AVIATION RISK 2020

SAFETY AND THE STATE OF THE NATION

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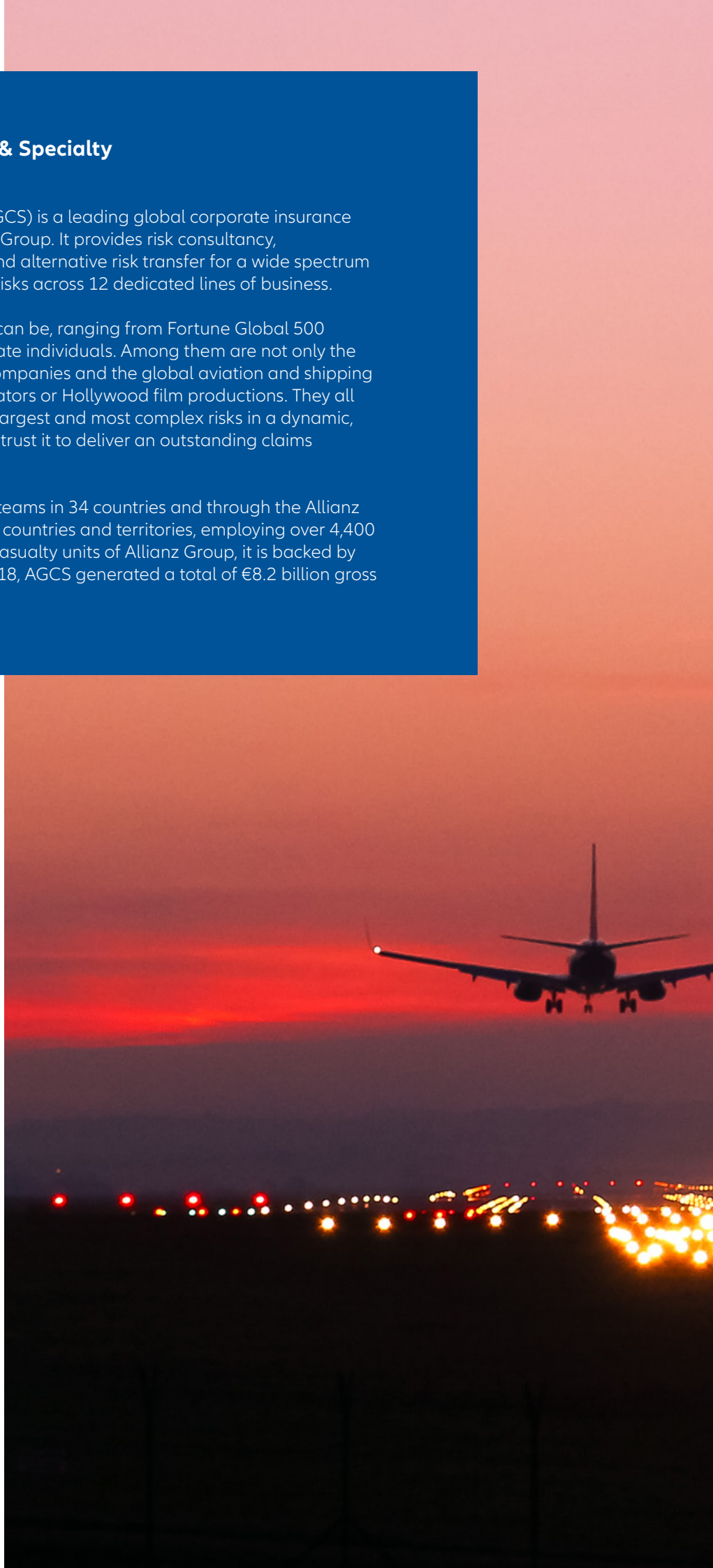
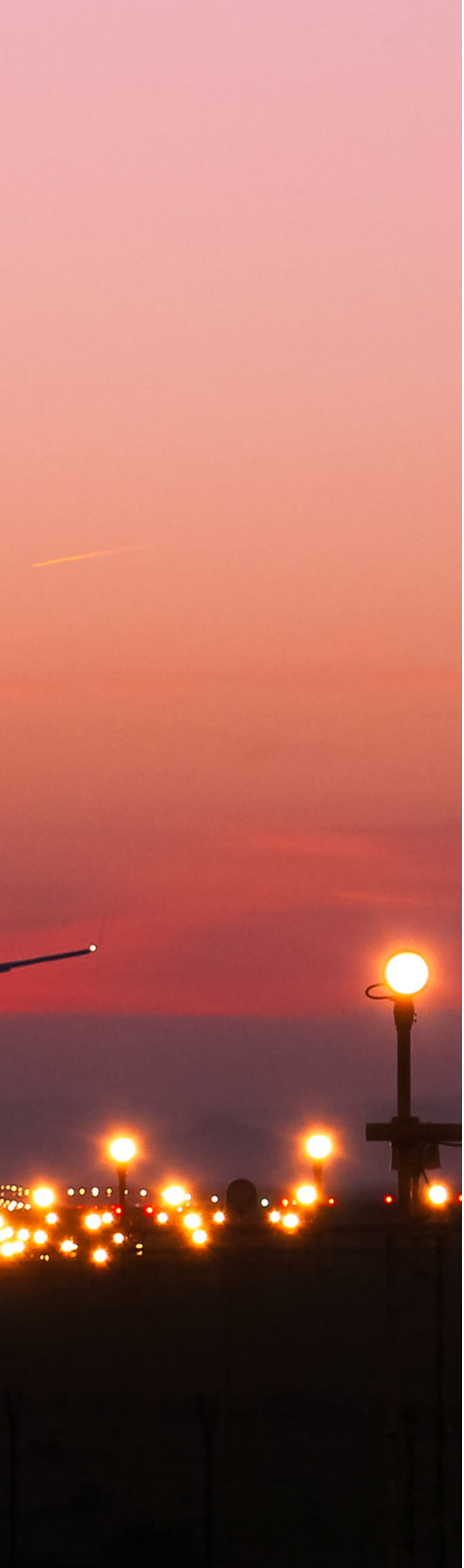
About Allianz Global Corporate & Specialty

Allianz Global Corporate & Specialty (AGCS) is a leading global corporate insurance carrier and a key business unit of Allianz Group. It provides risk consultancy, Property-Casualty insurance solutions and alternative risk transfer for a wide spectrum of commercial, corporate and specialty risks across 12 dedicated lines of business.

Its customers are as diverse as business can be, ranging from Fortune Global 500 companies to small businesses, and private individuals. Among them are not only the world's largest consumer brands, tech companies and the global aviation and shipping industry, but also wineries, satellite operators or Hollywood film productions. They all look to AGCS for smart answers to their largest and most complex risks in a dynamic, multinational business environment and trust it to deliver an outstanding claims experience.

Worldwide, AGCS operates with its own teams in 34 countries and through the Allianz Group network and partners in over 200 countries and territories, employing over 4,400 people. As one of the largest Property-Casualty units of Allianz Group, it is backed by strong and stable financial ratings. In 2018, AGCS generated a total of €8.2 billion gross premium globally.





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All values mentioned in this report in US$ unless otherwise stated

EXECUTIVE SUMMARY

This report focuses on safety developments in commercial aviation around the world. It identifies a number of insurance claims trends which are impacting the industry – including the top causes of financial losses – and highlights a number of risk trends and challenges that will impact the aviation sector and insurance landscape in future.

The findings have been produced with the assistance of Embry-Riddle Aeronautical University, the world's largest fully-accredited university specializing in aviation and aerospace.

50,000

aviation insurance claims analyzed by AGCS between 2013 and 2018

SAFER SKIES

Safety in the aviation sector is of critical importance. Despite a record number of passengers, statistics show that flying has never been safer. Between 1959 and 2017, there were 29,298 recorded deaths from 500 global commercial passenger jet fleet events. However, between 2008 and 2017, there were 2,199 fatalities from 37 events, or less than 8% of the total number. In 2017, for the first time in at least 60 years of aviation, there were no fatalities on a commercial airline. Even 2018, which saw a total of 15 fatal airliner accidents, ranks as the third safest year ever. The lifetime chances of a person dying in a commercial aviation accident are extremely unlikely compared with other forms of transport such as a car or bicycle accident, as well as other more unexpected scenarios such as accidental gun discharge or dog attack. ✈ Page 8

The continuous improvement in aviation safety can be attributed to a number of factors. Aircraft have become more reliable. Safety systems and cultures have improved enormously. A number of design implementations have had a dramatic impact on accident rates, including aerodynamic and airframe improvements, fail-safe design criteria, improvements to cockpit instrumentation and the increasing number of fly-by-wire controlled aircraft in operation. Improvements in science have also allowed the aviation industry to better understand how human factors affect safety. At the same time, there have also been significant improvements in manufacturing processes, aircraft operations and regulation. ✈ Page 9

CLAIMS DEVELOPMENTS

Although the improvement in the aviation sector's safety record – particularly with regards to the number of fatal accidents – cannot be questioned, it continues to see a high volume and growing magnitude of insurance claims, meaning aviators and insurers alike cannot be complacent. More costly repairs and engine claims, damage from foreign objects, ground collision incidents, slips and falls, fleet groundings, mis-fueling incidents, and liability awards, are just some of the areas in which insurers are seeing heightened activity. In recent years, the number of dollars paid in claims outstrips total insurance premiums in the aviation sector. ✈ Page 10

AGCS analysis of more than 50,000 aviation insurance industry claims worth more than €14.8bn ($16.3bn) over the past five years shows **collision/crash incidents account for over half the value of all claims** (57%) equivalent to €8.4bn ($9.3bn) – and over a quarter by number (27%). Loss of control in flight is the most frequent

Despite a record number of passengers, statistics show that flying has never been safer

cause of fatal accidents. Collision/crash claims also incorporate incidents such as hard landings, bird strikes and runway incidents such as incursions and excursions. The analysis shows there have been 470 runway incidents resulting in claims over five years causing over €800mn ($883mn) of damages. The average runway claim totals around €1.7mn ($1.9mn). ✈ Page 10

Increasingly sophisticated aircraft are also contributing to more expensive claims. In particular, more complex engines and, in some cases, composite materials – such as carbon fiber layers bonded with resin which are strong and light and help improve fuel efficiency – can be costly and more time-consuming to repair. More and more aircraft are using composite materials and significant damage is more expensive to repair than in traditional metal alloys. ✈ Page 12

The increasing complexity of aircraft design, technology and manufacturing is also leading to **more costly grounding incidents**, involving entire fleets, as in the case of the Boeing 787 Dreamliner in 2013, following electrical system problems stemming from lithium-ion batteries, and more recently following two fatal crashes involving the redesigned Boeing 737 Max within five months in 2018 and 2019. It is reported Boeing has put aside at least $5bn to cover costs related to the global grounding of the 737 Max[1]. Such incidents highlight the challenge in finding technical solutions to complex problems, which increases the time it takes to get grounded aircraft back into operation. Even after a fix is found, the task of retrofitting a fleet takes considerable time. Civil aviation and airline safety authorities have grown increasingly cautious and rightly so. However, this will likely result in more, and longer, groundings of aircraft in future. ✈ Page 13

Liability claims per passenger are increasing with many US plaintiff attorneys seeking higher awards from a wider range of incidents in light of fewer major airline losses. Higher awards are challenging at a time of growing passenger numbers and larger aircraft which can carry hundreds of passengers. With potential awards per passenger in the millions of dollars, a major aviation incident could subsequently result in a liability loss of $1bn. ✈ Page 14

Insurers are also seeing a higher level of foreign object damage claims. There were more than 14,600 reported collisions with wildlife in 2018, according to the US Federal Aviation Administration. Bird strikes are a notable contributor to aviation insurance claims resulting in excess of €330mn ($364mn) of damages in the past five years – over 1,000 claims were received by insurers, according to AGCS analysis. The average claim costs around $360,000 but some can cost as much as $16mn. Most occur when birds hit windscreens or fly into engines. The economic toll of bird strikes has been estimated at as much as $400mn a year in the US to $1.2bn worldwide. ✈ Page 15

With so many different types of aircraft using different fuels and additives, human error is a real risk and **mis-fueling of aircraft claims are also increasing.** Mistakes by ground crews can result in costly engine damage and repairs and lengthy groundings when fuel systems have to be replaced, but can also have catastrophic consequences, potentially causing jet engines to shut down in flight. ✈ Page 15

RISK TRENDS AND CHALLENGES

Pilot shortage causing issues – demand for new pilots is expected to total around 800,000 over the next 20 years – double the current workforce, driven by more airplanes, significant air travel demand and a tightening labor supply. The shortage of pilots has seen activity at flight schools increase

$16bn+

value of analyzed aviation insurance claims

1 BBC, Boeing takes $5bn hit over grounding of 737 Max, July 19, 2019

AVIATION RISK 2020 IN NUMBERS

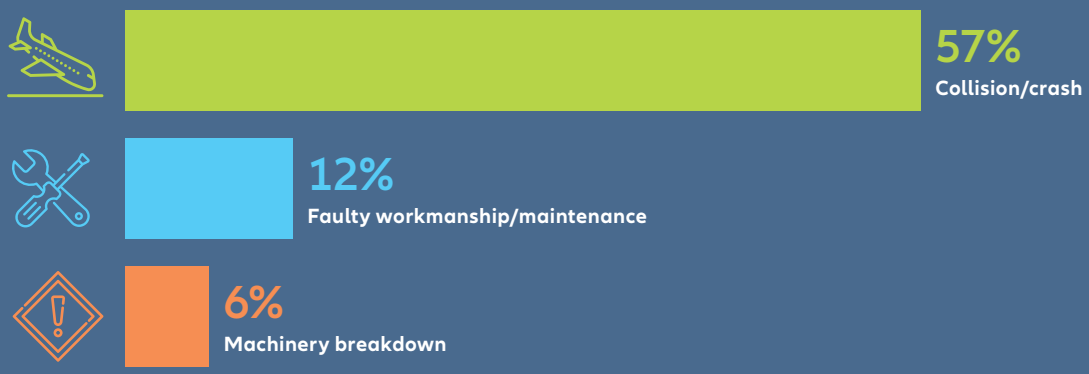
8bn
estimated number of air passengers by 2037 – double that of today.

2017 and 2018
were among the three safest years ever for the aviation industry for fatal plane crashes.

$10bn
cost of ramp incidents at airports per year.

$360,000
average cost of a "bird strike" claim on an airplane.

TOP CAUSES OF CLAIMS:



Based on analysis of 51,867 aviation insurance industry claims worth more than $16bn between 2013 and 2018. According to total value of claims.

CLAIMS TRENDS

- High volume and growing magnitude of claims
- Technology driving higher values and cost of repairs
- Grounding cases more costly
- Growing potential for larger liability awards
- Foreign damage object claims soar
- Mis-fueling incidents on the rise

RISK TRENDS

- Pilot shortage and fatigue
- Over-reliance on automation
- Exposures increasing at flight schools
- More turbulence from climate change
- Drone disruption
- Cyber business interruption threat growing
- Congested airports bring more on-the-ground accidents

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exponentially, and is resulting in an up-tick in risk. Growing demand is driving up the value of aircraft used in schools, which increasingly use more sophisticated planes to train pilots. The average insured value of airplanes in some schools has increased from around $100,000 in the past to $1mn today. Flying schools are prone to accidents, but claims are becoming more expensive with rising values and increased activity. Landing accidents are most common, but insurers are also seeing total losses. A shortage of pilots may also lead to issues such as pilots flying with less experience, reduced transparency of training in order to meet demand and pilot fatigue. ✈ Page 16

Overreliance on automation concerns – questions continue to be raised about pilots' overreliance on aircraft automation systems which can be life-threatening as technology becomes more complex. A number of major accidents highlight the challenges with interaction. Overall, training standards have improved but systems can still fail or be incorrectly operated, albeit rarely, and there needs to be a continued focus on pilots flying with and without automation in training. Pilots need to be better prepared to be able to take corrective actions in event of technical malfunction. ✈ Page 17

More turbulence on the way – turbulence is experienced every day on flights around the world. Extreme turbulence can cause structural damage to aircraft, which can cost millions of dollars while flight path and altitude changes to avoid turbulence are estimated to cost US airlines in excess of $100mn a year. In future, turbulence is expected to increase due to climate change with the North Atlantic flight passageway anticipated to see the greatest increase. This passageway is the route many international flights use to travel between North America and Europe with around 3,000 flights crossing the Atlantic on a single day. Turbulence is often unexpected. Pilots must be properly trained on how to handle it. ✈ Page 18

The rapid growth of drones – the commercial market in the US alone is expected to triple in size in the next five years – is one of the biggest issues impacting the aviation industry. Drones bring benefits to the air transportation system, such as the ability to undertake aerial surveys of terminal buildings, provide 3D maps of runways in order to identify maintenance work and the ability to quickly detect foreign objects at airports, thereby offering security support. However, as the number of drones increases, so do the risks. The number of aircraft near-misses with drones and other incidents of reckless behavior in or around airports is soaring. Safety reports involving drones in the US grew from zero in February 2014 to over 250 in June 2017 while the number of times a drone endangered the safety of an aircraft in UK airspace rose by more than a third in 2018 alone to 125. Even a small drone could cause as much as $10mn in physical damage alone if hitting an engine of an airplane. In the event of an incident, aircrafts could also be forced to make an emergency landing, resulting in delay or cancellation and significant economic loss. Drones have become safer as technology has improved. However, regulation continues to lag behind innovation. ✈ Page 19

Cyber risks such as hacker attacks, systems outages and data breaches rank as the major concern for aviation sector respondents in the **Allianz Risk Barometer 2019**, which surveys risk management experts around the world, just ahead of the closely related risk of business interruption (BI). With its reliance on IT systems for booking, ticketing and flight operations, the airline industry is particularly vulnerable to BI events, either from a malicious attack, human error or technical fault. According to the US Government Accountability Office, 34 IT outages affected 11 US airlines between 2015 and 2017 alone, 29 of which disrupted or cancelled flights. While awareness of cyber risk has increased, especially among aviation manufacturers, cyber risk management sophistication differs widely in the sector. ✈ Page 21

While accidents-in-flight continue to become less frequent, **accidents-on-the-ground remain problematic** – an issue that could exacerbate in future. In many cases, airport infrastructure has not kept pace with the rapid growth in passenger and aircraft numbers and it is anticipated that the vast majority of the world's airports will likely see infrastructure-related capacity issues within 10 years. Many are already dealing with weekly infrastructure-related delays. Ground congestion is not only cause for concern on the basis of delays, but also for safety as well. It has been estimated that ramp accidents can cost airlines as much as $10bn a year in direct and indirect costs. With more aircraft on the ground, crowded servicing areas and aprons are resulting in an increase in the number of collision incidents. Analysis of more than 500 loss events at 14 German airports by AGCS shows that damage to vehicles on the tarmac is a leading cause of insured losses. More than half of these events were due to collisions with pushback tractors, baggage trolleys, aerial work platforms or washing systems. Communication is an integral part of ramp guidance and ineffective communication can be at the heart of many ground accidents. ✈ Page 23

#1

Cyber risk ranks as the major concern for aviators, according to the Allianz Risk Barometer

1 INTRODUCTION
SAFER SKIES

The aviation industry supports 63 million jobs globally and underpins $2.7trn in economic activity[2] so safety in the sector is of critical importance. Aviation incidents and accidents will always captivate both media and public attention, as a number of recent crashes resulting in fatalities only too well demonstrate. Yet as highlighted in AGCS' and Embry-Riddle Aeronautical University's previous Global Aviation Safety Study there has been an ongoing decline in the number of fatal accidents over the past 60 years despite a significant growth in the number of passengers[3].

Between 1959 and 2017 there were 29,298 recorded onboard deaths from 500 global commercial jet fleet fatal accident events[4]. However, through the 10-year period from 2008 to 2017 there were only 2,199 fatalities from 37 fatal accident events, or less than 8% of the total number. Most fatalities occurred within the first 20 years after the introduction of a public jet service.

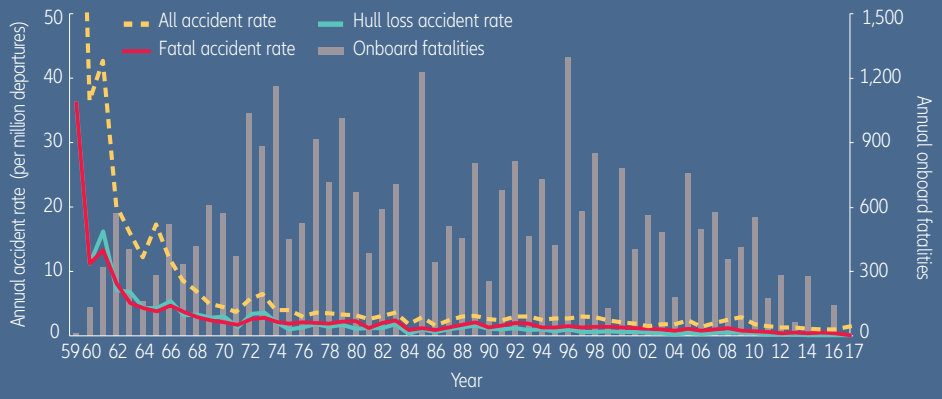
According to the International Air Transport Association (IATA)[5], there was just one major accident for every 8.7 million flights in 2017 – over four billion travelers flew safely on 41.8 million flights. For the first time in at least 60 years of aviation there were no fatalities on a passenger jet; a remarkable achievement by any measure. With more than one million people in the air at any one time, this impressive statistic is to be applauded but 2018 and 2019 to date have brought a number of fatal airline accidents, the worst being the loss of a Lion Air Boeing 737 off Indonesia in October 2018, which went down shortly after take-off with the loss of 189 people. On March 10, 2019, an Ethiopian Airlines 737 crashed after take-off with the loss of all 157 passengers. Overall, 2018 saw a total of 15 fatal airliner accidents with 556 fatalities among passengers and crew[6], but this still ensured it was the third safest year ever by the number of fatal accidents and the ninth safest in terms of fatalities according to the Aviation Safety Network[7]. In the European Union there has not been a fatal commercial accident since 2015. Meanwhile, in the US one passenger died in a commercial accident during 2018, the first death on a US airline flight in nine years.

IMPROVEMENT DRIVERS

Such continuous improvement in safety can be attributed to a number of different factors and positive trends. Aircraft have become more reliable, while safety systems and culture have improved enormously. A number of design implementations have had a dramatic impact on

ACCIDENT RATES AND ONBOARD FATALITIES BY YEAR

Worldwide Commercial Jet Fleet | 1959 through 2017



Since the 1950s the safety record of the aviation industry has seen significant improvement, based on accident rates. The accident rate is a measurement used to determine flight operations safety, which is measured by the number of accidents per million departures. During the 1950s and 1960s the accident rate was high, but within little over a decade it had declined significantly with recent accident rates at just over 0.01 per million for the US and Canada and 0.035 for the rest of the world.

Source: Boeing Statistical Summary Of Commercial Jet Airplane Accidents Worldwide Operations 1959 -2017, October 2018

aircraft accident rates, helping to significantly reduce risk, including aerodynamic and airframe improvements, fail-safe design criteria, improvements to cockpit instrumentation, as well as the increasing number of fly-by-wire controlled aircraft in operation.

The development of fly-by-wire aircraft has probably been the biggest safety advancement in recent decades, and is a key factor behind the large reduction in fatal air crashes in recent years, according to **Sebastien Saillard, Regional Claims Head Mediterranean Region at AGCS,** and **Guillaume Cadillat, Regional Claims Practice Leader Aviation and Space at AGCS.**

"Despite record numbers of passengers, statistics show that flying has never been safer. The number of aviation losses is drastically down," says Saillard.

"Fly-by-wire aircraft have resulted in a significant increase in airline safety and a reduction in large losses over the past 15 years. This is an ongoing trend, confirmed year-on-year by industry accident data."

"We have now had decades of experience of fly-by-wire technology, and, while there may always be a few exceptions, overall it has worked extremely well, significantly improving airline safety," adds Cadillat.

At the same time, engine manufacturers have almost eliminated the chance of an engine failure. Radio and avionics are extremely precise and systems integration provides extra information and backup. Improved air traffic control technology and better collision systems have also had a positive impact. For example, it is estimated that the risk of controlled flight into terrain in Western Europe and North America is now around 50 times less[8] than it was in the early 1990s due to the introduction of the Enhanced Ground Proximity Warning System (EGPWS), a terrain awareness warning system designed to alert pilots if their aircraft is in immediate danger of flying into the ground or another hazard.

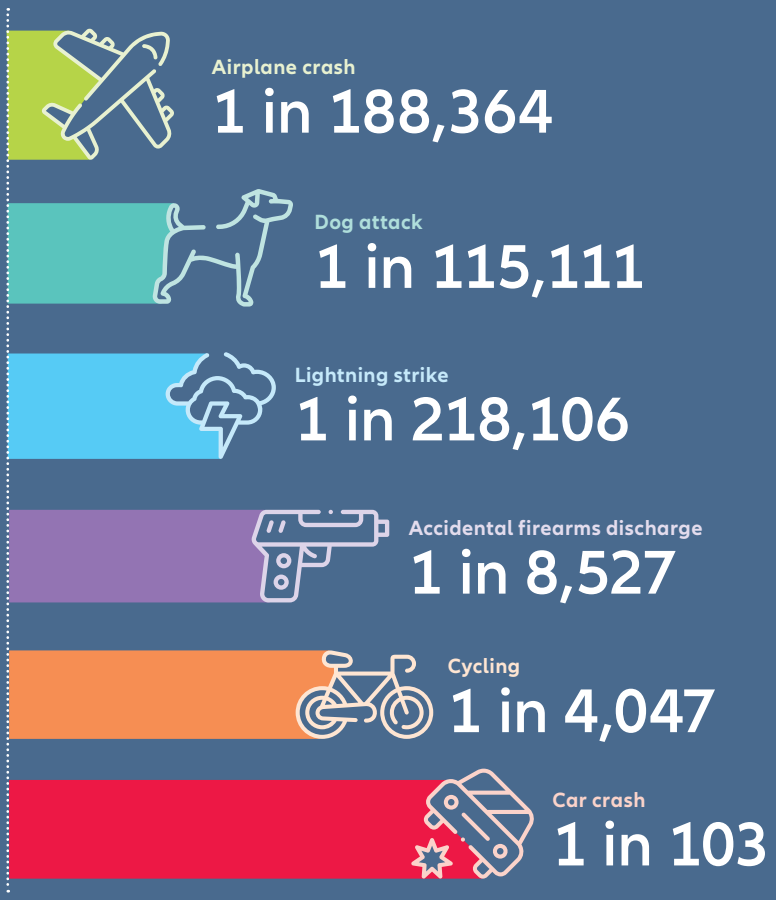
Pilots now have much more live information at their fingertips, while current navigation systems have the capability to determine an aircraft's position to the thousandths of a mile. Meanwhile, aircraft data collection devices can record thousands of parameters, increasing the understanding of operations and accidents.

Safety inspections are now far more effective. Aircraft inspections are much more detailed and stringent than in the past and have been quick to incorporate improved technologies. This means problems are increasingly identified and dealt with long before they become a significant issue. Another major factor has been the increased use of recurrent training, which refreshes the skills of pilots and crew, as well as helping them prepare for unusual or emergency situations. This has had a significant impact in reducing accidents and insurance claims.

Improvements in science have also allowed the aviation industry to better understand how human factors can affect safety. Pilot fatigue, training, crew resource management and other factors have become increasingly important issues. Meanwhile, there have also been significant improvements in manufacturing processes, aircraft operations, industry culture and government regulation.

DANGER OF DEATH... WHAT ARE THE ODDS?

Lifetime odds of death for selected causes



Source: US National Safety Council. Based on data from the National Center for Health Statistics – Mortality Data for 2017, as compiled from data provided by the 57 vital statistics jurisdictions through the Vital Statistics Cooperative Program. Population and life expectancy data are from the US Census Bureau. Deaths are classified on the basis of the 10th revision of the International Classification of Diseases (ICD-10).

Graphic: Allianz Global Corporate & Specialty

2 The Air Transport Action Group, Aviation Benefits Beyond Borders

3 Allianz Global Corporate & Specialty and Embry-Riddle Aeronautical University, Global Aviation Safety Study – A Review Of 60 Years Of Improvement in Aviation Safety

4 Boeing, Statistical Summary of Commercial Jet Airplane Accidents Worldwide Operations 1959 – 2017, Oct 2018

5 International Air Transport Association, IATA Releases 2017 Airline Safety Performance, 22 February 2018

6 Aviation Safety Network, Aviation Safety Network Releases 2018 Airliner Accident Statistics, January 2019

7 Aviation Safety Network, Aviation Safety Network Releases 2018 Airliner Accident Statistics, January 2019

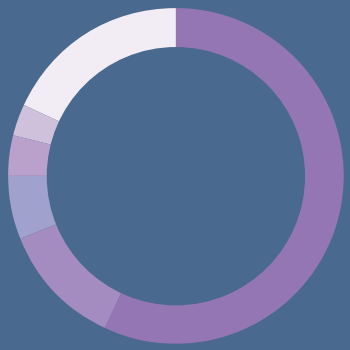
8 Honeywell Aero Technology, Key Technologies

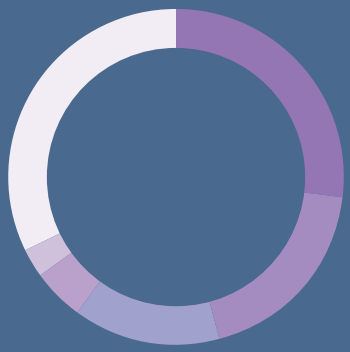
2 AVIATION CLAIMS DEVELOPMENTS

- **Safety improvement belies volume and magnitude of claims**
- **More sophisticated technology is driving higher values and cost of repairs**
- **Grounding cases more costly**
- **Growing potential for larger liability awards**
- **Foreign object damage claims and bird strikes soar**
- **Mis-fueling claims on the rise**

SAFETY IMPROVEMENT BELIES VOLUME AND MAGNITUDE OF CLAIMS

Despite the significant improvements that have been made to the aviation sector's safety record in recent decades – particularly with regards to the number of fatal accidents – the aviation insurance industry continues to see a high volume and growing magnitude of claims, meaning both aviators and insurers cannot afford to rest on their laurels. Foreign object damage, engine claims, ground collision incidents, slips and falls, groundings, mis-fueling incidents, as well as a trend for larger liability awards, are just some of the areas in which insurers are seeing heightened loss activity.





TOP CAUSES OF LOSS
AVIATION CLAIMS

By value of claims:

Collision/crash	**57%**
Faulty workmanship/maintenance	**12%**
Machinery breakdown (including engine failure)	**6%**
Travel issues (including luggage, delay)	**4%**
Damaged goods (including handling/storage)	**3%**
Other	**18%**

By number of claims:

Collision/crash	**27%**
Travel issues (including luggage, delay)	**19%**
Faulty workmanship/maintenance	**14%**
Slips and falls	**5%**
Defective products	**3%**
Other	**32%**

Source: Allianz Global Corporate & Specialty. Based on analysis of 51,867 aviation insurance industry claims worth approximately €14.8bn between July 2013 and December 2018.

Based on analysis of 51,867 aviation insurance industry claims worth more than €14.8bn ($16.3bn) over the past five years, unsurprisingly **collision/crash incidents** account for over half the value of all claims (57%) by value – equivalent to €8.4bn ($9.3bn) – and over a quarter by number (27%). This means that there have been 13,638 aviation collision/crash incidents resulting in claims over the past five years.

Such incidents do not just include major crashes in the air, however. They also incorporate events like hard landings, bird strikes and runway incidents such as incursions and excursions. Between July 2013 and the end of 2018 the analysis shows there were 470 **runway incidents** resulting in aviation insurance industry claims causing in excess of €800mn ($883mn) of damages/losses. The average claim totals in excess of €1.7mn (€1,724, 029) ($1.9mn). Most of the incidents were related to damage caused by over- and under-shooting the runway/taxiway, including collisions with fences, signs, ground equipment and even vehicles on the runway.

"The sheer volume and magnitude of claims handled by aviation insurers is often under-appreciated," explains **Dave Warfel, Regional Head of Aviation, North America at AGCS**. "At any one time Allianz alone will handle thousands of claims from the airline industry, airports and manufacturers. Many of these claims will be slips and falls, but even these can be very expensive.

"A concern is that the headline improvements in safety could lull the airline industry into a false sense of security. Thankfully, fatal air accidents for western-built jets are now infrequent, but the number of dollars paid in claims in recent years outstrips total insurance premiums." And that is even before you consider recent large losses like the Ethiopian Airlines and Lion Air crashes, and the subsequent grounding of the Boeing 737 Max, which is likely to be one of the biggest aviation manufacturing losses in history.

"An airline may not have experienced a large loss, but that does not mean that the industry is completely safe," says Warfel. "There are still risks. For every airline incident that makes the headlines, there are probably 10 or 20 that don't make it into the news, but are equally as challenging from a claims handling perspective and that are very expensive. Last year, for example, a fire during maintenance caused a $20mn loss, yet the incident would have gone largely unnoticed by the industry."

Overall, aviation insurance claims are increasing in frequency and severity, a reflection of higher values, increased repair costs and rising liability awards. The volume of claims is also a reflection of growth in air transport, with increased passenger numbers and more congested airports, as well as growing demands on airlines, manufacturers and ground services.

"The frequency of claims has been rising, keeping pace with the global increase in air traffic. Each year more people are flying and we see a correlation between passenger numbers and claims, such as slips and falls in airports and damage to aircraft from ground operators," says Warfel.

Headline improvements in safety have helped drive down the cost of insurance for airlines and manufacturers, but given the ongoing frequency of attritional claims, and rising severity, this means the industry's annual claims total outstrips its annual premium.

"The cumulative impact of loss events around the world adds up to a big number and easily eclipses the cost of large losses," says Warfel. "Whether it is small bodily injury claims, bird strikes or ground accidents, the frequency of rate of aviation claims is as large as ever."

According to AJ Gallagher Aerospace, worldwide airline passenger numbers increased by 139% between 2003 and 2017, while worldwide airline hull and liability premiums reduced by 64%. This equates to an 85% cut in the cost of insurance per passenger.

139%

growth in the number of airline passengers between 2003 and 2017

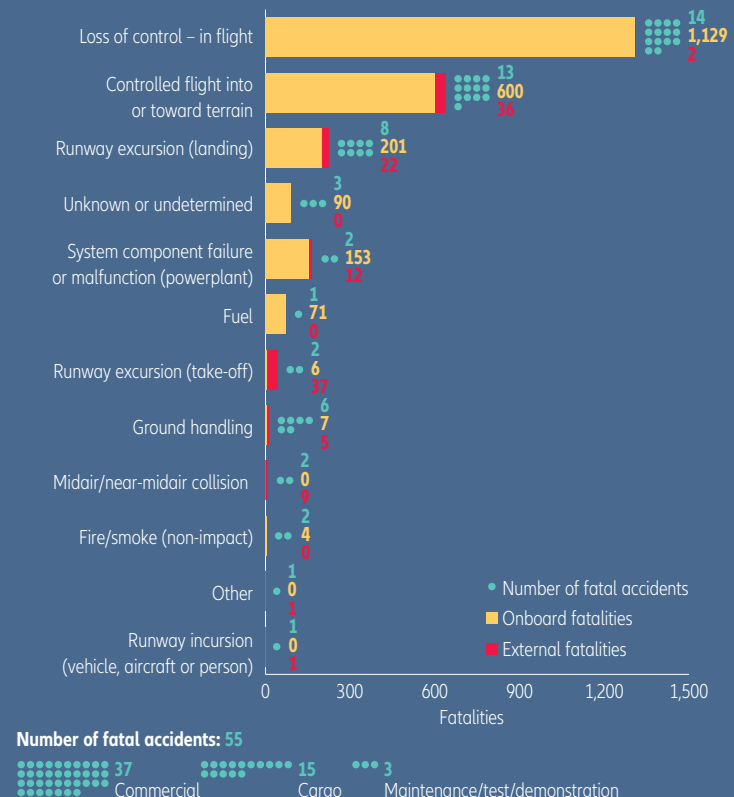
MORE SOPHISTICATED TECHNOLOGY IS DRIVING HIGHER VALUES AND COST OF REPAIRS

The increasing sophistication of new generation aircraft is leading to more expensive aviation insurance claims. In particular, more complex engines and new materials can be costly and more time-consuming to repair, driving up the cost of repairs and groundings.

Aircraft values have increased significantly in recent years, a reflection of more sophisticated

MOST FREQUENT CAUSES OF FATAL ACCIDENTS

Worldwide commercial jet fleet 2008-2017



Number of fatal accidents: 55

37 Commercial | 15 Cargo | 3 Maintenance/test/demonstration

Source: Boeing Statistical Summary Of Commercial Jet Airplane Accidents Worldwide Operations 1959 -2017, October 2018

Graphic: Allianz Global Corporate & Specialty

↑ The increasing complexity of aircraft design and manufacturing is leading towards a rise in costly grounding cases

← Insurers are seeing a trend towards replacement, rather than repair, of damaged aircraft components

engines and the growing use of composite materials in airframes. "A modern Boeing 777 or 787 can cost many millions of dollars and can be very expensive to repair," says Warfel. The value of these types of aircraft can easily exceed $100mn.

Repair costs for new generation aircraft are now much higher than their predecessors. Modern engines, in particular, are increasing in value. "We recently handled a claim where a rental engine was required while the aircraft's engine was repaired. The value of the rental engine was more than the entire aircraft, including its original remaining engine," explains **Dave Watkins, Regional Head of General Aviation, North America at AGCS**.

Composite materials – such as carbon fiber layers bonded with resin – are strong and light, and therefore help improve fuel efficiency. However, the claims experience has revealed a higher repair cost associated with composite materials, which are generally more expensive to manufacture than traditional metal alloys, more labor intensive to repair and often require a larger repair area.

"More and more aircraft are using composite materials. Minor damage to composite aircraft can be easier to repair and is not expensive, but larger damage is more expensive to repair in composite materials than traditional metal alloy," says Cadillat.

Changes in manufacturers' business models, as well as technical and regulatory considerations, are also affecting the cost of repairing engine and aircraft damage. As a result, insurers are seeing a trend towards replacement, rather than repair, of damaged aircraft components.

Manufacturers have shifted their focus away from repairs in favor of selling new parts and components, while repair and inspection protocols have become increasingly burdensome, according to Watkins.

"We have had claims where manufacturers are not willing to signoff repairs to composite airframes due to liability concerns, or where repair protocols are just too burdensome. We recently had a claim where an aircraft wing was damaged during maintenance. However, the manufacturer's repair and inspection protocols meant repair was not cost-effective. The result was a new wing, costing $10mn," says Watkins.

Increased complexity and changes to manufacturers' business models are also leading to longer repair times. "Some engines types are

almost impossible to replace," says Warfel. Manufacturers can also take much longer to inform insurers whether damage can be repaired and what is required than in the past.

"The time it takes to get an aircraft back into service has increased significantly. This has implications for insurers, but it has a massive impact on the airline that needs to find an alternative engine or aircraft," says Warfel.

"When an engine needs to be repaired, it may have to go back to the original manufacturer or an authorized repair facility, which creates a bottleneck and drives up cost. An airline may have to wait six months just to get in the line for repair."

GROUNDING CASES MORE COSTLY

"While technology has helped drive big improvements in airline safety, the increased complexity of aircraft design and manufacturing has also led to an increase in costly grounding claims for insurers," explains **Axel von Frowein, Global Product Leader Aerospace at AGCS**.

For example, the introduction of new aircraft and technology can lead to unexpected problems, grounding entire fleets. When the Boeing 787 Dreamliner was launched in 2013, a number of aircraft suffered from electrical system problems stemming from the lithium-ion batteries, causing the Federal Aviation Administration (FAA) in the US and airlines to ground the aircraft.

"Civil aviation and airline safety certification authorities have grown increasingly cautious. While the principle of precaution is welcomed from a safety perspective, it is likely to result in more, and longer, groundings of aircraft. Increasingly, we see aviation authorities are more demanding and careful, which they should be, and will continue to be," says Saillard.

The redesigned Boeing 737 Max was grounded in March 2019 after two of the newly delivered aircraft crashed within five months. Investigations into the Lion Air and Ethiopian Airlines accidents are ongoing, but they have highlighted potential risk considerations for technical innovation in the industry.

While the causes of the two 737 Max crashes are not fully known at the time of writing, attention has focused on the interaction of the pilots with the aircrafts' autopilot systems. In a bid to increase efficiency, Boeing changed the engines on the 737 Max, putting larger engines on an old aircraft design, requiring a software workaround, known as the Maneuvering Characteristics Augmentation System (MCAS). The pilots were reportedly unable to regain control of the aircraft after the MCAS repeatedly forced the aircraft to descend.

The grounding of the Boeing 737 Max, one of the fastest selling aircraft of all time, is likely to lead to one of the biggest airline manufacturers claims to date. The grounding has resulted in a large financial loss for the aircraft's manufacturer and airlines. It has been reported that Boeing has put aside almost $5bn to compensate airlines[9], a number of which have announced plans to cut routes and staff in response to the grounding and delays to aircraft on order.

"Such incidents highlight the challenge in finding technical solutions to complex problems, which increases the time it takes to get grounded aircraft back into operation," says **James Van Meter, Aviation Practice Leader, North America at AGCS**. "Even after a fix is developed and certified, the task of retrofitting a fleet will take a considerable amount of time. Grounded aircraft also require a tremendous amount of maintenance and upkeep to ensure they remain in an airworthy condition."

9 BBC, Boeing takes $5bn hit over grounding of 737 Max, July 19, 2019

$360,000

value of average bird strike insurance claim

Although, the grounding of the 737 Max is likely to result in a large claim for aircraft manufacturers' insurers, the financial impact for airlines is largely uninsured.

"Loss-of-use insurance cover has become increasingly relevant with the increased value of aircraft, and more importantly the revenue they represent to airlines," says Warfel. "Yet loss of revenues for grounding aircraft is largely uninsured by the airlines, which do not typically buy grounding cover."

GROWING POTENTIAL FOR LARGER LIABILITY AWARDS

Liability claims per passenger have soared as US plaintiff attorneys aggressively seek higher awards from a wider range of incidents.

Liability awards have risen dramatically. The rule of thumb for general aviation operators was $1mn to $3mn per passenger seat 10 years ago. Today, in certain circumstances, the numbers can be much higher than that. "With fewer major airline losses, plaintiff attorneys are fighting over a much smaller pool and are putting more resources into fewer claims, pushing more aggressively for higher awards and looking for more areas in which to seek compensation," says Watkins.

Southwest Airlines, together with aircraft and engine manufacturers, are currently facing litigation following an incident last year in which a woman was tragically killed when an engine blowout shattered a window on a Boeing 737. The family of the deceased passenger started legal proceedings against the airline, while a number of passengers on the flight sought damages. The compensation pay-out from such events can easily be in the multi-millions of dollars.

Increased liability awards are a particular challenge at a time of growing passenger numbers and a trend towards larger aircraft. In a drive for efficiency, airlines are flying more passengers, but on fewer flights. According to the Bureau of Transportation Statistics, the average number of US passengers per flight jumped from 69 to 91 between 2007 and 2017.

The new generation of aircraft carry hundreds of passengers at one time – the Boeing Dreamliner can carry 250 to 300 passengers while an Airbus A380 has capacity for around 600. With liability awards per passenger in the millions, a major aviation loss could easily result in a liability loss of $1bn.

FOREIGN OBJECT DAMAGE CLAIMS AND BIRD STRIKES SOAR

Ten years ago this year, US Airways Flight 1549, en route from New York's LaGuardia Airport to Charlotte, North Carolina, demonstrated all too well the dangers of birds within the immediate vicinity of operating aircraft. The Airbus 320-214 had to make an emergency landing in the Hudson River after a flock of Canadian geese severely damaged both engines. Fortunately, all 150 passengers and crew survived and the so-called **"Miracle on the Hudson"** was later turned into a film *Sully* with Tom Hanks as the plane's captain.

A decade later – in August 2019 – and in the so-called **"Miracle over Ramensk"** – a Russian passenger plane had to make an emergency landing in a cornfield near Moscow after striking a flock of birds, demonstrating that one notable area which is still posing a significant threat to flight safety and driving frequency of claims is damage to aircraft and engines from foreign objects, such as stones, misplaced tools and most commonly wildlife or bird strikes.

"Damage from foreign objects like bird strikes is nothing new in aviation, but we are seeing a high level of foreign object damage claims," says Warfel. For example, there were more than 14,600 reported collisions with wildlife in 2018,

There is an average of 40 bird strikes per day in the US

AGCS is seeing a growing number of mis-fueling claims with ground crew mistakes resulting in costly repairs and lengthy groundings

according to Federal Aviation Administration (FAA) data[10]. That equates to an average of 40 bird strikes per day in the US.

According to AGCS analysis of more than 50,000 aviation insurance claims, bird strikes are a notable contributor to aviation collision/crash incidents, resulting in excess of €330mn ($364mn) of insured damages between July 2013 and the end of 2018 – over 1,000 (1,032) related claims were received by insurers during this period in this data set. The average bird strike claim costs €327, 232 ($361,356) with some claims costing as much as €15mn ($16.6mn) and up. Most accidents occur when birds hit windscreens or fly into engines.

Estimates of the economic toll of bird strikes have been calculated at as much as $400mn a year in the US alone to $1.2bn worldwide, although conclusive numbers are hard to come by. Attempts are being made to further reduce the number of strikes on take-off and landing at airports through bird management and control. Many airports have implemented wildlife management plans and employ wildlife biologists to help safely move encroaching wildlife out of harm's way. Other approaches include utilizing sounds, lights, pyrotechnics, radio-controlled airplanes, decoy animals, lasers, dogs and bird capture and relocation methods. However, population increases in flocking birds, together with the growth in commercial air traffic, continue to pose challenges.

MIS-FUELING CLAIMS ON THE RISE

Mis-fueling of aircraft can result in costly damages, but it can also have potentially catastrophic consequences. With so many different types of aircraft in operation using different fuels and additives, human error is a real risk.

AGCS has seen a growing number of mis-fueling claims where mistakes made by ground crews have resulted in costly repairs and lengthy groundings.

"We have seen a number of incidents of mis-fueling that have resulted in damage to aircraft and grounding. This is an issue that is not receiving enough attention," says Watkins.

"We have had claims where ground handlers have put jet fuel in piston aircraft and vice versa. There have also been a series of diesel exhaust fluid (DEF) contamination incidents, where an incorrect additive has been unintentionally introduced into the aircraft, which can cause fuel system and engine damage, and in some cases, actually cause jet engines to shut down in flight. We had one particularly large claim where the whole fuel system had to be replaced, grounding the aircraft for a number of months."

10 USA Today, Planes Strike Birds More Than 40 Times A Day, FAA Data Shows, February 2019

3 AVIATION RISK TRENDS AND CHALLENGES

- Pilot shortage brings risk issues
- Training – over-reliance on automation concerns
- Risks growing at flight schools
- Pilot fatigue still a significant issue
- More turbulence on the way
- Drones bring increasing challenges and disruptions
- Cyber business interruption and data breach threat grows
- Accidents snd incidents on the ground problematic

PILOT SHORTAGE BRINGS RISK ISSUES

According to **Boeing's 2018 Pilot & Technician Outlook**, the projected demand for new pilots will number around 800,000 over the next 20 years[11]. This equates to a doubling of the current workforce and a record-high demand in the outlook's nine-year history. An anticipated doubling of the global commercial airplane fleet, significant air travel demand and the tightening labor supply are the main factors driving this development.

In its **Commercial Market Outlook 2019-2038**, Boeing estimated that year-on-year traffic growth averaged 6.7% during the past 10 years, setting a pace that exceeded the long-term average of 5%[12]. Low air fares, the growth of tourism and travel relative to total consumer spending in major economies, new airline business models and a growing middle class in large emerging markets are all driving this strength in air travel growth. For example, the average increase rate of the number of air passengers in China has been higher than 10% per year since 2011, while in India, the passenger growth per year has increased by more than 20%.

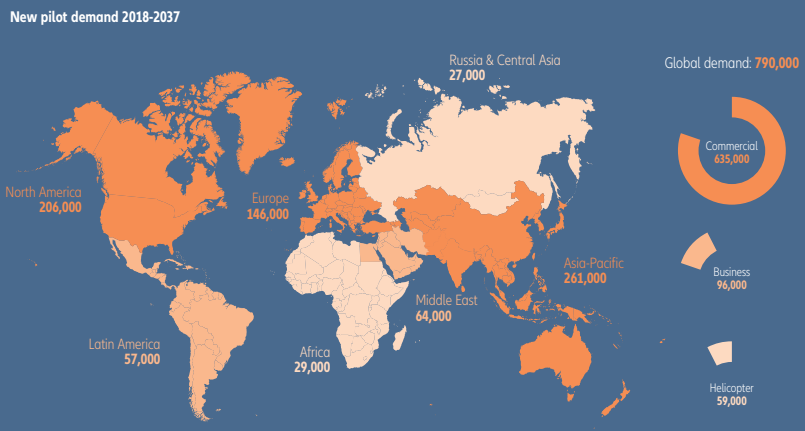
To meet the demand in the commercial market with the increasing number of passengers – the

11 Boeing, Pilot & Technician Outlook 2019-2038

12 Boeing, Commercial Market Outlook 2019-2038

13 International Air Transport Association, IATA Forecast Predicts 8.2 billion Air Travelers in 2037

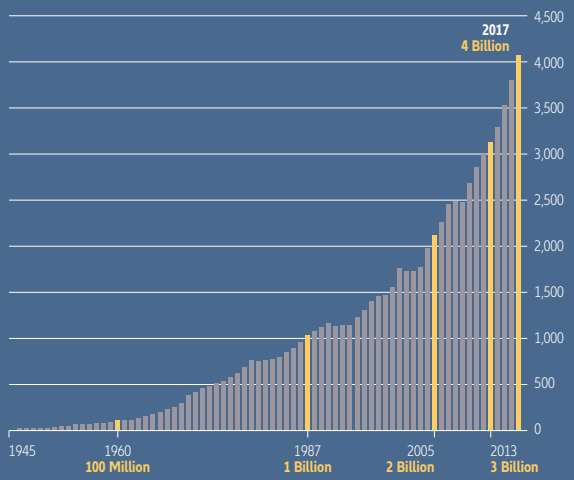
PILOT OUTLOOK BY REGION MAP



Source: Boeing Pilot & Technician Outlook 2018-2037, Pilot Outlook by Region Map, 2018

Graphic: Allianz Global Corporate & Specialty

ANNUAL PASSENGERS IN MILLIONS



Sources: Boeing, ICAO, IATA

Graphic: Allianz Global Corporate & Specialty

International Air Transport Association suggests current numbers could double to over eight billion by 2037[13] – Boeing estimates that the number of jet airplanes will break though the 50,000 barrier over the next two decades - double the number today.

Given the growing demand for pilots it seems there has likely never been a better time to obtain a pilot's license. However, at the same time, there are a number of issues which are ensuring the pilot shortage problem will not be easily solved, such as the increasing cost of pilot training and additional factors such as the significant increase in the amount of flight hours required to qualify in the US. The latter rule, while obviously well-intentioned and important from a safety perspective, has also exacerbated the pilot shortage problem, as it is making it more difficult – and taking longer – for new pilots to qualify.

"We already see the effect of pilot shortages on airlines and in general aviation," says Warfel. There is a huge demand for air crews and pilots, and this can lead to pilots flying commercial aircraft with limited experience and a low air-time.The pilot shortage is forcing operators around the world to manage the issue of less experienced crew members in the cockpit.

"This is becoming a real issue for the industry. Some airlines are now establishing their own flight schools *(see right)*, but new pilots will still need to get the right flight experience. The concern is that we will see more pilots flying with less experience and reduced frequency of training in order to meet demand," says Warfel.

TRAINING – OVER-RELIANCE ON AUTOMATION CONCERNS

Following a number of high-profile incidents in recent years culminating in two Boeing 737 Max 8 jets crashing within five months of each other in 2018 and 2019, questions continue to be asked about pilots' overreliance on aircraft automation systems which can be life-threatening as technology becomes more complex.

"Modern aircraft are more technologically sophisticated, which has had a significant impact on safety and efficiency, but has also raised concerns about how pilots interact with the technology," says Van Meter.

"There have been some major accidents that highlight the challenges with interaction

Loss frequency is rising with increasing activity at flight schools

RISKS GROWING AT FLIGHT SCHOOLS

As demand for airline pilots outstrips supply, pressure on commercial flight schools is growing, with implications for the availability of instructors and aircraft.

"The shortage of pilots has seen activity at flight schools increase exponentially, and this could result in an up-tick in risk," says **Dave Watkins, Regional Head of General Aviation, North America at AGCS**. "These operators may have to maximize utilization of aircraft and instructors in order to keep up with demand. That is why we are now focusing our attention on better understanding potential exposures from increased activity in flight schools."

Growing demand for pilot training is driving up the value of aircraft used in flight schools, which increasingly use more sophisticated planes to train pilots.

"The average insured value has increased from around $100,000 to $1mn today as airlines require pilots to be trained in more advanced aircraft. Increased demand for aircraft by flight schools has also led to a doubling of their value. In some cases, demand is such that it is becoming impossible to find certain types of aircraft," says Watkins.

Given the nature of flight training, flying schools are prone to accidents, but claims are becoming more expensive with rising values and increased activity. Loss frequency is already high in the flight training industry – landing accidents are most common, but insurers are also seeing total losses.

"This is a space where we expect minor accidents on a regular basis, but loss frequency is rising with increased activity. In addition, as aircraft values increase in this arena, we are seeing higher repair costs and longer repair times," says Watkins.

Pilot training standards have improved but systems can still be incorrectly operated

between pilots and technologically advanced systems– such as the 2013 Asiana Airlines crash at San Francisco airport in 2013 and now the two 737 Max incidents. Such events involve an element of human error, with an over-reliance on automated flight and the interface of pilots with complex aircraft systems often contributing factors," Van Meter adds.

Overall, pilot training standards have changed and improved over recent decades, but systems can still fail or be incorrectly operated, albeit rarely, and there needs to be a continued focus on pilots flying with and without automation in training. In particular, pilots need to be better prepared to be able to take corrective actions in event of a technical malfunction or adverse circumstance. It is also important to teach pilots about aircraft systems to improve their understanding of automation principles and work patterns. This can increase situational awareness and help avoid confusion during situations when automation fails.

PILOT FATIGUE STILL A SIGNIFICANT ISSUE

Largely ignored for the first 40 years of commercial jet aircraft, pilot fatigue has always posed a serious threat to the aviation industry and continues to do so. The consequences can be life-threatening, as well as producing unusual scenarios – in 2011 an Air Canada pilot caused an airplane to plummet when he became disoriented after falling asleep and mistook the planet Venus as the lights of another airplane on a collision course, injuring 14 passengers and two crew[14].

In a 2017 survey of more than 800 commercial airline pilots by the pilot's union, the British Airline Pilots Association (BALPA), 55% of respondents cited fatigue as the biggest threat to flight safety, ahead of terrorism[15].

It is estimated that pilot fatigue is responsible for around 15% to 20% of human error in fatal accidents, a figure that hasn't changed significantly since the early 1990s (for example in 1994 around 20% of reported aviation incidents were attributed to fatigue). Experts note that for pilots, being fatigued is like being drunk. Depending on the amount of sleep a pilot has had, the impairment on a pilot landing a plane at 05:00 in the morning can be the same as having a blood alcohol level of 0.08%, which is equivalent to the UK's drink-driving limit and more than the legal limit in many other nations[16].

No one wants tired pilots on the flight deck and attempts to create an industry-wide culture that understands and prioritizes fatigue need to be stepped up. Accurate data and fatigue monitoring are of crucial importance, as are removing any potential barriers to reporting incidents and ensuring systems are working.

Organizations such as BALPA have also previously called for an industry standard for what levels of fatigue are permissable. It supports the Karolinska Sleepiness Scale, which runs from 1 (extremely alert) to 9 (extremely sleepy, fighting sleep) as a way of measuring fatigue. It would like to see no pilot rostered to the point where they will reach Karolinska 8 (sleepy, some effort to keep awake) or 9 during a duty.

STRAP YOURSELF IN – MORE TURBULENCE ON THE WAY

In July 2019, at least 37 people were injured on board an Air Canada flight after the plane hit

Incidences of turbulence are expected to increase due to climate change

severe turbulence and had to make an emergency landing. The plane, carrying 284 passengers and crew, was travelling from Vancouver to Sydney but had to be diverted to Hawaii.

In the aviation industry, turbulence is experienced every day in flights around the world. Turbulence occurs when the air through which the aircraft is moving is disturbed, either by convective activity like thunderstorms or a large temperature gradient. The intensity of turbulence will range from light to severe and is determined by how fast the speed or direction of airflow is changing. Often, turbulence is unexpected, and pilots must be properly trained on how to handle it when it is encountered.

Since the severity of turbulence always fluctuates, light turbulence will cause the aircraft to experience slight changes in attitude or altitude. If the pilots encounter severe turbulence, the aircraft will be harder to control and have a greater variation in attitude and altitude. Extreme turbulence is the most severe form and could cause structural damage to the aircraft, which can cost as much as hundreds of millions of dollars a year. Flight path and altitude changes to avoid turbulence are estimated to cost US airlines as much as $100mn a year, and burn an additional 160 million gallons of fuel.

"Within the coming decades, turbulence is expected to increase due to climate change and the warming planet," says von Frowein. It's been suggested that the North Atlantic flight passageway will see the greatest increase in turbulence. This passageway is the route many international flights use to travel between North America and Europe and any changes here can have a significant influence on aviation, since nearly 3,000 flights cross the Atlantic on an average day. According to the University of Reading in the UK, it is estimated that by 2050 to 2080, changes to the jet stream from climate change will result in an increase of clear-air turbulence of 113% over North America, and as much as 181% over the North Atlantic[17].

DRONES BRING INCREASING CHALLENGES AND DISRUPTIONS

The rapid growth of unmanned aerial vehicles (UAVs), or drones, is one of the biggest issues to impact the aviation industry for decades. Aerospace analysis company Teal Group anticipates a $93bn investment in commercial drone technology worldwide over the next 10 years and also expects the worldwide non-military drone market, dominated by manufacturers in China, to triple in size to $14.3bn in sales over the same period from $4.9bn in 2019, as it benefits from a gradual opening of US airspace by the FAA and increased use by commercial industries[18].

In the US alone, almost 900,000 hobbyist owners had registered their drones by the end of 2018 according to the FAA since it mandated online registration for drones in 2015. Meanwhile, the market for commercial drones – which can be used for anything from lifeguard duties to police tackling crime, to site inspections to delivering of medical supplies – is accelerating. The FAA expects growth will continue – by 2023, this market will triple in size, with an estimated 823,000 drones flying at that time[19].

Drones bring a host of potential benefits to air transportation systems in particular. For example, they can be used to undertake aerial surveys of terminal buildings or provide 3D maps

14 Reuters, Sleepy Air Canada pilot thought Venus was a plane, April 16, 2012

15 British Airline Pilots Association, balpa.org, Pilot Fatigue

16 BBC News, Pilot fatigue 'one of the biggest threats to air safety', October 11, 2012

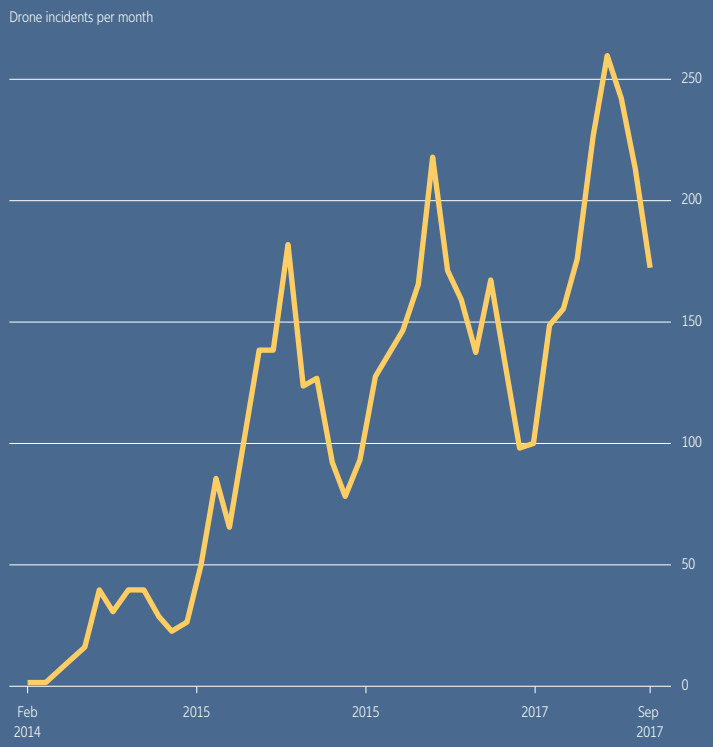
17 CNBC, Climate change will increase the risk of severe turbulence on planes, research says, October 2017

18 Reuters, Global Drone Market Estimated To Reach $14bn Over Next Decade, July 17, 2019

19 Federal Aviation Administration Aerospace Forecast Fiscal Years 2019 -2039

NUMBER OF SAFETY REPORTS INVOLVING DRONES IN THE US

February 2014 – September 2017



Source: Federal Aviation Administration, Bloomberg

Graphic: Allianz Global Corporate & Specialty

The number of drone incidents in the US has soared from zero in February 2014 to 260 in June 2017. Reported incidents are only expected to rise as more people acquire drones, some of whom might not be versed in the rules and regulations.

Commercial aircraft are at the greatest risk of an incident with a drone during take-off and landing

of runways in order to identify and aid maintenance work – this can be much quicker and safer than using people. They can also be used to quickly detect foreign objects around airports, potentially eliminating the need to close down a runway, as well as offering support to security by identifying any threats quickly, while also acting as a visual deterrent.

However, as the number of drones flying in the skies have increased, so have the risk exposures. AGCS has already experienced a small number

of claims resulting from drones falling to the ground, the majority of which have been caused by loss of battery power, often due to pilot inattention during the flight. Fortunately, no one has been hurt in these incidents.

Even more serious is the fact that the number of aircraft near-misses with drones and other incidents of reckless behavior in or around airports is also increasing. Drones constitute a considerable risk to manned airplanes. Even though many weigh only a few pounds, the motors and other metallic equipment that power them can cause significant damage to aircraft engines, windshields and wings. It is estimated that even a small drone could cause as much as $10mn in physical damage alone if hitting an engine of an airplane (excluding liability costs). Commercial aircraft are at the greatest risk of an incident with a drone during take-off and landing. In the event of an incident, aircrafts could also be forced to make an emergency landing, resulting in delay or cancellation, incurring significant economic loss.

For example, the number of times a drone endangered the safety of an aircraft in UK airspace rose by more than a third last year, according to the UK Airprox Board. It recorded 125 dangerously close encounters in 2018, up from 93 in 2017 and 71 in 2016. Severe disruptions occurred at Gatwick Airport, London's second busiest, resulting in 1,000 flight cancellations or diversions and affecting 140,000 passengers, when recreational drones reportedly appeared over the airport for three days in December 2018. Similar drone incidents with airliners or near airports occurred in late 2018 and early 2019 in Tijuana, Mexico, Newark, New York, London's Heathrow Airport, Dubai and Singapore, to name but a few. Estimates put the cost of Gatwick's December drone closure in excess of $60mn[20], while airliner EasyJet confirmed it lost £15mn ($18.5mn) as a result. In the wake of the incident, Gatwick spent about £5mn ($6mn) on anti-drone equipment, which can detect and jam communications between a drone and its operator.

Although significant strides have been made around the world when it comes to introducing regulations controlling drone use over the past five years, there is still much work to be done and although most drone operators operate within these correct regulations and boundaries, the above examples show there are a growing number of exceptions to these rules.

Standards of drone regulation can also differ significantly around the world. Some countries are well regulated, whereas in others regulation can be either very light or non-existent, which can increase the risk of a dangerous incident occurring, such as a collision.

At the same time, methods of mitigating and reducing the potential threats posed by drones to airports and airlines continue to evolve, such as 'geo-fencing', whereby software uses the global positioning system (GPS) or radio frequency identification (RFID) to define geographical boundaries. It can then pick up those signals, process them and display them on an on-screen map. If protecting an airport, the system should emit an audible tone announcing that it has spotted a drone and airport staff can immediately see where both the drone and operator are located. However, although geo-fencing technology is a good mitigation against hobbyists that may stray into the wrong area, it can be less effective against individuals with malicious intent if they have already found out how to override it.

Data sharing and collaboration on drone safety analysis are still in the early stages of maturity while the investigation of certain near-miss drone sightings would be useful in validating the effectiveness of safety controls. Such analyses would help guide the drone industry's ongoing safety research and design. First and foremost, careless and reckless operators need to be held accountable.

CYBER BUSINESS INTERRUPTION AND DATA BREACH THREAT GROWS

Cyber risks, including cyber-attacks, IT systems outages and data breaches, were ranked as the top future peril by aviation sector respondents in the **Allianz Risk Barometer 2019**, which surveys sector risk management experts, just ahead of the closely related risk of business interruption. The increased concern for cyber is not surprising, given high profile cyber incidents for airlines, airports and aerospace manufacturers in recent years.

In June 2019, European aerospace manufacturer ASCO was hit by a suspected ransomware attack, disrupting production and forcing the Belgium-based company to resort to workarounds to clear a backlog of orders. The incident followed a ransomware attack at Boeing in 2018, although that attack was quickly contained. Airports have also been targeted by disruptive cyber-attacks – last year one affected departure boards at the UK's Bristol airport while Cleveland Hopkins International Airport in the US suffered a similar attack in April 2019.

$60mn

estimated cost of disruption to the UK's Gatwick Airport in December 2018 from drones

20 Fortune, Gatwick's December Drone Closure Cost Airlines $64.5mn, January 22, 2019

Over 200 companies are developing passenger-carrying autonomous aircraft

DRONE INSURANCE LOSS ACTIVITY AND THE RISE OF BVLOS

As drone technology and reliability has improved, insured losses from drones have shown a positive trend. However, a move towards electric powered flight and more autonomous drones will bring far greater challenges.

"AGCS insures drones globally – covering both hull risks and liability for operators – and we have seen losses improve to some degree, as drones have become more reliable and battery and guidance technology has improved," says **James Van Meter, Aviation Practice Leader, North America at AGCS**.

"The drone industry is on the cusp of a transformative development, with the development of electric unmanned aircraft that are able to fly beyond visual line of sight (BVLOS)," adds **Axel von Frowein, Global Product Leader Aerospace at AGCS**. "If drones can be safely integrated into commercial airspace, commercial drones may soon become commonplace – used for deliveries, inspections, agriculture and even urban air mobility services that can carry tourists, serve offshore oil platforms and carry out emergency evacuations."

The Federal Aviation Administration recently granted licenses to a number of logistic companies to test drone delivery systems in the US and authorized its first BVLOS flight for a public safety agency, the Chula Vista California Police Department. Last year, Xcel Energy used a drone to inspect electric power lines in Colorado – marking the first BVLOS flight by a US utility company.

In addition to carrying cargo, small autonomous passenger drones are undergoing testing. Uber plans to test its air taxi technology in 2020, with the aim of launching commercial operations from 2023. Dubai, Singapore and China are among the states and countries embracing the technology with plans to launch passenger services in coming years – Dubai conducted its first test of a drone taxi service in 2017.

One of the world's largest manufacturers of consumer drones recently announced that its drones will be equipped with ADS-B sensors from 2019, which will enable them to be seen and tracked by other aircraft and air traffic control.

However, BVLOS flight has some significant regulatory and safety challenges ahead. Switzerland recently suspended a medical drone delivery service after the vehicle crashed close to a pre-school. The drone service, which delivers samples to Swiss hospitals, had made over 3,000 successful flights since its launch in 2017.

"Drones have become safer as the technology has improved," says Van Meter. "However, the regulatory landscape continues to lag behind technological advancement as we are seeing in the continued growth of the unmanned autonomous flight sector.

"There are now over 200 companies developing passenger-carrying aircraft. With a lot of companies investing in this technology there will be another learning curve in aviation and drone safety."

"With its reliance on IT systems for booking, ticketing and flight operations, the airline industry is particularly vulnerable to business interruption events, either from a malicious attack, human error or technical faults," says von Frowein. A number of US airlines have suffered cancellations and long delays caused by IT system or hardware failures in recent years – according to the Government Accountability Office there were 34 IT outages affecting 11 US airlines between 2015 and 2017, 29 of which directly disrupted or cancelled flights[21].

A number of airlines have also fallen victim to some high profile data breaches in recent years. In March 2019, Cathay Pacific revealed a data breach had exposed the personal data of over nine million customers, the largest known data breach in the aviation sector to date. British Airways faces a £180mn ($230mn) fine from the UK's data protection regulator for a 2018 data breach that affected 500,000 passengers, the largest fine proposed under the EU's General Data Protection Regulations since they were introduced in May 2018.

Despite the prevalence of cyber events in the aerospace sector, AGCS has, to date, had very few cyber claims under aviation hull and liability policies.

This is in large part a reflection of the coverage purchased by airlines and manufacturers to date. As coverage evolves, cyber will no-doubt shape future aviation claims.

There is an ongoing discussion and an examination of the extent to which aviation insurance coverages currently do or do not cover cyber risk. In general, aviation insurance will cover physical damage to an aircraft resulting from a cyber-attack, but losses related to data and IT system outages are typically excluded. However, specific coverages are being developed to cover such risks in the aviation sector.

While awareness of cyber risk has increased, especially among aviation manufacturers, AGCS sees varying degrees of cyber risk management maturity when undertaking risk assessments according to Warfel.

"Cyber is becoming an important risk for the aviation sector – a more visible risk that all organizations now consider. However, the level of sophistication among clients differs widely. Not all companies assess and measure the level of cyber risk in their organizations and when asked about their cyber exposures, the responses vary greatly. When it comes to cyber risk management and insurance purchasing, what we see is still very much in its infancy."

TOP RISKS IN THE AVIATION SECTOR FOR 2019

Risk	Percent	2018 rank	Trend
1 **Cyber incidents (e.g. cyber crime, IT failure/outage, data breaches, fines and penalties)**	**43%**	2 (44%)	▲
2 Business interruption (incl. supply chain disruption)	**37%**	1 (45%)	▼
3 Changes in legislation and regulation (e.g. trade wars and tariffs, economic sanctions, protectionism, Brexit, Euro-zone disintegration)	**36%**	4 (26%)	▲
4 Market developments (e.g. volatility, intensified competition/new entrants, M&A, market stagnation, market fluctuation)	**33%**	3 (33%)	▼
5 Natural catastrophes (e.g. storm, flood, earthquake) **NEW**	**19%**	-	▲

Cyber is the top risk concern for the aviation sector, but as yet, these fears have not manifested themselves seriously in aviation insurance claims.

Source: Allianz Risk Barometer 2019
Figures represent how often a risk was selected as a percentage of all responses for that industry sector.
Responses: 86
Figures don't add up to 100% as up to three risks could be selected.

ACCIDENTS AND INCIDENTS ON THE GROUND PROBLEMATIC

While accidents in flight continue to become less frequent, ground accidents remain problematic and this issue could be exacerbated in future. According to the International Air Transport Association, 96% of the world's 100 busiest airports will likely see infrastructure related capacity issues within the next 10 years, and 45% are already dealing with weekly delays related to airport infrastructure[22]. This airport ground congestion is not only cause for concern on the basis of delays and inconveniences, but for safety as well. When there are too many planes on the ground or within any certain area on an airport's surface, safety margins can become too thin for comfort and air traffic control and air traffic systems ramp controllers can become overloaded and overwhelmed with traffic and an accident can occur.

It has been estimated that ramp accidents can cost airlines as much as $10bn a year in direct and indirect costs with non-compliance, with operating procedures a significant contributor to this loss tab. The Flight Safety Foundation has previously estimated that around 27,000 ramp accidents and incidents occur worldwide annually[23].

The rapid growth in air travel – the number of air passengers is expected to double to almost eight

21 US Government Accountability Office, Commercial Aviation, Information on Airline IT Outages, June 2019

22 International Air Transport Association, Airport of the Future, 2017

23 The Flight Safety Foundation, Covering The Ground, August 2012

Congested airports mean ground accidents are likely to increase further in future

96%

of the world's 100 busiest airports will see capacity issues within the next 10 years

billion in the next 20 years – is also resulting in more congested airports.

Increased air travel congestion in and around airports has become a problematic issue. In many cases, airport infrastructure has not kept pace with the rapid growth in passenger and aircraft numbers. With more aircraft on the ground, servicing areas and aprons have become more congested and this is resulting in an increase in the number of collisions with other aircrafts or ground handlers.

Analysis of 523 loss events at 14 German airports last year by AGCS shows that damage to vehicles on the tarmac is a leading cause of insured losses. More than half of these events were due to collisions with pushback tractors, baggage trolleys, aerial work platforms or washing systems.

For example, the introduction of a new form of tow-truck (that wraps-around an aircraft's front landing gear) has resulted in several large claims. A number of tow-trucks have caught fire while in operation, damaging aircraft – one resulted in the total loss of a Boeing 777.

Before an airport invests in new ramps, taxiways, and runways, the first question should always be, is there an alternative? It takes a large amount of effort, but reorganizing and optimizing large operations such as those at major airports can be extremely beneficial. Using a system such as the Jeppesen Total Airport and Airspace Modeler (TAAM), a 4D gate-to-gate simulation tool that accurately predicts and analyzes the impact of airspace and airport operations to find where weak areas are within a specific airport operation and implementing and trying new rules and different flows, can impact the efficiency of the operation.

In many cases, airports do not have the most logical runway-to-gate and gate-to-runway flows and this can tie up traffic on ramps and taxiways, especially those with continuous arrivals and departures. Optimizing taxiway flow around an airport in a way that makes sense for both the tenants of the airport and air traffic control, and that works with all possible runway configurations for that specific airport, is a major step to successfully moving forward. Ensuring ground traffic flow does not disrupt smooth operation of the airport is key to reducing aircraft delays and risks of aircraft incidents. Reorganizing taxiway directional flow in a way that creates "one way" taxiways around the airport has proven to be one of the best and most successful methods when running simulations on the TAAM software along with the strong avoidance of runway crossings if possible to limit the runway interference which can cause many delays on both sides.

Communication is an integral part of ramp guidance and ineffective communication can be at the heart of many ground accidents. The most frequent parts of the airplane to be hit during a ramp accident or incident are the aft cargo door, forward fuselage, and wing-mounted engines. These areas of the airplane are large, and fairly visible. Possible causes of these incidents include distractions, such as using phones while driving service vehicles, airplane noises, communicating with others, etc., to name a few. Dealing with a heavy workload or fatigue can also be contributing factors behind such incidents.

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