gogo BUSINESS AVIATION

ANATOMY OF AN AIR-TO-GROUND (ATG) NETWORK

The technology and security of doing business at altitude

FLIGHT PLAN

CHAPTER 1

A CHANGING INDUSTRY

A CONTEXT OF CHANGE

It was a good summer.

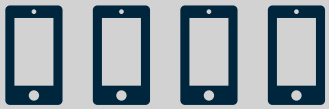
On June 29, 2007, the iPhone hit store shelves and transformed how people used, shared, and accessed data. This was more than a paradigm shift in the telecom market; it was a new way of thinking and connecting with others. It isn't a stretch to say that society changed — and with it, the world of business.

Today, we're past the point where anyone should be shocked by the need to connect during a flight — business moves much too swiftly now. With skyrocketing data consumption and demand for more sophisticated technologies, it pays to understand what's really going on when you connect from 35,000 feet.

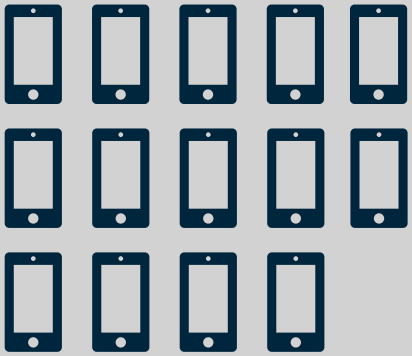
This eBook will help you do just that.

COME FLY THE CHANGING SKIES

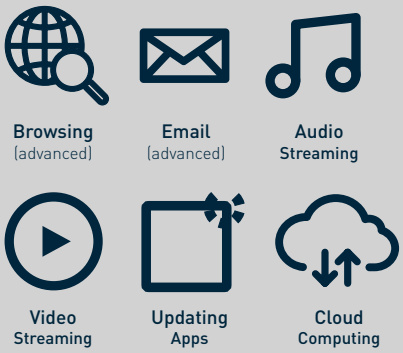
2013 2018

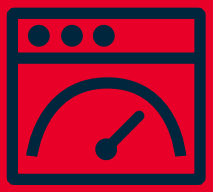


AVERAGE NUMBER OF MOBILE DEVICES ON A BUSINESS AIRCRAFT



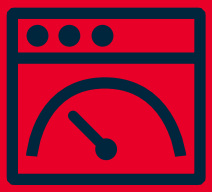
PRIMARY DATA USES





INFLIGHT CONNECTIVITY EQUIPMENT

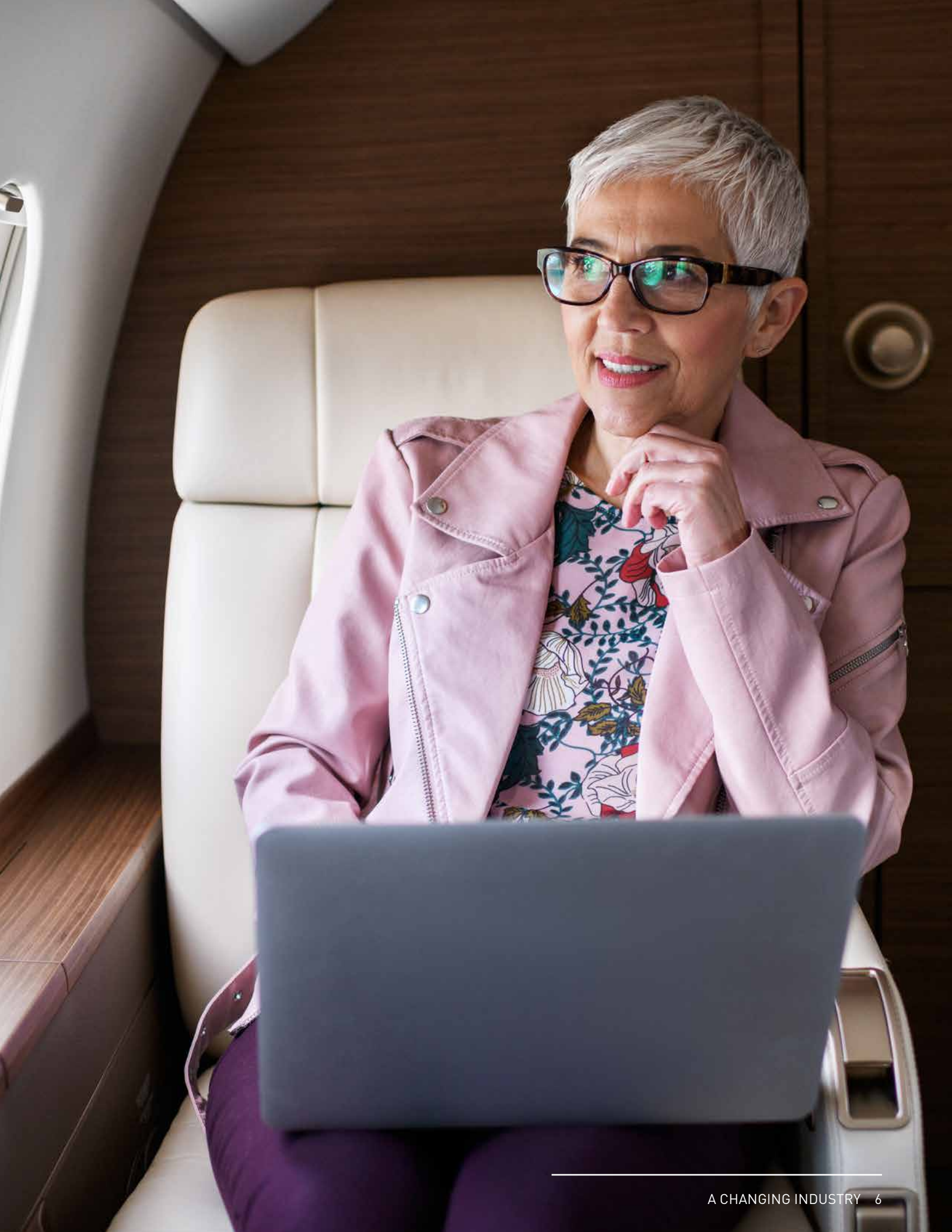
Remains unchanged with fewer upgrades.

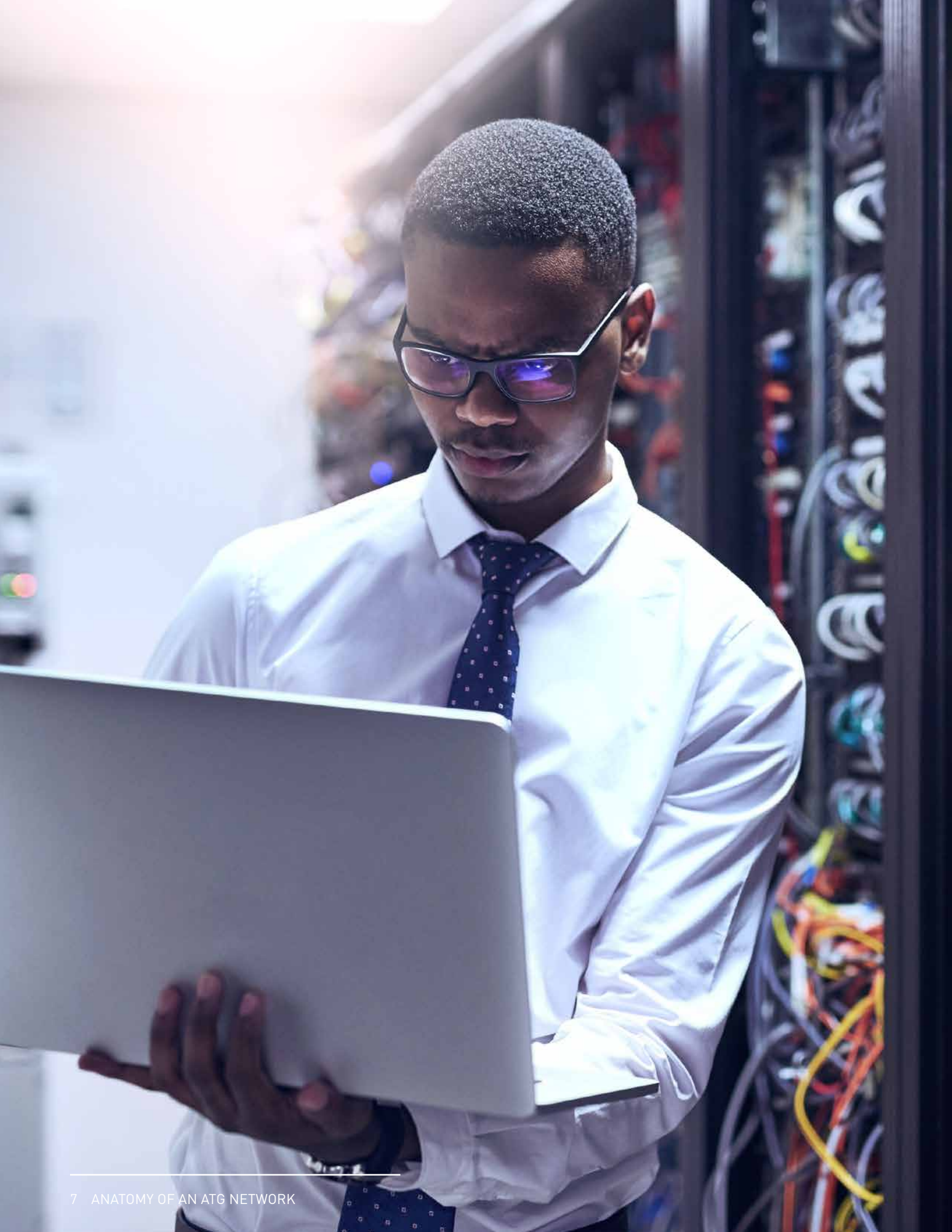


FIRST THINGS FIRST: THE ROLE OF THE PROVIDER

Although Gogo's bread and butter is creating better connectivity platforms for business aircraft, one of the most important things we do on behalf of our customers is manage and optimize existing networks and systems, since not everyone can upgrade every few years.

We're fortunate that we don't have the barriers that other providers do. Unlike other companies, we own and manage our air-to-ground (ATG) network at the infrastructure level, including ground towers and base stations, hardware and software, and specially licensed frequencies. This means we can modify almost any aspect of our system according to what's best for our customers, rather than what's feasible for some distant third-party provider. This lets us continuously manage our network to ensure loads are balanced, traffic is routed properly, and finite bandwidth is distributed to serve everyone.





BUILD IT AND THEY WILL COME

Starting in the early 2000s, Gogo secured important spectrum (radio frequency) and began building our network infrastructure. This was an audacious investment at the time, but it has provided a lot of long-term value for us and our customers. Today, we manage and operate our data centers (there are two in the U.S.), and own every other component of the ground network.

As a result, the customer experiences:

- More uptime
- Standardization
- System redundancy
- Efficiency
- Completely compatible system components
- Quick problem resolution

WHY VERTICAL INTEGRATION MATTERS

Inflight connectivity can feel like a complex beast, but there is glorious simplification in choosing systems that are vertically integrated — in other words, those that are owned, developed, and managed centrally rather than being at the mercy of third-party vendors. Naturally, there are some components that have to be subcontracted, but to the degree that we can simplify and localize control, we can improve the customer experience.

GOGO SOLELY MANAGES MOST OR ALL OF THE FOLLOWING FUNCTIONS:

Year over year Gogo is recognized for providing excellent customer service and this level of control and consistency is why.

It's practical: when your components are designed and built to be compatible and have been proven over time, there are fewer system issues. And when issues arise, we understand the problem quickly and can provide the correct help.

CHAPTER 2

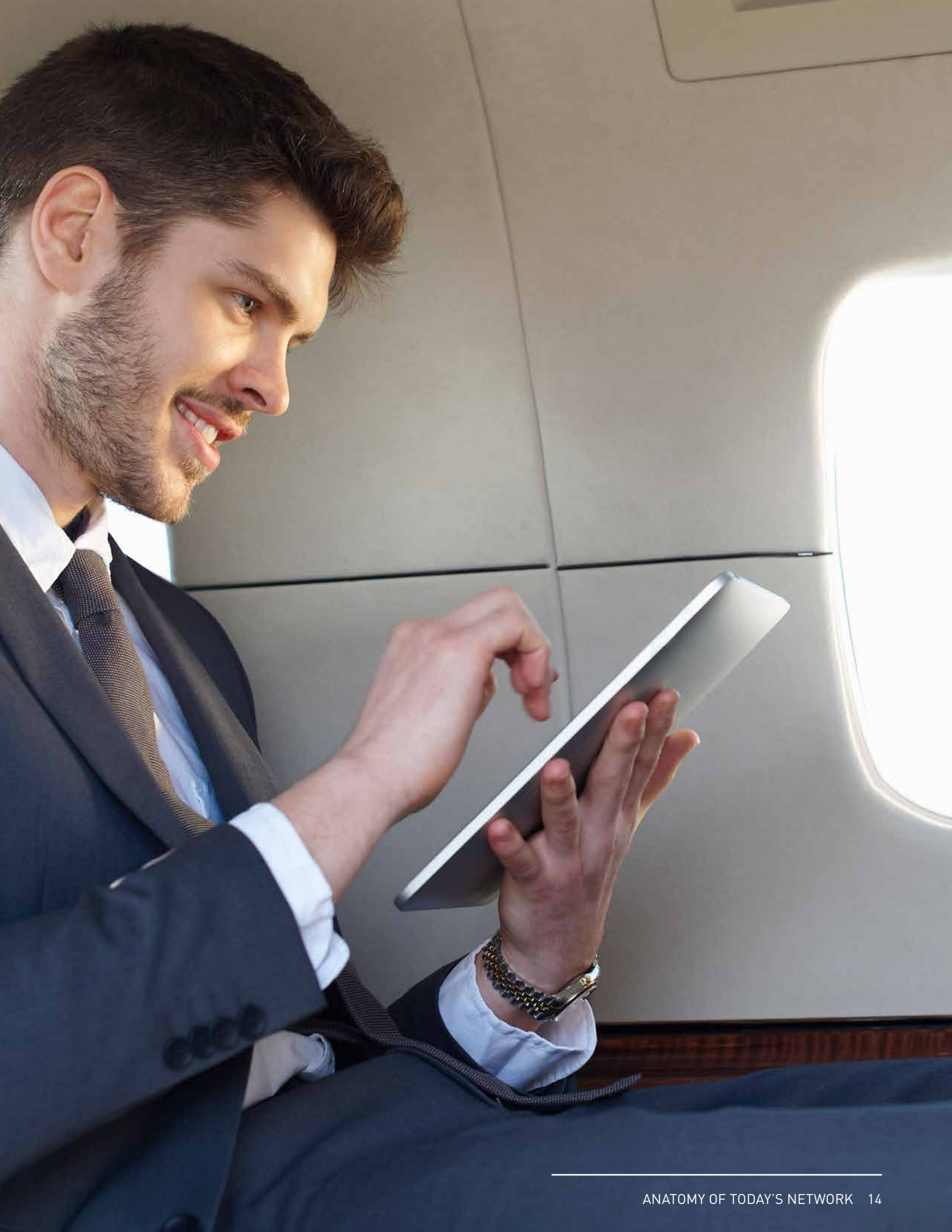
ANATOMY OF TODAY'S NETWORK

BUZZING THE TOWER: ATG IN DETAIL

If you want to send an email from a business aircraft to somewhere else, you're probably using either an air-to-ground (ATG) or satellite network. The one you choose depends on your aircraft type, your mission, where you're flying, and your budget.

A general rule is that ATG serves most U.S. customers (and parts of Canada and Alaska), while satellite connectivity enables aircraft to stay connected overseas globally.

For most business passengers in North America, ATG is the most familiar form of connectivity. It's analogous to how your cell phone connects at (almost) any given point on the ground: a cell tower routes the data from your aircraft to and from the destination device or entity.



Gogo's ATG network is made up of the following key components:

Land-based network infrastructure
The ATG ground systems that transmit, route, and receive data to and from your aircraft.

Aircraft antenna technology
The equipment on your aircraft that receives and transmits data to and from other parts of the network infrastructure

In-cabin Wi-Fi network
Routers, servers, wireless antennas, personal devices and other elements that make data accessible to users

Gogo engineers were convinced early on that acquiring proprietary infrastructure and ATG technology was valuable to the company and the customer. With so many parties interacting and competing within most telecommunications infrastructures, providing good service can get complicated and bureaucratic unless you own your own network (see chapter 1).

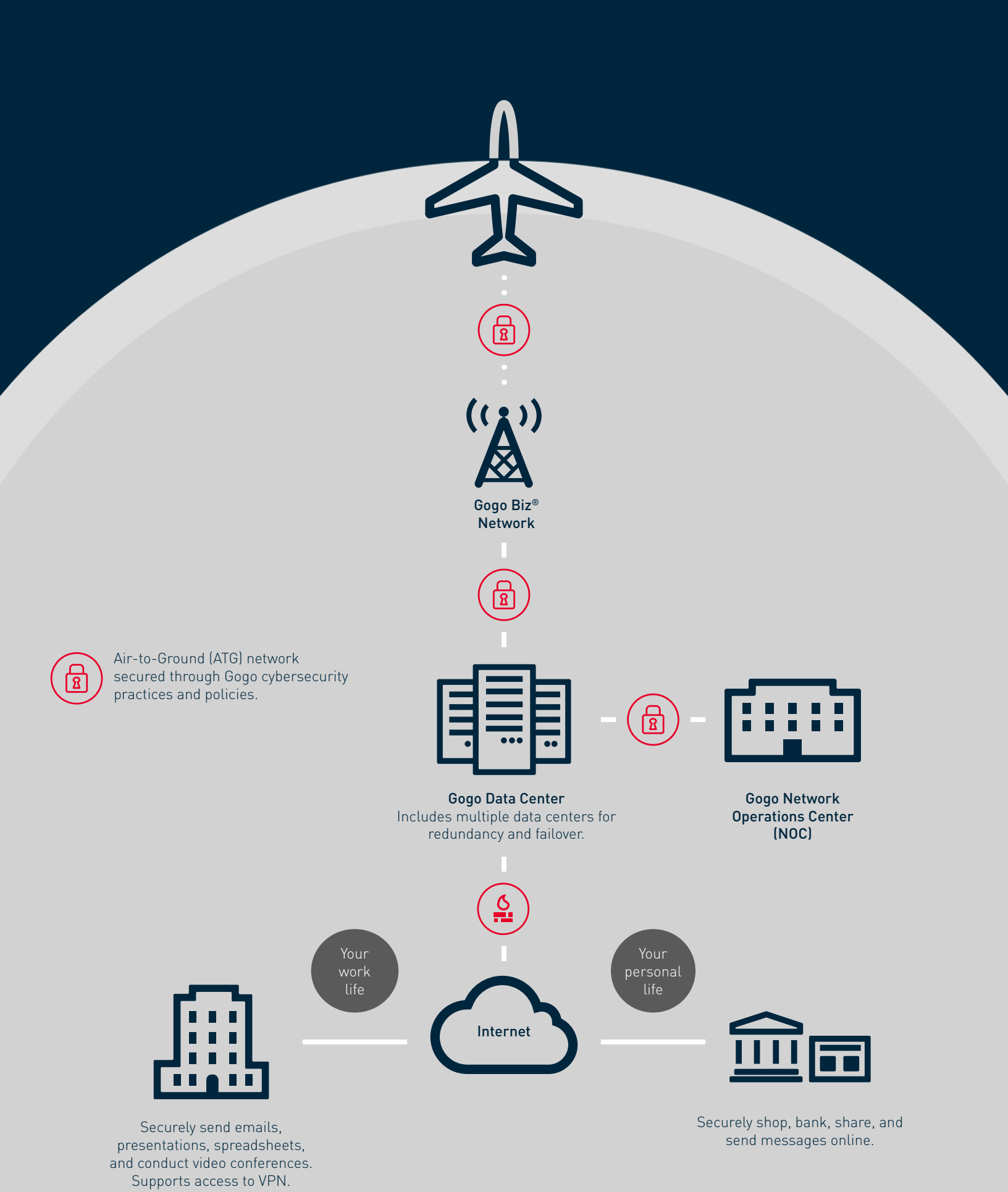
For ATG, Gogo leverages a proprietary frequency (850 GHz) to provide connectivity to aircraft with our systems on board, across a network of more than 250 cellular towers emitting their signals into the air.

THE BIG PICTURE: YOUR LAND-BASED NETWORK IN ACTION

Your inflight internet connection depends on the coverage and reliability of your land-based network infrastructure. When you make a call, send a text, or connect to the internet from your aircraft, that action triggers an intricate, interdependent set of wireless technologies that use available towers and network connections covering your flight path.

Gogo has more than 250 cellular towers covering the continental U.S., and portions of Canada and Alaska. These link the various components necessary to connect you to your life on the ground. Important elements of this infrastructure include RF antennas, spectrum (radio frequency), base stations, switching stations, and fiber-optic cables.

When you push send, the data from your device on the aircraft is transmitted, collected, directed, received, and rerouted through a complex process that takes place within seconds.


Gogo Biz®
Network
Air-to-Ground (ATG) network secured through Gogo cybersecurity practices and policies.
Gogo Data Center
Includes multiple data centers for redundancy and failover.
Gogo Network Operations Center (NOC)
Your work life
Your personal life
Internet
Securely send emails, presentations, spreadsheets, and conduct video conferences. Supports access to VPN.
Securely shop, bank, share, and send messages online.

YOUR IN-CABIN WI-FI NETWORK

You're cleared for takeoff and your engines are rumbling to life, pushing you skyward. You're buckled in, ready to go — and already thinking business.

What happens next? Here's a look at the technology that brings your business to altitude.

SERVERS

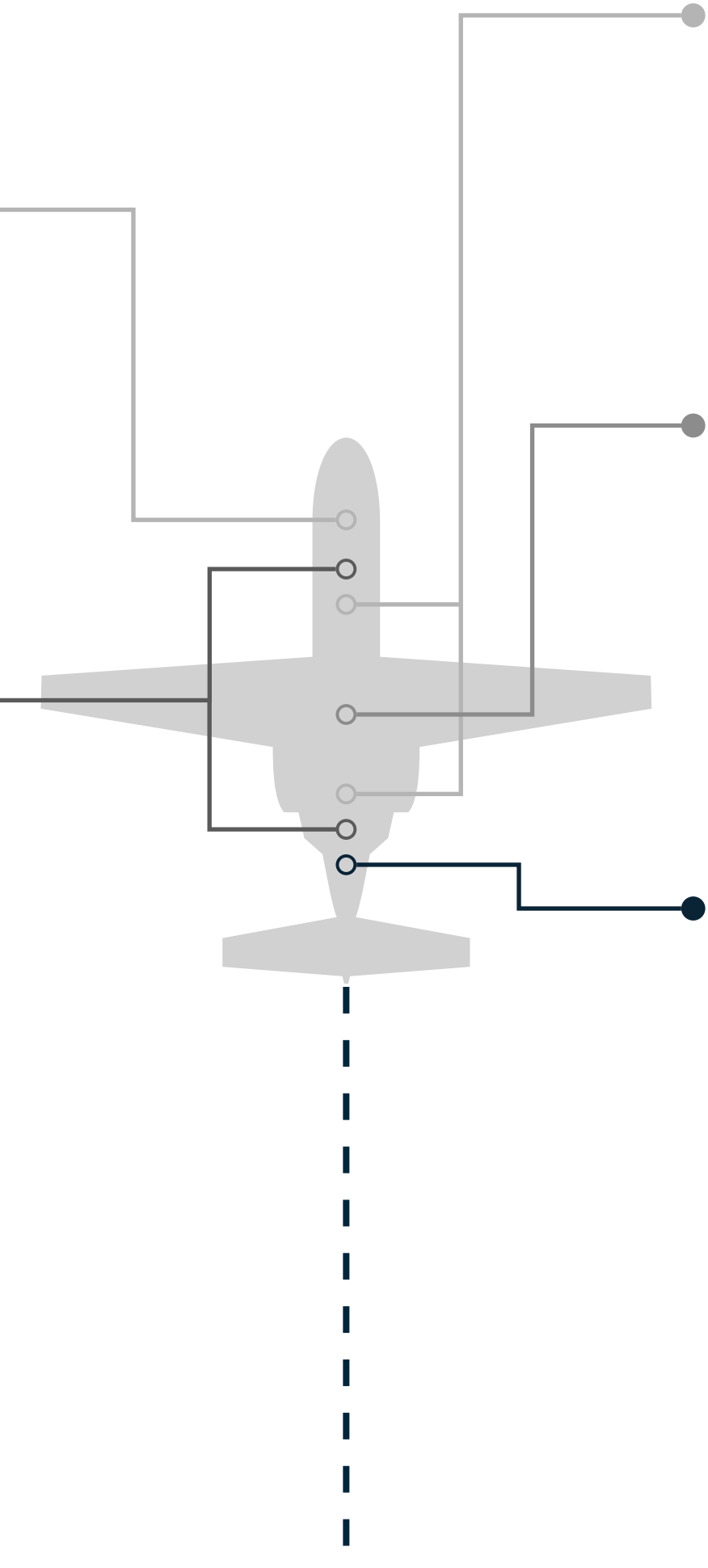
Servers provide and manage access to centralized storage and applications. Among other things, your onboard server allows you to pre-download and store content for inflight entertainment (easing network congestion and reducing data or service costs for streaming).

Performance keys: Viewing movies and other video content offline, rather than online, can help you conserve bandwidth for other inflight activities and help avoid higher fees.

AIRCRAFT ANTENNAS

Fuselage-mounted aircraft antennas send and receive signals to and from the cellular source. These antennas are designed to pick up the best signal in the closest range.

Performance keys: The antenna technology you use could depend on the aircraft you fly, the system you choose, and what you want to do when you connect during flight.



WI-FI ANTENNAS

Your in-cabin Wi-Fi antennas are optimized for aircraft. Their placement will depend on your usage needs and plane type.

Performance keys: Smart placement ensures optimized signal performance with minimal interference. This is especially important if you have multiple users accessing the system simultaneously.

DEVICES

The average flyer brings several mobile devices onboard, and their independent (sometimes invisible) data usage directly impacts system performance. Manage your servers and routers all you want, but if each of the devices you bring onboard is gobbling up bandwidth, your system will be impacted.

Performance keys: Take inactive devices out of the in-cabin ecosystem by powering them down. (See next section for more related tips.)

ROUTERS

Routers can be mystifying, but they're the indispensable midpoints between your external antenna(s) and the in-cabin Wi-Fi antennas. The best routers provide a balance of processing speed and cost.

Performance keys: Avoid congesting the cabin with too many active devices, since this can degrade your router's capacity. The system you choose will determine how many is too many, but in general, fewer devices connecting at the same time yields better performance.

KEY PERFORMANCE INDICATORS DURING TRANSMISSION

Latency

In inflight connectivity (IFC), latency refers to how long it takes a packet of data to get from Point A to Point B. Because of the enormous distances and speeds involved, latency can impact performance on any airborne system.

Speed and bandwidth

Speed is an intuitive measure of a connection's quality, but bandwidth is the operative factor when determining performance. Consider this in automotive terms: A three-lane freeway and a six-lane freeway might have the same speed limit (throughput speed), but the larger one can allow higher amounts of traffic (data) to pass through.

THE BANDWIDTH THIEF

Background data, or passive data, is the data a device uses without you knowing it. iCloud, iTunes, automatic app updates, and Microsoft 365 can use enormous amounts of background data without contributing anything to your active tasks, and their thirst for resources is climbing.

So, what can you do, as a user, to mitigate their effects and take control of your bandwidth? Here are four tips:

Routers and signal management

Router technology sets the bar for how well your in-cabin Wi-Fi network performs. Available data speeds, frequency ranges, wireless standards, and radio channels all affect your data transfer.

Handoffs

As an aircraft flies across the country, it is "handed off" from one ATG tower to the next. The moment of the handoff can be a point of service disruption (dropped calls, lost service) if the infrastructure isn't properly managed.

Backhaul and data centers

Outbound data is transmitted to base stations, which are connected to a data center through cables known as the backhaul. Gogo owns and secures its own data centers and backhaul. This offers full redundancy, and our data centers are staffed by experts who understand Gogo's protocols, software, and systems.

1. Turn off any devices (smartphones, laptops, tablets) that will not be used during the flight.

Many devices that have previously been on the network "remember" it and log on automatically, processing passive updates and iCloud transfers.

2. Turn off iCloud and automatic updates on inactive personal devices.

These noncritical functions will happily resume when you land.

3. Shut down applications you don't need.

4. Don't stream audio or video on non-streaming data plans.

See our earlier publication, **"Inflight connectivity: A guide to doing business at altitude"** for tips on selecting the right plan for your needs.

A LITTLE DIRECTION, PLEASE

Your ATG aircraft antennas are constantly sweeping the ground for the connections that will keep you most productive. The antennas come in two primary types.

Omnidirectional **Dual-directional**

An omnidirectional antenna transmits and receives signals in 360 degrees, whereas a dual-directional antenna does so along two distinct paths.

You might think that a 360-degree sweep is innately better, but it's more complicated than that. Because dual-directional antennas' energy and field of reception are concentrated along these distinct paths, they can offer more power and better performance for heavy streaming and other high-throughput tasks. On the other hand, omnidirectional antennas are more affordable to install and operate.

CHAPTER 3

SECURITY OVER AIRBORNE NETWORKS

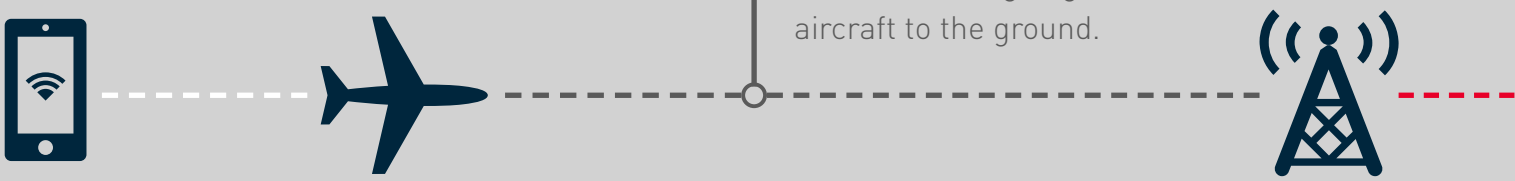
REAL SECURITY BUILT IN, END TO END

Everybody knows that cybersecurity can be risky business, and the data breaches we hear of on the news highlight how vulnerable companies and individuals can be.

That's why, at Gogo, we realize the need to stay ahead of potential security threats and to be vigilant in securing and protecting our customers' information when they connect during flight. Since our start, we've built security into the design and delivery of our networks and systems — security is in our DNA, you could say.

WHAT HAPPENS WHEN YOU PUSH SEND

Aircraft to ground station:
Gogo uses a licensed spectrum and proprietary link encapsulation to secure data going from the aircraft to the ground.



Here are a few of the ways we've built Gogo's infrastructure to be secure:

- Threat assessment and vulnerability testing built into product development
- Clear standards at all stages of development and delivery
- Use of the most advanced network design
- Continuous monitoring and analysis of potential risks
- Partnerships with the FAA and other organizations to establish and update best practices
- Wireless access points secured via WPA2, an industry standard technology that has bypassed many old wireless vulnerabilities
- Routers equipped with firewalls and network segmentation to prevent intrusion from malicious actors online

VERTICAL INTEGRATION, REVISITED

You might have anticipated that security is another area where vertical integration is a huge benefit. Because Gogo owns and manages our infrastructure, we have a much better understanding of our risk exposure and can act swiftly if needed. With ownership comes standardization and fewer points of vulnerability.

Ground station to data center:
Gogo owns and secures its ground stations and backhaul cables, ensuring security continuity.

Data center to internet:
Our two data centers are firewalled and segmented, protecting key components of the network and providing redundancy.

THE COCKPIT IS SECURE

One common concern about IFC is that by connecting your plane to Wi-Fi you're also providing a path for hackers to manipulate crucial cockpit and navigation systems. Can someone really disable your weather radar through your Wi-Fi?

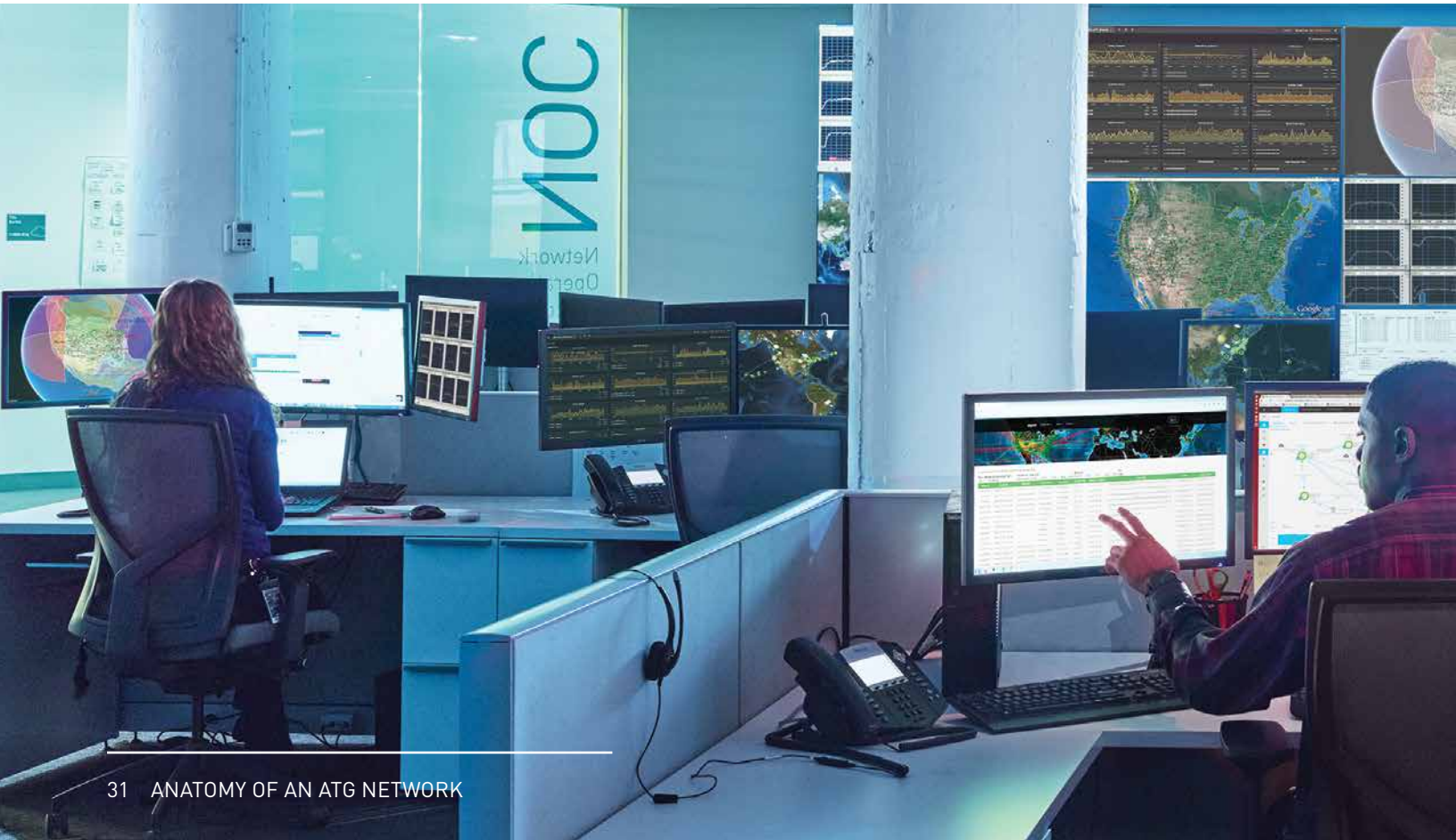
The answer is no. Avionics and flight systems are separate from the Gogo inflight connectivity systems. In the few cases where Gogo needs information from the avionics, these connections are listen-only, meaning that the avionics are never accessible from Wi-Fi components.

INSIDE THE NETWORK OPERATIONS CENTER

The Network Operations Center (NOC) is a beehive of activity, and it's all directed at supporting the customer experience.

Separate from our two data centers, the NOC is effectively the eyes looking in at the network's performance at all times. It provides:

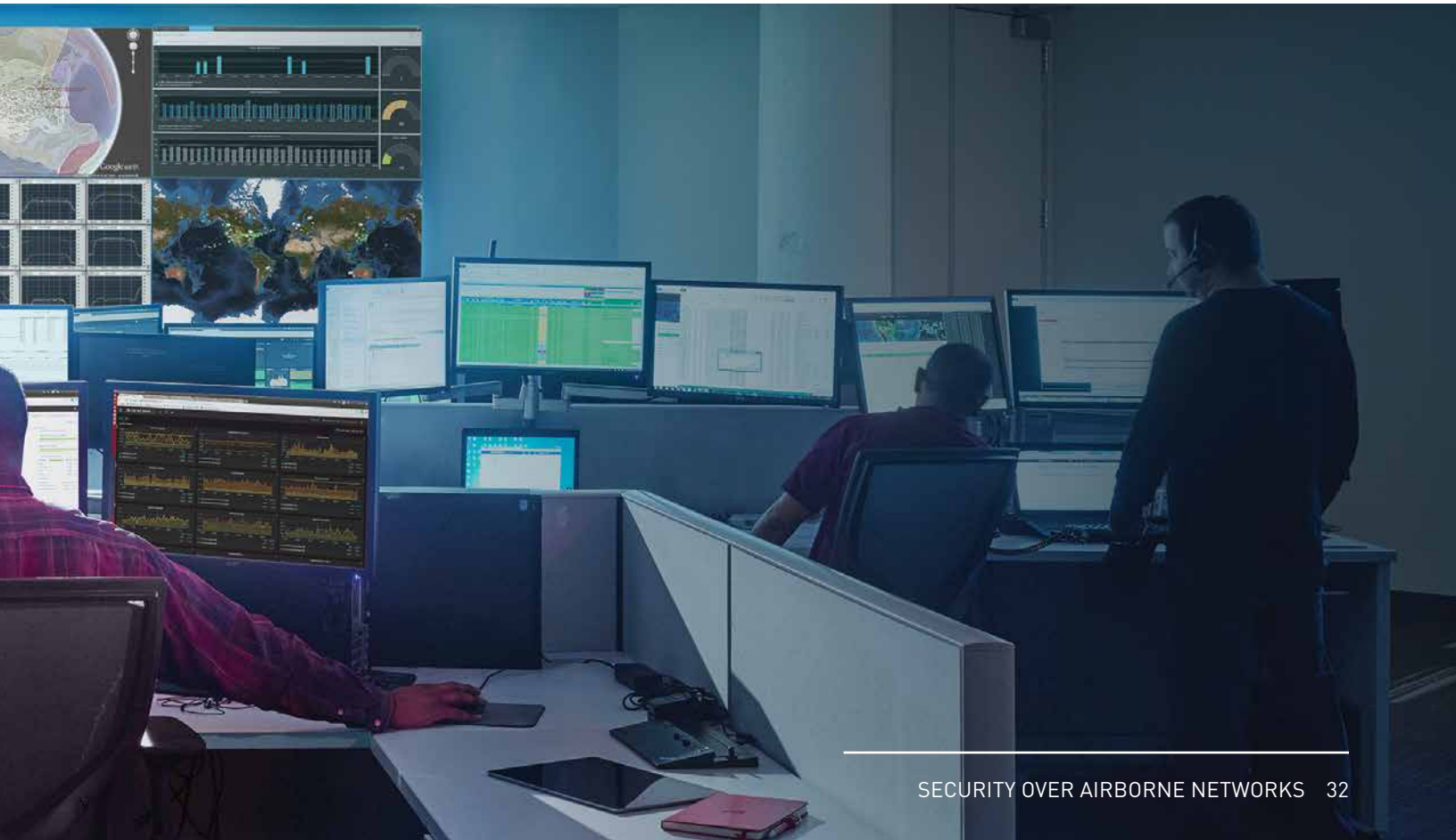
- Continuous monitoring and support of the airborne network
- 24/7 tier 1 and tier 2 support
- A full staff of data systems, wireless, and IP support personnel directly available to users



TIPS FOR FLYING MORE SECURELY

Users can take control of their own security by following these easy practices:

- VPN — Use your corporate VPN when connecting to your own network.
- Install and maintain up-to-date anti-virus software.
- Use two-factor authentication.
- Use a password manager to securely store your passwords.

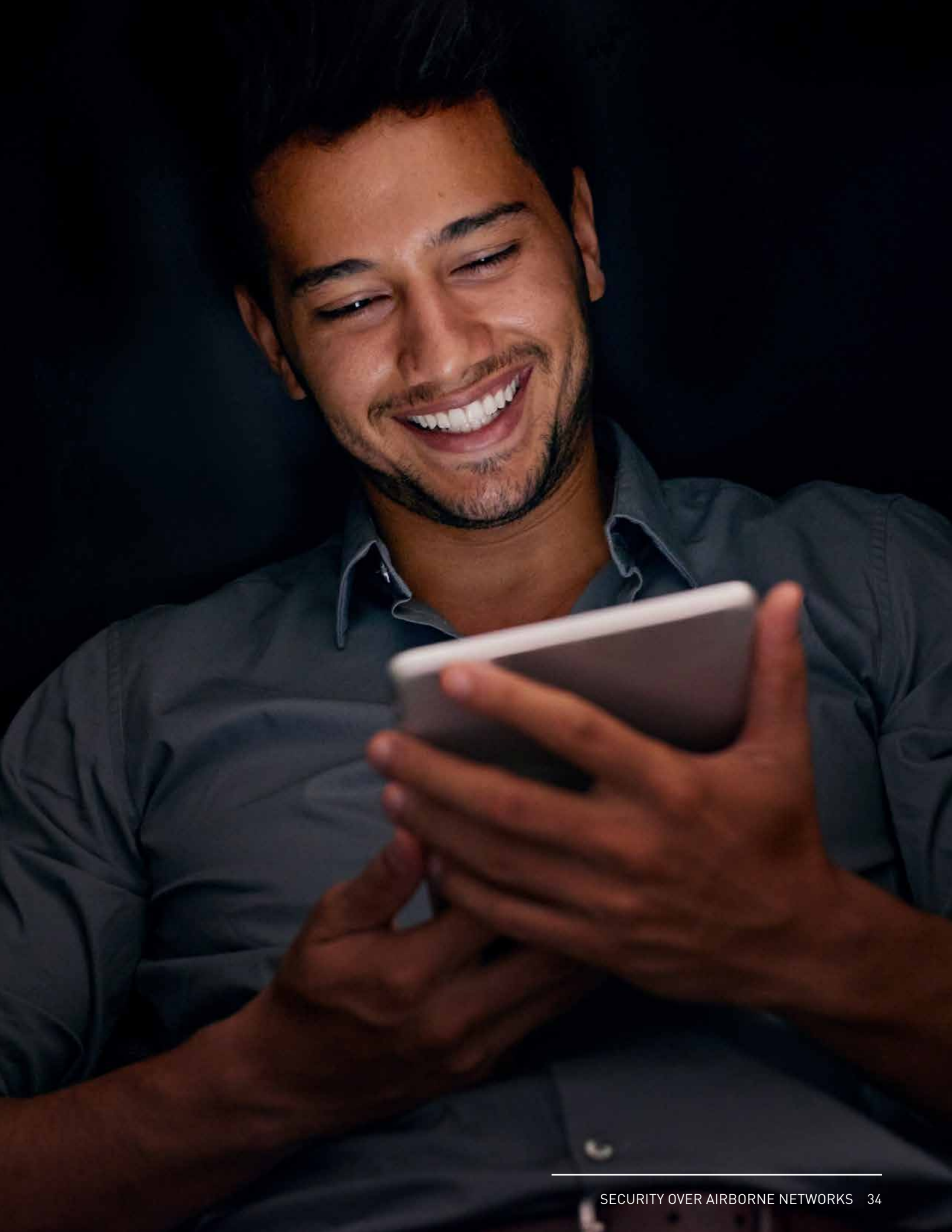


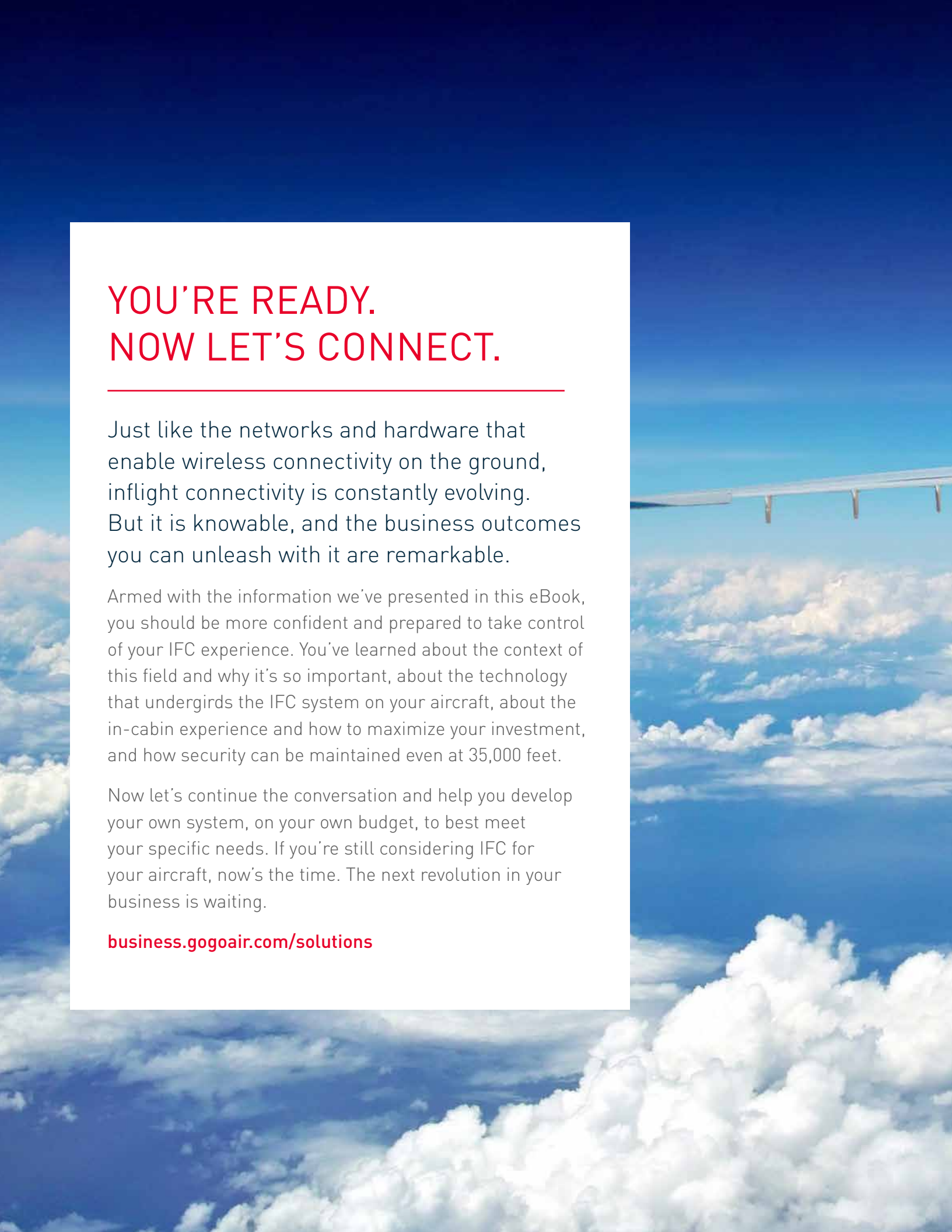
THE FUTURE OF SECURITY

Data security isn't something you're ever finished with — this is an ever-changing field, and what matters is your posture to the evolving risks. Lunging from fad to fad won't do: Cybersecurity demands a steady, comprehensive approach born of experience.

There is a lot the average user can do to stay secure, too. Despite extreme scenarios of nation states hacking accounts (scary but exceedingly rare), most users are safe using our systems and their normal VPN, just like they do on the ground.

Obviously, you can never be 100-percent certain. But you can embrace some smart practices and pick a provider that's 100-percent diligent and tested over time.





YOU'RE READY. NOW LET'S CONNECT.

Just like the networks and hardware that enable wireless connectivity on the ground, inflight connectivity is constantly evolving. But it is knowable, and the business outcomes you can unleash with it are remarkable.

Armed with the information we've presented in this eBook, you should be more confident and prepared to take control of your IFC experience. You've learned about the context of this field and why it's so important, about the technology that undergirds the IFC system on your aircraft, about the in-cabin experience and how to maximize your investment, and how security can be maintained even at 35,000 feet.

Now let's continue the conversation and help you develop your own system, on your own budget, to best meet your specific needs. If you're still considering IFC for your aircraft, now's the time. The next revolution in your business is waiting.

business.gogoair.com/solutions

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