Waypoints

BEYOND NEXTGEN

TOMORROW'S TECHNOLOGIES

Today's Air Traffic Demands

L3HARRIS™


“Together, FAA and L3Harris are developing technologies at the speed of safety to meet tomorrow’s operational demands”

Waypoints

GLOBAL AIR TRAFFIC MODERNIZATION

Features:

NON-EXPORT-CONTROLLED INFORMATION

© 2020 L3Harris Technologies, Inc. | 03/2020

L3HARRIS™

FAST. FORWARD.

[EXECUTIVE NOTE]

Advancing Safety Through Avionics Leadership

> “We must continue to invest and develop industry-leading avionics solutions to create safe and secure skies for the future.”

In 2019, the total global airline’s flights reached 39.4 million, carrying 4.6 billion passengers. Additionally, we continue to see growth for unmanned aircraft systems as they are integrated into controlled airspace throughout the world.

Even as we are faced with unprecedented times, we still see a need for efficient and globally harmonized technologies that will continue to ensure safety and efficiency as the industry globally expands. This includes crucial components that elevate pilot awareness are integrated into the flight deck avionics.

ADS-B is the predominant technology that provides harmonized safety and efficiency. ACSS, an L3Harris and Thales Company, is a leader in ADS-B technology and at the forefront of bringing this technology into the cockpit.

ADS-B Out transmits specific aircraft information, including the speed, position, altitude, and direction for Air Traffic Controllers.

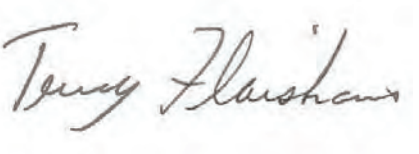
Allowing pilots to see the same information about surrounding aircraft significantly enhances their situational awareness enabling them to taxi and fly safer and more efficiently. As leaders in communication and surveillance products, we recognized the value of ADS-B In technology early and had the first certified cockpit solution in 2007. However, at that time, much of the industry wasn’t equipped with ADS-B Out; now they are, and now is the time for airlines to leverage it.

One of the greatest advantages of ADS-B In technology is that it is one of the first avionics technologies that is an add-on application to existing TCAS equipment. In-flight applications allow precise spacing in adverse weather conditions, more direct routing resulting in fuel savings, and improvements in overall block times in & out of airports. Ground applications help reduce the likelihood of runway incursions with aircraft and other vehicles.

L3Harris is working with airlines and airport authorities globally to thoroughly understand the full benefits this technology will bring to airlines and passengers. For airlines and airports, ADS-B In means greater safety, efficiency, and higher throughput. This can help increase capacity, minimize flight times and predict better block times without adding additional runways.

Similarly, we are seeing a reduction in workload of the ATC controller. With ADS-B In, the controllers will gain increased confidence because they know that the pilots have a tool that gives them precise information about the aircraft they are following.

Avionics technologies are moving faster than ever before, the passenger travel needs will continuing to be in high demand, and the industry is preparing for the integration of unmanned aircraft into controlled airspace. L3Harris continues to be at the forefront of avionics technology that will help shape the future.



Terry Flaishans
President
Commercial Avionics


“Redefining what’s possible and helping you prepare for tomorrow’s challenges.”

[EXECUTIVE NOTE]

Continuing Excellence In Air Traffic Management

> “As complexity continues to grow in the NAS, we must rise to the challenge and continue to deliver operational excellence while maintaining the safest airspace in the world.”

Our National Airspace System (NAS) is transforming at an unprecedented rate. Continuous growth in air transportation coupled with uncertainties involving weather frequently results in less predictable airspace performance. As complexity continues to grow in the NAS, we must continue to deliver operational excellence while maintaining the safest airspace in the world.

L3Harris sees a new horizon for air traffic technologies and we are positioned to play a big part, even under uncertain times. We continue to support the Federal Aviation Administration (FAA) with multiple NAS critical infrastructure programs in data communications, surveillance and information management. We are also engaged in the continuous technical evolution of the world’s largest, safest air traffic telecommunications network known as the FAA Telecommunications Infrastructure (FTI), by investing in new technologies and solutions that will continue the seamless operational insight and excellence across all those capabilities.

2018 came and passed with new and different challenges to our Nation’s airspace and L3Harris met them head on. That year ended without seeing an increase in delays despite the combination of increased air traffic and major weather events. One of the major contributors to keeping delays from growing was Data Communications (Data Comm), an L3Harris led FAA program deployed at 62 airports across the NAS that enables controllers and pilots to communicate more effectively with loadable route clearances. In fact, since its launch 2.5 years ahead of schedule in 2017, the program has prevented tens of thousands of communication errors, saved millions of minutes in delays, and reduced CO_2 emissions.

Not only was operational excellence achieved, but new technologies continue to be qualified and integrated into the NAS both safely and efficiently. FTI, the critical conduit to over 150 NAS systems and applications, reached another major milestone by delivering over 100,000 safe system upgrades encompassing over 4,000 FAA and partner facilities. This signifies a decades-long partnership between the agency and industry dedicated to delivering new, reliable and mission critical services safely, while providing the network scalability required to outpace the future of air travel.

2020 has brought a new set of challenges and L3Harris continues to building key surveillance technologies for global needs. Our team will conitnue to expanded beyond traditional air traffic infrastructure and into the cockpit with Automatic Dependent Surveillance – Broadcast (ADS-B) In and ADS-B Out as well as Unmanned Aircraft Systems (UAS) infrastructure development. We couple these developments with our new cloud-based System Wide Information Management capabilities for more efficient services.

As industry providers, we must remain in the forefront to deliver the gold-standard of safety and execution integrity for our partners across the globe.

Kelle Wendling
Vice President & General Manager, Mission Networks

YOUR PARTNER BEYOND NEXTGEN

L3Harris meets the challenges of complex airspace with scalable technologies to link thousands of personnel, sites, and ATC solutions for faster, safer operations. With passenger traffic doubling by 2036 and unmanned traffic expected to increase dramatically, L3Harris continues to evolve FAA infrastructure to meet demand while delivering mission-critical reliability.

Visit us online at www.L3Harris.com.

L3HARRIS™
FAST. FORWARD.

Optimizing ADS-B In

Flight Deck Technologies Enhance Pilot Situational Awareness

According to the FAA, ATC typically handles 44,000 commercial flights per day, and the one thing the 2,789,000 passengers on those flights all have in common is, regardless of weather, they want to arrive at their destination on time.

Keeping all those flights on time throughout the NAS puts a lot of pressure on controllers and flight crews. That's one of the reasons the FAA implemented the Automatic Dependent Surveillance-Broadcast (ADS-B) program. Aircraft equipped with ADS-B Out continually transmit their location, intention, speed, direction, and altitude in real-time, enabling controllers to better coordinate flow even during peak traffic times.

SafeRoute+ ADS-B In enhances situational awareness in the cockpit.

SafeRoute+ from ACSS brings all of the real-time situational awareness ADS-B benefits provides to ATC directly into the flight deck. And for aircraft already equipped with ACSS ADS-B Out, it's a simple process and does not require the installation of EFBs. All it takes is a simple software upgrade to the existing TCAS 3000SP™ or T3CAS® computers, and the addition of the new ACSS ADS-B Guidance Display (AGD) to deliver unparalleled awareness of other aircraft within the broadcast area.

This creates an en route environment of shared traffic situational awareness between pilots and air traffic controllers.

According to Captain Dave Surridge, A320 Captain and Senior Manager of Optimization, Policies and Procedures for American Airlines, and a lead pilot in the carrier's SafeRoute+ trial flights, while the system delivers exceptional situational awareness in all phases of flight, its most valuable during the critical approach phases of the flight.

CDTI-Assisted Visual Separation (CAVS)

By displaying the precise location and airspeed of the traffic ahead, SafeRoute+ CAVS enables crews to continue their approach with "visual approach accuracy" even in low visibility situations. Some studies have shown that CAVS has been able to reduce final approach time by as much as 14%, in addition to reducing go-arounds. This application will help keep airports running at full capacity, even during reduced visibility conditions.

Interval Management Spacing (IMS)

By providing accurate, time-based spacing between aircraft, IMS helps flight crews maintain consistent, well-spaced arrival flows to an airport. The benefits are reduced time flow, lower probability of vectors and go-arounds, and a reduction in aircraft inter-arrival spacing variance, resulting in enhanced block time predictability and the maximization of runway capacity.

In-Trail Procedures (ITP)

ITP provides flight crews with a vertical profile view of traffic over 100 nm away, which enables the crew to plan and execute climbs to more favorable altitudes when the aircraft is out of ATC radar coverage. The FAA has released studies that show transatlantic ITP-equipped aircraft saving an average of 670 pounds of fuel and transpacific flights realizing an average savings of 521 pounds of fuel.

Awareness in the air.
Awareness on the ground

While the in-flight benefits of ACSS SafeRoute+ are considerable, Captain Surridge stressed that the new-generation technology has shown to offer significant safety and traffic management advantages during ground operations.

Surface Area Movement Management (SAMM)

By providing a real-time moving map of equipped aircraft in the terminal, taxiway and runway areas, SAMM provides enhanced situational awareness for ground operations, which dramatically reduces the likelihood of runway incursions.

"It definitely has potential for helping improve ground operations and safety during taxi operations," Captian Surridge said. "There is so much SafeRoute+ can do and we are just beginning to explore what all the benefits are."

"We are currently working with the FAA to create new criteria that will allow advancements in avionics technology to benefit the national airspace system, the airlines and our customers," Captain Surridge said. "In addition to our work with the FAA, we have talked to a lot of the air traffic controllers who have helped us during our initial flight tests and they are also excited to get the system operational on our aircraft."

"They are looking for new ways that they can use this new technology to make their jobs more efficient," he said. "Together, we are aiming to achieve increased efficiency and resiliency for our major hub operations."

Because SafeRoute+ is a non-integrated solution, as these new capabilities are introduced, airlines will be able to migrate from basic to more advanced applications, while keeping costs specific to their operations.

SafeRoute+ is simple to use.

Obviously, along with delivering advanced situational awareness capabilities, pilots want a system that is intuitive and easy to operate.

"Because the system uses existing navigational displays and MCDU's, the good news on this front is there is minimal training required for flight crews to get the most out of SafeRoute+," Captain Surridge said. "The system is very intuitive and easy to follow. Because we all are very familiar with the ACSS system and the TCAS displays, it's a very simple transition to get familiar with the new ADS-B In displays."

"American Airlines has had the system on our Airbus 330s for a while, and the training has proven to be minimal compared to the benefits that the system delivers," he said. "From our experience, SafeRoute+ brings the greatest advancements in flight crew situational awareness to today's aircraft with the smallest investment in aircraft upgrades."

Delivering Airport Operational Excellence

Data Comm Saves FAA and Passengers Millions of Dollars in Delays

2.8 million passengers fly in and out of airports in the United States every day. With passenger demand growing constantly, the Federal Aviation Administration (FAA) and their partners must evolve by continually making operational improvements.

Data Communications (Data Comm), a FAA NextGen initiative developed in partnership with L3Harris, provides Controller Pilot Data Link Communications (CPDLC) between air traffic controllers and pilots so they can more efficiently and safely transmit clearances, advisories, flight crew requests, and other essential messages with the touch of a button. Data Comm helped the FAA deliver operational benefits by avoiding air traffic delays in 2018. Despite an increase in bad weather and air traffic between 2017 and 2018, average delays remained flat thanks in part to this NextGen solution.

Deployed at 62 towers across the United States, Data Comm reduces the need for voice communications during pre-departure operations. This saves time on the runway, shortening delays, lowering carbon emissions and reducing errors during peak departure clearance periods. During the year, over 500,000 minutes of delays were saved, more than 600,000 minutes of communications time were saved and 4.7 million kilograms of CO_2 emissions were prevented.

Data Comm is constantly saving time and fuel for the aviation industry by streamlining pilot and controller processes. Not only does the solution help with passenger movements, but it is being used for the transportation of freight.

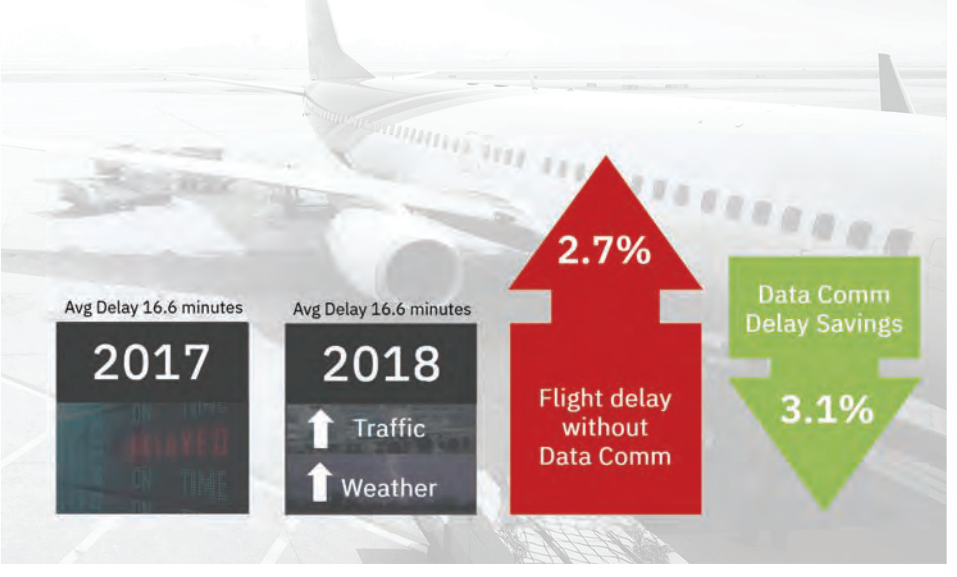
"I have easily seen Data Comm save me 7 to 15 minutes in getting a clearance for takeoff. For UPS, we really have a time-critical sort," said a UPS pilot. "Every minute I'm delayed could affect the transfer of packages onto 40 aircraft waiting in Louisville."

With the ability to send clearances over text instead of voice communications, read-back hear-back errors are more easily avoided. Operators can more effectively focus during peak airport hours.

"I've had several experiences where the controller has to issue a Full Route Clearance, when I point out that the aircraft is CPDLC they immediately breathe a sigh of relief." Said a controller at George Bush Intercontinental Airport in Houston, Texas. "(Received) a reroute, controller sent the clearance via CPDLC and 3 minutes later they were rolling down the runway. That would have been at least 10-20 min traditionally; if they needed more fuel, (it would have been) up to an hour."

With air traffic complexity and weather continuing to evolve, FAA and L3Harris stand ready to deliver even greater operational excellence to U.S. and global airspace. Data Comm is transitioning into en route operations to further reduce delays related to weather and congestion. By allowing controllers to send messages directly to pilots en route, United States airspace will continue to be the safest, most efficient in the world.

Together, FAA and L3Harris are developing technologies at the speed of safety to meet tomorrow's operational demands.



2018 DATA COMM DELAY SAVINGS IMPACT

Average delay remained flat despite increased weather and traffic – Data Comm benefits offset operational impacts

SAFETY. EFFICIENCY. ADS-B LEADERSHIP.

SafeRoute+ is a suite of ADS-B In applications bringing real-time aircraft information and situational awareness benefits directly into the flight deck. This economical upgrade provides operators safety and efficiency for the entire flight, especially during the critical approach phase.

Visit L3Harris online at www.L3Harris.com/SafeRoute

ACSS®
An L3Harris & Thales Company

L3HARRIS™
FAST. FORWARD.

> “The FAA expects that airlines will invest in ADS-B In avionics in order to take advantage of the benefits available in the near future.”

ADS-B Information Streamlines Operations

ADS-B In Applications Will Be In-Demand Around The World

In its most basic form, Automatic Dependent Surveillance-Broadcast (ADS-B) Out continually transmits an aircraft's location, intention, speed, direction, and altitude in real-time to ATC, so controllers can more safely and efficiently route traffic into and out of today's increasingly congested airspace.

While the safety enhancements enabled by ADS-B Out are proving to be an unparalleled success, it quickly became apparent that the same, highly detailed aircraft position/intention information that ATC sees would be equally beneficial if it were available inside the cockpit of those aircraft.

Aircraft equipped with ADS-B In capabilities deliver all the real-time situational awareness benefits that the technology provides to ATC directly into the flight deck.

"ADS-B In applications can improve efficiency, capacity, and safety throughout the National Airspace System (NAS). Specifically, applications such as Airborne Situation Awareness (AIRB) augments a pilot's traffic situational awareness, which improves safety," Paul Takemoto, FAA Spokesperson said. "Additionally, improved identification of surrounding aircraft enables pilots to make more informed clearance requests to ATC, which can support flight efficiencies."

While every flight crew will benefit from this information, in many instances the cost to upgrade legacy aircraft is extremely high.

ACSS SafeRoute+. The affordable solution to delivering ADS-B In into the cockpit.

SafeRoute+ from ACSS is the easiest way to create an en route environment of shared situational awareness between pilots and ATC.

All it takes is a simple software upgrade to the existing TCAS 3000SP™ or T3CAS® computers, and the addition of the new ACSS ADS-B Guidance Display (AGD) to deliver unparalleled awareness of other aircraft within the broadcast area.

As far as what types of ADS-B In capabilities will be most advantageous to pilots and controllers, Takemoto said that, along with much greater Airborne Situational Awareness (AIRB), the three of the capabilities that will currently deliver the greatest benefits are CDTI-Assisted Visual Separation (CAVS), In Trail Procedures (ITP) and Interval Management (IM).

"CAVS assists pilots in maintaining visual separation during visual approach procedures, improving arrival throughput by allowing visual approach operations to continue when they would have otherwise been stopped," he stated. "In-Trail Procedures (ITP) allows pilots to climb or descend to optimal altitudes in oceanic airspace when they otherwise could not, due to traffic. The benefits of ITP are fuel savings and the corresponding environmental benefits from operating more closely to the aircraft's optimal cruise altitude."

"Interval Management (IM) utilizes ground-based and flight-deck systems to provide precise inter-aircraft spacing between aircraft, providing air traffic controllers with another tool to manage traffic flows," Takemoto said. "There are many different types of clearances within the scope of IM, but they all provide for increased traffic flow capacity in high-density arrival and approach environments."

"The FAA expects that airlines will invest in ADS-B In avionics in order to take advantage of the benefits available in the near future. AIRB and CAVS can yield benefits now, as well as ITP in certain oceanic domains," he said. "IM will become available over the next few years, which gives airlines time to equip their fleets. Equipping early may give an airline a competitive advantage."

Speaking of equipping now, because SafeRoute+ is a non-integrated solution, as various new capabilities are introduced, airlines will be able to migrate from basic to more advanced applications while keeping costs specific to their operations.

One of those "future applications" Takemoto described is Trajectory Based Operations (TBO). TBO is an Air Traffic Management (ATM) method for strategically planning, managing, and optimizing flights throughout the operation by using time-based management, information exchange between air and ground systems, and the aircraft's ability to fly precise paths in time and space.

"ADS-B is a foundational technology supporting TBO, which promises benefits in high-density operations," he said. "Accordingly, the FAA will continue implementing proven technologies that support its vision for Trajectory Based Operations."

ADS-B In will be in-demand around the world.

While the U.S. is the only Air Traffic Control system that currently uses visual approaches, the added situational awareness and safety benefits of technologies like SafeRoute+ may be the motivation for other countries to evaluate the advantages of ADS-B In enabled approaches like CAVS, ITP, and IM.

European ADS-B In implementation.

ACSS is currently working with the FAA, Eurocontrol, ICAO, Airbus, the SESAR Joint Undertaking and NLR, in various studies to evaluate, test, and monitor the benefits of ADS-B In technologies to improve traffic flows.

Additionally, ACSS is currently partnering with Thales to participate in a major demonstration of ADS-B In-based surface ADS-B applications that are scheduled to run through 2022.

China's move to ADS-B In.

As the Civil Aviation Administration of China (CAAC) begins to prepare for its own ADS-B Out mandate, ACSS, with support of Thales ASW/ATW and other major providers, is socializing the many benefits of ADS-B In at various CAAC events.

ACSS is also working with the CAAC in promoting the use of ADS-B in through an ongoing series of demonstrations and evaluations. For example, ACSS, Airbus, and Thales recently conducted a very successful ADS-B In demonstration with three Juneayo Airlines aircraft in Shanghai.

India's ADS-B In implementation plan.

As one of the largest, and fastest-growing in-country airspace systems, the Indian government has already identified ADS-B In technology for improved throughput through the country. ACSS is working closely with India's aviation leaders to play an active role in ADS-B In technologies at major airports.

Throughout the world, ADS-B In is proving to be a major enabler of not only greatly enhanced situational awareness in the air, but also on the ground. The unparalleled accuracy of the locating capabilities of ADS-B In will provide a major step forward in reducing the number of runway incursions during low-visibility situations.

> "AIRB and CAVS can yield benefits now, as well as ITP in certain oceanic domains."

ACSS SafeRoute+. Using ADS-B In information to streamline ATC operations.

Airlines that retrofit their fleet with ACSS SafeRoute+ will not only take advantage of the flight efficiencies of ADS-B In technology, their flight crews can also make better real-time decisions, which will aid ATC in optimizing traffic flow in all visual conditions.

TRUSTED AND RELIABLE TODAY. PREPARED FOR THE FUTURE.

L3Harris' expertise spans on-aircraft avionics, integrated airport security and the complete pilot training offering - coupled with our latest flight data services we support operators to improve safety and increase operational efficiencies.

Visit us online at www.L3Harris.com/CommercialAviation

L3HARRIS.COM

L3HARRIS™
FAST. FORWARD.

Successful ADS-B In Retrofit Flight Test

ADS-B In Retrofit Program (AIRS) Receives TSO and STC Certifications

Now that the US and European ADS-B Out mandates are done, it presents clear opportunities for airlines to take advantage of ADS-B In technology. ACSS, an L3Harris and Thales Co., remains ahead of the game with their SafeRoute+ retrofit solution, specifically developed to bring efficiencies and increased safety in airline operations.

Captain Dave Surridge, A320 captain and senior manager of optimization, policies and procedures for American Airlines, and a lead pilot in the carrier's SafeRoute+ trail flights, "While the system delivers exceptional situational awareness in all phases of flight, it's most valuable during the critical approach phases of the flight."

"This new technology brings the same aircraft-specific data that ATC uses into the flight deck, and that allows flight crews to get a more complete picture of what the ADS-B equipped aircraft around them are doing," Captain Surridge said. "That bigger picture enables us to make better decisions about how the current stage of the flight is going to be conducted."

"ADS-B In applications can improve efficiency, capacity, and safety throughout the National Airspace System (NAS). Specifically, applications such as Airborne Situation Awareness (AIRB) augments a pilot's traffic situational awareness, which improves safety," Paul Takemoto, FAA Spokesperson said. "Additionally, improved identification of surrounding

aircraft enables pilots to make more informed clearance requests to ATC, which can support flight efficiencies."

On September 15 and October 27, 2019, the ACSS Engineering team completed the flight tests for the SafeRoute+ ADS-B In retrofit solution with American Airlines and the FAA on their Airbus A321 aircraft. This test is part of the FAA-AAL-ACSS ADS-B In Retrofit Spacing Evaluation project (AIRS) that was kicked-off in July 2016. Two American Airbus A321 aircraft participated in demonstrating the system capabilities during a lengthy, over four-hour flight test originating from Phoenix Sky Harbor.

About AIRS

The FAA, American Airlines, and ACSS signed a Memorandum of Agreement for the operational evaluation of the ADS-B In applications of Cockpit Display of Traffic Information (CDTI) Assisted Visual Separation (CAVS) and Interval Management Spacing (IM-S) in July 2016.

CAVS provides the flight crew with the capability to use the CDTI to assist in acquiring and maintaining visual contact with a preceding aircraft while performing visual separation on an approach in Visual Meteorological Conditions.

IM Spacing provides the capability for Air Traffic Control to issue a clearance for a flight crew to achieve and maintain a specified spacing goal with respect to a designated aircraft. The spacing can be expressed in terms of a distance or a time. The IM Spacing provides speed guidance to the flight crew to maintain the spacing specified in the IM Clearance.

The FAA AAL ACSS ADS-B In Retrofit Spacing Evaluation (AIRS Eval) project meets multiple FAA objectives:

- Promotes the early adoption of ADS-B In applications by fielding a cost-effective retrofit solution that applies to a large potential market.
- Collects operational data during IM and CAVS operations to evaluate benefit.
- Demonstrates applications, procedures and operations that support the FAA's processes for making IM extensive throughout the NAS.

Operations Into Phoenix Sky Harbor

Phoenix Sky Harbor (PHX) is the proposed airport for the inital operational evaluation. CAVS arrival operations do not require ATC involvement and can be performed on any arrival into PHX. IM-S operations do require ATC involvement, as the controller must issue an IM Clearance to initiate the operation.

IM Spacing operations are proposed for westbound arrivals through Albuquerque Center (ZAB) and into the Phoenix TRACON (P50). Westbound arrivals through ZAB carry about half of the arrival traffic into PHX. EAGUL6 is the busiest westbound arrival with the most potential benefit for IM Spacing.

IM Spacing clearances will be issued prior to the top of descent and could terminate at the TRACON boundary or continue through P50 to the final approach fix. The controllers will not require any special ground automation support for the operational evaluation. The controllers will know which aircraft are equipped with the IM Spacing application by checking the aircraft type since AAL plans to equip the entire A321 fleet.

TSO & STC Certification

The FAA granted the Technical Standard Order (TSO) authorization for the SafeRoute+ software and the new ADS-B Guidance Display (AGD) sold by ACSS and developed by L3Harris. The STC has also been issued for SafeRoute+ software and hardware installation on the American Airlines A321 fleet consisting of 319 aircraft.

"Airlines have spent a lot of money equipping their aircraft with ADS-B Out so that air traffic controllers have better aircraft data to route flights safely and more efficiently," said Terry Flaishans, President of ACSS. "This program enabled us to work side-by-side with pilots and the FAA to develop a viable retrofit solution that enables airlines to take advantage of that same information; thereby enhancing safety, enabling better decision making and ultimately greater airport efficiency."

"Captain David Surridge, A320 Captain and Senior Manager of Optimization, Policies and Procedures for American Airlines, and I demonstrated the system with numerous pilots in our simulators, specifically to solicit feedback during the development phase to ensure it was easy to learn and use by the pilots," said Chuck Manberg, Technical Fellow and Lead ADS-B engineer at ACSS. "The operational and human factors research was instrumental in making SafeRoute+ affordable and adoptable."

American Airlines is now equipping 319 A321 Aircraft with the newly certified SafeRoute+ solution.

Air Traffic Resiliency Must Be Measurable

Enabling Safety Through Resilient Technologies

In May 2019, the Resorts Ballroom in Atlantic City, NJ hosted an event focused on the future of air travel. With technical co-chairs from the Federal Aviation Administration (FAA) and National Aeronautics and Space Administration (NASA), the Air Traffic Control Association (ATCA)-led event focused on the latest ideas and trends likely to impact air traffic control (ATC).

A major theme of the conference was resilience in air traffic management (ATM) systems and infrastructure. Panelists noted that the over-arching theme is comprised of key elements which include policy, process, people and technology. For any system, resilience depends on the proper construction of each of these elements and each is, in turn, dependent upon the others. For the technology element, many new technologies promise significant efficiency gains and can often achieve this through aggregation of processing, data and information management and communications. In some cases, the likelihood of a system outage might stay the same or even decrease as a result of implementing a new technology, but the impact to National Airspace Systems (NAS) operations may increase significantly. This critical balance was referenced during the conference's final panel "When Safety Meets Efficiency: Implementing New Technologies".

How can the aviation industry advance new concepts and move forward with technology implementations quickly and safely? To do so, it is crucial to begin with common terminology defined through FAA led engagements with industry.

How do you accurately define the resiliency of a system that will be integrated into or leveraged within the NAS? What about other meaningful

terms such as survivability, sustainability, availability, avoidance and diversity? In many cases they are interdependent. Every word must be defined in relation to its counterparts so the aviation community can use them consistently to reduce risks to the entire system. Even a word like diversity needs further sub-definitions when being discussed in a modern network by use of pretenses like physical, electrical or logical.

The need for standardized and consistent FAA terminology is most apparent when discussing network resiliency, which is measurable through mathematical calculations and analyses based on other clear definitions.

For example, if the NAS network infrastructure is critical to operations, and a high bandwidth fiber line is accidentally cut in an Iowa cornfield, there must be "physical" diversity. This means that a separate independent line that is continuing to provide service to that area, or another available line with some measurable separation requirement is necessary, otherwise the entire system could be at risk. Likewise, if an IP storm, black hole, denial-of-service or other cyber threat is present in your network, you need an observable and measurable way to guarantee that traffic gets to its destination(s).

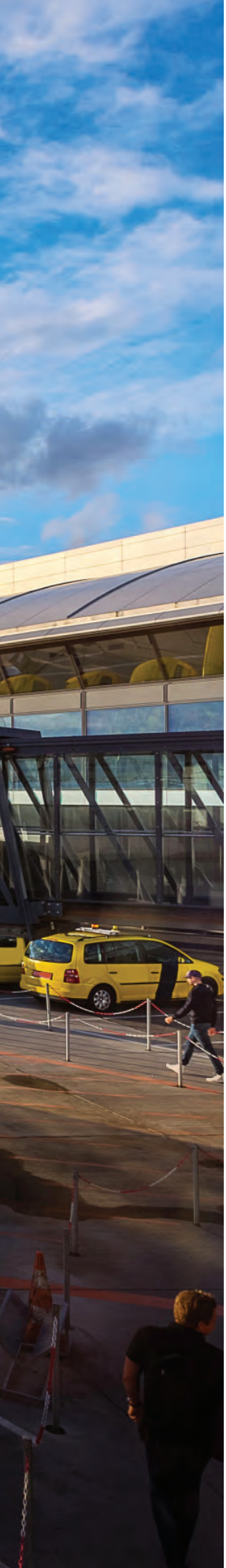
In 2017, the Department of Transportation Inspector General report identifying FAA top management challenges stated, "Resiliency is the ability of NAS systems, services, and facilities to be able to withstand and rapidly recover from air traffic operational capacity-impacting events." The definition provided was certainly not meant to be exhaustive, but it helps further amplify the need for exactness of terms when discussing any NAS system. Without supporting definitions and requirements, one network provider might interpret the stated ability to "withstand" as a need to propose dual independent networks. Alternatively, a second network provider might focus on the "rapidly recover" aspects and propose a singular network with more diverse circuit paths.

Is either network solution acceptable? Or, is the correct interpretation that both are necessary? The safety of the flying public demands certainty. The expectation from industry must be that any requirement set provided by the FAA has unambiguous and exhaustive definitions of all the resiliency subfactors. The definitions must include how they will be measured and how they will be used to calculate overall system resiliency. With this added clarity, the FAA and industry will jointly and confidently be better prepared to move innovations forward efficiently and safely.

Upcoming opportunities to begin to close the gaps are just ahead at key conferences such as the ATCA Annual Conferences in Washington, D.C. But conferences alone are not inadequate. The FAA and the aviation industry must come together on a variety of topics through frequent and specifically targeted outreach events designed to establish explicit definition sets for many of the innovations discussed at the symposium. The next decade of safe air travel is upon us, and it is our collective responsibility to do it at the speed of safety.

> "The next decade of safe air travel is upon us, and it is our collective responsibility to do it at the speed of safety."

> “By moving at the speed of safety industry can effectively integrate new, mature technologies and foster continued growth across the entire NAS.”

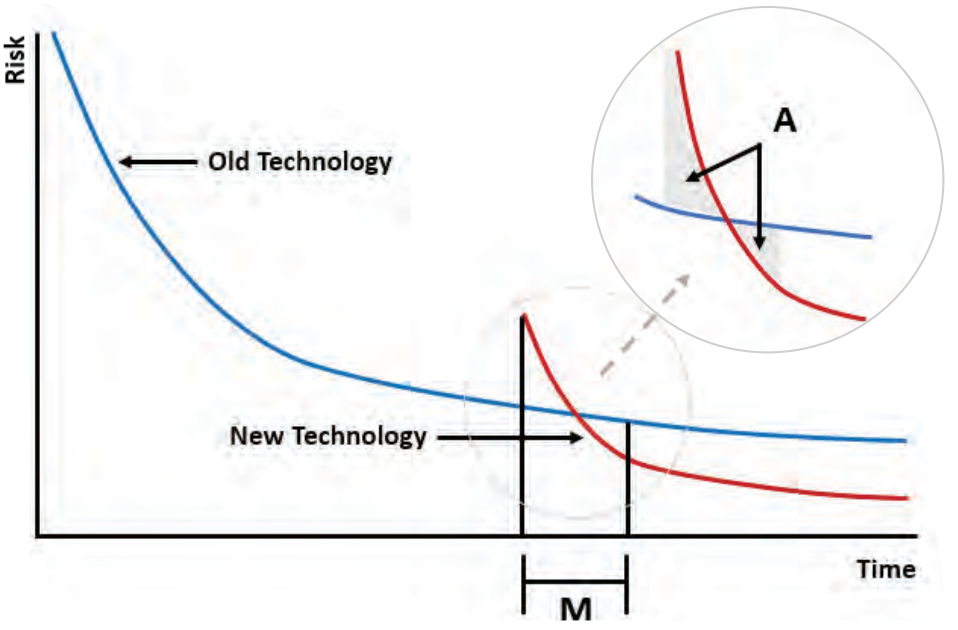


Technology Advancements At The Speed Of Safety

Excerpts From The White Paper Published in the ATCA Journal Of Air Traffic Control

Safety and innovation are two core components to any industry. While technical innovation can enhance growth and create new opportunities, safety must always be considered when adapting to any environment, especially critical infrastructure. If not integrated at the right level of maturity, major impacts can happen to the industries which said technologies are being implemented.

When the Federal Aviation Administration (FAA) was first established, it was chartered to "provide for the promotion of civil aviation in such manner as to best foster its development and safety, and to provide for safe and efficient use of the airspace by both civil and military aircraft, and for other purposes". This led to the creation of the National Airspace System (NAS) and the establishment of a safe and efficient airspace environment for civil, commercial, and military aviation. Over time, the NAS has become a critical component of the FAA's mission to provide safety and efficiency in aviation



operations. In 2013, the President signed Presidential Policy Directive-21 (PPD-21), Critical Infrastructure Security and Resilience which defined the 16 Critical Infrastructure sectors for the United States.

With aviation considered as a critical infrastructure component in the United States, safety is an essential driver behind technology decisions that impact the NAS. As a result, some FAA solutions may take longer to integrate into the system when compared to other industries. However, as technologies mature, they present added efficiencies that the FAA can leverage to enhance air operations while providing a secure infrastructure to support air operations.

> “Networks grew larger, more complex, drove additional management resources and became expensive to operate.”

Over the past fifteen years, the NAS infrastructure has evolved to incorporate a broad host of communication technologies to increase efficiency and meet safety standards. Some examples of these technologies include dense wavelength division multiplexing (DWDM) over fiber, cellular wireless, SATCOM, and microwave transport. To integrate these technologies into the NAS, they were tested and approved by the FAA. In recent years, the commercial networking industry has introduced a new set of network technologies such as network function virtualization (NFV), software-defined networking (SDN), software-defined wide-area networking (SD-WAN), 5G wireless, and advanced cybersecurity capabilities. Each of these advancements shows promise, but can also lead to deployment and operational questions and concerns. Most importantly, how quickly can a company or entity benefit from emerging technologies while avoiding unacceptable risk? Also known as “the speed of safety,” the answer to this fundamental question is dependent on the criticality of the network accepting the risk.

The speed of safety is not just relevant to the networking industry, but has a broad context that is applicable across multiple industries. An example of this concept is when aircraft manufacturers began switching from conventional mechanical flight controls to a fly-by-wire glass cockpit architecture. This conversion to electrical signals allows flight control computers to monitor and control aspects of flight once entirely controlled by the pilot. However, the conversion came with great risk. Airbus presented at the Flight Safety Conference in 1997 that between 1982 and 1984 aircraft with an automated glass cockpit had more hull losses per departure than conventional aircraft. This changed as technology risks were mitigated over time through consistent improvements to the cockpits systems and safety mechanisms.

To illustrate this phenomenon, the maturity curve (See below) postulates the type of safety curve that applies to many applications and their lifecycles. Segment M represents the maturity period, whereas Region A represents an acceptability

area. Both shaded area s within the acceptability area might be acceptable to a general audience, but for a critical mission such as execution of the FAA NAS, only the second Region A area beginning below the old technology line should be considered as acceptable. If interrelated technologies are introduced the risk can be compounded. Choosing a technology with the right level of maturity will yield the best results for the user.

NFV

The impact of technology maturity on a mission-critical network can be illustrated through SDN and NFV capabilities. SDNs grew from the need to offer more network flexibility without the increased costs of operating and maintaining a large network infrastructure. Like SDN, NFV was developed to reduce costs and accelerate service development for network operators.

Where SDN decouples routing control from network devices, NFV decouples network functions from dedicated hardware and moves these functions to virtual appliances. It removes the need to purchase expensive, proprietary hardware that provides a unique function like routing, encryption, firewalls and load balancing. Instead it enables the ability to move these functions to less expensive devices that support virtualization. Virtualization reduces dependency on dedicated hardware appliances and

allows for improved scalability and customization across the entire network. NFV is also designed to reduce the manual effort of maintaining network devices by automating the application of standard configurations to devices. This reduces the impact of accidental misconfigurations caused by manual device management.

While NFV offers significant value and cost savings it also has its challenges. In traditional networks, proprietary hardware such as routers and switches are often designed as dedicated appliances with built-in failure protections or hardware configurations specifically to meet network traffic loads. In a NFV environment, however more generic components are used which may not be able to support throughput challenges. In addition, NFV software packages may contain open-source code or solutions which can add to the complexity of building a standardized and scalable infrastructure. This can lead to inconsistent architectures that can negatively impact network service offerings.

To address these challenges, organizations can leverage NFV solutions that have a standard baseline of hardware and software components that have been validated by industry and meet basic compliance standards. NFV solutions should be interoperable with legacy hardware and networking components to aide with migration efforts to the newer architecture. By building a standard component baseline, organizations can avoid complexities in managing "white box" solutions from vendors where the underlying hardware is inconsistent. This can cause connectivity issues or configuration management challenges.

Selecting vendors that offer NFV solutions that follow common government compliance requirements is a best practice. For example, many government customers require that their data be encrypted in transit. To comply with this requirement, the NFV vendor can be required to meet standards like the Federal Information Processing Standards Publication 140-2 (FIPS 140-2), Security Requirements for Cryptographic Modules. This publication has a specific set of standards for the cryptographic module on the device that is used to provide encrypted communications. The level of compliance requires evidence of evaluation and validation by government agencies and assures confidentiality and integrity of the information protected within the solution.

SD-WAN

SD-WAN is the next evolution in software-defined networking. Where SDN is designed for local area networks (LANs), SD-WAN was designed to bring NFV and SDN technologies to their maximum capabilities. SD-WAN has revolutionized how network architectures are designed, deployed, managed and secured across the WAN by removing the need for separate networks to pass different types of data.

Traditionally, organizations had to use separate network architectures and paths to pass different types of data, as shown in Figure 2. SD-WAN devices virtually collapse these separate networks and create a single network designed to optimize application performance.

SD-WAN technologies have existed for many years, but the growth of cloud services and the rapid adoption of virtualization has shifted networking priorities. In the past, when more bandwidth or routes were needed, more devices were added to the network. As a result, networks grew larger, more complex, drove additional management resources and became expensive to operate. SD-WAN changes this model by creating network architectures optimized by dynamically selecting routes through software logic, placing a greater focus on how available bandwidth and routes are enhanced to support applications and services.

SD-WAN controllers remove the routing logic and control from individual network devices and manage all available routes to determine the best path for a service based on its performance needs. As depicted in Figure 3, it can include broadband (internet), a private multi-protocol label switching (MPLS) network, cellular wireless network (4G LTE or 5G), or satellite. There are some satellite communication providers who have adopted SD-WAN technologies to optimize their service offerings to customers which can add additional services to SD-WAN deployments. The SD-WAN controller, knowing the network parameters, will send data on the optimal path that meets the application performance requirements set for a specific service. The controller can use one network type or a combination of all available network paths so mission-critical industries, like air traffic services, receive the appropriate network priority to prevent communication delays or outages due to lack of bandwidth.

SD-WAN technologies are designed to enhance application performance by automating management of network resources. It removes the need to physically manage network devices independently, creating the ability to orchestrate management. The solution provisions resources by creating virtual overlays across by separating the upper stack from the lower stack of the Open Systems Interconnection (OSI) Model.

Another recent addition to the SDN model is the idea of a Software Defined-branch (SD-branch). An SD-branch is an evolving technology that integrates SD-WAN technologies at the code level with SD-security technologies into a single device that automates network management and security protection.

Although SD-WAN has many strengths it also imposes some risks to the network. For networks that rely on predetermined routes with strict path diversity and avoidance requirements, the automated changing of routes and procedures have the potential to introduce jeopardy conditions. As a precautionary measure, the orchestrator overlay should be well vetted, rigorously tested for failsafe operation, and policies should be coordinated with end users of the network. Without this added precaution, the advancements associated with SD-WAN can place the network configuration in a state that does not meet the more stringent requirements of life-critical networks.

LTE and 5G Cellular Wireless

Long Term Evolution (LTE) is the term given to the 4th generation (4G) high-speed radio technologies for cellular mobile communication systems. It has been around for many years and provides a valuable way to transmit data over airwaves. 4G enables mobile device users the ability to stream data at high speeds, which allowed the widespread adoption of mobile video streaming services. Soon 5G will be available offering even higher

bandwidth and data transport options.

As a core information transportation option, 5G cellular wireless is an alternative way to establish connectivity to remote sites, which can be difficult and/or costly to reach with terrestrial telecommunications. Coupled with SD-WAN technologies, 5G cellular wireless communications can offer supplementary paths for data to aid in application performance and total network resiliency.

To reduce costs, cellular wireless providers share their transport with multiple customers in the public sector. While there are efforts underway for private 5G backbones, these solutions still share resources with a limited customer set and cause challenges with prioritization. While the promise of higher bandwidth over the airwaves sounds like a great option for data paths, limiting the use of cellular wireless to non-critical services is a prudent approach. LTE has latency and jitter issues which is problematic when critical services may require extremely low tolerances to both. Leveraging SD-WAN can aid in boosting network and application performance to minimize these impacts.

Another challenge to consider when looking to adopt an LTE network is that cellular data is exposed to cyber threats. They can be directed towards exploiting or impacting radio frequency (RF) communication paths. A denial of service of wireless devices and networks is also possible. Saturating the device with RF noise, or jamming, could severely degrade a RF signal and in some cases, cause a device to shut down. In this example, technologies like SD-WAN are configured to recognize communication path interruptions and can often re-route traffic seamlessly and avoid the impacted link.

For commercial use, LTE might be a viable access solution to reach the masses and provide voice and data services, but for life-critical applications, like air traffic management, it may not be a suitable solution. Commercial networks are built on the premise of “best-effort” delivery which directly introduces delays and varied latencies often impacting applications that are unforgiving towards network changes.

Prioritization can alleviate congestion, but it cannot resolve oversubscription. Traffic can be re-routed around failure points, but it might come at a price of added latency. With the accelerated deployments of 5G networks, wireless might start to be a viable redundant path option for life-critical services since it provides ultra-reliable, low-latency, secure connections for data transmissions.

Security

In the past, life-critical networks were isolated or segmented from public network traffic. This separation mitigated many common threats from exploiting the network. Time division multiplexing (TDM) leverages unique communication technologies which cannot comingle with newer internet protocol (IP) solutions and limits exposure of TDM data to common threats that impact IP networks. Unfortunately, TDM is now a legacy communication medium that is being phased out by vendors. Technologies like voice over Internet Protocol (VoIP) are replacing older TDM solutions to take advantage of lower cost IP network transports and eliminate the need for separate infrastructures. In doing this, critical communication systems are exposed to a large volume of cyberattacks that threaten IP-based networks daily across industries.

Critical infrastructures present a high-value target for both nation-state actors and hacker groups and additional safeguards are needed to defend life-critical data, systems, and networks from cyberattacks.

One of the largest threats to critical networks is a denial of service (DoS), or distributed denial of service (DDoS). Malicious actors often use DDoS attacks to flood a network endpoint with data packets using various techniques to prevent access to services or render the endpoint useless. They can paralyze an organization by causing network, server, and application downtime and/or service degradation which leads to major impacts to critical services.

Another challenge for critical networks is an insider threat, also known as the human error factor. Insider threat is often thought of as malicious but can often be accidental. While organizations can standardize methods and procedures for taking actions on network devices or systems, mistakes can happen. However, recent advancements in automation and orchestration for network and security devices have helped minimize human error impacts. Technologies like SD-WAN are designed to limit the amount of human interaction with devices and build in standardized configurations that can be tested prior to being deployed across the network. SD-WAN also offers built-in security functions like firewalls and intrusion detection and prevention systems (IDPS) that can further mitigate threats to the network and offer a single control platform to manage network security configurations.

While new technologies offer a multitude of benefits to protecting critical systems from cyberattacks, care must be taken on how these technologies are implemented across the network. Integrating new solutions and protections into a known baseline can initially cause negative and disruptive impacts to services and communications. A transitional period, typically based on the criticality and complexity of the network, must be part of the risk mitigation process and allows the network to be appropriately monitored and adjusted.

While these challenges will decrease over time, it is important to consider these initial deployment challenges that could cause operational impacts.

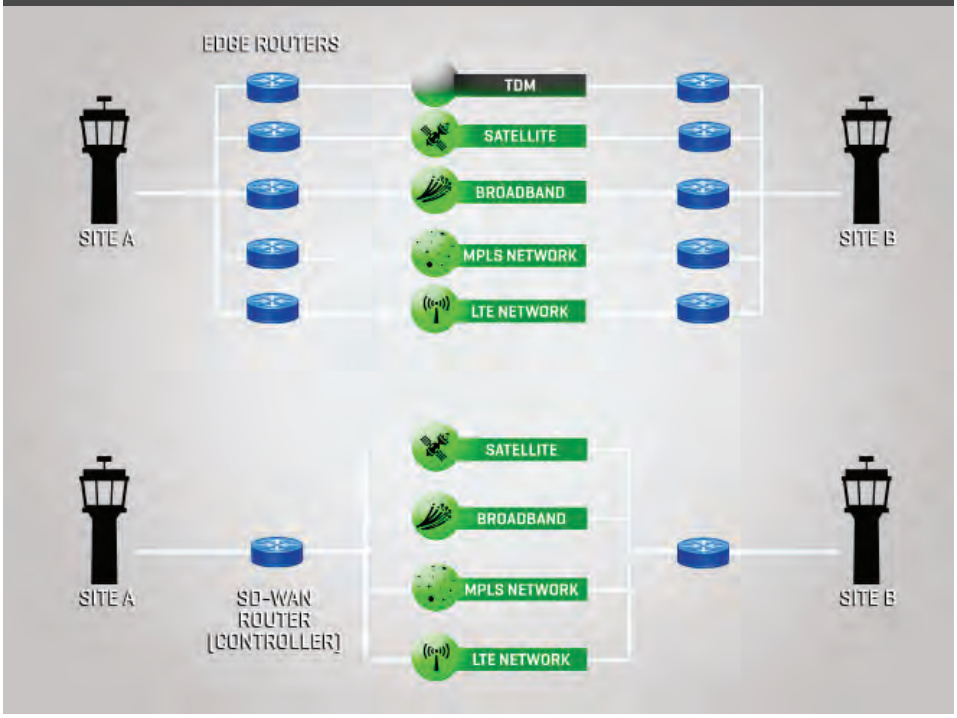
Conclusion

Technology advancements are constantly changing how organizations operate and offer more efficient services that have created new ways to engage customers. However, this rapidly changing environment can come with great risk to those organizations that provide mission-critical services over infrastructures that require stability and security.

The FAA's mission to provide the safest and most efficient airspace in the world must be done with careful consideration. As new technologies evolve and mature, it is important that the FAA carefully evaluate the technical improvements offered against the associated risk being introduced and the potential operational impact of accepting that level of risk.

Adopting new technologies and integrating them into safety critical, or even efficiency critical environments can pose their own risks. SD-WAN, NFV, 5G LTE and advanced security capabilities, require balancing risk against innovation to allow them the ability to provide safe and efficient air operations. By moving at the speed of safety industry can effectively integrate new, mature technologies and foster continued growth across the entire NAS.

A TYPICAL TDM & IP TECHNOLOGY VS. AN SD-WAN ARCHITECTURE



> “By moving at the speed of safety industry can effectively integrate new, mature technologies and foster continued growth across the entire NAS.”

L3Harris Is Making Realtime Airports A Reality

Air travelers around the world accept delays and inefficiencies as part of the airport experience when traveling, particularly around the holiday season – but do they need to be? L3Harris Technologies worked with UK NATS, the British air traffic services provider, to roll out a unique Demand Capacity Balancing (DCB) digital twin solution to streamline airport operations and ideally, make travel delays a thing of the past.

The fully-operational L3Harris DCB solution is unique in the marketplace, as it

delivers on what competitors might claim to offer but only L3Harris has rigorous proof of performance: implementation at the busiest airport in Europe, London Heathrow. The L3Harris DCB solution has been in operational use at Heathrow Airport since the summer of 2017 and has enabled airport operators to considerably reduce air and ground delays when compared to conventional air traffic flow management (ATFM) methods.

Using state-of-the-art simulation and analytics, DCB predicts how weather, network congestion, planned airport maintenance work and available airport infrastructure impact the airport´s operation plan. The DCB digital twin solution feeds into Heathrow's 2nd generation A-CDM portal to create several alternative plans that model and minimize operational impacts with a rolling Airport Operational Plan (AOP). The optimal plan is then selected and shared with airport stakeholders to ensure reduction in air holding and ground delays, and missed connections, all of which ultimately enhance the overall passenger experience.

"Heathrow Airport has been an excellent case study to validate the unique strengths of the DCB solution," said Gary Dixon, General Manager UK NATS for Heathrow Airport. "In providing an accurate rolling prediction of the airport's traffic demand and capacity, and integrating local and global weather forecast data, DCB has improved Heathrow Airport's predictive schedules and helped streamline our air and ground operations."

DCB unlocks valuable flight prediction data modelled against known airport capacity and its operational procedures to give airport operations managers radically improved situational awareness concerning likely upcoming "hot spots" for delays and other trouble, such as runways, stand plans, flight connections, immigration, baggage halls, etc.

DCB's second phase, which supports the future concepts of Target Time of Arrival (TTA), was successfully validated with support from Eurocontrol NMOC, NATS and Heathrow Airport.

Initial validation results were obtained from the pan-European ATM research and development initiative SESAR, which orchestrated Very Large Demonstrations (PJ24) to determine the impacts of the DCB on European air traffic flow. The initial results showed considerable reduction of air traffic and ground operational delay compared to conventional ATFM regulations by as much as 41 percent. Further validations of the L3Harris DCB solution will be done in 2020.

The L3Harris DCB solution meets the European ATM Master Plans for High Performance Airports by provision of a rolling AOP (AOP11) that is in alignment with SESAR (AF2 and AF4) and provides a complete picture to balance aircraft demand and capacity from months in advance until the day of operations. DCB also enables seamless integration into Network Operation Plan (FCM05) and corresponding APOC related objectives.

"We are confident that the value of DCB will be recognized by all capacity constrained airports around the Globe," said Frank Koehne, Managing Director, L3Harris Technologies. "Joining together this valuable new air segment element with the existing ground segment of A-CDM, will enable a step change for the airport operator to influence more intelligent arrivals as opposed to the first come, first served randomness of today's airport operations. The performance of the DCB solution at Heathrow Airport is an outstanding testament to the benefits that predictive planning based on data analytics can provide to even the busiest of customers."

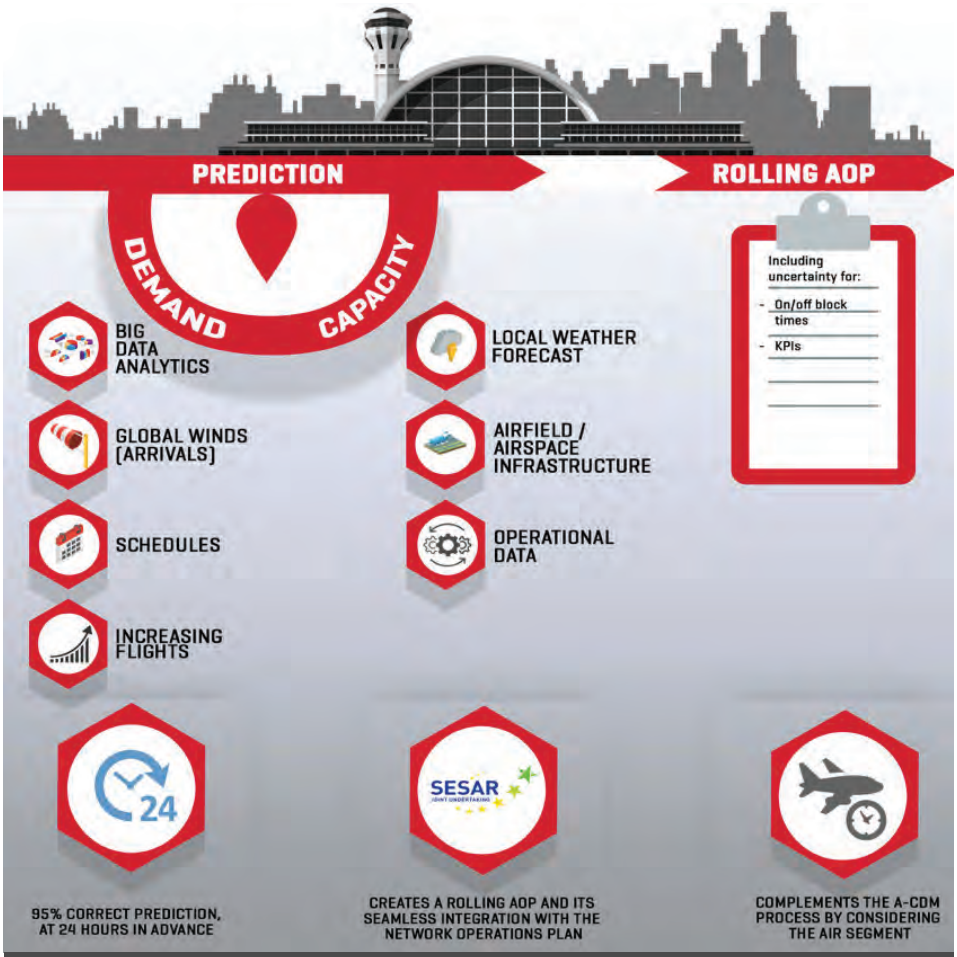


ILLUSTRATION OF HOW DCB GATHERS AIRPORT INFORMATION TO INCREASE AIRPORT EFFICIENCIES FOR AIRLINES

CONNECTED CAPABILITY

A SUM GREATER THAN ITS PARTS

Few people are aware of the depth and breadth of our expertise. It extends into every aspect of commercial aviation – from training pilots, to securing dependable avionics systems, as well as security and analytics.

This varied expertise helps to ensure we remain leaders in innovation – transforming the commercial aviation landscape.

Training technology

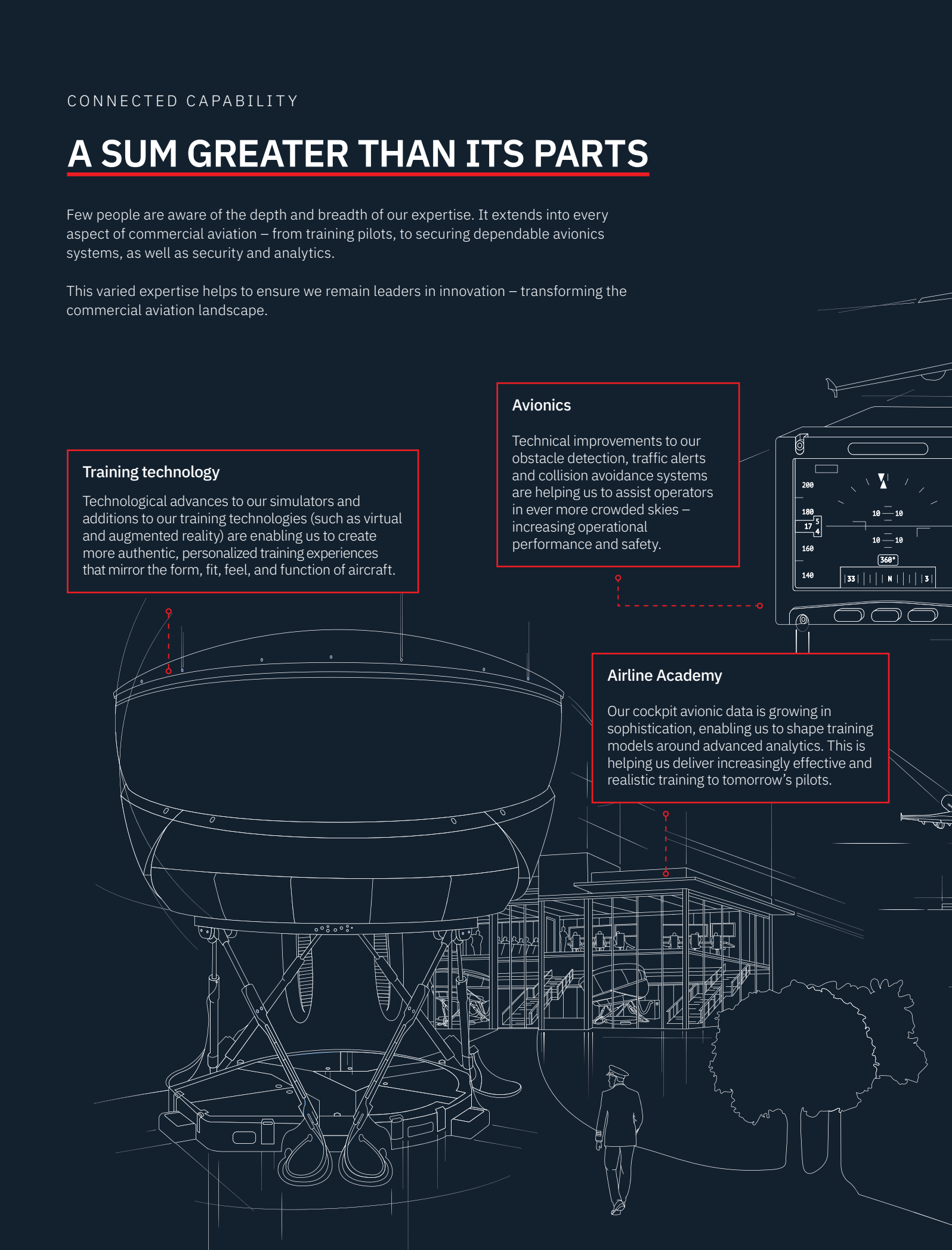
Technological advances to our simulators and additions to our training technologies (such as virtual and augmented reality) are enabling us to create more authentic, personalized training experiences that mirror the form, fit, feel, and function of aircraft.

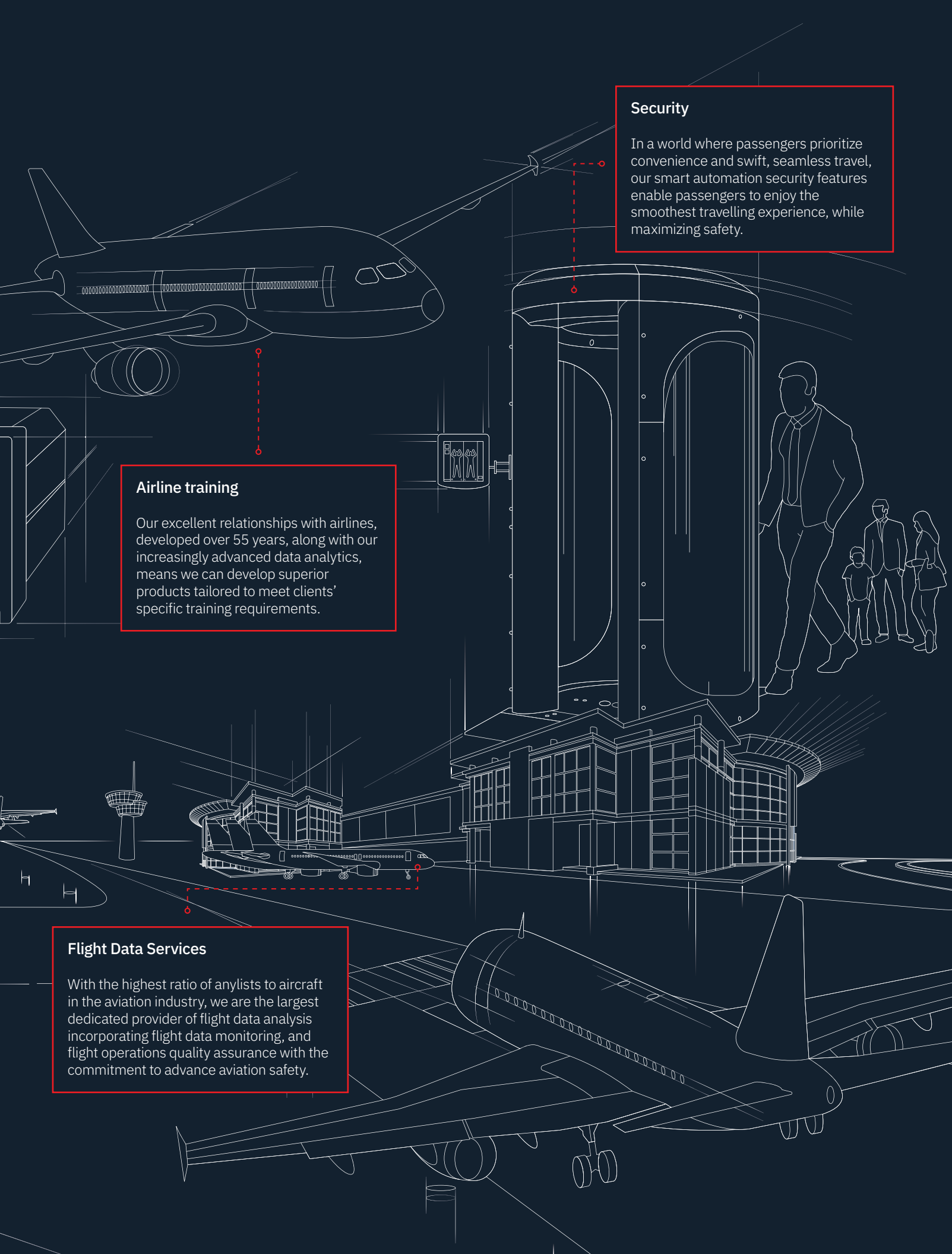
Avionics

Technical improvements to our obstacle detection, traffic alerts and collision avoidance systems are helping us to assist operators in ever more crowded skies – increasing operational performance and safety.

Airline Academy

Our cockpit avionic data is growing in sophistication, enabling us to shape training models around advanced analytics. This is helping us deliver increasingly effective and realistic training to tomorrow's pilots.





Security

In a world where passengers prioritize convenience and swift, seamless travel, our smart automation security features enable passengers to enjoy the smoothest travelling experience, while maximizing safety.

Airline training

Our excellent relationships with airlines, developed over 55 years, along with our increasingly advanced data analytics, means we can develop superior products tailored to meet clients' specific training requirements.

Flight Data Services

With the highest ratio of anylists to aircraft in the aviation industry, we are the largest dedicated provider of flight data analysis incorporating flight data monitoring, and flight operations quality assurance with the commitment to advance aviation safety.

FAST. FORWARD.

WAYPOINTS, Beyond NextGen

© 2020 L3Harris Technologies, Inc. | 03/2020

L3Harris Technologies is an agile global aerospace and defense technology innovator, delivering end-to-end solutions that meet customers' mission-critical needs. The company provides advanced defense and commercial technologies across air, land, sea, space and cyber domains.

L3HARRIS™