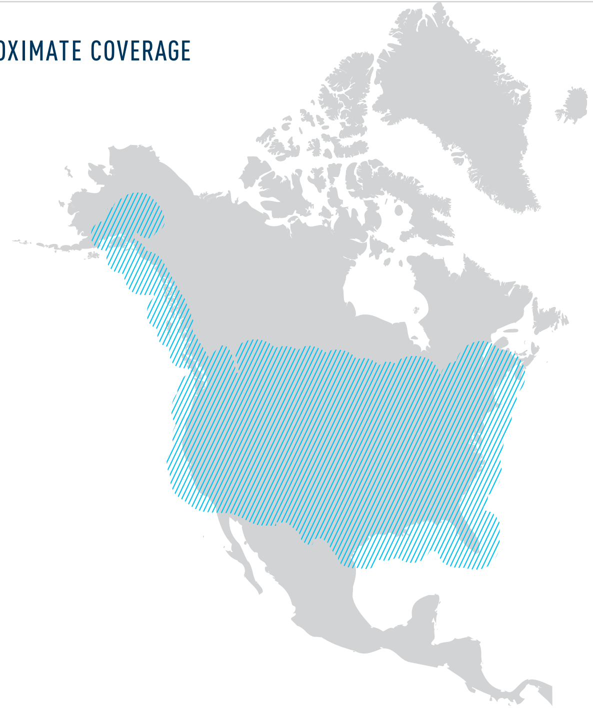
LATENCY

Medium

AVAILABILITY

Estimated 2014

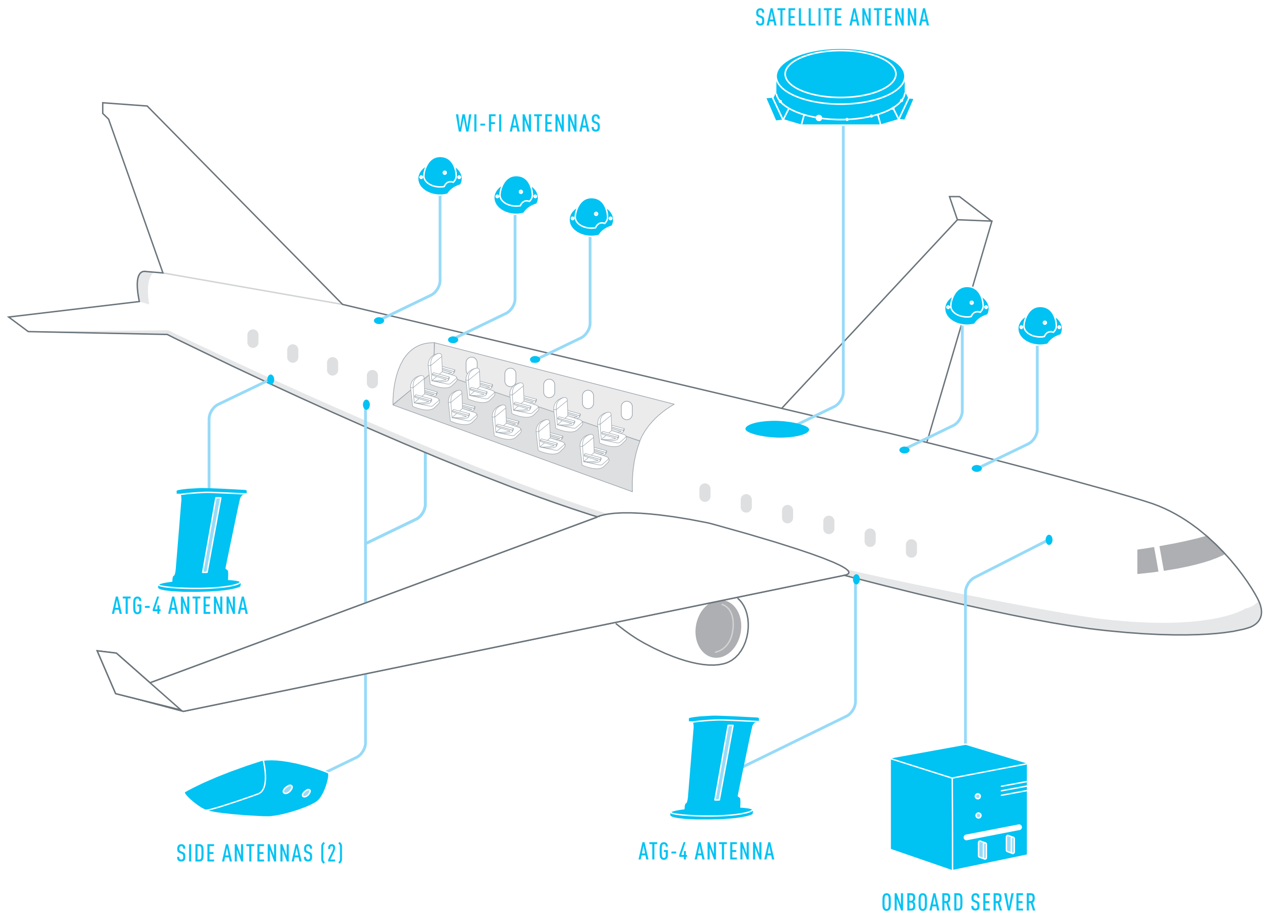
APPROXIMATE COVERAGE



PERFORMANCE HIGHLIGHTS

Hybrid technology using Ku-band satellite antenna for forward link to the aircraft and Gogo's ATG-4 antenna for return link to the ground.

KEY EQUIPMENT



5.7

2Ku

FREQUENCY

10.7-14.5 GHZ

PEAK DATA SPEEDS

70 MBPS

NUMBER OF AIRCRAFT

2 trials announced

OWNER/OPERATOR

Proprietary to Gogo and leverages Intelsat and SES Ku satellites

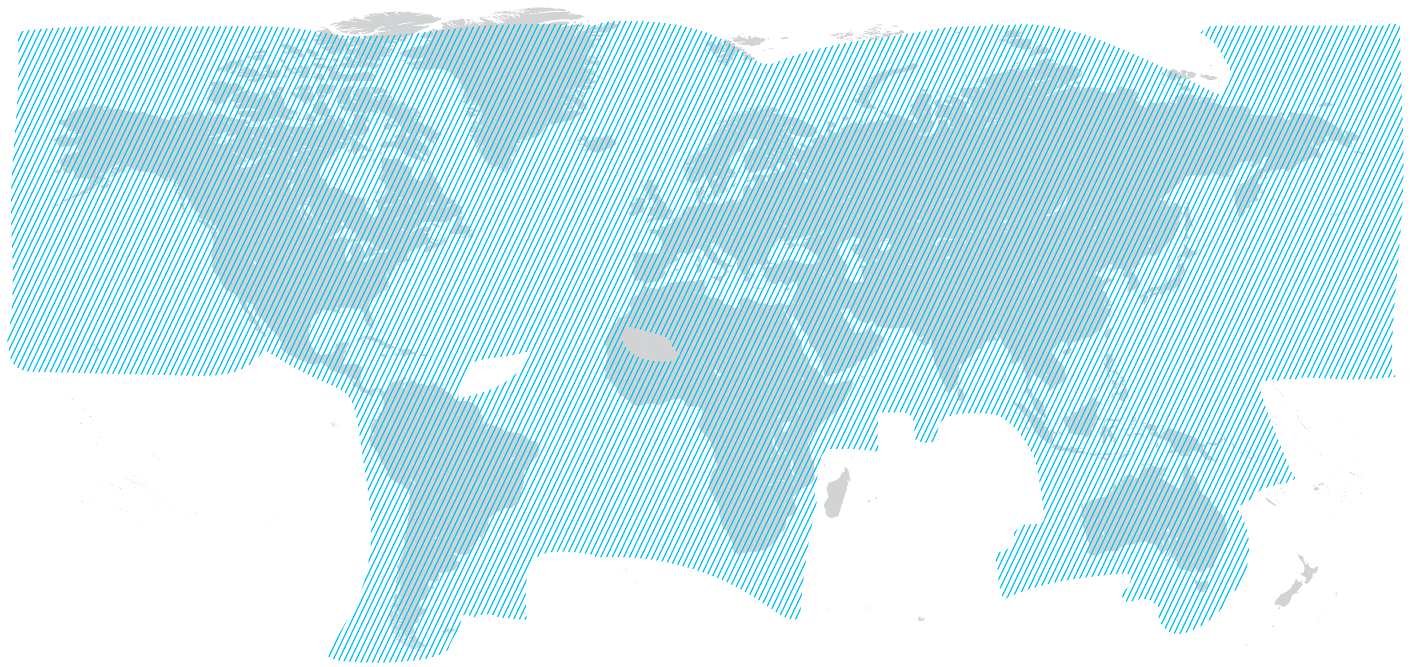
LATENCY

High

AVAILABILITY

Estimated mid-2015

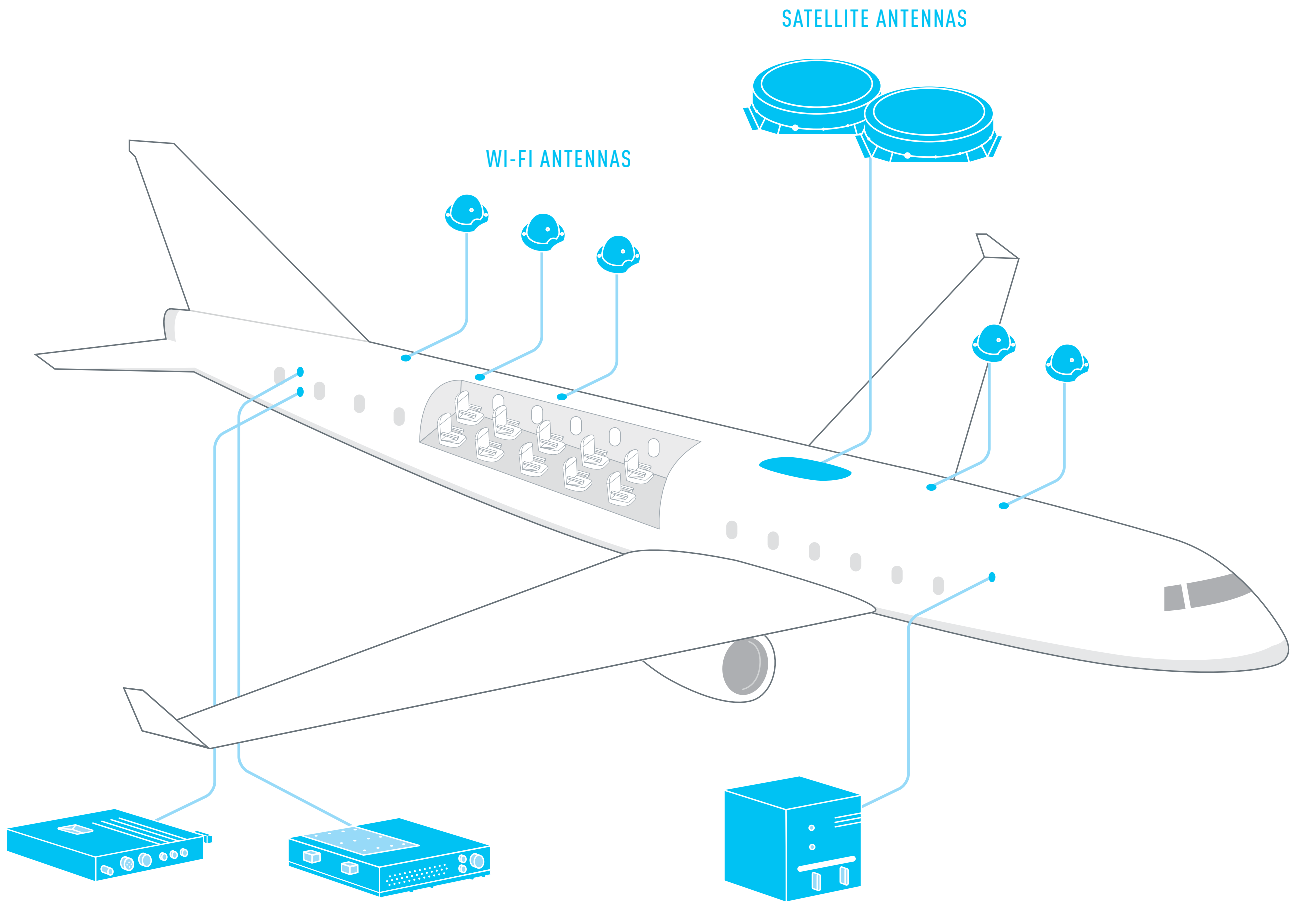
APPROXIMATE COVERAGE



PERFORMANCE HIGHLIGHTS

Delivers unprecedented performance and enhanced equatorial coverage – ideal for IPTV.

KEY EQUIPMENT



06

Consumer insights

The proliferation of personal electronic devices has changed the behavior of people across the globe. But what does that mean for the air travel industry?

For starters, the adoption of devices has led to the expectation of around-the-clock connectivity – including flight time. Naturally, by understanding the needs and habits of connected travelers and aligning with their expectations, airlines can serve them better. This includes not only which devices travelers use and how they use them, but also what their basic needs are when they travel, and what they're willing to pay for.

For air travelers, this means a more satisfying experience overall. For the airlines who serve them, the right inflight offerings can lead to higher take rates and increased revenue per passenger.

The data in this chapter is just a sample of years of research that includes focus groups, panels, surveys among customers and global travelers, and social media, as well as hundreds of thousands of real interactions with customers while in flight.

By interpreting it, we can gain insight into who these connected travelers are, their attitudes and behaviors, what motivates them, and how these aspects change in different regions around the globe. Armed with these insights, airlines are better equipped to gain and maintain the loyalty of these valuable customers.

6.1

Connected PEDs are on the rise

Personal electronic device usage is already the norm amongst travelers across the globe

	LAPTOP	TABLET	SMARTPHONE
US	74%	37%	56%
Canada	71%	32%	48%
Mexico	92%	58%	83%
Brazil	90%	57%	81%
UK	85%	50%	73%
France	85%	47%	69%
Germany	87%	44%	75%
Italy	91%	48%	79%
Netherlands	82%	58%	69%
Japan	71%	25%	41%
China	90%	79%	94%
South Korea	74%	38%	92%

The majority of travelers board a plane with a PED

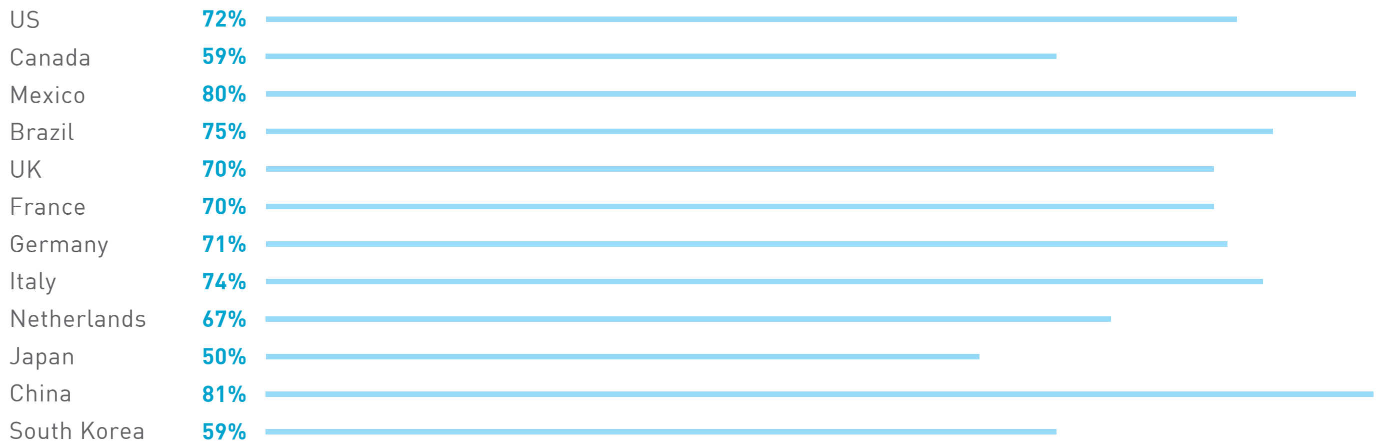
	LAPTOP	TABLET	SMARTPHONE	AT LEAST ONE PED
US	31%	23%	47%	74%
Canada	28%	18%	34%	62%
Mexico	48%	38%	73%	93%
Brazil	49%	33%	68%	89%
UK	25%	30%	59%	82%
France	29%	26%	57%	77%
Germany	26%	22%	60%	78%
Italy	30%	33%	57%	87%
Netherlands	23%	32%	58%	83%
Japan	20%	13%	33%	54%
China	48%	60%	90%	99%
South Korea	32%	24%	84%	93%

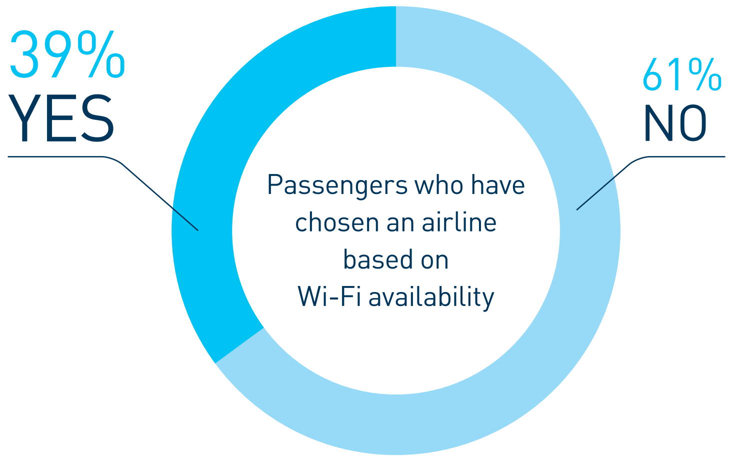
Source: Gogo Global Category Attitude & Usage Study, October 2013

6.2

The air travel industry is seeing the effects

Percentage of passengers who prefer to use their PEDs over embedded devices





72% Prefer to watch movies & tv shows on their own device

79% Want to text from their device

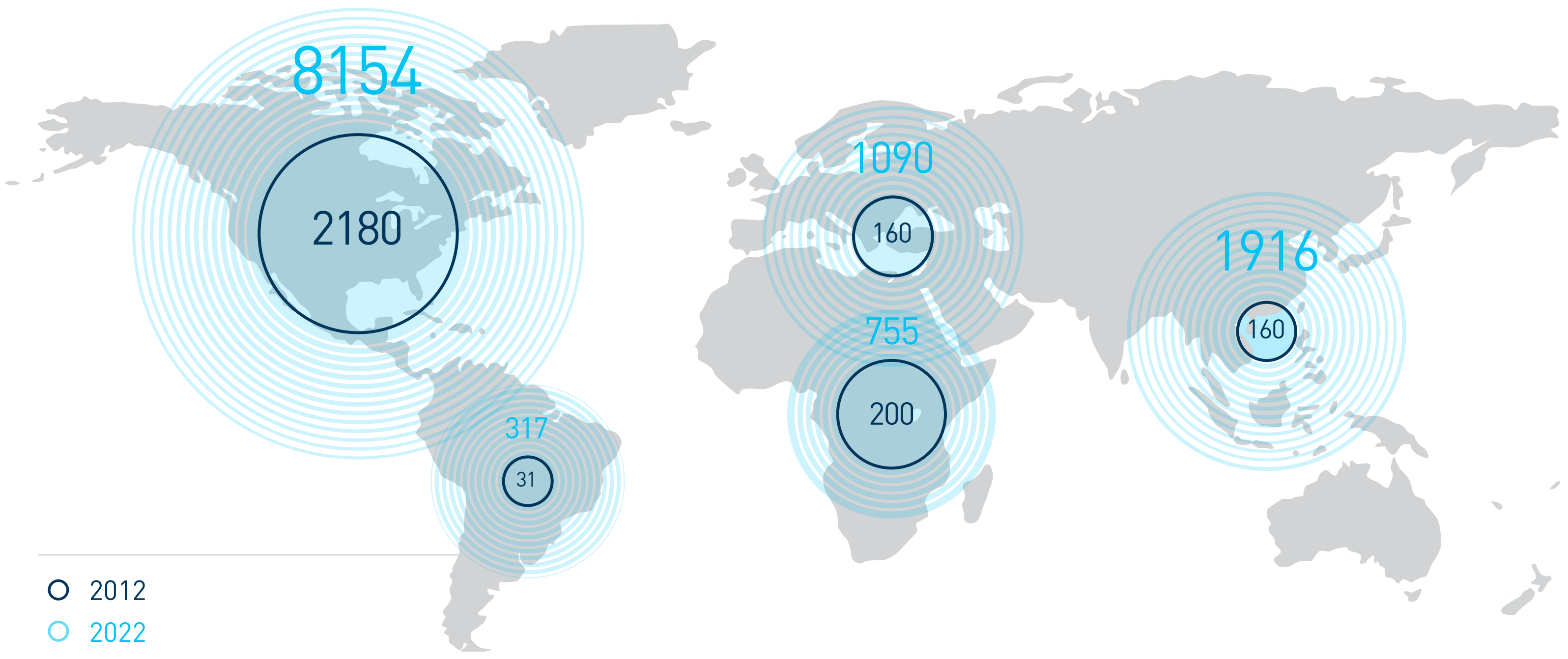
33% Are willing to pay

Source: Gogo Global Category Attitude & Usage Study, October 2013

6.3

To meet demand, the number of connected aircraft is expected to rise sharply in the near future

Number of current and forecasted connected commercial aircraft



Source: EuroConsult Prospects for In-Flight Entertainment and Connectivity, April 2013

07

Beyond inflight connectivity

As inflight connectivity evolves, it begins to blur the line between connectivity and entertainment.

The growth of video streaming and internet protocol television (IPTV) on the ground illustrates this point quite clearly. With set-top boxes that can deliver video content and live programming to our televisions over the internet connections to our homes, consumers have recognized alternatives to traditional cable TV offerings.

Similar trends can be seen in the aviation industry. Where traditional overhead-monitor and seatback-screen systems were once the only practical option for bringing video entertainment onboard, wireless systems that deliver video content to passengers' devices over the in-cabin Wi-Fi network have emerged as viable options.

Other applications for connected aircraft have begun to emerge recently as well, including voice services and SMS text messaging over the internet. There are also development platforms that enable airlines and third-party software developers to create new ways to increase operational efficiencies and improve the passenger experience.

7.1

Wireless inflight entertainment

Whatever entertainment decisions an airline makes for its fleet and its customers, there are some common considerations.

Content protection is critical and digital rights management requirements must be met to prevent piracy. With that in place, a business model must be selected: should an airline offer video entertainment on a pay-per-title basis, or pay-per-flight? Should some or all passengers enjoy complimentary access? Should there be content targeted to business travelers as well as leisure?

A variety of models are available, and the best one for a given airline depends on its unique circumstances. In some cases, offering a variety of models may be the right option.

Even though personal electronic devices have proliferated at a rapid rate, not every passenger who steps onboard carries one with them. In the interest of serving every passenger, some airlines have chosen wireless entertainment as a complement to traditional seatback and overhead systems.

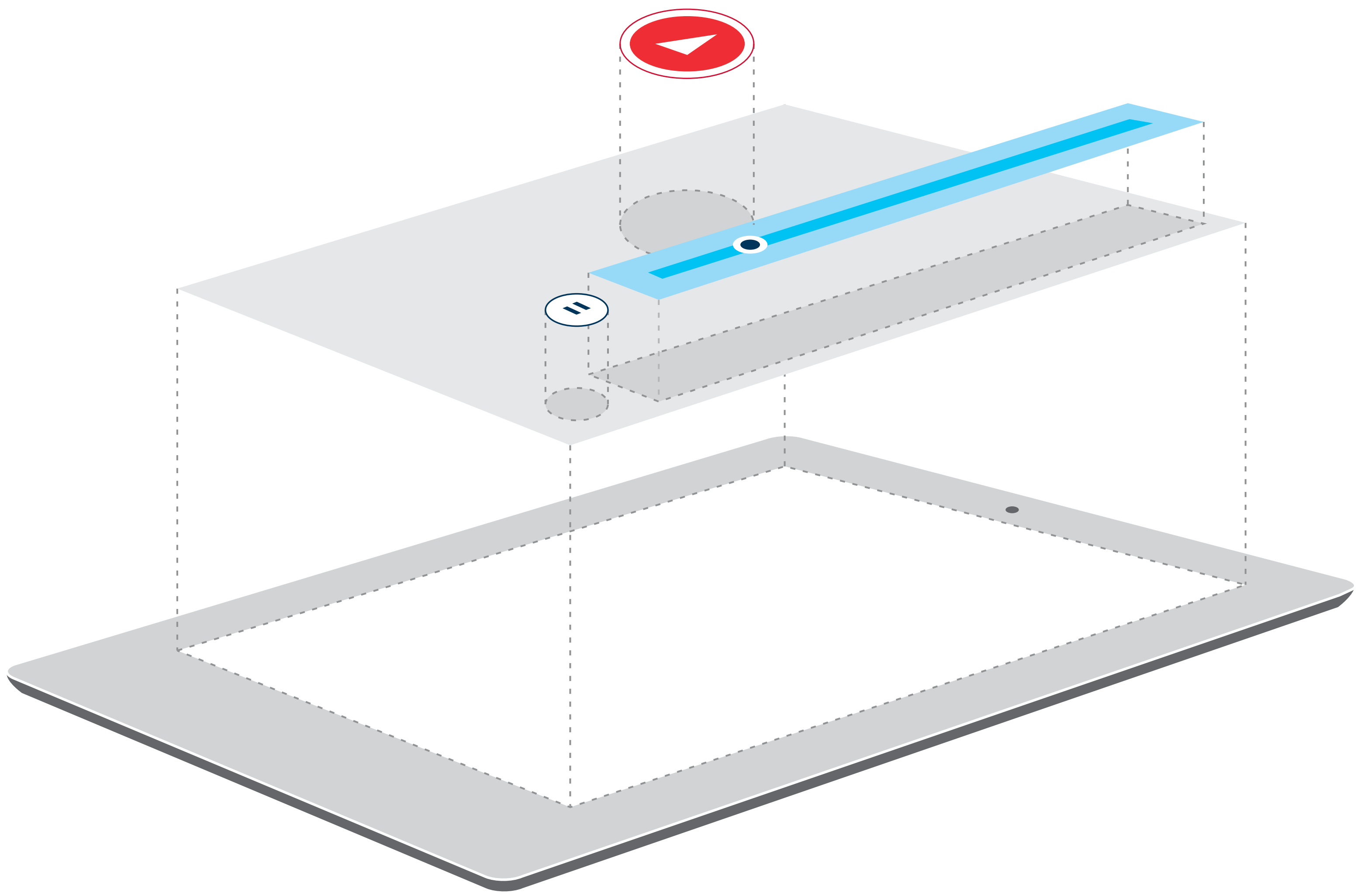
IPTV

IPTV allows users to stream video content straight from the internet. This content includes live television, time-shifted television (which allows users to watch in-progress programming from the beginning), and video-on-demand services.

ONBOARD CONTENT

This inflight entertainment solution stores video content on the onboard server. Depending on the digital storage capacity, it's currently possible to store hundreds of movies and TV shows on the aircraft so passengers can enjoy video on demand on their personal electronic devices. This storage capacity will only increase as data compression improves and the cost to store it declines, allowing even more video content to be carried onboard.

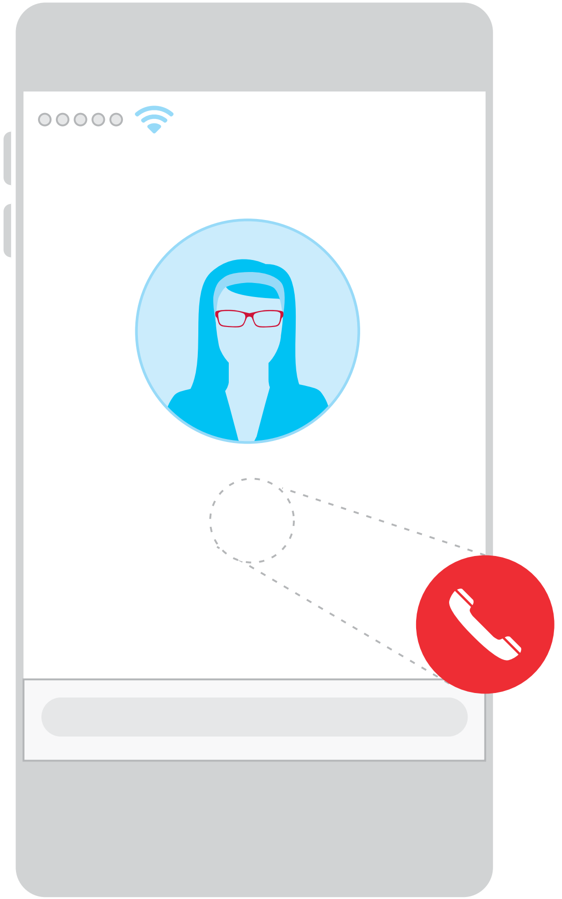
Onboard streaming systems are a lower-cost alternative to traditional seatback systems. The cost to install is lower, there is less maintenance, and because passengers can use their own devices, there is no need to replace the onboard video screens when they become outdated. Onboard streaming service can even be integrated into the airline's app, which can drive downloads and create a sustained and engaging experience with customers.



7.2
Voice services

Technology that enables voice services in flight has been around for some time.

Picocell systems (small, cellular base stations) made it possible, but this solution requires the installation of special equipment on the aircraft. With the Wi-Fi roaming network options currently available, no additional equipment is required for aircraft equipped with inflight connectivity systems. And given the significant percentage of flyers who carry smartphones today, the prospective market for voice service is evident.



7.3
Inflight text messaging

As text messaging has become a staple of mobile communication, the desire to offer this service inflight has increased.

With the potential to communicate with friends, family, and colleagues – to provide status updates, coordinate airport transportation, schedule meetings, etc. – it's easy to understand why inflight text messaging is an attractive offering for air travelers. With inflight connectivity onboard, there are multiple options to make texting possible:

SHORT MESSAGE SERVICE (SMS)

Short Message Service (SMS) uses standardized communications protocols to allow users to send short texts using mobile phones – either by internet, cellular network, or picocells.

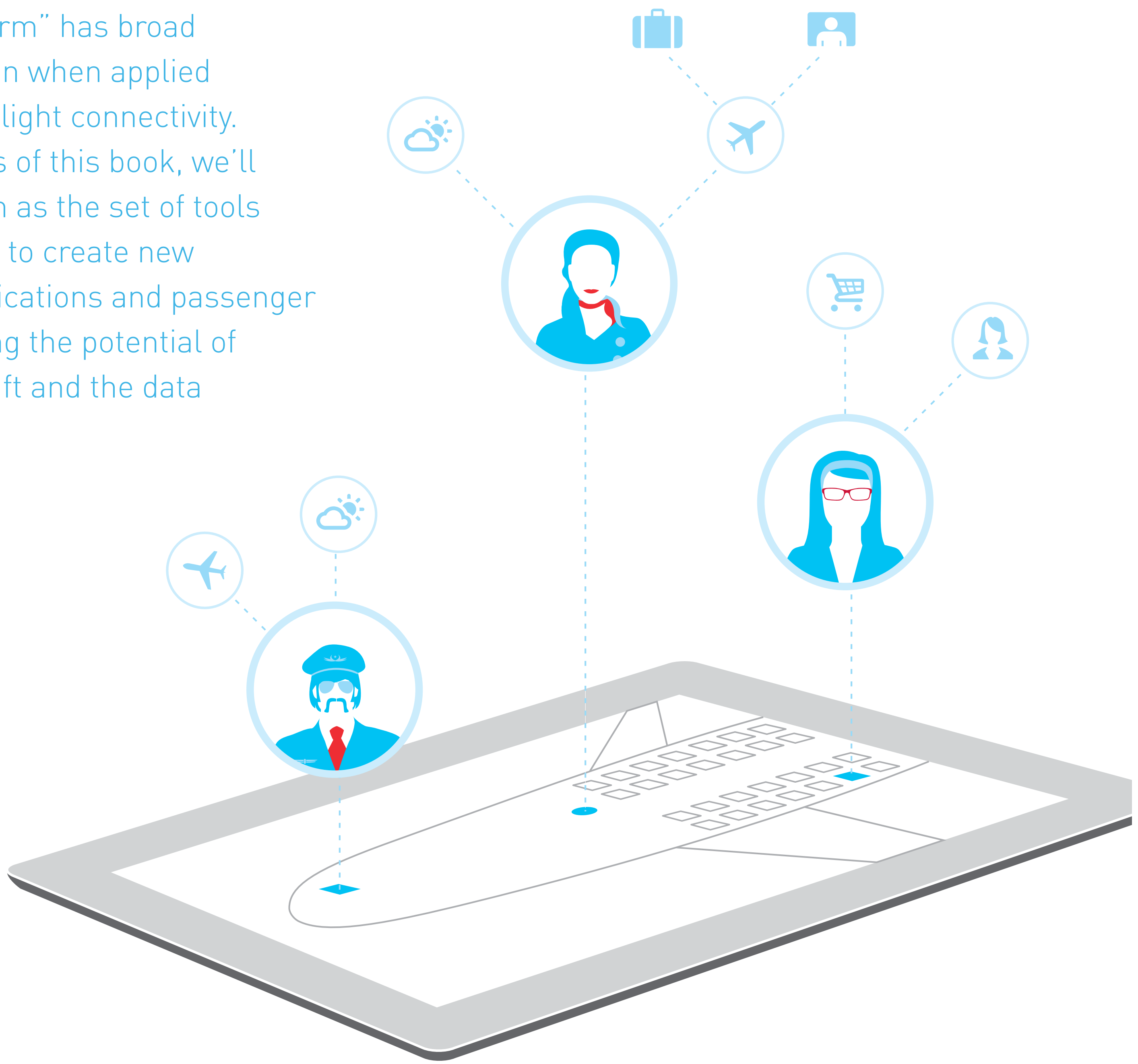
INTERNET-PROTOCOL BASED TEXTING SERVICE

There are also internet-protocol (IP) based texting services, such as Apple's iMessage, Google Hangouts, Facebook Messenger, WhatsApp, WeChat, Viber, and many others. Such IP-based solutions can be offered to passengers wherever internet access is available. They can even be made proprietary to the airline and, if desired, offered within the airline's mobile app.

7.4

Platforms

The term "platform" has broad implications, even when applied specifically to inflight connectivity. For the purposes of this book, we'll define a platform as the set of tools that can be used to create new operational applications and passenger experiences using the potential of connected aircraft and the data they produce.



OPERATIONAL APPLICATIONS

When it comes to platform-enabled applications for airline operations, the opportunities for efficiency gains are largely untapped. Considering that the B787 Dreamliner generates approximately 500 gigabytes of data over the course of an 8-hour flight, these opportunities become more apparent.

For flight attendants, a platform can create the ability to report any onboard maintenance issues in flight, so crews

on the ground can prepare accordingly. Emergency medical support can be enlisted well ahead of the aircraft's arrival, with a summary of symptoms and critical passenger info already in the hands of response teams. In addition to providing another channel for ancillary revenue, real-time credit card transactions can reduce fraud and minimize the risk of lost revenue. Customer recognition applications can give crews the information they need to create the personal and customized experiences that can lead to long-term loyalty.

With a connectivity platform implemented, even the aircraft's jet engines, avionics systems, and other equipment can be continuously monitored for optimal performance, allowing crews to make calibrations and informed decisions in real-time. Cockpit and cabin communications can be enabled and improved upon. Up-to-date weather information, turbulence mapping, and other information to improve situational awareness can be readily communicated to pilots and crew. It's not a question of whether such platform can improve the efficiency and safety of operations, but rather to what extent they can be improved.

PASSENGER APPLICATIONS

For passengers, information such as customer status, destination and origin, device type, locale, or itinerary start and end dates can be used to create experiences that are personal and uniquely relevant to each user. Recommendations can be made that lead to a more satisfying travel experience. Tools like bag tracking and inflight rebooking can be made available to put passengers at ease.

For preflight connectivity sales, a connectivity platform can enable dynamic and flexible merchandizing that scales across airline channels and customer touch points. Third-party applications that tap into this geo-flight and customer data can be used to enable new and exciting experiences for networking, communication, gaming, and more. The opportunities are limitless when a platform is opened to developers to conceive and create experiences that have yet to be imagined.

7.5

Wrap-up

01

The possibilities for connectivity-enabled aircraft include streaming video services, IPTV, voice & text services, and much more.

02

Wireless inflight entertainment presents a multitude of options – in terms of both content and flexible business models.

03

IPTV is video content streamed directly from sources on the internet, including live-streaming television and video on demand.

04

Streaming onboard content does not require a connection to the internet. Content is stored on an onboard server and made available to passengers over the in-cabin Wi-Fi network.

05

Voice and text services using connectivity are available today and require no additional equipment onboard the aircraft.

06

Development platforms are beginning to realize the potential of connected aircraft by using data to create new passenger experiences and increase operational efficiencies.

A word on Gogo

Gogo is an aero-communications service provider. Our focus is on solving the engineering challenges of providing secure, reliable connectivity to the aviation industry – anywhere in the world – and on supporting every aspect of this service, however our individual airline partners see fit.

Gogo has 20+ years of combined experience in inflight communications for commercial and business aviation. This unmatched experience has taught us how to deliver inflight connectivity solutions and ensure their performance. We do it not only by providing the right technology for every aircraft and its mission, but also by supporting that technology within our global network.

A

Appendix:
Glossary of Terms

APPLICATION PROGRAMMING INTERFACE (API):
Common term in software development. An API is provided by a software platform that is hosted on a server and which - via these interfaces - exchanges data with other programs/ software platforms.

ATG (AIR-TO-GROUND)
Inflight connectivity technology that uses a network of cellular towers on the ground to provide connectivity to aircraft; may refer specifically to Gogo's ATG network in North America, which was the first such inflight connectivity solution.

ATG-4
Gogo's next generation Air-to-Ground Network. Compared to ATG, ATG-4 triples peak capacity to each plane, which allows more passengers to access the internet with a more consistent browsing experience.

BANDWIDTH
The common measure of capacity to carry signals. For analog transmission, it is measured in cycles per second; for digital transmission, it is measured in bits per second.

BEAMWIDTH
The width of a beam between a satellite and an antenna; effective beamwidth is determined by the aperture of the antenna. With asymmetric apertures, the wider portions create narrower beams while narrower portions create wider beams. In tropical regions, effective beamwidth determines how much interference with other satellites occurs.

BROADBAND
An advanced communications capability offering high-speed, broadband communications that enables users to originate and receive high quality voice, data, graphics, and video communications using any technology.

DOWNWARD LINK
Signal transmission from the internet provider to the customer.
See also: Return link

FAIRING
Smoothing structural materials added to aircraft in order to reduce drag; these typically cover spaces between aircraft parts.

FORWARD LINK
The link, or communication channel connecting devices, sent from a fixed location to a mobile user.

GEOPLANE
An imaginary line that runs through the sky, connecting all the geostationary satellites in Earth's orbit.

GIMBALED ANTENNA
Asymmetric inflight connectivity antennas that rotate on two axes to physically point their beam toward the target satellite.

HANDOFF
The process by which the beam connecting an aircraft is transferred from one satellite or cell tower to another.

HOSTING
A service that allows consumers to store and share content on the internet, e.g., Web hosting allows consumers to share information on the internet or even create a Web page.

IFC
Inflight connectivity.

IFE
Inflight entertainment.

IFEC
Inflight entertainment and connectivity.

INTERNET PROTOCOL TELEVISION (IPTV)
A digital television service, delivered using IP over a network infrastructure, which may include delivery by a broadband connection.

INTERNET SERVICE PROVIDER (ISP)
Non-facilities based provider that offers its customers broadband internet access via dial-up, ISDN, T1, or other connections.

LATENCY
Refers to the time delay experienced between two devices in communication with one another. Delays can be due to inherent/intrinsic or congestion related issues.

LINE-FIT
To equip (airplanes) with equipment or devices as they process through the manufacturing line.

LIVE HELP / LIVE CHAT
Ability to acess customer care representatives via a chat application.

Mbps
Megabits per second; unit of data transfer rate used to measure bandwidth.

MECHANICALLY-PHASED-ARRAY ANTENNA
Symmetric, fixed-position inflight connectivity antenna; instead of rotating toward the satellite target, these next-generation antennas use internal mechanics to synthesize a beam in the desired direction.

MODEM
An abbreviated term for "modulator-demodulator." A modem converts digital signals into analog signals (and vice versa) enabling computers and other devices to send and receive data over the telephone networks. The most common modems are V.90, cable, and DSL.

NETWORK
Specifically, a telecommunications network that allows computers and other devices to exchange data along connection points using either wired or wireless media.

NETWORK INTERFACE
The physical point in a customer's home or place of business where the telephone devices and/or inside wiring are connected to the transmission lines of the local telephone service provider.

NETWORK TRAFFIC MANAGEMENT (NTM)
Centralized surveillance of conditions and traffic that maximizes the traffic throughput of the network during times of overload or failure and minimizes the impact of one service on the performance of others.

NODE
A network junction or connection point. Typically, it is the point at which host processors, communications controllers and terminals attach to the network.

PACKETS
A formatted block of information, usually binary, organized in a specific way for transmission over a data network.

PORTAL
The "home page" passengers see when they open their browsers and try to connect to the internet inflight.

RADOME
Protective cover that shields satellite antennas from damage due to weather, debris, or birds while improving aerodynamics.

RETRO-FIT
To equip (airplanes) with equipment or devices not available at the time of manufacturing.

RETURN LINK
The link, or communication channel connecting devices, sent from a mobile user to a fixed location.

ROUTER
A device that controls message distribution between multiple optional paths in a network. Routers use routing protocols to gain information about the network, routing metrics, and algorithms to select the "best route."

SERVER
A shared computer on the LAN or other network that provides service to the network users by managing shared resources and may provide information via the Web.

SKEW ANGLE
The angle by which, relative to a position on a satellite's meridian, the polarization of a satellite signal is rotated at a given position on the earth. Skew angle generally increases with decreasing latitude. For airborne antennas with asymmetric beams, high skew angle is associated with degraded performance in tropical areas due to interference from other satellites.

SMS TEXT MESSAGING
SMS stands for "short message service"

SPECTRUM
A continuous range of frequencies, from approximately 3 kHz to 300 GHz, made up of invisible electro-magnetic waves that surround the earth and are used for radio transmission and reception and other purposes.

SPOT BEAM
A satellite signal with specifically concentrated intensity to create a connection with a localized geographic area.

STREAMING
Process of delivering multimedia by which the user is constantly receiving and presented data rather than having to download all of it at once.

TAKE RATE
The number of passengers per aircraft who use and/or purchase a service (in the case of this book, it refers to inflight connectivity service).

THROUGHPUT
The rate of successful delivery of data over a communication channel (such as from a satellite or cellular tower to an aircraft).

UPWARD LINK / UPLINK
Signal transmission from the customer to the service provider.
See also: Forward link

VIRTUAL PRIVATE NETWORK (VPN)
A method that allows for private network access via a public network, thereby connecting remote users while maintaining the security, functionality, and policies of the private network.

VOICE OVER INTERNET PROTOCOL (VOIP)
A method for converting analog audio signals (i.e. those used over traditional telephone lines) into digital data that can be transmitted over the internet.

WIDE BEAM
A satellite signal delivered via a single, broad beam to a large geographic area, even an entire continent; also known as a regional beam or broad beam.