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AIRCRAFT MAINTENANCE MAGAZINE


HUMAN FACTORS IN AIRCRAFT MAINTENANCE: **UNDERSTANDING AND MANAGING ERRORS**

THE FUTURE OF FLIGHT : **REDUCED CREW OPERATIONS**

OPTIMIZING AIRCRAFT MAINTENANCE: **CONCEPTS, DETAILED METHODOLOGIES, AND FUTURE DIRECTIONS**

# BITE TEST: THE EYES AND EARS OF AVIATION MAINTENANCE

**Dear Esteemed Readers,**

As we embark on a new chapter in 2025, the aviation industry stands at a pivotal moment, shaped by resilience, innovation, and adaptation. The past few years have tested the sector's endurance, yet the industry has emerged stronger, fueled by advancements in sustainability, digitalization, and next-generation technologies. While global recovery continues, the landscape of air travel is evolving, bringing both challenges and opportunities for airlines, MRO providers, and aerospace manufacturers.

Sustainability has transitioned from a long-term goal to an immediate priority. The widespread adoption of Sustainable Aviation Fuel (SAF) is central to reducing the industry's carbon footprint, driven by stringent environmental regulations such as the European Union's Fit for 55 package and ICAO's decarbonization initiatives. In response, the United States and Asia-Pacific nations are introducing significant incentives for SAF production and integration. Turkey is actively aligning with these global efforts, as Turkish Technic and domestic aerospace manufacturers lead pioneering initiatives in sustainable aviation.

The digital revolution continues to reshape the Maintenance, Repair, and Overhaul (MRO) sector, driving operational efficiency and predictive capabilities. Artificial intelligence, big data analytics, and digital twin technologies are now critical components of modern maintenance strategies. These advancements are enabling airlines to enhance aircraft lifecycle management, optimize inventory control, and improve overall fleet reliability. European, American, and Asian MRO hubs are rapidly adopting these technologies, and Turkey is no exception. With Istanbul Airport solidifying its position as a key regional MRO hub, Turkey is strengthening its role in the global aviation maintenance landscape.

Aircraft manufacturers are pushing the boundaries of innovation, accelerating the development of fuel-efficient, environmentally sustainable aircraft. Boeing and Airbus remain at the forefront of this transformation, while electric and hybrid aircraft concepts are gaining traction. Startups in the United States, European sustainability programs, and China's ambitious investments in next-generation aircraft are intensifying global competition. Meanwhile, Turkey's aerospace and defense sector is making notable strides. The KAAN fighter jet is set to undergo its first test flights, and advancements in Unmanned Aerial Vehicles (UAVs) are reinforcing the country's growing prominence in next-generation aviation technologies.

Geopolitical tensions continue to impact global air travel, introducing new operational and financial risks. The ongoing Ukraine-Russia conflict, the Israel-Palestine crisis, and escalating tensions in key regions are forcing airlines to rethink their strategies. Airspace restrictions, rerouted flight paths, and rising insurance costs are adding complexity to international operations. While U.S. and European carriers work to mitigate these challenges, airlines in China and the Middle East are capitalizing on regional stability to strengthen their market positions. Turkey's strategic location remains an invaluable asset, serving as a vital transit point for global air traffic and reinforcing its role in international connectivity.

Turkey's aviation ambitions extend beyond air traffic management, with significant investments in infrastructure, fleet expansion, and MRO capabilities. Istanbul Airport has firmly established itself as one of the world's leading transfer hubs, attracting increasing global attention. Simultaneously, Turkey's technical maintenance and MRO sector continue to draw interest from international operators seeking cost-effective, high-quality maintenance solutions. As demand for efficient and reliable MRO services rises, Turkey is positioning itself as a key player in the global aviation maintenance industry.

The year ahead presents both obstacles and opportunities for aviation professionals worldwide. As the industry undergoes a profound transformation, the next decade of air travel will be defined by technological advancements, sustainable practices, and strategic innovation. By embracing these changes, the aviation sector is set to soar into a new era of growth and resilience.

As we navigate this journey together, we extend our best wishes to all our readers for a prosperous and successful 2025. May this year bring continued progress, new opportunities, and groundbreaking achievements in aviation.

With our deepest respect and warmest regards.

Ömür CANİNSAN

UTED President

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# Turkish Technic and SunExpress Strengthen Their Long-Standing Partnership with Two Major Agreements

Turkish Technic, a global leader in the aircraft maintenance, repair, and overhaul (MRO) sector, has reinforced its long-standing partnership with SunExpress, a joint venture of Turkish Airlines and Lufthansa, by signing two significant agreements.

Under the newly signed component support agreement, SunExpress will gain access to Turkish Technic's extensive component inventory and comprehensive maintenance and repair capabilities for the next five years.

This service will cover SunExpress's Boeing 737NG and Boeing 737MAX fleets, ensuring optimal component availability and minimizing aircraft downtime.

The second agreement includes landing gear maintenance, repair operations, and spare parts supply for SunExpress's Boeing 737NG fleet.

Through these comprehensive agreements, Turkish Technic will continue to support SunExpress in maintaining operational continuity and fleet readiness while enhancing SunExpress's ability to provide timely and reliable services to its passengers.

Regarding the agreement, Turkish Technic's CEO and Board Member, Mikail Akbulut, stated:
"Our partnership with SunExpress, spanning over a decade, continues to grow stronger with these new agreements. We are delighted to contribute to SunExpress's operational efficiency through our extensive component services. We thank SunExpress for their trust in our expertise and look forward to strengthening Türkiye's position in the global aviation industry together."

Commenting on the continuation of the collaboration, SunExpress CEO Max Kownatzki said:
"Our long-standing partnership with Turkish Technic reflects our commitment to safety and efficiency. The component support and landing gear maintenance services we receive will help us sustain our operational reliability and performance at the highest standards. We believe this collaboration will contribute to our operational excellence and enable us to provide our customers with safe and dependable services."

## SunExpress Joins AMOSeTL Development Team

As part of its commitment to digital transformation, SunExpress has also joined the AMOSeTL (AMOS electronic TechLog) development team. Alongside Condor, Luxair, Malaysia Airlines, El Al, Sideral, Cebu Pacific, and other industry leaders, SunExpress contributes to refining and testing AMOSeTL functionalities. This initiative represents the final phase of the airline's Paperless Aircraft Maintenance Operations Project, as it aims to completely replace traditional paper-based technical logs.

- By implementing AMOSeTL, SunExpress will:
- Reduce aircraft weight by eliminating paper logbooks.
- Minimize transcription and data handling errors.
- Ensure real-time access to accurate aircraft maintenance records worldwide.
- Improve operational efficiency and sustainability.

With this transition, SunExpress becomes the first airline in Türkiye to implement fully paperless aircraft maintenance and one of the few airlines globally to achieve this milestone. The airline continues to enhance its processes for greater efficiency, cost savings, and environmental sustainability, and Swiss-AS is proud to support this transformation.

## FAA Warns Boeing 757 Operators on Hydraulic Hose Failures

The US Federal Aviation Administration (FAA) has issued a safety bulletin urging Boeing 757 operators to inspect and replace flexible hydraulic hoses in the landing gear to prevent failures. The advisory follows multiple incidents where the left-hand hydraulic system was lost due to hose fatigue, including a DHL 757-200 freighter accident in Costa Rica on April 7, 2022. After suffering a hydraulic failure mid-flight, the crew returned to San Jose, but the aircraft veered off the runway upon landing, sustaining severe damage. Investigators linked the failure to material fatigue in a landing-gear actuator hose. While the FAA has not mandated an airworthiness directive, it emphasizes that repeated stress can degrade hoses over time. Boeing previously issued a service letter in March 2023, advising proactive hose replacements. The FAA now urges all 757 operators to follow Boeing's recommendations to reduce failure risks.


## Thales Extends IFE Maintenance Partnership with Vietnam Airlines

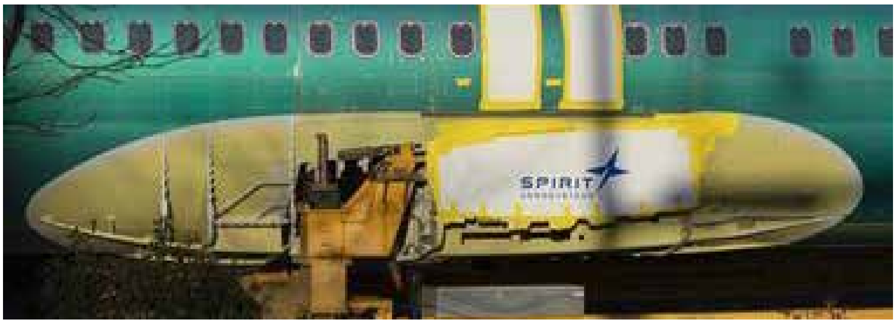
Thales has renewed its agreement with Vietnam Airlines to provide FlytCARE services for maintaining the airline's inflight entertainment (IFE) systems. The contract, signed with Vietnam Airlines Engineering Company (VAECO), covers maintenance for the IFE systems on the airline's Airbus A350 and Boeing 787 fleets. It also includes spare parts availability at Noi Bai International Airport in Hanoi and Tan Son Nhat International Airport in Ho Chi Minh City. Vietnam Airlines operates 27 A350s and Boeing 787s, all equipped with Thales' AVANT IFE systems. This extended partnership reinforces Thales' long-term collaboration with Vietnam Airlines, ensuring high-quality service and reliability for passengers across its global network. While primarily designed for military roles, the PHASA-35 has potential civilian applications, including communications, border security, and disaster relief, according to BAE.

## EASA Certifies Safran's First Electric Motor

The European Union Aviation Safety Agency (EASA) has granted a type certificate to Safran Electrical & Power for the 125 kW ENGINeUS 100B1, making it the first electric motor approved under the CS-23 standard. The approval paves the way for more powerful motors that may equip hybrid-electric regional aircraft. Moreover, Safran is preparing to use derived hybrid-electric technologies on the RISE demonstration program for a more efficient engine on narrowbody aircraft. Safran's new motor inaugurates a new certification regulation. The Pipistrel Velis Electro two-seater was previously certified with a house-designed electric propulsion system. EASA approved the aircraft and its motor under the light sport aircraft category. The ENGINeUS is three levels higher in terms of certification requirements, Regis Rossotto, EASA's product certification manager for the engine, said on the sidelines of a Feb. 3 press briefing. "With Safran, we did in-depth failure analysis," he explained. "Endurance trials and environmental testing, which include extreme temperature, altitude, electromagnetic interference and icing conditions, were comparable to what we require from a helicopter turbine engine."

## Eastern Airlines Technic Signs 12-Year APU Maintenance Agreement with Lufthansa Technik

Eastern Airlines Technic (EASTEC), a subsidiary of China Eastern Airlines, has entered into a 12-year exclusive maintenance agreement with Lufthansa Technik for the auxiliary power units (APUs) of its Airbus A350 fleet. Under the agreement, Lufthansa Technik will provide comprehensive MRO services for the Honeywell HGT1700 APUs at its specialized maintenance facility in Hamburg, Germany. As an officially certified repair partner for this APU type, Lufthansa Technik ensures high-quality service through its advanced repair center and global supply network. This long-term partnership builds on more than 20 years of collaboration between Lufthansa Technik and China Eastern Group, which includes maintenance agreements for Boeing 777 passenger and cargo aircraft. The deal also strengthens Lufthansa Technik's presence in the Chinese market and supports its goal of becoming a leading A350 APU maintenance provider in the region.




## Spirit AeroSystems Shareholders Approve Boeing Acquisition Deal

Spirit AeroSystems' shareholders have approved the company's acquisition by Boeing, paving the way for the deal to be finalized by mid-2025. The agreement, initially announced in June 2024, comes as Boeing faces increasing pressure to improve quality and safety in its production system. Spirit, a key supplier for Boeing, including 737 fuselages, has also been under scrutiny for manufacturing quality issues. Boeing aims to integrate Spirit's Boeing-related operations to enhance oversight and streamline production. Meanwhile, Airbus has expressed plans to acquire Spirit's operations that supply Airbus components. The approval marks a significant step in the restructuring of the aerospace supply chain.


## Ryanair Expands Maintenance Capabilities with New Dublin Hangar and Potential Engine Overhaul Insourcing

Ryanair has begun construction on a 40 million airframe maintenance hangar at Dublin Airport, aiming to strengthen its internal MRO capabilities. The four-bay facility will support both line and heavy maintenance, complementing the airline's outsourced operations across Europe. In response to global supply chain issues in the engine aftermarket, Ryanair is also exploring the insourcing of engine overhauls. CEO Michael O'Leary stated that the airline is considering establishing one or two in-house engine maintenance shops within the next 12-18 months to mitigate long turnaround times. Meanwhile, ongoing Boeing 737 MAX delivery delays have forced Ryanair to adjust fleet plans, keeping older 737s in service. The broader aviation industry is also facing challenges with current-generation narrowbody aircraft, leading to increased pressure on maintenance resources.


## Japan Airlines' Innovative Step Toward Sustainability

Japan Airlines (JAL) is taking a major step in sustainable aviation by applying a riblet-shaped coating to its Boeing 787-9 aircraft. Developed with JAXA and Orwell, this innovation helps reduce fuel consumption and carbon emissions. As part of a pilot program, JAL has applied the coating to 30% of a 787-9 fuselage. On the Tokyo/Narita-Frankfurt route, this could save 119 tons of fuel annually, cutting CO2 emissions by 381 tons. Following successful trials on a Boeing 737-800, JAL is now expanding its use on long-haul aircraft. If proven effective, the airline plans to implement this technology across its fleet, reinforcing its commitment to net zero emissions by 2050.

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## Nayak Expands with Nordic MRO Acquisition

Nayak remains focused on European line and base maintenance rather than expanding into components and engines. The acquisition aims to enhance services in the Nordic region and across Europe. The new organization will operate under the name Nayak-LM Nordic AB, combining both companies' operations. Nayak's Düsseldorf facility, with an 8,500 m hangar, handles aircraft up to the size of an Airbus A330. Nordic MRO will add its expertise in ATR base maintenance, supporting airframe heavy maintenance demand expected to reach $120-140 million annually over the next decade.

Both companies provide line maintenance for various commercial aircraft, as well as airworthiness management and engineering services.

## GA Telesis Expands into Latin America with New Headquarters in El Salvador

GA Telesis has opened its new Latin America and Caribbean headquarters in San Salvador, aiming to expand business opportunities and MRO services in the region. Initially focused on component distribution and used serviceable material, the hub will also explore MRO services such as aircraft systems, landing gear, and auxiliary power units. CEO Abdol Moabery highlighted Latin America's rapid aviation growth, with a 31% increase in MRO demand expected over the next decade. The company plans to partner with OEMs to tackle supply chain challenges and may introduce Specialized Procedures Aeroengine Hospitals (SPAHs) for faster engine repairs. San Salvador was chosen for its skilled bilingual workforce and proximity to MRO provider Aeroman. Leading the expansion is Bosco Rico, newly appointed VP for Latin America and the Caribbean, who brings over 25 years of industry experience. GA Telesis is also eyeing regional technology talent to support its AI and blockchain initiatives, following the launch of its WILBUR platform and R&D Center in Turkey. Existing operations in Mexico City, São Paulo, and Santiago will now report to the San Salvador headquarters to enhance regional coordination.


## Airbus Delivers 62 Aircraft to 37 Customers in October

In October, Airbus maintained strong production momentum, delivering 62 aircraft to 37 customers worldwide. Single-aisle models dominated, with 56 deliveries. The A321neo led with 32 units delivered to airlines such as Jet2, Delta Airlines, and easyJet, followed by 14 A320neos for carriers like IndiGo and China Eastern. The A319neo saw two deliveries to China Southern and Tibetan Airlines. The A220 family contributed eight deliveries, including seven A220-300s to Air France, Breeze, and Delta Airlines, and one A220-100 to ITA Airways. Widebody deliveries included two A350s for Lufthansa and Japan Airlines, three A330neos for Corsair, Virgin Atlantic, and Delta Airlines, and one A330-200 for the Royal Saudi Air Force. These deliveries highlight Airbus' global reach and adaptability to customer needs.


## Delta commits to test new designs for Airbus wings

Delta Air Lines and Airbus have announced a partnership to develop advanced aerospace technologies, focusing on efficiency and sustainability. Unveiled on January 7 at the CES conference in Las Vegas, the collaboration highlights Delta's commitment to innovation in aviation. Delta, which operates about 480 Airbus aircraft and plans to acquire 200 more, will work with Airbus's UpNext unit on projects such as improved wing performance, fuel efficiency, superconductivity, and advanced aircraft systems. A key focus is Delta's involvement in Airbus's GEESE program, which tests fuel-saving techniques through jets flying in close formation, leveraging aerodynamic lift from leading aircraft. Delta will participate in the next phase of GEESE tests in late 2025, building on earlier trials with airlines like Air France and Virgin Atlantic. The partnership also includes joint efforts to expand sustainable aviation fuel (SAF) availability at Delta's Minneapolis-St. Paul hub, supporting both companies' goals for greener aviation.


## FEAM Aero in a New Era for Electric and Hydrogen-Powered Aircraft

FEAM Aero is expanding into advanced air mobility (AAM) by partnering with UrbanLink Air Mobility to support its electric vertical-takeoff-and-landing (eVTOL) fleet and other electric aircraft. UrbanLink's fleet, launching in April 2024, includes cutting-edge electric vehicles and plans for operations in the U.S. and Europe.

FEAM brings extensive infrastructure, including 50+ global stations, maintenance facilities, and a training program to prepare mechanics for electric and hydrogen-powered aircraft. Partnerships with SkyDrive and ZeroAvia further position FEAM as a leader in AAM maintenance and innovation, with plans for hydrogen production and support for next-generation aircraft. With its bold vision and strategic collaborations, FEAM Aero is shaping the future of sustainable aviation.

## BAE presents latest test success with the high-flying PHASA-35

BAE Systems has shared updates on its PHASA-35, a solar-powered, ultra-long-endurance aircraft developed by its subsidiary Prismatic, as it moves closer to operational deployment by 2026. During recent trials at Spaceport America in New Mexico and over the White Sands Missile Range, the PHASA-35 flew for 24 hours, reaching an altitude of over 66,000 feet and operating in the stratosphere. The uncrewed aircraft, weighing 150kg with a 35m wingspan, carried a BAE-developed software-defined radio payload, demonstrating its suitability for military intelligence, surveillance, and reconnaissance (ISR) missions. The tests were sponsored by the US Army Space and Missile Defense Command Technical Center. Prismatic CEO Bob Davidson called the trials a significant milestone, highlighting efforts to accelerate development. Meanwhile, BAE announced an upgraded PHASA-35 model with over double the solar power capacity, enabling extended and more complex missions starting next year. While primarily designed for military roles, the PHASA-35 has potential civilian applications, including communications, border security, and disaster relief, according to BAE.


## Emirates Receives Its First Airbus A350-900

Dubai-based Emirates (EK/UAE) has welcomed its first Airbus A350-900, a significant milestone in the airline's fleet expansion strategy. This aircraft is the first of 65 A350-900s ordered, which will support the establishment of a new "Mega Hub" at Dubai World Central (DWC) airport. Configured with a three-class cabin—32 business class, 21 premium economy, and 321 economy seats—the A350 also features Airbus' HBCplus satcom system, providing global connectivity. As the most modern and efficient aircraft in the 300-410 seat range, it can operate on a 50% SAF fuel blend, helping Emirates achieve its emissions goals. Powered by Rolls-Royce Trent XWB engines and featuring wings manufactured in North Wales, the A350 fleet will play a pivotal role in broadening Dubai's economic agenda, with plans to connect 400 cities to its trade map over the next decade.

## Italian Government Approves Piaggio Aerospace Sale to Baykar Technologies

The Italian government has approved the acquisition of Piaggio Aerospace by Turkish UAV manufacturer Baykar Technologies, ending the company's six years in extraordinary receivership. The sale includes all of Piaggio's assets and operations.

Baykar was chosen from three bidders after the Ministry of Business and Made in Italy determined its plan best serves Piaggio's creditors and employees. The acquisition aims to secure Piaggio's future, maintaining its workforce and production capabilities while revitalizing its industrial operations.

Baykar plans to expand its presence in the European aerospace market and has committed to strengthening Piaggio's aircraft production, engine maintenance, and component manufacturing activities. Financial terms of the deal were not disclosed.

Piaggio has been in financial distress since 2018 when its main shareholder, Abu Dhabi's Mubadala, withdrew support. Despite multiple failed attempts to find a buyer, this acquisition offers a clear plan for Piaggio's long-term recovery and growth.

## Vertical VX4 moves on to the flight-test plan's Phase 2B

Vertical Aerospace has entered Phase 2B of flight testing for its VX4 prototype, successfully performing piloted low-speed maneuvers at Kemble airfield in England. Chief test pilot Simon Davies conducted the January tests, which included roll, yaw, and spot-turn maneuvers, with speeds capped at 20 knots. Since its first flight in July 2024, the VX4 has progressed from hovering to low-speed operations, utilizing lift from its eight propellers. Vertical Aerospace is collaborating with the UK Civil Aviation Authority (CAA) to secure approval for Phase 3 wingborne flight tests. This phase will test manual control of the VX4's flight surfaces and forward rotors. The VX4, featuring advanced aerodynamics with flaps, flaperons, ailerons, and ruddervators, aims for certification and service entry by 2028. Future testing will evaluate transitions between thrustborne and wingborne flight modes at speeds of 40–75 knots. In preparation, the company has added test pilot Tim Eldridge to its team and anticipates the maiden flight of a second VX4 prototype, currently being completed by GKN Aerospace, in Q2 2025.


## Lufthansa Group Strengthens Fleet with Order for Five A350-1000s

On December 20, 2024, Lufthansa Group announced the purchase of five additional Airbus A350-1000 aircraft, increasing its total order for this type from 10 to 15. Valued at approximately $2 billion, these aircraft are set for delivery between 2028 and 2030. Currently, Lufthansa operates 28 A350-900s, with 47 more expected by 2031. The A350-1000, 73.8 meters long, offers about 15% more passenger capacity than the A350-900. Lufthansa plans to use these fuel-efficient twin-engine aircraft to replace older four-engine models, such as the Boeing 747-400 and Airbus A340 series. With this latest order, Lufthansa has now ordered 770 aircraft from Airbus, solidifying its status as the manufacturer's largest customer worldwide.

## Jeju Air Boeing 737-800 Aircraft Crashes While Landing at Muan: 179 Dead

Jeju Air's Boeing 737-800, operating as flight 7C2216 from Bangkok, Thailand, crashed while attempting to land at Muan International Airport on the morning of December 29, 2024. Initially, rescue teams reported that one passenger and one crew member survived, found in the tail section of the aircraft. By 21:00, 12 hours after the accident, authorities confirmed the deaths of 179 people. Two crew members were rescued and taken to hospitals in Seoul.

### Investigation into the Cause of the Crash

According to local transportation officials, the pilots made a Mayday call to Air Traffic Control after a bird strike. BBC reports that the bird strike occurred while the aircraft was attempting to land, and the pilots communicated with ATC, who then directed the plane to land from the opposite direction. The aircraft attempted to land but was unable to deploy its landing gear. After landing without the gear, it skidded and collided with a wall. The pilot in the cockpit has over 9,800 flight hours and has been in the position since 2019.

# Air Canada DH8 Plane Crash Land and Catches Fire

Landing gear is crucial for ensuring an aircraft's safe takeoff and landing. A malfunction can prevent the aircraft from landing smoothly and lead to serious safety risks. If landing gear fails, the aircraft can become uncontrollable, skid on the runway, or result in fire hazards. Following recent news of a South Korean plane crashing during landing, another alarming incident occurred when an Air Canada DH8-400 aircraft landed with a broken landing gear at Halifax Stanfield International Airport on Dec 29, 2024. The plane, traveling from St. John's to Halifax, scraped its left wing on the runway during landing, sparking a fire. Passenger Nikki Valentine described the dramatic moments, saying, "We heard a loud crash as the wing scraped the pavement, and we started seeing fire on the left side of the plane." Videos clearly showed the aircraft scraping the runway and sparking a fire. Fortunately, none of the 73 passengers and crew members on board were injured. This event marks the latest example in a series of aviation accidents in Halifax. Previous incidents, including those in 1965, 1998, and 2015, highlight Halifax's place in aviation history. For instance, in 1998, Swissair Flight 111 veered off course due to smoke in the cockpit but crashed into the ocean before reaching Halifax, killing 229 people. This event in Halifax emphasizes the importance of regular maintenance for landing gear systems and the readiness of airports' emergency response capabilities. The functionality of landing gear systems is critical not only for aircraft maintenance teams but also for passenger safety.


## Pegasus Airlines Orders 200 Aircraft from Boeing:
# A Surprise 737 for Turkey's Youngest Fleet

Turkish low-cost carrier Pegasus (FlyPGS) has made a historic deal with US manufacturer Boeing, placing an order for 200 aircraft to strengthen its fleet in line with its growth strategy. The order consists of a firm purchase of 100 Boeing 737 Max 10s and an additional 100 options for more Max 10s. Deliveries of the first aircraft are expected to begin in 2028. With an average fleet age of 4.5 years, Pegasus currently operates the youngest fleet in Turkey and ranks among the youngest fleets globally. Pegasus CEO Güliz Öztürk stated that, following the pandemic, the airline has contributed to Turkey's target of attracting 100 million visitors and generating 100 billion USD in tourism revenue by achieving record growth in the tourism sector.

## Tragedy Over the Caspian:
# Passenger Flight Struck by Missiles, Investigation Underway

The flight, en route from Baku to Grozny, was struck by three surface-to-air missiles that caused critical damage to its flight controls. Despite the pilots' efforts to manage an emergency landing across the Caspian Sea, the aircraft broke apart on impact and caught fire. Remarkably, 29 passengers survived, with many recounting hearing three loud explosions before the aircraft lost control. Crash site investigations revealed shrapnel damage to the tail and elevators, corroborating survivors' accounts.

The Kremlin released a rare statement expressing deep condolences and wishing a speedy recovery to the injured. While stopping short of directly admitting responsibility, Russian authorities cited active air defenses in the region due to ongoing attacks by Ukrainian drones. Officials also suggested that electronic countermeasures may have interfered with the plane's guidance systems.


## Robinson Helicopter Advances Safety and Efficiency with New Upgrades and Training

Helicopter's improved empennage for the R22, R44, and R66 models. The new empennage, featuring a symmetrical horizontal stabilizer and tailcone, enhances flight safety and roll stability, particularly during high-speed flights. This upgrade is now standard on new Robinson models and is available as a retrofit option. Following FAA approvals, Robinson has delivered 250 new helicopters and over 700 retrofit kits, with a discounted price of $3,600 for the retrofit kits through December 2025. Additionally, the service life of the R22 and R44 main rotor blades has been extended from 12 to 15 years. In 2025, three new training courses will be introduced: R66 Transition, Avionics and Autopilot Familiarization, and Post-Maintenance Procedures. These courses aim to equip pilots with the skills necessary to safely and effectively perform post-maintenance flights. These advancements strengthen Robinson Helicopter's commitment to enhancing flight safety and operational efficiency.

## Tragic DHL Cargo Plane Crash Near Vilnius: **Investigation Underway**

On November 25, 2024, a DHL Boeing 737 cargo plane en route from Leipzig to Vilnius Airport (VNO) crashed near Liepkalnis Hill while approaching the runway. The aircraft struck a two-story residential building at 05:28 local time, causing a fire. Emergency teams, including Vilnius Airport's fire brigade, responded promptly. One pilot was rescued with injuries, and two of the four on board received medical attention. Unfortunately, one person lost their life. The cause remains unknown, but ATC recordings show the crew was in contact with controllers before the crash. Despite being cleared to land, the crew did not respond to ATC.


## TUI Fly Belgium Boeing 737 Nose Landing Gear Collapses at Brussels Airport

On Wednesday, January 8, 2025, a Boeing 737 operated by TUI fly Belgium (TB) suffered a collapse of its nose landing gear while parked at Brussels Airport. The incident occurred after TUI Airways' flight TB1012 arrived from Málaga (AGP), Spain. The airline has announced that an investigation is underway to determine the cause of the incident. The incident occurred after the aircraft's mobile airstairs were removed. According to witnesses, all doors were initially secured during departure preparations, but a flight attendant mistakenly reopened one of the main boarding doors, causing the crew member to fall from the aircraft. The Airport Ambulance Service responded quickly to the situation, and the injured crew member was taken to Queens Medical Centre in Nottingham for treatment. The UK's Air Accidents Investigation Branch (AAIB) has launched an investigation into the incident.


## Lufthansa Technik and Microsoft Forge Partnership to Revolutionize AI in MRO

Now, the MRO industry is going to see a sea change with Lufthansa Technik teaming up with Microsoft to lead from the front in integrating artificial intelligence into aircraft maintenance processes. In this strategic collaboration, the Azure AI Services and cloud platform by Microsoft are being put to work for more than 50 AI-driven use cases, targeting complex challenges and redefining MRO efficiency. The partnership is a cornerstone of Lufthansa Technik's "Digitize the Core"-a vision to revolutionize its core operations with clearly advanced digital technologies. The initiative aims at enhancing service delivery by smoothing workflows and introducing cutting-edge solutions that set new benchmarks in MRO excellence. Dr. William Willms, the Chief Financial Officer of Lufthansa Technik, underlined the transformative power of this deal: "The collaboration enables us to tap the power of AI in solving complex challenges, further improving operations, and bringing additional value to our customers.". Sample key use cases are optimizing layover planning, where AI is expected to reduce aircraft time on the ground by 5-10%, saving operators much money. Equipping it with LLMs and memory-enabled cognitive architecture will empower Lufthansa Technik to handle immense volumes of data-from technical instructions and images toward extracting actionable insights and automating such complex tasks. This AI-driven approach ensures not only a boost in efficiency but also an improvement in the accuracy and reliability of the processes involved in maintenance. As this partnership develops, it will certainly set new standards for MRO and push faster, cost-effective, innovative solutions in aviation. The collaboration of Lufthansa Technik with Microsoft underlines that AI is going to be the future of MRO and will open doors toward a more digitally advanced aviation ecosystem.


## Swiss Flight Attendant Dies After Emergency Landing Incident

A flight attendant for Swiss International Air Lines has died a week after the jet was forced to land in Austria over smoke filling the cabin and cockpit. The December 23 flight from Bucharest to Zurich diverted to Graz, where 74 passengers safely evacuated from the Airbus A220-300. One of the two crew members who were hospitalized after the incident died Monday in intensive care, the flight attendant. Swiss confirmed that all passengers who required medical attention have since been discharged.


## Wizz Air strikes deal with P&W as many aircraft remain grounded

Hungarian low-cost carrier Wizz Air, together with its UK subsidiary Wizz Air UK, has reached an agreement with Pratt & Whitney due to engine issues that have caused many of its aircraft to remain grounded. The issues are affecting Wizz Air's A320neo aircraft powered by Pratt & Whitney PW1100G-JM engines, with approximately 40 of these aircraft expected to stay grounded throughout 2025, and possibly into 2026. The agreement with Pratt & Whitney includes a support package to facilitate the necessary engine inspections, as well as compensation for the downtime of the aircraft. In a statement, the airline said, "The company continues to take proactive measures to minimize the financial and operational impact of grounded aircraft and will continue working with Pratt & Whitney to ensure the aircraft return to service as quickly as possible." Wizz Air has removed about 1,000 engines from its Airbus fleet for inspection for microscopic cracks. Despite the ongoing challenges, the airline still plans to add 50 more A320neo family aircraft to its fleet in the next 18 months. The issues have impacted the airline's financial performance, leading to lower-than-expected growth in 2024. However, the airline expects to return to a growth trajectory by 2026, with a 20% increase in seat capacity during this period.

M.Murat BAŞTÜRK
Part -147 Type Training Instructor

# HUMAN FACTORS IN AIRCRAFT MAINTENANCE: UNDERSTANDING AND MANAGING ERRORS

**Aviation is one of the industries where safety must be maintained at the highest level. Modern aircraft are complex engineering marvels consisting of thousands of components, and each element must operate according to the highest safety standards. Additionally, ensuring safe and uninterrupted operations involves intricate maintenance processes. However, ensuring the safe operation of aircraft depends not only on technological systems but also on the people responsible for maintenance, repair, and inspection processes.**

Human factors play a crucial role in aircraft maintenance. Maintenance technicians, engineers, and inspectors play a critical role in ensuring that aircraft meet operational requirements. Errors in aircraft maintenance do not only pose technical and operational risks but also result in significant economic losses. Engine failures, maintenance-related flight delays, and cancellations can cost airlines millions of dollars. So, how can we reduce human errors in maintenance processes and enhance safety? In an era of rapidly advancing technology, how can we integrate traditional maintenance practices with cutting-edge innovations?

This article examines the role of human factors in aviation maintenance, the most common types of errors, methods used to manage these errors, and how emerging technologies are being integrated into maintenance processes.

**The Importance of Human Factors in Aircraft Maintenance**

Human factors in aircraft maintenance analyze how technicians are affected by physical, psychological, and environmental conditions and how these factors impact their job performance. Maintenance processes often require technicians to work meticulously on complex systems under time constraints.

According to the Federal Aviation Administration (FAA), human errors in aircraft maintenance directly contribute to approximately 15% of aviation accidents. Studies conducted by the International Civil Aviation Organization (ICAO) indicate that a significant portion of these errors is directly linked to stress and time pressure experienced by maintenance technicians. The urgency of completing tasks on time can lead to overlooked procedures.

For example, in a Boeing study analyzing 122 maintenance errors, the errors were categorized into four main types:

1. **Omissions:** Skipping or forgetting a required maintenance step.
   - **Example:** A step in a test card being missed during maintenance, leading to unreliable results.

2. **Improper Installations:** Incorrect or incomplete installation of components.
   - **Example:** A missing washer on a bolt during a modification, causing extended parts to create damage.

3. **Wrong Parts:** Installing the wrong component or using a part incompatible with the aircraft model.
   - **Example:** Installing an incorrect component in an aircraft engine.

4. **Other Factors:** Incorrect documentation, procedural misapplication, and poor communication.
   - **Example:** Inadequate information transfer during shift changes, leading to major maintenance errors.

Another study categorizes human errors in aircraft maintenance into three main types based on technicians' knowledge and skill levels:

- **Skill-based errors (48%)**

Errors occurring due to routine tasks becoming automatic.

**Example:** An experienced technician assuming a different procedure is identical and performing the steps incorrectly.

- **Rule-based errors (28%)**

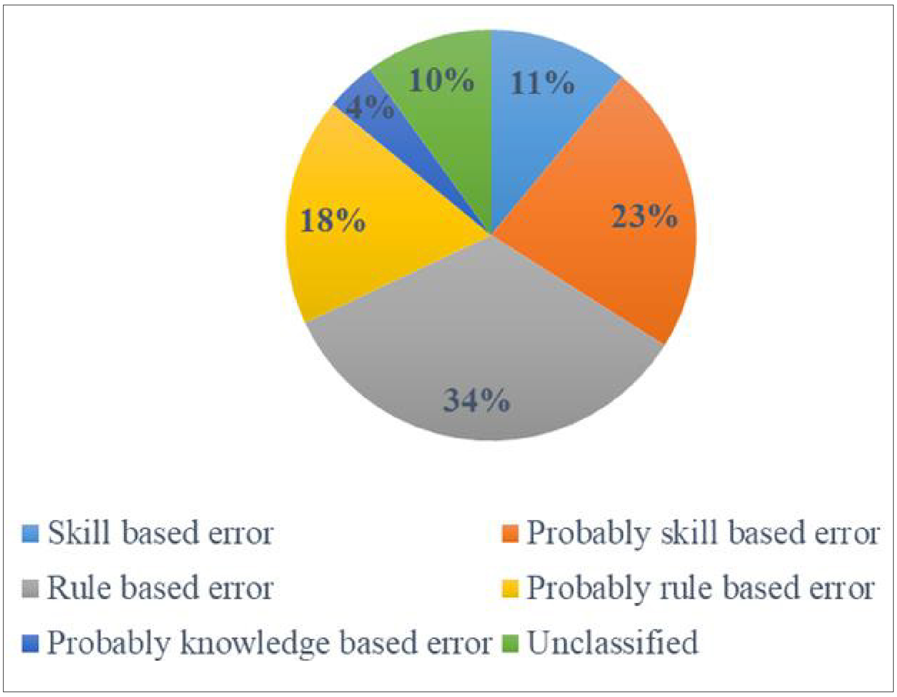
Misapplying procedures or following incorrect rules.

**Example:** A technician not using the proper tool for component replacement.

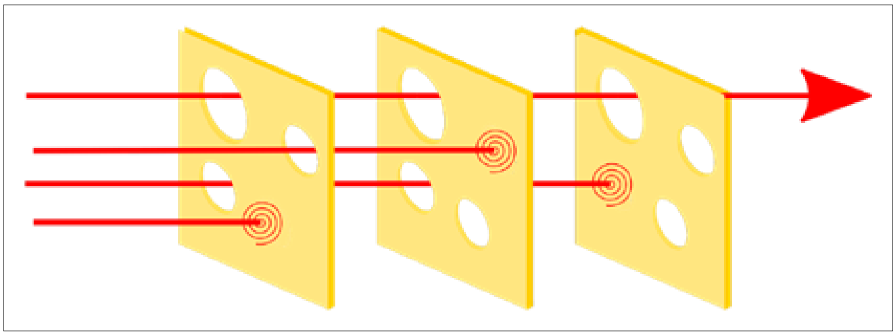
- **Knowledge-based errors (24%)**

Mistakes due to lack of experience or training.

**Example:** An experienced technician working on a new aircraft model without proper training, relying solely on past experience.




Australian Transportation Safety Board (ATSB)



These classifications demonstrate that most maintenance errors originate from human factors and are largely preventable.

Many of these errors are due to improper working conditions, shift changes, fatigue, and lack of communication.

In addition, James Reason's "Swiss Cheese" model, which classifies errors in more detail, shows that accidents are often caused by a combination of many small errors. Although there are many lines of defense in the system, mistakes can have serious consequences due to vulnerabilities in these lines of defense.

**Accidents and Economic Impacts of Human Factors**

Some of the largest aviation accidents in history were caused by maintenance errors:

**American Airlines DC-10 Crash (1979)**

On May 25, 1979, an American Airlines McDonnell Douglas DC-10 lost its left engine and pylon during takeoff from Chicago O'Hare Airport, leading to a crash. The root cause was a maintenance shortcut—instead of removing the engine and pylon separately, the maintenance crew removed them as a single unit to save time. This caused microscopic cracks in the pylon attachment points, which later failed during flight. 273 people lost their lives.

**Japan Airlines Flight 123 (1985)**

On August 12, 1985, a Japan Airlines Boeing 747 suffered a structural failure and crashed into a mountain, killing 520 people. The accident was caused by a faulty repair in 1978. Instead of following Boeing's recommended repair procedure, a faster but incorrect repair was performed. Seven years later, metal fatigue led to the failure of the cabin pressure bulkhead, causing a loss of control.

**Southwest Airlines Flight 1380 (2018)**
On April 17, 2018, a Southwest Airlines Boeing 737 suffered an engine failure en route from New York to Dallas. A fan blade, weakened by metal fatigue, detached and struck the fuselage, shattering a window. A passenger was partially ejected and lost her life. The root cause was the failure to detect metal fatigue during maintenance inspections.

These incidents show how critical human factors are in aviation maintenance and that mistakes can have serious consequences. According to a cost analysis by Boeing, engine failures caused by maintenance errors cost an average of $500,000 per incident. In addition, delays caused by aircraft maintenance errors cost airlines an average of $10,000 per hour.

**Methods of Preventing and Managing Errors in Aviation**
Various strategies and programs have been developed in the aviation industry to minimize human errors and increase operational safety and efficiency. We can list them as follows.

**1. Reactive Error Management (Result-Oriented Approach)**
Reactive error management aims to analyze the errors and accidents that occur and to take measures to prevent similar incidents in the future. This approach involves making systematic improvements by learning from past events.

The main reactive error management tools are:

- **Accident and Incident Investigation Boards:** National and international aviation authorities examine accidents and serious incidents in detail, conduct root cause analyzes and publish safety recommendations.
- **Error Reporting Systems:** These are the systems that enable aviation personnel to report errors voluntarily or compulsorily. These reports are analyzed within the framework of confidentiality principles and help to identify systematic problems.
- **Internal Audit and Review:** Aviation enterprises regularly review their operational processes and procedures, detect errors and take corrective measures through their internal audit mechanisms.

**2. Proactive Error Management (Preventive Approach)**
Proactive error management encompasses strategies to prevent failures before they occur. This approach focuses on the early identification and elimination of potential risks and hazards.

The main methods applied within the scope of proactive error management are as follows:

- **Risk Assessment and Management:** Potential risks in operational processes are identified, analyzed and reduced to acceptable levels. This process involves a cycle of continuous monitoring and improvement.
- **Training and Awareness Programs:** Raising awareness and training of staff on human factors is one of the cornerstones of proactive error management. Trainings enable staff to recognize and prevent potential mistakes.
- **Promotion of Communication and Teamwork:** Effective communication and teamwork play a critical role in preventing mistakes. Creating clear communication channels ensures that team members work in harmony with each other.

**3. Maintenance Resource Management (MRM)**
Maintenance Resource Management (MRM) is a training and management program developed to reduce human errors in aircraft maintenance processes. MRM aims to improve team communication, leadership, situational awareness and decision-ıaking processes.

he key components of the MRM rogram are:

**Intra-Team Communication:** Effective communication increases the coordination of maintenance teams and helps prevent mistakes.

**Leadership and Decision Making:** Leadership skills and correct decision-making processes increase the effectiveness of maintenance operations.

- **Situational Awareness:** The ability of staff to accurately assess the current situation and anticipate potential risks is critical in preventing mistakes.

- **Stress and Fatigue Management:** Stress and fatigue can negatively affect human performance. MRM offers strategies for managing these factors.

**4. Human Factors Analysis and Classification System (HFACS)**
HFACS is a model developed to analyze and classify human errors. This system examines errors at four main levels:

1. **Safety Culture and Organizational Factors:** The organization's general understanding of security, policies and procedures.

2. **Audit and Management Practices:** Audit and control mechanisms of the management level.

3. **Environmental and Situational Factors:** Working environment, equipment condition and environmental conditions.

4. **Individual Mistakes:** Individual mistakes of the staff, such as lack of knowledge, inexperience, or carelessness.

The implementation of HFACS helps organizations better understand the root causes of human errors and take preventative measures accordingly.

**5. Technological Support and Automation**
With the development of technology, various automation and support systems have been developed to reduce human errors in maintenance processes. These systems provide guidance to maintenance personnel and help detect potential errors in advance.

**Prominent technological supports include:**
**Digital Maintenance Manuals and Checklists:** Traditional paper-based maintenance manuals and checklists are based on manual processes that are prone to human error. Digitalization offers a huge opportunity to make maintenance processes more reliable. Electronic maintenance manuals ensure technicians have access to the most up-to-date procedures and prevent the use of incorrect documentation. Digital systems integrated with mobile tablets and smart devices in aviation allow maintenance records to be kept accurately. Aircraft manufacturers and airlines use these systems to avoid the wrong selection of components or procedures.

**For example;** Lufthansa Technik and Boeing are expanding electronic maintenance management systems (e-Maintenance Systems), which allow technicians to digitally control every maintenance step. Thanks to these systems, the use of wrong parts or incomplete maintenance procedures are detected and warnings are given.

**Augmented Reality (AR) and Virtual Reality (VR) Based Training:** One of the biggest challenges for aviation maintenance technicians is being able to repair complex systems without errors and quickly adapt to new aircraft models. Augmented reality (AR) and virtual reality (VR) help technicians manage these processes more efficiently and accurately. AR-based maintenance systems enable technicians to accurately repair complex components with live guidance. VR simulations make it possible for

technicians to learn maintenance procedures without risk and practice before making mistakes in the real world. For example; Airbus and Boeing have developed VR-based training systems for maintenance technicians. Airbus' "HoloLens" project provides technicians with real-time AR-powered maintenance processes, minimizing errors.

**Artificial Intelligence (AI) Assisted Maintenance and Predictive Maintenance:** Artificial intelligence and big data analytics offer innovations that can revolutionize aircraft maintenance. Traditional maintenance methods are usually based on reactive or scheduled maintenance, but predictive maintenance reduces the risk of errors by ensuring that components are replaced before they fail. Sensors predict maintenance requirements by collecting real-time data from engines, hydraulic systems, and flight computers. AI-based analytics guide technicians by identifying maintenance requirements and prevent misdiagnoses. For example; Rolls-Royce's "Engine Health Monitoring" system analyzes the operating data of aircraft engines, predicts potential failures in advance and reports them to airlines, GE Aviation and Pratt & Whitney have developed artificial intelligence-supported engine analysis systems, increasing the prediction rate of failures by 30%

**Robotics and Automated Fault Detection Systems:** Robots are increasingly being used to minimize human-induced maintenance errors. In particular, unmanned aerial vehicles (drones) and climbing robots are used to identify cracks, paint abrasions and structural defects on aircraft surfaces that are difficult to detect with the naked eye. Drones can scan airframes to detect surface damage and paint wear. Autonomous robots can perform inspection of complex parts such as landing gear and engine components.

**For example,** Airbus has developed an AI-powered system that automatically examines airframes with advanced maintenance drone systems. Magnetic climber robots developed by Invert Robotics have reduced maintenance times by 50% by detecting cracks in areas that technicians cannot reach.

**Blockchain-Based Maintenance Records:** Blockchain technology is used to ensure that aircraft maintenance records are secure and immutable. In traditional maintenance record systems, it is possible for records to be altered or updated with incorrect information, but blockchain-based systems reduce the risk of errors by making the maintenance history transparent and secure. All maintenance operations are stored in encrypted and verifiable blocks. Airlines can prevent transactions with incorrect information by detecting erroneous records in maintenance processes. Honeywell Aerospace has announced that it has reduced transcription errors by 40% by storing the maintenance history of aircraft components in a blockchain-based system.

New technologies and error management systems developed to minimize human errors in aviation maintenance make the industry safer and more efficient. Digitalization, artificial intelligence, augmented reality, and automation technologies are among the most important tools to help prevent errors caused by human factors. In the coming years, blockchain-based maintenance records, predictive maintenance systems, and robot-assisted inspections will become widespread in the aviation maintenance industry, greatly reducing human errors.

**References:**

Hobbs A. An Overview of Human Factors in Aviation Maintenance (AR-2008-055). 2008. Retrieved from

https://www.atsb.gov.au/media/27818/hf_ar-2008-055.pdf.

International Civil Aviation Organization. (ICAO). Human Factors in Aircraft Maintenance and Inspection

(Circular 253-AN/151). 1995. Retrieved from mid.gov.kz/images/stories/contents/253_en.pdf.

National Transportation Safety Board (NTSN). Aircraft accident report of Continental Express flight #2574 (Tech. Rep. No. NTSB/AAR-92/04). 1992.

https://www.clickmaint.com

Boeing, Air Transportation Association (ATA). Industry Maintenance Event Review Team. The Boeing Company, Seattle, WA: Boeing; 1995.

Olaganathan, R. (2024). Human factors in aviation maintenance: understanding errors, management, and technological trends. Global Journal of Engineering and Technology Advances, 18(2), 92.

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# THE NECESSITY OF EFFECTIVE USE OF TROUBLESHOOTING MANUALS BY AIRCRAFT MAINTENANCE TECHNICIANS TO SOLVE AIRCRAFT SYSTEM FAILURES

**Troubleshooting Manual (TSM) is a technical guide used by Aircraft Maintenance Technicians (AMTs) to systematically identify and resolve issues in aircraft systems. It offers step-by-step instructions, flowcharts, and tests for diagnosing and repairing problems in mechanical, electrical, avionics, and hydraulic systems. These manuals are crucial for ensuring accurate fault isolation, safety, and compliance with regulations.**

**What is Troubleshooting?**
A troubleshooting manual (TSM) is a technical document that aircraft maintenance technicians (AMTs) use to systematically find, identify, and fix problems in aircraft systems. It provides step-by-step instructions for isolating problems, flowcharts, and tests to help technicians efficiently identify and repair issues in mechanical, electrical, avionics, and hydraulic systems. Aircraft Maintenance Technicians (AMTs) rely on Troubleshooting Manuals (TSMs) or Fault Isolation Manuals to efficiently diagnose and resolve technical issues in aircraft systems. These manuals are essential because they provide a structured, step-by-step approach to identifying and fixing faults, ensuring safety, accuracy, and regulatory compliance.

**Steps of the Troubleshooting Process for Aircraft Maintenance Technicians**
The troubleshooting process follows a systematic approach to identify and resolve aircraft malfunctions. Here are the essential steps:

**Identify the Problem ➾** Gather information from pilots, maintenance logs, and fault messages.

**Understand the System ➾** Review aircraft manuals (AMM, TSM, FIM) and system schematics.

**Collect Data ➾** Use diagnostic tools, Built-In Test Equipment (BITE), and Centralized Fault Display System (CFDS) messages.

**Analyze Possible Causes ➾** Narrow down the issue by checking related components and previous occurrences.

**Develop a Troubleshooting Plan ➾** Follow logic trees, decision-making flowcharts, and system tests.

**Test and Verify the Fault ➾** Conduct system tests and isolate the faulty component.

**Apply the Corrective Action** ➾ Repair or replace the defective part.

**Verify the Solution** ➾Perform operational tests to ensure the issue is resolved.

**Document the Process** ➾ Record findings, corrective actions, and test results for compliance and future reference.


**Airbus and Boeing Concept**
Aircraft manufacturers publish documents that must be kept up to date for important tasks such as aircraft maintenance and repair. Airbus uses the Troubleshooting Manual to solve problems in aircraft systems, while Boeing uses the Fault Isolation Manual. For instance, The Airbus Aircraft Family's maintenance philosophy is based on the Centralized Fault Display System (CFDS) and Troubleshooting Manual (TSM). It consists of two levels: component replacement and troubleshooting at line and main base.

The Centralized Fault Display System (CFDS) is designed to simplify maintenance tasks by showing fault messages in the cockpit and allowing the flight crew to perform specific tests. The CFDS directly monitors and diagnoses problematic Line Replaceable Units (LRUs) in aviation systems, displaying the identified items to the maintenance crew. This is accomplished primarily through an analysis of all cockpit events generated by aircraft system monitoring. The CFDS additionally assists in preventing improper equipment removals by doing a detailed analysis to identify the responsible LRUs.

On the other hand, The Boeing Standard Fault Isolation Practices describe the processes and principles used to identify and eliminate defects on Boeing aircraft. This is typically described in a Fault Isolation Manual (FIM). The FIM is a valuable tool for maintenance staff because it provides a methodical approach to troubleshooting and isolating issues in the aircraft's systems and components. It is designed to guide the technician from the general problem to the specific faulty component by following a logical troubleshooting process.

Boeing has created an Interactive Fault Isolation Manual (IFIM) to make it easier to discover and fix defects. This interactive manual is part of Boeing's continued commitment to providing efficient and effective solutions for aircraft troubleshooting and maintenance. The IFIM is a web-based program that makes it easier to discover the appropriate fault isolation task for a specific defect and then displays it in an easy-to-follow format.W

**Key Reasons Utilizing TSM or FIM During Aircraft Maintenance**

**Airworthiness and Safety**
Aircraft safety is the most important thing in aviation and these manuals help AMTs ensure that all systems function correctly. By following the TSM, technicians can systematically diagnose and eliminate faults before they cause serious problems. TSMs

| Feature | Airbus Troubleshooting Manual (TSM) | Boeing Fault Isolation Manual (FIM) |
|---|---|---|
| **Purpose** | Guides AMTs in diagnosing and troubleshooting aircraft faults | Provides fault isolation procedures for identifying faulty components |
| **Aircraft Manufacturer** | Airbus (A320, A330, A350, A380, etc.) | Boeing (737, 747, 777, 787, etc.) |
| **Methodology** | **Symptom-based troubleshooting (**Technician starts with a malfunction symptom and follows structured steps to identify the fault**)** | **Fault-based troubleshooting (**Technician follows a fault code and logic tree to isolate the faulty component**)** |
| **Decision-Making Process** | **Step-by-step fault isolation flowcharts** | **Logic trees and decision trees** |
| **Fault Codes Reference** | Uses **Centralized Fault Display System (CFDS)** and **Built-In Test Equipment (BITE) messages** | Uses **Central Maintenance Computer (CMC)** and **BITE system messages** |
| **Integration with Digital Systems** | **AIRMAN Web, e-TSM, Skywise Predictive Maintenance** | **Boeing Maintenance Toolbox, Airplane Health Management** |
| **Regulatory Compliance** | Follows **EASA, FAA, ICAO** guidelines | Follows **FAA, EASA, ICAO** guidelines |
| **Predictive Maintenance** | Uses **AI and big data analytics** via **Skywise** to predict potential failures before they happen | Boeing's **AHM v.2 system** integrates predictive maintenance for proactive fault isolation |
| **Tablet/EFB Integration** | e-TSM is available on **Electronic Flight Bags (EFBs) and tablets** for real-time troubleshooting | Boeing FIM is **digitized in the Boeing Maintenance Toolbox**, accessible via EFBs |
| **Technician Skill Level Requirement** | Requires **more interpretation and system knowledge** to analyze interactions | Provides **more direct guidance**, making it easier for less experienced AMTs |

provide verified procedures that minimize the risk of incorrect repairs that could compromise safety ensuring proper repairs. Aviation authorities (FAA, EASA, ICAO) require maintenance procedures to follow standardized troubleshooting guidelines to maintain airworthiness.

**Systematic Approach to Fault Diagnosis**

Aircraft are complex machines with thousands of interconnected systems. Troubleshooting manuals help AMTs follow a logical process to find and fix faults efficiently. TSMs provide flowcharts, fault isolation procedures, and guided tests to narrow down the root cause of a malfunction enabling step-by step troubleshooting. Instead of guessing or using trial and error, AMTs can methodically rule out possible causes, saving time and effort, in other words, efficient problem-solving. Following structured troubleshooting procedures ensures that AMTs do not overlook critical details or make costly mistakes.

**Reducing Aircraft Downtime and Maintenance Costs**

Airlines and operators aim to keep aircraft operational and minimize the time spent on maintenance. TSMs contribute to achieve this by streamlining troubleshooting processes. By following the TSM, technicians can quickly determine the issue, reducing delays in getting the aircraft back in service. Proper troubleshooting prevents the unnecessary replacement of components, which can be costly and time-consuming. AMTs can efficiently allocate manpower, tools, and spare parts by using the TSM's guidance to target the actual issue and thus optimizing resource use.

**Improving Technician Efficiency and Knowledge**

TSMs serve as an essential learning resource for both new and experienced AMTs. By using TSMs regularly, technicians improve their diagnostic abilities and troubleshooting efficiency. Aircraft manufacturers update TSMs regularly to incorporate new technologies and troubleshooting methods. Many aviation maintenance training programs use TSMs to teach technicians standardized troubleshooting techniques.

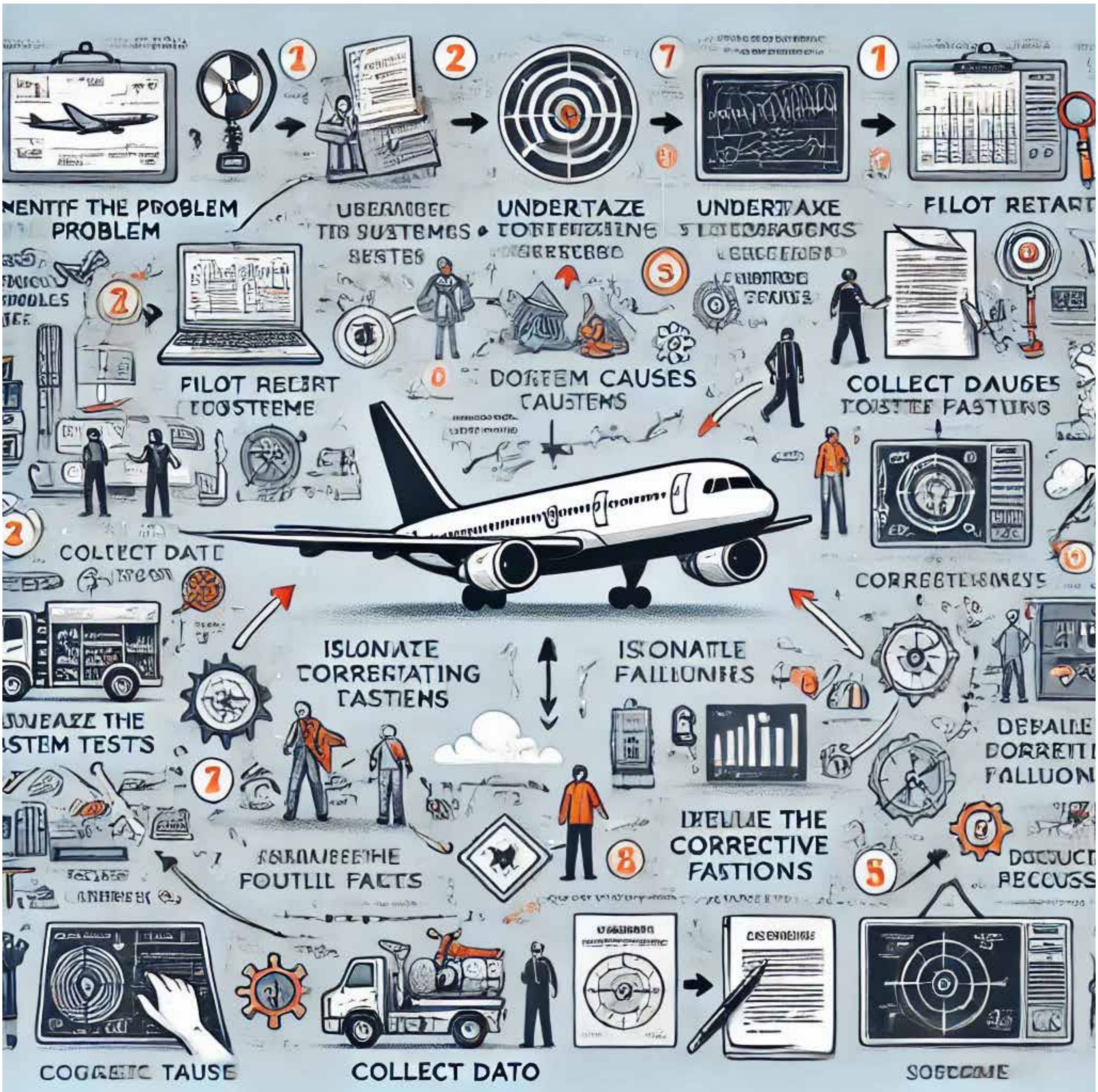
**Supporting Preventive and Predictive Maintenance**

Troubleshooting manuals enables AMTs detect early signs of potential failures, enabling proactive maintenance. By analyzing historical fault data in TSMs, technicians can address underlying issues before they cause significant problems so preventing future failures. Proper troubleshooting reduces repeat failures, improving overall aircraft performance and reliability. TSMs encourage AMTs conduct predictive maintenance by identifying trends and common failure points reducing unscheduled maintenance.

**Complementary Factors Using These Manuals in Operation**

**Assisting in Troubleshooting Complex Systems**

Modern aircraft have advanced avionics, fly-by-wire controls, and automated diagnostic systems that require precise troubleshooting techniques. Many aircraft have self-diagnostic systems that provide error codes by using Built-In Test Equipment (BITE). TSMs aids technicians interpret these codes and determine corrective actions. A failure in one system can affect others in interconnected system analysis. TSMs provide AMTs understand system interdependencies and locate faults efficiently.




The manuals guide technicians on how to use specialized diagnostic tools such as multimeters, oscilloscopes, and hydraulic testers for accurate diagnosis.

**Enhancing Regulatory Compliance**

Aviation maintenance is strictly regulated by organizations like the FAA (Federal Aviation Administration) and EASA (European Union Aviation Safety Agency). Airlines and maintenance providers must follow approved procedures outlined in TSMs to maintain compliance to meet legal requirements. Many TSMs include documentation guidelines that ensure accurate maintenance recording of faults and repairs, which is essential for audits and inspections. Failure to follow correct troubleshooting procedures can result in fines, legal action, or loss of maintenance certification so this avoids regulatory penalties.

**Standardizing Maintenance Procedures**

Aircraft manufacturers, such as Boeing, Airbus, and Embraer, develop Troubleshooting Manuals to ensure all AMTs follow the same diagnostic procedures worldwide. Regardless of location, all technicians use the same structured approach to troubleshooting, ensuring reliable results. TSMs are created based on extensive testing and engineering data, ensuring that AMTs follow the correct procedures. Standardized troubleshooting steps creates easy communication among technicians across different shifts or locations understand and continue the work seamlessly.

### Qualifications Required for Aircraft Maintenance Technicians to Use Troubleshooting Manuals

To properly utilize these manuals, AMTs must possess a combination of education, certification, practical experience, technical skills, and soft skills.

**Educational Background**

A strong educational foundation is crucial for AMTs to understand aircraft systems and troubleshooting procedures. The minimum educational requirement is typically a high school diploma or its equivalent, with a focus on mathematics, physics, and technical subjects. Many AMTs further their education by attending an aviation maintenance program at an FAA- or EASA-approved school (especially PART-147 Basic Training), where they receive structured training in areas such as: Aircraft structures and aerodynamics, Powerplant systems (engines and propulsion), Avionics and electronic systems, Hydraulic, pneumatic, fuel systems etc. These programs equip AMTs with theoretical knowledge and practical experience in maintaining and troubleshooting aircraft.

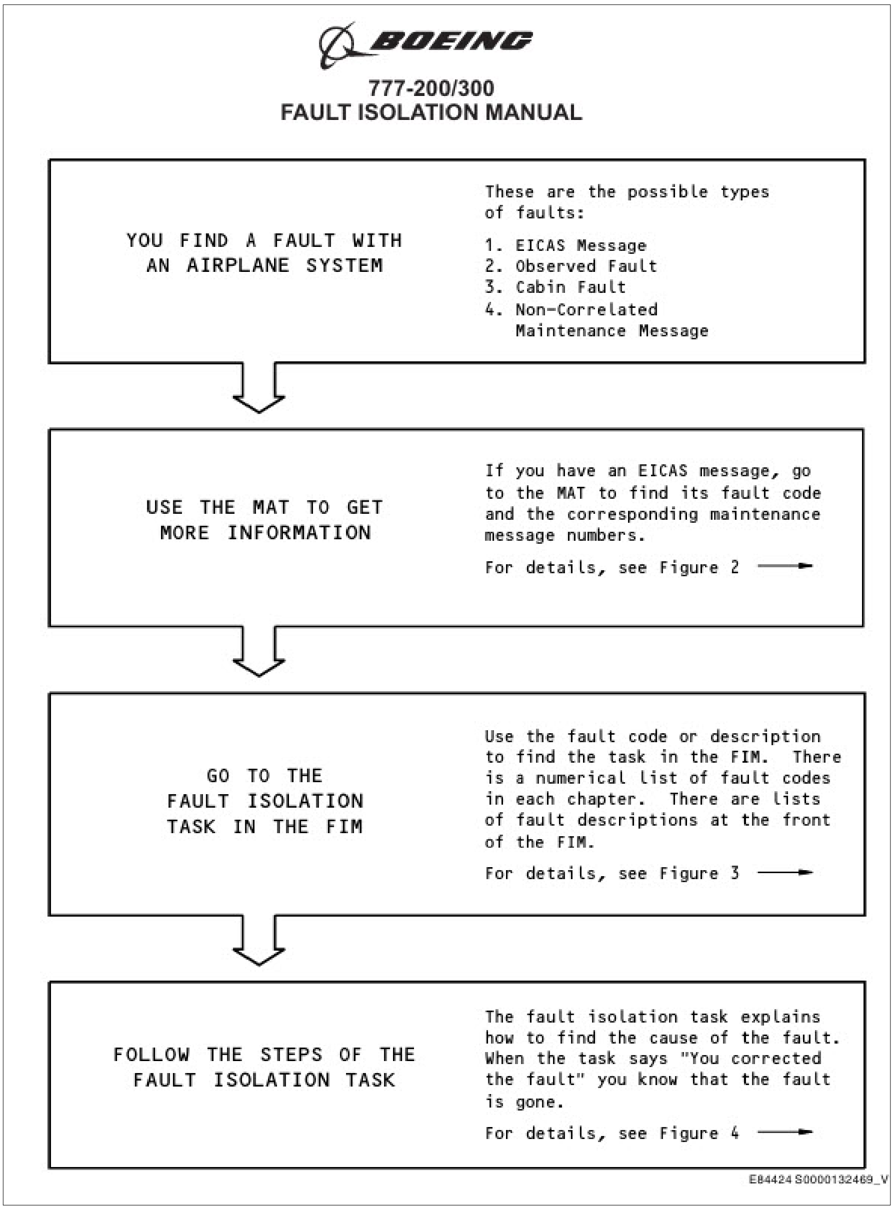
**Certifications and Licensing**

To work as an AMT and use troubleshooting manuals effectively, technicians must obtain the necessary certifications and licenses. These certifications ensure that AMTs meet industry standards and regulatory requirements. The primary certifications include:

FAA Airframe and Powerplant (A&P) Certificate required in the U.S., qualifies AMTs to perform maintenance, inspections, and repairs on aircraft systems.

EASA Part-66 License: In Europe, AMTs must obtain a Part-66 license, categorized into different levels (e.g., B1 for mechanical, B2 for avionics, and B1/B2 combined for both).

Other Regional Certifications: Various aviation authorities worldwide, such as CASA (Australia), CAAC (China),




and DGCA (Türkiye), have similar certification requirements. These certifications validate an AMT's ability to interpret and apply troubleshooting procedures outlined in manuals like the TSM or FIM.

**Practical Experience**

While theoretical knowledge is essential, hands-on experience is equally important. Most aviation regulatory bodies require AMTs to complete a set number of hours in practical training before they can be certified. On-the-job training (OJT) helps technicians develop their skills in:

- Diagnosing system malfunctions using troubleshooting manuals
- Utilizing aircraft diagnostic tools and software
- Conducting fault isolation and performing corrective actions
- Working with specific aircraft models (e.g., Boeing 737, Airbus A320)

Practical experience enhances an AMT's ability to navigate troubleshooting manuals efficiently and make accurate maintenance decisions.

**Technical Skills**

To effectively use troubleshooting manuals, AMTs must possess a range of technical skills, including:

**Reading and Interpreting Technical Documentation:** AMTs must be able to understand complex schematics, wiring diagrams, and flowcharts presented in troubleshooting manuals.

**Diagnostic Proficiency:** The ability to systematically analyze symptoms, use Built-In Test Equipment (BITE), and interpret fault messages from onboard aircraft systems.

**Use of Specialized Tools:** AMTs must be skilled in using multimeters, oscilloscopes, hydraulic testers, and software-based diagnostic tools.

**Computer Literacy:** Many troubleshooting manuals are now digital (e.g., Boeing Maintenance Toolbox, Airbus e-TSM), requiring familiarity with computer-based maintenance tools.

**Soft Skills**

In addition to technical expertise, AMTs must develop essential soft skills to work efficiently with troubleshooting manuals and within a team. Key soft skills include:

**Problem-Solving Ability:** Troubleshooting manuals provide structured guidance, but AMTs must use logical reasoning and experience to diagnose and fix issues accurately.

**Attention to Detail:** Even minor errors in reading or interpreting troubleshooting procedures can lead to incorrect diagnoses and safety risks.

**Communication Skills:** AMTs must document maintenance actions clearly and communicate findings with engineers, pilots, and other technicians.

**Adaptability and Continuous Learning:** Aviation technology is constantly evolving, requiring AMTs to stay updated on new troubleshooting methods and system advancements

**Specialized Training and Type Training**

Some AMTs undergo type-rating training, which provides in-depth knowledge of specific aircraft models. Airlines and maintenance organizations often require AMTs to complete type-specific training for aircraft like the Boeing 787 or Airbus A350. This training includes:

1. Advanced troubleshooting techniques tailored to a specific aircraft type
2. Hands-on training with real-world fault scenarios
3. Understanding how different aircraft systems interact in troubleshooting procedures
4. Type ratings and specialized training significantly enhance an AMT's ability to efficiently use troubleshooting manuals for aircraft maintenance.

Aircraft Maintenance Technicians utilize Troubleshooting Manuals (TSMs) because they provide a structured, accurate, and standardized approach to diagnosing and fixing aircraft issues. These manuals enhance safety, efficiency, compliance, and cost-effectiveness, making them an indispensable tool in aircraft maintenance. By following TSM or FIM procedures, AMTs ensure that aircraft remain airworthy, reliable, and operational, ultimately contributing to the overall safety and efficiency of the aviation industry.

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# INSOMNIA AND FATIGUE IN FLIGHT OPERATIONS

**As it is known, one of the most important problems of those working in the aviation industry is insomnia and the excessive fatigue that develops as a result. Sleep is a state of recharging for the human being. According to the results of scientific studies conducted on the sleep needs of an adult, it is found that a normal person needs 7-9 hours of sleep per day, including uninterrupted, deep and REM (Rapid Eye Movements) sleep.**

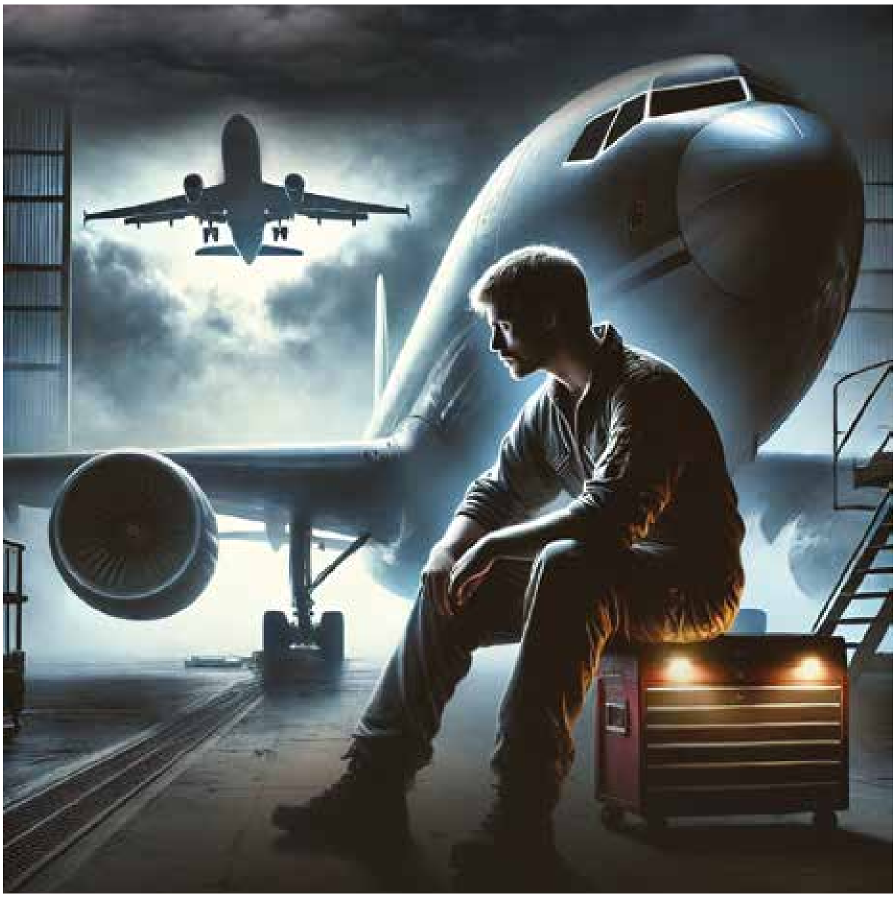
It is known that insomnia or insufficient sleep leads to excessive fatigue, which has a direct effect on flight safety, that excessive fatigue (fatigue) can also be measured thanks to recent developments, and that the effect of excessive fatigue on a person is almost equivalent to consuming certain amounts of alcohol. Despite these facts, unfortunately, many fliers do not fully understand the effects of excessive fatigue. Therefore, tired fliers continue to fly in a "fatigue-exhausted" state without realizing it, causing flight insecurity. In order to better understand the importance of sleep in terms of flight safety, it would be useful to first examine the general structure of sleep.

**Stages Of Sleep**

Sleep is a physical and mental activity that includes many stages, where the sensory organs work actively and allows the person to refresh. Studies have revealed that sleep consists of 5 stages. Accordingly, there are N1, N2, N3, N4 and REM (Rapid Eye Movements) stages. Since there are no eye movements between N1-N4, they are called Non-REM stages.

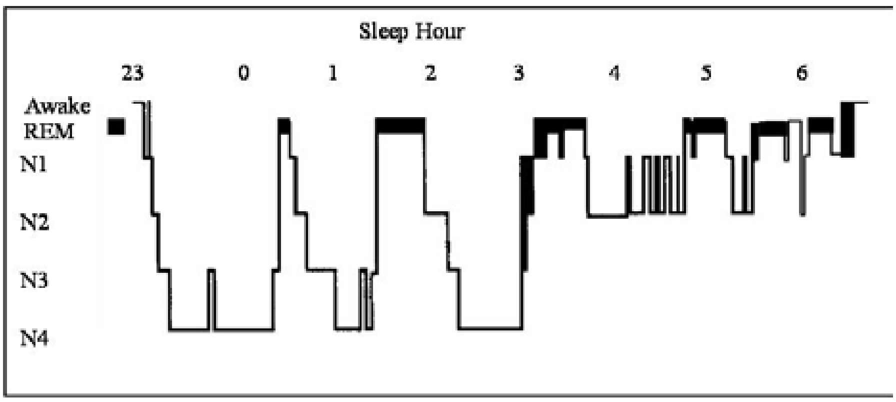
If we briefly examine these stages; first of all, a person enters the N1 stage while falling asleep. This stage is the transition stage between wakefulness and sleep. Brain activities slow down, the person becomes unresponsive to sounds and images, and the eyes completely close and begin to make slow and involuntary movements. In addition, sudden muscle movements and contractions can also be encountered during this stage. Since it is the first stage of sleep, if this stage exceeds 10 minutes, what happened a few minutes before sleep can be forgotten, in other words, memory loss occurs.

After this stage, the first stage is N2, where brain waves become irregular and make sudden oscillations. Here, brain waves are irregular, and in the next stage, N3, there is a transition to slow-wave sleep, which occupies 20-50% of brain activity. At this stage, the eyes are still motionless, but the brain waves become more regular. The N4 level is one stage above N3, and the slow-wave movements here occupy more than 50% of brain activity. It is more difficult to wake up a person sleeping at this level than at the N1 level. Especially people awakened at the N3 and N4 levels may take a few minutes to wake up, and they may remain unresponsive and insensitive at this level, so pilots who perform controlled resting sleep in the cockpit during the flight should pay attention to this stage and wake up before passing through this stage. The fifth stage is the REM stage, which is different from the other sleep stages in many ways. Here, the eyes are in constant motion, the brain is in constant activity and is producing random waves, and the muscles are now completely still and have entered a completely resting phase. The REM phase is also called the "dream phase" because dreams often occur during this stage. The immobility of the muscles makes it easier to dream.



**Sleep Architecture**

During the night, a person completes their sleep with the transitions between the sleep stages mentioned above in a predictable pattern. As shown in the Sleep Architecture Figure, this is called a sleep cycle. The cycle here is generally unbroken and shows a course depending on the hours during sleep. Each cycle takes approximately 90 to 120 minutes. In each sleep cycle, the N1 stage is completed within 5 minutes and the other stages and Non-REM stages are completed and the sleep cycle ends with the REM stage, and sleep activity continues with these sleep cycles throughout the night. In the first half of the night, REM sleep is generally low and sleep activity is continued with Non-REM sleep. This situation covers approximately the first 4 hours of sleep. The recharging REM sleep of a person occurs more commonly after this time period. As shown in Figure 8, the last two cycles of sleep are completed completely with REM between N1 and N2. There may be brief awakenings during sleep from time to time, a person cannot notice most of these awakenings, which can last for a total of 10 minutes during the night and usually occur in adults. Sleep refreshes a person, but this refreshing occurs in a rhythm. Unlike a machine, a person completes his life and activities in a routine that depends on the light conditions of a day, this routine is called Circadian Rhythm, it is useful to examine the Circadian Rhythm to better understand the subject.

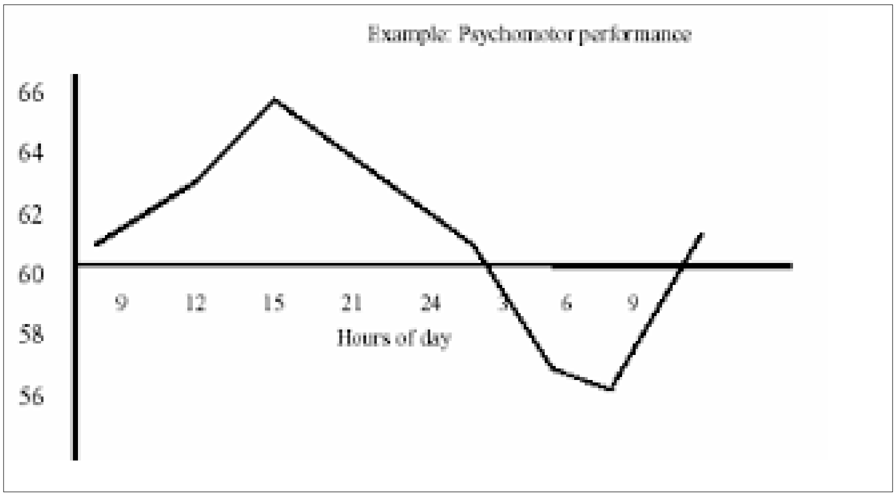



**Sleep Architecture**

**Circadian Rhythm**

Circadian rhythm is the natural cycle that guides our daily lives. Circadian clock regulates physiological processes such as sleep, wakefulness, body temperature regulation, hormone secretion and physical and cognitive performance within this rhythm. For example, body temperature, which is lower during sleep, is increased to normal temperature approximately 1.5-2 hours before waking up thanks to the circadian clock, and this occurs at the time when a person's mental and physical competence during the day is adjusted. For example, the circadian clock of a person who normally wakes up at 0700 is activated at 0500-0530, preparing the person for the new day. Accordingly, it is accepted that

a normal person spends 0200-0600 hours asleep and the circadian clock is activated between 0300-0500. For those who can purify their sleep from environmental conditions such as light and sound, the 24-hour circadian clock can be extended to 25 hours. In fact, the extension or shortening of the cycle here is due to the flexibility of the circadian clock and is the most important part of the issue for us fliers. While people generally have difficulty falling asleep earlier than their normal sleeping hours, they do not have much difficulty falling asleep later, in other words, extending the day. Although the rhythm here is generally programmed over 24 hours, the effect of the distinction between day and night, and therefore the light conditions, is important. However, the problem that concerns us closely is the sudden changes in advancing or regressing this rhythm. These sudden changes have become the lifestyle of pilots flying 24/7 and captains flying ER flights. Despite this lifestyle, human pilots experience problems in adjusting their circadian clocks and, as a result, cases of extreme fatigue (fatigue) are encountered. The main problem here is that the circadian clock cannot adjust itself quickly enough to the sudden changes in time zones, sleep periods, and day/night differences. Physical adaptation to such sudden changes can take days or even weeks, and this is due to the changes in the day/night change that regulates the circadian clock. For example, a pilot who has to go to a 7-hour time difference after an ER (Extended Range) flight or a captain who has to fly at night and sleep during the day as a result of the flights in his monthly schedule falling at night, has his circadian clock order disrupted. However, the problem is that these pilots do not have enough time to adapt to the new order. Accordingly, pilots who cannot adapt to the new circadian clock are forced to fly during the hours they need to perform. In this regard, the physiological capabilities of the pilots are shown in the time zones and performance graph below, as shown in the figure. Accordingly, while pilots show the highest level of performance between 0900-0200, this performance decreases after 0200. A pilot who cannot prepare himself for the new time zone will experience a decrease in performance and feel fatigue, feeling like it is midnight, even though it is normally the middle of the day. The effects of this excessive fatigue will also be similar to the behavior of an alcoholic body.



### Cycle Of Daily Pyschomotor Activıties

**Fatigue**

This condition, which usually develops due to sleeplessness and is called Fatigue, is a physical and mental exhaustion or fatigue that exceeds the normal fatigue limits of a person. While it is physically described as the muscles losing their ability to work at the desired level, it is mentally expressed as the inability to perform actions such as comprehension, understanding, interpretation and application in events that require brain skills. Physical fatigue usually occurs due to lack of sleep and not exercising, while mental fatigue is caused by the disruption of the circadian rhythm mentioned above, lack of sleep, stress and intense work tempo.

Pilots are affected by both types of fatigue mentioned here due to their normal working routines. Pilots who are exposed to fatigue, who need to have constant attention and DF, have increased reaction times, decreased attention levels, decreased memory capacity and are forced to adopt an introverted behavior pattern in flight. The most important problem here is that the effects mentioned above are

latent, unnoticeable and affect all functions of the person after fatigue caused by sleeplessness. As shown in the table below, sleeping with eyes open, not hearing radio conversations, disruption of communication during the task and partial incapacity-unconsciousness are the events experienced in the cockpit after fatigue.

Especially in the takeoff and descent phases that require intense attention during the flight, making non-standard movements, incorrect SID or STAR, approach practices, unstable approaches, generally decreasing flight competence, fixation on an event, decreased attention or shifting it to one side, disruption of prioritization between tasks, forgetfulness, wrong decision making and their decrease, fixation on an event, decreased attention or shifting it to one side, disruption of prioritization between tasks, forgetfulness, wrong decision making and SA loss as a result of these are the most striking situations experienced after fatigue.

What to do to combat fatigue and sleeplessness; First of all, resting sufficiently during off-duty times, doing sports, taking up hobbies, taking controlled rests during the flight, establishing an effective ECM with the other cockpit member and benefiting from his/her observation skills, ensuring that the cabin crew checks the cockpit at regular intervals and creating awareness about fatigue in the crew planning departments of the companies. It is very important for pilots working at a high flight tempo to combat sleeplessness and fatigue in order to ensure flight safety and to perform their duties effectively. Here, it should be ensured that the pilots who feel tired are rested, kept away from flight activities for a certain period of time, and that all pilots understand the effects of fatigue in refresher training.

**Reference:** Başdemir, M. Melih, "Tüm Havacılar İçin Ekip Kaynak Yönetimi", Beta Yayınevi, İstanbul, 2020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# ROOTS OF CREW RESOURCE MANAGEMENT IN AVIATION

**It is an inevitable truth that, it will never be possible to reduce human error to zero. The nature of human being has always potential to make mistakes under almost any condition or situation, especially under stressful conditions. In this manner, despite the enhancements in aviation technology and higher standards implemented, human error continues to be the major cause in most of the aircraft accidents. Since the late 70s, Crew Resource Management (CRM) has become a perfect tool to enhance non-technical skills of flight crews, proactively mitigate the negative effects of threats and errors during flight operations. Throughout the evolution of CRM in the last 45 years, even its coverage widened from to cockpit to almost all areas of aviation, the focus has been remained constant; minimizing the incidents and accidents caused by human factors and make the air transport safer.**

Beginning from the early 50s, the use of jet-powered aircraft in airline transportation led to the rapid development of commercial air transportation. In addition to the advantages such as the ability of new generation passenger aircraft to reach longer distances faster and to carry more passengers, the complexity of modern aircraft systems has brought new risks for pilots. Factors such as the increase in the number of flight crew required for growing modern passenger aircrafts, the rapid pace of transition to new and complex systems, and the effort to meet the increasing passenger demand with more frequent flights have led to an increase in aircraft accidents.

To prevent the accidents that occurred, detailed studies were carried out, and the technical and mechanical factors causing the accidents were tried to be eliminated quickly. With the support of developing technology, turbo-jet engines have become safer, aircraft navigation and avionics systems have been developed, and electronic warning systems have been widely used [1].

One of the most remarkable developments on the prevention of accidents was the use of flight recorders. Between the years 1950-70, Flight Data Recorder (FDR) and Cockpit Voice Recorder (CVR) devices were started to be used, and their use was made compulsory by the International Civil Aviation Organization (ICAO). All technical data and team conversations collected from these recording devices showed that, most of the accidents

were caused by human errors, and these errors occur mostly due to interpersonal communication, poor decision making under stress and lack of effective leadership.

The 70s went down in history as a period in aviation history when fatal plane crashes occurred one after the other. These unfortunate events have changed the course of accident prevention studies in aviation and paved the way for the focus of research to evolve from technical factors to human factors. Briefly mentioning the most important of these events that changed the perspective of aviation safety will provide a better understanding of the factors affecting the emergence of CRM.

**Eastern Air Lines Flight 401:** In December 1972, a Lockheed L-1011-1 Tristar crashed into the Everglades, Florida. The crash occurred because of flight crews concentrated on troubleshooting inoperative landing gear indicator light. Focusing on the problem, crew accidentally pressed the button that took the plane out of autopilot control

and no one in the cockpit noticed as a result, the plane crashed near the airport causing 101 passengers and crew died. In the research conducted after the accident, it was reported that all three people in the cockpit focused on the landing gear warning light at the same time, the necessary crew coordination to control the aircraft was not accomplished, the communication between the crew was poor and their situational awareness was not sufficient. In the technical examination of the aircraft, it was revealed that the landing gear was actually opened, and the malfunction was only caused by the explosion of the warning light bulb.

**Tenerife Disaster:** Two Boeing-747, KLM and Pan Am, collided on the runway in March 1977. Since a security threat was reported at Gran Canaria airport on the day of the accident, all aircraft bound for it were diverted to Los Rodeos airport, which caused a very busy day at the airport. The KLM aircraft, which had been waiting in line for more than two hours to take off, headed the runway and requested take-off permission. The heavy fog on the square restricted the view of both the tower and the pilots, and the Pan-Am aircraft, which landed on the runway at the same time, collided disastrously with the accelerating KLM aircraft. The post-accident investigation clearly revealed that there had been a major communication error between the KLM flight crew. The captain started the take-off without understanding the statements of the second pilot speaking to the tower, the second pilot

remained a spectator to this move of the second pilot due to the high-power distance between them and the collision occurred within seconds. Among the other contributor factors, KLM Captain's erroneous decision to take off has played important role in this deadliest accident in aviation history.

**United Airlines Flight 173:**
In December of 1978, a United Airlines DC-8 on approach into Portland, Oregon, requested delay vectors due to an unsafe landing gear indication. While troubleshooting the unsafe indication, they failed to monitor their fuel state. The flight crews' fixation on the landing gear indication resulted in fuel starvation and subsequent crash near the Portland airport. According to the investigation report, the failure of the captain to monitor properly the aircraft's fuel level and to properly respond to the low fuel level and the crewmembers' advisories regarding the fuel state were the main reasons of the accident. Contributing to the accident was the failure of the other crewmembers to fully comprehend the critically of the fuel state or to successfully communicate their concern to the captain. The landing gear problem had just disordered effect on the flight crew's performance. The main reason was the breakdown in crew management and teamwork during a malfunction of an aircraft system in flight.

**Air Ontario-1363:** A Fokker F28-1000 aircraft crashed just after take-off in Dryden in 1979. Operational lapses and environmental threats had important contribution to the accident which has been perceived as a driver to broad the scope of CRM trainings.

Those accidents eventually led to awareness of human factors'

importance and training programs emerged by airline companies during 70s.[2] The CRM concept in aviation was first discussed in a workshop organized by National Aeronautics and Space Administration (NASA) in 1979. Within the scope of the workshop, the communication and coordination problems among the crew that resulted with fatal accidents were discussed and a "Cockpit Resource Management" program offered for the airline companies.

**Evolution of CRM**
CRM experienced remarkable growth. While the initial objective was to prevent aircraft accidents owing to flawed cockpit crew attitude, communication, and leadership, it evolved from 'cockpit' to 'crew' in a short period of time. CRM has also adapted to optimize human performance and reduce human errors.

The evolution of CRM is generally summarized in five distinct generations analogy. After the expansion of beyond the cockpit, CRM has become a systematic concept in aviation safety. Today, along with the error management concept, CRM focuses on involves cognitive and social skills, encompasses a wide range of knowledge and attitudes including situation awareness, problem solving, decision making, monitoring, communications, teamwork, and cultural issues covering not only pilots but also flight attendants, maintenance personnel, dispatchers, and air-traffic controllers.

**1st Generation:** Cockpit Resource Management: The conference 'Resource Management on the Flightdeck' sponsored by the National Aeronautics and Space Administration (NASA) in 1979 was attracted a considerable attention of the aviation sector. It was the outgrowth of the long research into the aviation accidents and the role of the human factors. The research results revealed that human errors in communication, leadership and decision making are the main causes the accidents. It is demonstrated the necessity to implement a resource management training program in which the human factor was also included in all aspects. In this way, the first-generation program was named as "Cockpit Resource Management" since it was designed to include the pilots only.

United Airlines showed special interest to the conference. The company had an accident in 1965 which results in 43 people lost their lives. During the landing of the Boeing-727 model under the control of the co-pilot, the captain's intervention on the throttle levers caused the accident. Captain ignored co-pilot's warning and prevented his intervention to correct the problem. This accident clearly revealed that there was a serious lack of CRM within the company. Shortly after the conference, United Airlines developed a CRM training program with the support of NASA and Texas University psychology professor Robert Helmreich and his team. In this manner, the first comprehensive CRM program was put into practice within United Airlines in 1981.

Following United Airlines, other US airline companies also created their own CRM programs and started the initial CRM trainings for their pilots. The feedback from the CRM trainings from United Airlines indicated that the main reason of the communication breakdown in the cockpit is the power distance between the captains and the first officers. This resulted with redesignation the training program with a captain focus.

United Airlines' first-generation CRM program was based on Blake and Mouton (1964)'s Management Style Matrix (Managerial Grid). In the matrix, leadership style of the pilots was evaluated with either business or human-centered perspective aiming to determine their managing styles so correcting the mistakes in individual behaviors such as the authoritarian behavior. Other airlines' programs also focused on individual psychological deficiencies, leadership style, communication, problem solving, etc. The most important deficiency of this generation's programs was that CRM trainings were applied only once for pilots. It was usually one or two-day, one-time awareness training. The necessity of applying these trainings to all pilots at regular intervals in the form of refresher trainings was understood only after a certain period. The trainings, which were initially taught only in the classroom environment, have been expanded by using simulator facilities. Although most of the pilots trained, it is seen that some pilots resisted and opposed these training processes, and the changes made in the internal rules within the scope of CRM.[3]

**2nd Generation:** Cockpit and Cabin Resource Management: After the first workshop in 1979, NASA organized another event called "Cockpit Resource Management Training" in 1986.[4] During this workshop, it was seen clearly that CRM attracted a great attention in air transportation sector and many airline companies from all over the world had already prepared and applied their CRM programs to their aircrew. In the second generation, the most important improvement was widening the concept from "Cockpit Resource Management" to "Crew Resource Management" including all personnel contributing to the flight operation. Delta Airlines has been the first airline company to prepare and implement a program that covers the entire team, contrary to the pilot-based approaches in first-generation programs. With the second generation, CRM programs have started to be prepared in a modular structure and in a separate status from other technical trainings of aviation, which are team-oriented rather than individual, based on inter-individual relations. Situation awareness and stress management also added the training curriculum and improving of crew synergy aimed. Overall, the second generation was certainly a period that the participation in CRM trainings increased significantly. CRM started to be implemented by airline companies all over the world, leaving the borders of the USA.

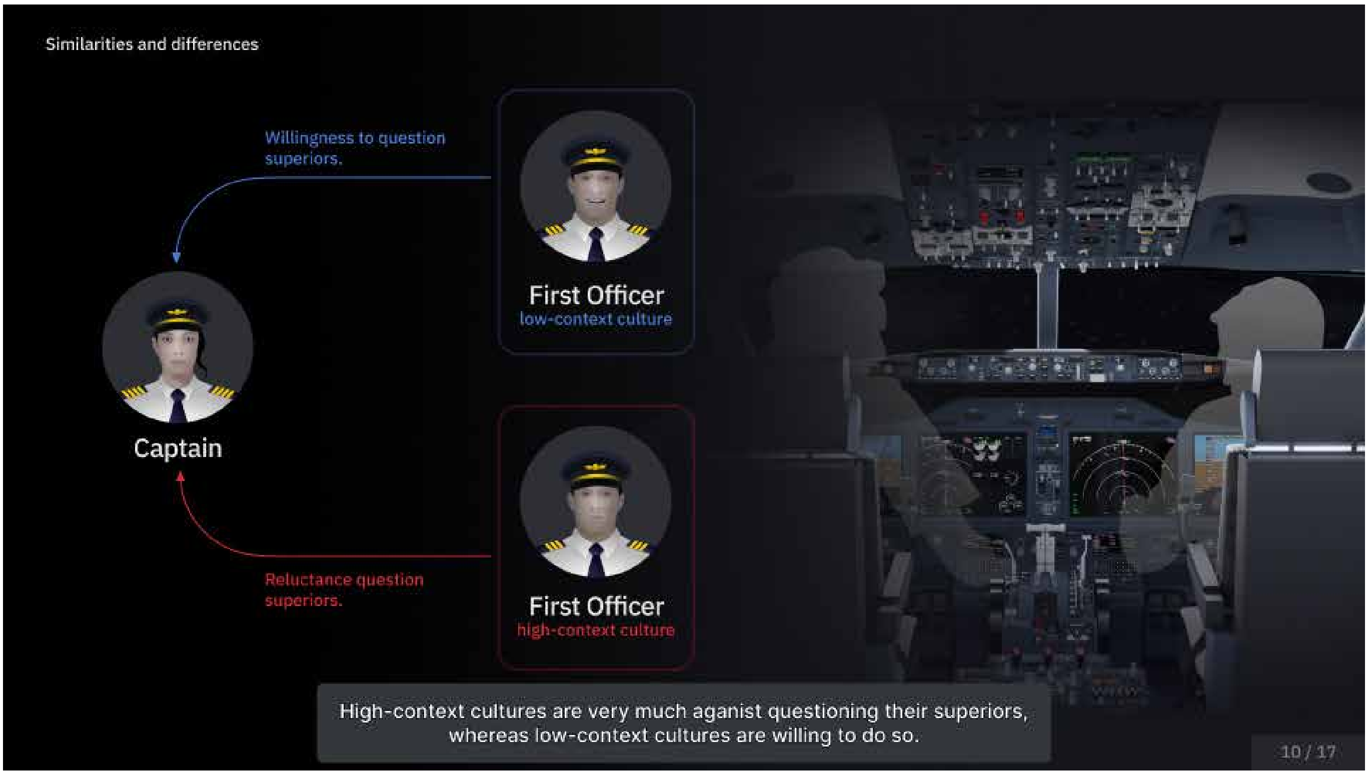
**3rd Generation:** Error Management Oriented CRM: British Midland Airlines' Boeing 737 aircraft was involved in an accident in 1989. The accident developed when one of the aircraft's engines started to burn in the air. The pilots, who were supposed to silence the faulty engine, accidentally silenced the only operating engine due to the


lack of coordination resulted in crash and death of 47 people on board. "Organizational Error" theory introduced by James Reason (1990) in parallel with the lessons learned from the Midland airlines accident has been an important factor in reshaping the third generation CRM. Reason stated that, "there are many different factors that cause accidents and that accidents can occur if factors such as planning, timing, design, foresight, and communication errors exist within the organization".[6] Recognizing the sources of organizational error and creating a safety culture at the organizational level were the focus of third generation's applications. The leadership and coordination trainings of crew were increasingly continued, and the CRM awareness trainings given to cabin crew were extended to cover flight operations specialists and maintenance personnel.

**4th Generation:** A Systematic Approach to CRM: American Civil Aviation Authority (FAA) in the 90s had remarkable role in shaping the fourth generation CRM approaches. FAA developed a comprehensive program and revealed it for use of the airline companies in the United States. FAA's systematic methodology in CRM trainings enabled companies to apply standardized basics as well as to chance to customize the training content in accordance with its own culture and needs. Contrary to traditional approaches, FAA program provided flexibility in trainings, enabled developing realistic scenarios in simulator environment, by taking the organization culture into account. Standard Operation Procedures-SOPs have been developed for using especially in emergency conditions and detailed checklists developed. SOPs was seen one of the most important safety management tools throughout the 2000s. The flexibility offered to airline companies gave the positive outcomes quickly. Companies adapted the FAA qualification program into their CRM training programs and created their own SOPs. CRM became an integral part of the flight along with the technical skills and this led to the positive effect of crew qualifications reducing the accident rates.

**5th Generation:** Global Perspective on CRM: After increasing awareness of cultural issues, CRM focused back on its strategic concept of safer flight. In this manner, "Threat and Error Management-TEM" was born based on the studies at the University of Texas. The theoretical foundation of TEM was based on Reason (1990)' s theory of human factors and accident causes. Accordingly, the flight crew struggles with three basic elements to prevent the occurrence of an accident: "threats", "errors" and "undesirable situations". TEM provides a structured and proactive approach to use in identifying and avoiding the threats and errors in an everyday operation environment to achieve and maintain the safety margin of flight. With the "normalization" of human error, new error management strategies have started to be created within the scope of CRM, which includes the continuous evaluation of the high threat environment, has been created.

CRM basically means the effective management of all available resources including other crew members, procedures, the machine




interface, and themselves to achieve safe and efficient flight operations. This management of resources was the original essence of CRM training as the Lauber's (1987) widely known definition implies "the effective utilization of all available resources -information, equipment, and people- to achieve safe and efficient flight operation". [5]

CRM is a living process for all crew to identify possible threats to air operations by communicating and carrying out a plan to avoid or mitigate those threats. It also reflects the application of human factors knowledge to crew interaction. Several CRM skills are expected to be performed which involves monitoring and cross-checking, communication and coordination, workload management, situation awareness. Non-technical skills are at the center of flight crew's core competencies and essential skills.

In today's modern airline training systems, flight crew's performance is assessed into three main categories: knowledge, skill, and attitude. CRM mainly focuses on attitude, which can be resulted in temporary changes in behavior, and the successful integration of non-technical skills into technical skills.

A common mistake while trying to understand the nature of CRM is underestimating its importance and evaluating technical piloting skills and CRM skills separately. Both are highly interconnected to each other and neither of them can be isolated. By their nature, CRM skills are deeply infused into and affect the proper performance of technical skills. Flight crew pays enormous price if he fragments technical skills and non-technical skills without realizing their interconnectivity. In today's advanced flight deck environment with complex automated systems, it's obvious that flight crews must go beyond the technical rudder and stick skills. This can be obtained by awareness and effective CRM training which enhances a critical set of observable interpersonal human behaviors and augments technical expertise to create a more productive and safe flight environment.

One should always keep in mind that CRM is not a magical tool to eliminate all errors and assure safety in aviation. Error is an inevitable result of the natural limitations of human performance. On the other hand, CRM can be used to manage error and minimize the accidents. Safe and efficient flight operations depend on flight crew's success not only on the acquisition of sound technical knowledge and skills but also on the mastery by their cognitive and interpersonal skills which form the basis of good CRM.

**References**


Wiener, E. L., Kanki, B. G., & Helmreich, R. L. (Eds.). (2010). Crew resource management. Academic Press.

G., Helmreich, R. L., & Anca, J. (Eds.) (2010). Crew Resource Management. Waltham: Academic Press.

Helmreich, R. L., Merritt, A. C., & Wilhelm, J. A. (1999a). The evolution of crew resource management training in commercial aviation. The international journal of aviation psychology, 9(1), 19-32.

Orlady, H. W., & Foushee, H. C. (1987). Cockpit Resource Management Training. In Cockpit Resource Management Training Workshop; Cockpit Resource Management Training Workshop NASA Ames Research Center, Moffett Field, CA.

Lauber, J. K. (1987). Cockpit resource management: Background and overview. In H. W Orlady & H. C. Foushee (Eds.), Cockpit resource management training: Proceedings of the NASA/MAC workshop (NASA Conference Publication No. 2455, pp. 5-14). Moffett Field, CA.

Reason, J., 1990. Human Error. Cambridge University Press, Cambridge.


M.Berk GÜNEŞ
Pilot

# THE FUTURE OF FLIGHT : REDUCED CREW OPERATIONS

**Imagine boarding a long-haul flight where, instead of the familiar sight of two pilots in the cockpit, advanced automation and cutting-edge AI assist a single aviator at the controls. Reduced Crew Operations (RCO) is no longer just a futuristic concept—it's rapidly evolving into a reality that could reshape commercial aviation as we know it.**

With pilot shortages, rising operational costs, and leaps in automation technology, airlines and aircraft manufacturers are exploring ways to streamline cockpit operations while maintaining safety and efficiency. But as the industry moves toward this shift, critical questions remain: How will regulators respond? Can passengers trust planes with fewer pilots? And most importantly, is the world ready for this new era of flight?

**Definition of Reduced Crew Operations (RCO) and Single Pilot Operations (SPO)**

Reduced Crew Operations (RCO) and Single Pilot Operations (SPO) are emerging aviation concepts designed to optimize flight crew requirements through advanced automation and operational efficiencies. RCO refers to reducing crew members on long-haul commercial or military flights while still maintaining more than one pilot on board. This typically involves strategic rest periods and enhanced workload-sharing techniques. In contrast, SPO involves operating a commercial transport aircraft with only one pilot in the cockpit, supported by sophisticated onboard automation systems and remote ground-based piloting assistance. These approaches aim to improve efficiency, address pilot shortages, and reduce operational costs while ensuring safety standards are equivalent to traditional two-pilot operations. Successful implementation of RCO and SPO requires advancements in avionics, regulatory adaptation, and rigorous safety protocols to ensure seamless and reliable flight operations

For decades, small private planes and military fighters have operated with a single pilot, yet commercial airlines have long relied on two-person cockpits. Current U.S. Federal Aviation Regulations (FAR 121.385) mandate a minimum of two pilots for most commercial air carriers. However, rising crew costs and an anticipated pilot shortage are pushing the industry to rethink traditional cockpit operations. Airlines, particularly regional and commuter operators, are feeling the financial strain from salaries, benefits, and ongoing training, prompting serious discussions about RCO and SPO. These concepts, powered by advanced automation and enhanced ground-based flight support, could revolutionize long-haul and military aviation while maintaining safety at levels comparable to two-pilot operations.

SPO, in particular, presents both the greatest challenges and the most significant cost-saving potential. Eliminating the first officer role could cut cockpit crew costs nearly in half. Additionally, future aircraft designed specifically for single-pilot operations could feature smaller, lighter cockpits, further enhancing economic efficiency. While the shift to RCO and SPO raises questions about safety, regulation, and public perception, one thing is clear: the aviation industry is on the verge of a transformation that could redefine the role of pilots in commercial flight.

**The Ground Operators in RCO and SPO**

As the aviation industry explores RCO and SPO, the role of ground operators is evolving to ensure safety and efficiency. One emerging solution is the Hybrid Ground Operator (HGO) model, where trained professionals handle multiple flights, overseeing everything from pre-flight planning to gate arrival. If a flight encounters an unexpected issue, it is seamlessly transferred to another HGO under supervisory guidance, ensuring dedicated support when needed. Another approach is the Specialist Ground Operator Unit, which divides responsibilities between Ground Associates (GAs)—who manage routine dispatch and flight monitoring—and Ground Pilots (GPs), who provide one-on-one support for off-nominal situations. This division of labor ensures that pilots in distress receive immediate, expert assistance without disrupting normal operations. Additionally, a Harbor Pilot role, inspired by maritime navigation, is being explored. These specialists possess in-depth knowledge of complex airspace, such as the New York City Metroplex, and assist aircraft as they navigate high-traffic terminal areas, reducing the workload on both air and ground crews. By leveraging these advanced operational models, the industry aims to maintain the highest safety standards while optimizing crew resources and improving overall flight efficiency.

**Anticipated Risks of RCO and SPO**

While RCO and SPO offer promising cost savings and operational efficiencies, they also introduce significant risks that must be carefully addressed. One of the most serious concerns is pilot incapacitation or psychological distress. With fewer crew members in the cockpit, monitoring and supporting a pilot experiencing mental health issues or medical emergencies becomes more challenging. Psychological effects of isolation and prolonged workload management are another concern, as a single pilot may experience increased stress and decision-making fatigue, particularly during long-haul operations.

Workload management is also a critical factor. While automation can assist with routine tasks, the absence of a second pilot removes the crucial element of cross-checking, decision support, and immediate human intervention during high-stress situations, such as system failures or severe weather events. Fatigue management presents another challenge, as a single pilot is more susceptible to exhaustion, especially on extended flights where strategic rest breaks are difficult to implement without a co-pilot. Furthermore, reliance on ground-based support introduces new vulnerabilities, such as potential communication delays, cybersecurity threats, and the ability of remote personnel to effectively respond to rapidly evolving in-flight situations. Without proper safeguards, these risks could undermine the safety and reliability of RCO/SPO, making it essential for aviation regulators and industry leaders to develop rigorous protocols, advanced automation safeguards, and comprehensive pilot support systems before widespread adoption.

## The Germanwings Accident and Its Relevance

The Germanwings Flight 9525 accident on March 24, 2015, is one of the most significant cases highlighting the risks associated with reduced cockpit staffing and pilot psychological well-being. The Airbus A320, en route from Barcelona to Düsseldorf, crashed into the French Alps, killing all 150 people on board. Investigations revealed that the co-pilot, Andreas Lubitz, deliberately initiated the aircraft's descent while the captain was locked out of the cockpit. Lubitz, who had previously been treated for severe depression and suicidal tendencies, concealed his condition from his employer and continued flying despite being declared unfit for duty by medical professionals.

This tragedy exposed critical vulnerabilities in crew monitoring, mental health screening, and cockpit access protocols. Traditionally, the presence of two pilots in the cockpit provides a safeguard against such incidents—one pilot can intervene if the other is incapacitated or makes poor decisions. However, with SPO, such a safeguard would be significantly weakened. If a lone pilot experiences a medical emergency, psychological distress, or malicious intent, there may be no immediate

intervention. Although ground-based support operators could monitor pilot behavior remotely in an SPO setup, their ability to react in real-time—especially in a scenario like Germanwings 9525—would be extremely limited.

This incident underscores the importance of rigorous psychological screening, continuous mental health support, and fail-safe cockpit access procedures. For RCO/SPO to be implemented safely, the aviation industry must ensure that robust monitoring systems, emergency protocols, and automation safeguards are in place to prevent similar tragedies.

## Conclusion

As the aviation industry embraces RCO and SPO to improve efficiency and reduce costs, it is clear that these innovations hold great potential. However, the transition to these new operating models must be approached with caution to ensure that safety, pilot well-being, and operational reliability remain top priorities. While advancements in automation and ground-based support systems are making RCO and SPO more feasible, addressing the risks of pilot fatigue, workload distribution, and psychological health is crucial. With careful planning, robust protocols, and ongoing technological advancements, the industry can work toward a future where these new operational paradigms enhance both the economic sustainability and safety of aviation.

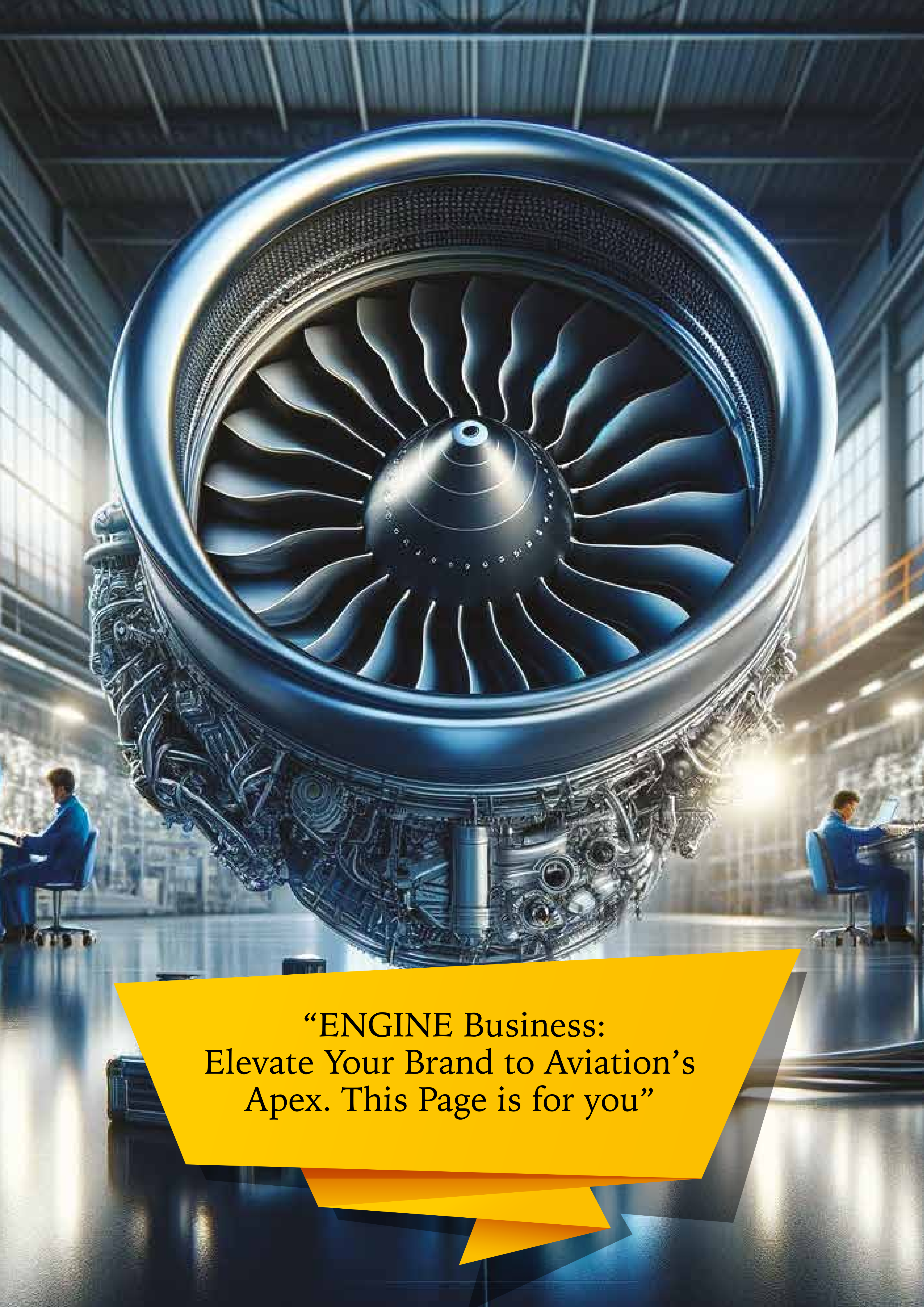

**References**

Sky News. (2015, July 1). Germanwings £70k Compensation Offer 'Divisive' https://news.sky.com/story/germanwings-70k-compensation-offer-divisive-10354019

Matessa, M., Strybel, T. Z., Vu, K.-P. L., Battiste, V., & Schnell, T. (2017). Concept of Operations for RCO SPO. Moffett Field: NASA Ames Research Center. Retrieved from NASA Ames Research Center website: https://api.semanticscholar.org/CorpusID:115409093

Pixabay. (2025). 5.3 million+ Stunning Free Images to Use Anywhere - Pixabay. https://pixabay.com/

Air Line Pilots Association International. (2024). A Gamble with Safety: Reduced-Crew Operations Reduced-Crew Operations. McLean. Retrieved from https://www.alpa.org/-/media/ALPA/Files/pdfs/news-events/white-papers/white-paper-reduced-crew-operations.pdf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# HUMAN FACTOR IN AVIATION
## RELATIONSHIP BETWEEN TECHNICIAN COMPETENCIES AND ATTITUDE ONE OF THE RARE JOBS WHERE MISTAKES HAVE SEVERE CONSEQUENCES:
# AVIATION TECHNICIAN

Competence can be most simply defined as the set of behaviors required to perform a task or duty. In the aviation industry, being a technician is an important job and a sensitive duty. This importance and sensitivity grow even more, especially for those who physically interact with the aircraft and perform operations on it. Technicians work in a field where the cost of an error is significantly high. We all know that, just like pilots, there are many examples in aviation history where mistakes, oversights, or negligence by technical personnel have had a direct impact on flight safety.

If we ask what is the most essential factor that ensures a technician produces correct and desirable results in such an important job, the answer would be "technician competencies." In aviation maintenance, for a technician to perform their job effectively, they must possess competencies such as knowing and using relevant resources, maintaining healthy communication, working efficiently in teams, solving problems, making decisions, and managing workload. Based on what we have discussed so far, let's continue asking questions: What is the fundamental prerequisite for a technician to acquire and apply these competencies effectively? Let's try to answer this in the next section.

**The Trıad Of Knowledge – Skıll – Attıtude**

The answer to the above question brings us to the triad of knowledge, skill, and attitude. Knowledge refers to the tested and rational resources that we need to apply in a particular field. We cannot expect someone to do something they do not know. For example, if we want a skilled technician to become a trainer, we cannot simply put them in a classroom and ask them to teach. First, we need to bring their knowledge level in this new field to the required standard. To achieve this, we enroll them in training processes where they acquire the necessary knowledge. Especially in the aviation industry, a technician's job is entirely based on rules, procedures, and documentation—there is no other way. Once we determine that their knowledge level is sufficient for the job, we move on to the next stage.

The next stage is the skill phase. A job or task cannot be performed by simply possessing knowledge. Particularly in aviation maintenance, obtaining the authority to certify work requires a long period of transforming knowledge into experience. For this reason, specific timeframes are defined at each certification stage of a technician. Until this period is completed and the required tasks are approved by experienced personnel, authority is not granted. This demonstrates that knowing is valuable, but being able to apply that knowledge is essential. There is a saying: "If knowledge alone were enough, no one would smoke." Everyone knows smoking is harmful, dangerous, and unhealthy, yet many still fail to develop the skill to quit.

Now, let's move on to the third and most crucial step of this discussion: attitude.

We are all familiar with the phrase, "Do it as if it were your first time, every time." The key characteristic of people with the right attitude is precisely this. Individuals who develop the right attitudes continue to perform their jobs with the same level of diligence and care, even after 30 years in the field. Think back to when you first started working—you paid close attention to everything, strictly followed documentation,

aimed to complete tasks on time, refrained from being lax, and criticized those who did not work properly. Unfortunately, over time, these positive behaviors diminish in some people. However, individuals who develop and maintain the right attitudes do not fall into this trap.

That is why experts assert that knowledge and skill alone are not enough to determine whether someone is competent in a particular field. Today, to consider someone competent and capable of performing their job properly, we also require the right attitude alongside knowledge and skill. For an aviation technician to successfully apply their competencies and perform their job safely, they must embrace this golden triad: Knowledge – Skill – Attitude.

**A Hıghly Valuable Key Concept: Attıtude**

We have briefly covered knowledge and skill—these are concepts that we are all somewhat familiar with. Now, let's take a closer look at a topic we do not discuss as often: attitude.

Attitude can be defined as the set of thought patterns that a person develops over time and uses to manage situations and events they encounter. Each of us has numerous thought patterns stored within us. When we face a situation in the outside world, we respond to it using these pre-existing patterns. Let's consider an example: You are a technician and running late for work. You notice that the traffic is terrible and think, "I won't make it on time." Suppose you have a slight inclination toward the attitude of "Nothing will happen to me." Based on this attitude, you begin driving in the emergency lane, exceeding the speed limit, and making unsafe lane changes. Eventually, you make it to work on time. You then think to yourself, "I made it, and nothing bad happened. I believed I could do it, and I did." This experience reinforces your "Nothing will happen to me" attitude because you saw a benefit from it.

Now, let's consider a second scenario. Again, you are running late, take the same risks, but this time, a traffic patrol spots you and pulls you over. You try to explain your situation, but they issue you a fine. As you continue your journey, you find yourself thinking, "I should have left earlier to avoid this fine and still arrive on time." Why are you now criticizing the attitude that you previously approved of? Because this time, you suffered a consequence. Attitudes form and strengthen when we perceive benefits from them. When we experience harm, we begin to question and diminish those attitudes. However, even attitudes that we recognize as harmful take time and significant effort to change.

Let's now give an example from ourselves : Imagine a technician whose dominant attitude is being hasty. This technician is experienced and highly skilled at their job.

However, in a rush to move on to the next aircraft, they hastily replaced a component incorrectly. The incorrectly installed component caused a failure in the hydraulic system, rendering the aircraft's hydraulic systems completely inoperative. At this point, there was nothing left for the pilots to control. The result was an accident or incident caused by loss of control.

Was the root cause of this situation a lack of knowledge? No.

Was it a weakness in the ability to apply what they knew? No.

The reason was simply acting with an incorrect attitude—haste.

Please remember that the root cause of the biggest accident in aviation history, the Tenerife disaster, was a flight crew that was feeling significant time pressure that day and acted accordingly—in other words, they acted hastily. This crew consisted of highly experienced professionals who were exceptionally skilled at their jobs. We know that behind the mistakes made by individuals whose knowledge and experience levels are beyond question in aviation, there are often incorrect attitudes. Attitudes are not something that can be observed externally. We cannot see a person's attitude. What we can observe in individuals are their behaviors. Attitude is the mechanism behind behaviors. In our examples, the "nothing will happen to me" attitude led to the behavior of exceeding speed limits in traffic, while the attitude of haste led to the behavior of replacing a component too quickly. This shows us that in order to change our behaviors, we must first change our attitudes. However, even before that, as human beings, we need to strive to develop the right attitudes in the process of personal growth. Creating something new is easier than changing an existing one. What influences the formation of attitudes in us? Which factors determine and shape our attitudes? The factors that influence the formation of attitudes in individuals can be listed as follows:

**Past experiences**

Everything we have experienced up to this point in our lives affects the formation of our attitudes. In particular, we can say that negative experiences have a significant impact on attitude formation.

**Social environment**

The social environment in which we live affects us from the outside in. In other words, what happens around us shapes our inner world. The thought patterns that are accepted in the family and culture we grow up in are likely to develop in us as well. Conversely, thought patterns that are not accepted have a lower likelihood of forming within us.

**Education**

Education is another important factor in the formation of attitudes. Particularly, continuous and effective education has a significant impact on both attitude formation and retention. On the other hand, the lack of proper education can lead to the development of incorrect attitudes.

**What we read, listen to, and watch**

Beyond the factors mentioned above, what we hear, see, and read the most in our daily lives also contributes to the formation of our attitudes.

**In Conclusion**

We are familiar with the word "amateur" and use it in everyday language. This word is often used to describe a person's level of knowledge and skill in a particular job or task. We commonly hear phrases like "They are an amateur," "You're approaching this too amateurishly," or "That's an amateur perspective." However, the true origin of the word "amateur" comes from the Latin word amare, meaning "love" or "passion." It signifies a deep, heartfelt dedication to something.

As mentioned earlier in this article, people who perform their work with genuine passion—those who embody the amateur spirit—continue to work every day with the same care and motivation as they did on their first day. A person who possesses knowledge and skills, is equipped with the right attitudes, and carries out their job with heartfelt love and commitment will exhibit their competencies more effectively, avoid mistakes, and contribute significantly to safety.

Wishing you safe and efficient work.


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Arif TUNCAL PhD
Aviation Research Association

# DECISION-MAKING IN AVIATION

**Decision-making is a fundamental process that affects every aspect of life, with individuals making hundreds of decisions daily. While most of these decisions involve simple preferences with minimal consequences, some are context-dependent and evaluated based on their outcomes as either "correct" or "incorrect". The decision-making processes of humans are inherently complex and prone to error, often assessed afterwards.**

Errors in decision-making can be attributed to various cognitive and situational factors, which are sometimes classified as "incorrect". Common types of such errors include ignoring or neglecting relevant information or alternatives, leading to suboptimal outcomes. Additionally, overestimating one's knowledge or abilities can result in overconfidence, which may negatively influence decision outcomes. Another frequent error involves miscalculating the potential impact or probability of specific outcomes, which can distort and misguide decision processes.

Ethical lapses can also adversely impact decision-making, leading to unfavorable choices. Furthermore, disregarding critical information or failing to recognize significant patterns can weaken decision-making processes, potentially resulting in adverse outcomes.

In the aviation sector, the processes of decision-making, while rooted in fundamental cognitive mechanisms similar to other domains, are distinctly influenced by the high-risk and dynamic nature of the context. Professions such as air traffic control, piloting, and aircraft maintenance technicians require effective decision-making under time constraints, incomplete information, and conflicting objectives. In the extant literature, judgment and decision-making are often interlinked; while decision-making is based on the analysis of facts, judgment incorporates a value component. These two processes reflect the outputs of an individual's attention and memory mechanisms.

Human errors in aviation have a significant impact on the effectiveness of decision-making processes. Research indicates that 42% of human errors in aviation result from decision-making errors, 35% from action errors, and 23% from information errors [1]. Decision-making errors are often associated not with simple mistakes in executing intentions but with flaws in the intentions themselves. Such errors frequently arise from the decision-maker's misunderstanding of the situation or reliance on incomplete information. Determining the correct decision can be challenging due to ambiguous standards and the complexity of the situation. Moreover, the weak correlation between the decision-making process and its outcomes can lead to misleading evaluations of decisions.


**Aeronautical Decision Making**
The Federal Aviation Administration (FAA) defines Aeronautical Decision-Making (ADM) as a systematic mental process used to determine the most effective course of action for a given situation. ADM is a critical process aimed at enhancing flight safety for aviation professionals [2]. This process adopts a multidimensional approach, encompassing not only technical skills but also the accurate assessment of situations, the analysis of potential scenarios, and the selection of an appropriate action plan. The foundation of ADM is rooted in systematic thinking and problem-solving techniques. To implement ADM effectively, personnel are required to possess both theoretical and practical cognitive abilities, along with adequate training.

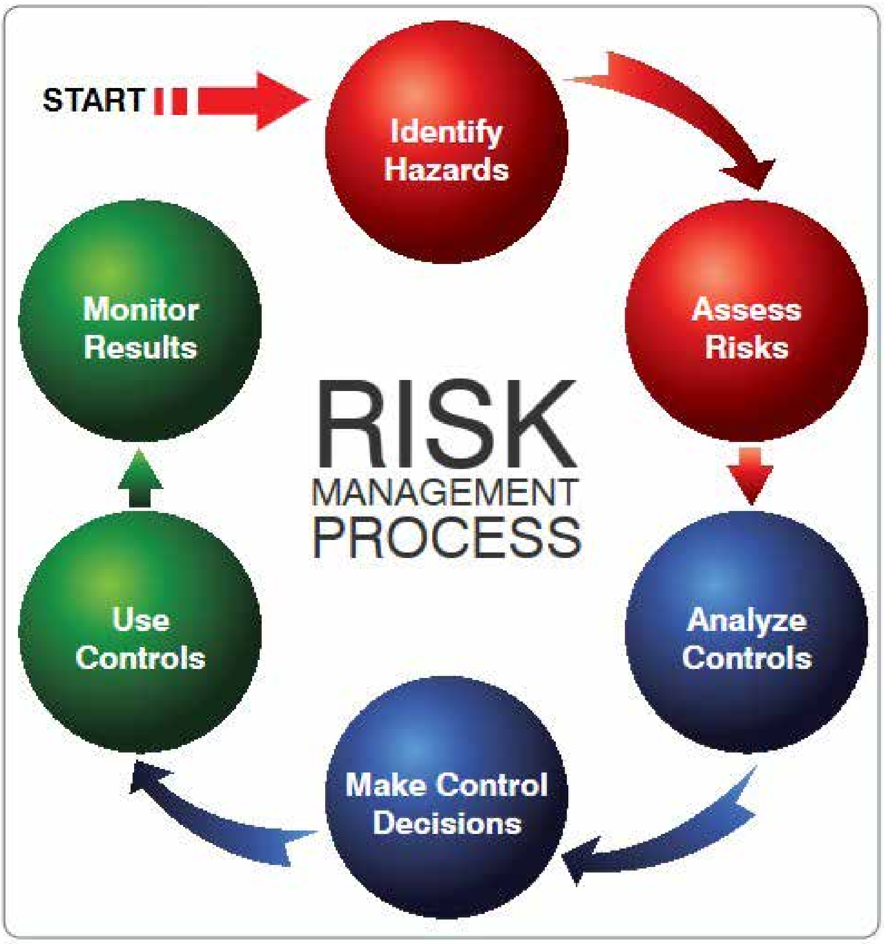
ADM is comprised of three stages: perception, understanding, and process. In the initial stage, the precise perception of the prevailing situation is ensured. During this phase, environmental factors and potential risks must be accurately identified, and critical information must not be overlooked. The second stage entails the analysis of the perceived information within its context to derive meaning, as well as the identification of the underlying causes of factors influencing the current situation. The third stage involves the use of available information to predict future scenarios more effectively and to develop an appropriate action plan. ADM promotes not only responsiveness to current conditions but also a long-term, proactive approach.

To support ADM, the FAA has developed various frameworks, including the Risk Management Model (RMM), the DECIDE Model, and the 3P Model (Perceive, Process, Perform). The DECIDE Model comprises six fundamental steps: Detect, Estimate, Choose, Identify, Do, and Evaluate. These steps provide a comprehensive framework, beginning with the analysis of a situation and culminating in the evaluation of outcomes resulting from implemented decisions. The DECIDE Model is particularly useful under time pressure, enabling logical and systematic decision-making in complex scenarios.

Another essential component of ADM is the Risk Management Model (RMM), which involves identifying potential hazards, prioritizing them appropriately, and determining an acceptable level of risk. This model does not aim to eliminate risks entirely but to reduce them to a manageable level. Awareness of risks and preparedness to address them are especially critical in high-risk aviation environments.

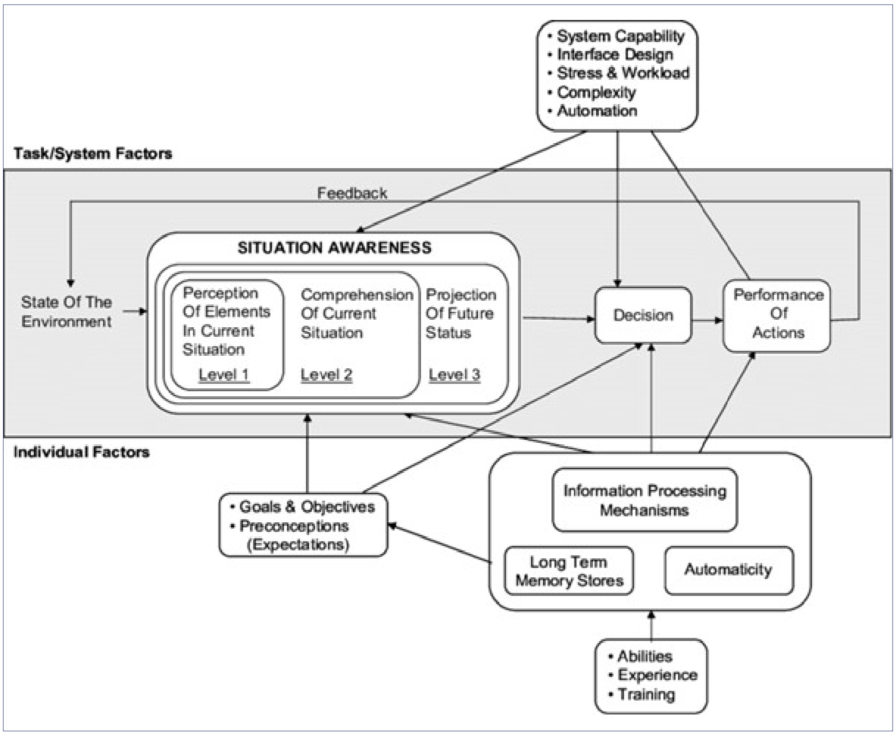
The 3P Model, a simplified and user-friendly version of ADM, incorporates three phases: Perceiving hazards, Processing them in relation to the overall situation, and Performing appropriate actions. The 3P approach enables real-time decision-making, thereby providing increased flexibility in managing complex situations.

**Situational Awareness and Decision-making**
Decision-making processes in aviation are directly related to Situational Awareness (SA). Situational Awareness involves the processes by which decision-makers perceive environmental factors, comprehend their meaning, and anticipate future scenarios. According to a leading model in the literature, situational awareness consists of three stages: perception, comprehension, and projection [3]. Perception (Level 1 SA) is the process of recognizing environmental factors



and the current characteristics of a situation. Comprehension (Level 2 SA) refers to the interpretation of the perceived information in alignment with the decision-maker's goals, while projection (Level 3 SA) involves assessing the current situation and predicting potential future scenarios. These processes form the foundation of effective and accurate decision-making. Both individual factors (goals, expectations) and system factors (workload, automation, interface design, etc.) influence the levels of situational awareness.

Situational awareness, especially in dynamic and rapidly changing flight environments, is considered a fundamental element of effective decision-making processes. Deficiencies in situational awareness are a significant cause of accidents in aviation. A study investigated the types and frequencies of SA errors in aviation by examining reports related to flight safety in the FAA's reporting database through searches for the term "situational awareness" [4]. The findings revealed that 76.3% of identified errors were Level 1 SA errors, 20.3% were Level 2 SA errors, and 3.4% were Level 3 SA errors. These results indicate that most situational awareness errors in aviation are related to the failure to accurately perceive and monitor available information. Such deficiencies can lead to misjudgment of risks, particularly in dynamic and high-stress environments, thereby creating a basis for incorrect decision-making.




**Cognitive Biases: Confirmation Bias, Overconfidence, and Hindsight Bias**

Cognitive biases that affect decision-making processes play a critical role in flight safety within the aviation industry. Among these biases, confirmation bias and overconfidence are particularly significant. Confirmation bias refers to the tendency of individuals to seek out and give more weight to information that supports their existing beliefs or assumptions [5]. This can lead to the neglect of alternative viewpoints and potential risks, hindering focus on critical information. In high-risk industries like aviation, confirmation bias can create a misleading sense of accuracy, leading to faulty decision-making and jeopardizing flight safety.

Similar to confirmation bias, overconfidence is another cognitive bias that negatively impacts decision-making processes. Overconfidence describes the tendency of individuals to overestimate their knowledge, skills, or decision-making abilities [6, 7]. This can lead to inadequate risk analysis and the simplification of complex situations, resulting in poor decisions. In the aviation sector, particularly during emergencies or unexpected scenarios, the effects of overconfidence become more pronounced and can have serious consequences for flight safety. Recognizing both confirmation bias and overconfidence is crucial for developing strategies that minimize these effects.

Another important concept related to these biases is hindsight bias [8, 9]. Hindsight bias occurs when individuals develop a false sense of having predicted the outcomes of past events. This bias typically manifests as thoughts like "I knew that already" or "I expected that result" after learning the outcome of an event. Hindsight bias makes it difficult to understand the reasons behind past mistakes, preventing lessons from being learned. In aviation, hindsight bias is frequently observed during accident and incident investigations. Investigators' knowledge of the outcome can make it challenging to understand why decisions made at the time seemed rational. This tendency may lead decision-makers to overlook factors such as available information, time pressure, and uncertainty during the investigation process. Additionally, hindsight bias can cause individuals to develop a blaming attitude toward themselves or others, which can negatively impact team performance and trust. To minimize the impact of hindsight bias, it is recommended to adopt analysis methods in accident investigations that are conducted "without knowledge of the outcome". These approaches not only facilitate learning from past mistakes but also contribute to the development of more effective and reliable decision-making processes in the future. Consequently, the effects of cognitive biases at both the individual and team levels can be minimized, ultimately enhancing flight safety.

**Development of Decision-Making Processes**

Technological and educational interventions aimed at enhancing decision-making processes in aviation not only improve flight safety but also focus on optimizing individuals' cognitive capacities. In this context, augmented reality (AR) and virtual reality (VR) based simulations enable the real-time testing and enhancement of decision-making skills. These simulations provide participants with complex and realistic scenarios, allowing them to analyze various dimensions of decision-making processes. Additionally, these technologies aim to enhance individuals' situational awareness and their capacity to cope with stress.

Decision Support Systems (DSS) play a critical role in supporting decision-making processes in modern aviation operations. These systems utilize big data analytics and artificial intelligence algorithms to provide aviation professionals with context-specific recommendations. Especially under uncertainty and time pressure, the informational support provided by these systems minimizes the risk of faulty decision-making. Automated alert mechanisms inform users of potential hazards while offering alternative solutions, thereby improving operational efficiency.

Training programs aim to enhance decision-making abilities at both individual and team levels. Crew Resource Management (CRM) and Team Resource Management (TRM) training, in particular, improve communication, collaboration, and leadership skills, increasing the effectiveness of decisions made within a group. These programs enable team members to synchronize their situational awareness and make more informed decisions in critical situations. Additionally, stress management and cognitive load reduction techniques help decision-makers optimize their mental processes.

The effectiveness of decision-making processes in aviation should be supported not only by technology and training but also by a systematic approach. Advanced data integration accelerates the flow of information across different



units of aviation operations, allowing decision processes to be executed more coordinately. Furthermore, multidisciplinary research conducted to better understand and improve decision-making processes combines knowledge from fields such as human factors and psychology, providing a more comprehensive understanding. These integrated approaches are considered key elements in minimizing human errors and enhancing flight safety standards in aviation.

**References:**

[1] Hooey, B. L., & Foyle, D. C. (2006). Pilot navigation errors on the airport surface: Identifying contributing factors and mitigating solutions. The International Journal of Aviation Psychology, 16(1), 51-76.

[2] Federal Aviation Administration (FAA) (n.d.). Aeronautical Decision-Making. https://www.faa.gov/sites/faa.gov/files/04_phak_ch2.pdf

[3] Endsley, M. R. (1995). Toward a theory of situation awareness in dynamic systems. Human factors, 37(1), 32-64.

[4] Jones, D. G., & Endsley, M. R. (1996). Sources of situation awareness errors in aviation. Aviation, space, and environmental medicine, 67(6), 507-512.

[5] Nickerson, R. S. (1998). Confirmation bias: A ubiquitous phenomenon in many guises. Review of general psychology, 2(2), 175-220.

[6] Pallier, G., Wilkinson, R., Danthiir, V., Kleitman, S., Knezevic, G., Stankov, L., & Roberts, R. D. (2002). The role of individual differences in the accuracy of confidence judgments. The Journal of general psychology, 129(3), 257-299.

[7] Moore, D. A., & Healy, P. J. (2008). The trouble with overconfidence. Psychological review, 115(2), 502.

[8] Roese, N. J., & Vohs, K. D. (2012). Hindsight bias. Perspectives on psychological science, 7(5), 411-426.

[9] Hoffrage, U., & Pohl, R. (2003). Research on hindsight bias: A rich past, a productive present, and a challenging future. Memory, 11(4-5), 329-335.


ENSURING SAFETY IN AIR TRAVEL:

# THE IMPORTANCE OF EMERGENCY PREPAREDNESS AND EVACUATIONS

**Air travel remains the safest form of transportation, thanks to a combination of well-maintained aircraft, trained flight crews, and rigorous safety protocols. While the chance of an emergency is minimal, knowing how to act in case one arises can make all the difference in ensuring passenger safety.**

**Air Travel: The Safest Mode of Transportation**
Air travel remains the safest mode of transport, thanks to a robust aviation system that ensures aircraft are well-maintained and flight crews are properly trained. While commercial aviation operates with an exceptional safety record, emergency situations can occasionally arise. In such instances, being prepared and following established protocols can make a crucial difference in ensuring passenger safety.

Although the likelihood of an emergency evacuation is extremely low, it is essential for passengers to be aware of proper evacuation procedures. High-profile incidents, such as the 2009 Hudson River landing and the 2024 Haneda Airport accident, have demonstrated the effectiveness of emergency evacuations when passengers and crew adhere to established safety protocols. In both cases, all passengers and crew on the commercial aircraft were successfully evacuated without fatalities.

Understanding the key elements that contribute to a successful evacuation can help passengers stay prepared in the unlikely event of an emergency.

**Passenger Responsibilities During an Evacuation**

**1. Pay Attention to Safety Briefings**
Before every flight, cabin crew provide safety demonstrations, which detail emergency procedures. Even for frequent flyers, it is important to pay attention, as aircraft configurations and safety equipment vary by model. Additionally, reviewing the safety card provided in the seat pocket can reinforce important procedures.

If seated next to an emergency exit, passengers must listen carefully to the instructions provided by the cabin crew. Some emergency exits require passenger assistance in opening the door, making it critical to understand their operation.

**2. Follow Crew Instructions**
Cabin crew undergo rigorous training to handle emergency scenarios. In an evacuation, following their guidance

is paramount. Flight attendants are trained to manage panic, coordinate movement, and ensure that emergency exits are used efficiently.

**3. Secure Your Seatbelt During Critical Phases of Flight**
During taxi, takeoff, and landing, seatbelts should be tightly fastened around the hips. This positioning provides maximum support in case of an impact. Even during cruise, keeping the seatbelt loosely fastened is advisable to prevent injuries from unexpected turbulence.

**4. Leave Your Luggage Behind**
Time is of the essence during an evacuation. Attempting to retrieve personal belongings not only slows down the process but also increases the risk of injury and may obstruct evacuation paths. Past incidents have shown that passengers attempting to carry luggage during evacuations can severely hinder the escape process, putting lives at risk.

**Aircraft Design for Evacuation Safety**
Aircraft manufacturers must adhere to strict certification requirements to ensure that aircraft can be evacuated swiftly and safely in an emergency. Several key design elements contribute to this:

**1. Emergency Exits**
Aircraft are equipped with multiple emergency exits, whose number and placement depend on the aircraft's size and passenger capacity. These exits must be easily accessible, clearly marked, and simple to operate in an emergency.

**2. Evacuation Equipment**
Aircraft are equipped with various safety features to facilitate a successful evacuation, including:

Fire-resistant materials to minimize the spread of flames.

Smoke detectors and fire extinguishers for onboard fire suppression.

Emergency lighting systems to guide passengers even in low-visibility conditions.

Evacuation slides and rafts to enable rapid exits.

Crash-resistant seating to enhance passenger safety in the event of an impact.

Emergency oxygen systems to provide breathable air in case of cabin depressurization.

**3. Evacuation Testing**
Before an aircraft is certified, manufacturers must demonstrate that it can be fully evacuated within 90 seconds using only half of its exits. This stringent requirement ensures that passengers can evacuate in the shortest time possible. The tests are conducted under ideal conditions with physically capable volunteers, making real-life evacuations potentially more challenging.

Before every flight, the crew conducts meticulous safety inspections to ensure that all emergency equipment is fully operational. A common phrase heard during these procedures,

"crosscheck complete," signifies that another crew member has verified the necessary safety checks. These protocols are in place to maintain the highest safety standards, and passengers also play a role in this process by reporting any unusual occurrences, such as smoke in the cabin or visible damage to the aircraft.

Seating arrangements are another important consideration in ensuring passenger safety. Airlines strategically place individuals with reduced mobility and families with young children in seats that allow for easier access to emergency exits. Keeping children seated with their guardians enhances their ability to receive assistance when needed, improving overall emergency preparedness.

Although emergencies in commercial aviation are rare, preparedness remains a key factor in ensuring safe outcomes. Listening to safety briefings, following crew instructions, wearing seatbelts properly, and leaving personal belongings behind during evacuations all contribute to a swift and efficient response. The aviation industry remains steadfast in its commitment to safety through continuous training, advanced aircraft technology, and strict regulatory standards, ensuring that air travel continues to be the safest mode of transportation worldwide.

# WHAT ARE EVTOL AIRCRAFT?

One of the newest innovations in recent transportation technologies is the eVTOL aircraft. These electric vertical take-off and landing aircraft are also known as air taxis or flying taxis for short distances. Powered by batteries, eVTOLs can hover and fly like a helicopter; they are usually designed to carry two to six passengers, including the pilot. (A helicopter is also considered a VTOL.)

**The potential use cases for eVTOL aircraft are as follows:**

1. **Air Taxi Services:** Air taxis could transport passengers quickly and comfortably over short distances.

2. **Emergency Services:** In emergency services such as ambulance, firefighting, and search-and-rescue operations, eVTOLs can provide rapid intervention, especially in situations where traffic delays might hinder response times.

3. **Logistics and Cargo Transportation:** eVTOLs can facilitate quick deliveries, especially for short distances, by saving time. For example, logistics companies like UPS may use eVTOLs in this field.

4. **Tourism and Entertainment:** Companies offering special tours or city sightseeing could use eVTOLs to provide tourists with aerial views.

5. **Public Services:** eVTOLs could be utilized in police and military operations for surveillance, monitoring, and support tasks.

**Characteristics of eVTOL Aircraft:**
eVTOL aircraft offer many advantages over helicopters and other aircraft due to their design and power structure:

- **Less Noise**: In their forward flight, they use wing-induced lift as they accelerate and rotor speed is lower than helicopters, which reduces noise levels.

- **Increased Safety:** Because they have multiple rotors, when one rotor fails, the others take over. In addition, eVTOLs' energy systems are redundant, so the vehicle can continue to operate even if the battery pack fails.


- **Ease of Use:** Thanks to the computerized flight control system, eVTOLs can be controlled more easily and efficiently.
- **Use in Urban Environment:** Allows for urban flights without the need for traditional runways; suitable for short-haul applications such as postal services and emergencies.

However, e-VTOL aircraft lack the equipment and weight capacity for missions such as search and rescue and firefighting.

**Future of The e-VTOL**

EVTOL is a revolutionary innovation whose foundations have long been laid with the projects we have referred to as “flying cars” for many years. Although the debut of eVTOL in the aviation industry dates back approximately 10 years, it has rapidly evolved with different concepts tailored to various market needs. While there has not yet been a major breakthrough in the Far East (Japan, China, Korea), companies in the USA and Germany are making significant and innovative progress in this field. One of the main reasons for this advancement is the high demand for fast transportation and ease of use in the United States.

It is expected that eVTOLs will spread to many countries over the next 10 years for different purposes, with various designs emerging. In this context, UPS Cargo has been observed as one of the most common user and operator companies. While transportation and taxi services are moving towards more regional and localized concepts, the development of personal use is an exciting aspect to watch.


# EUROPEAN UNION AVIATION SAFETY AGENCY (EASA) HAS ISSUED A NEW COMMISSION IMPLEMENTING REGULATION (EU) 2025/111

**European Union Aviation Safety Agency (EASA) has issued a new Commission Implementing Regulation (EU) 2025/111 of January 23, 2025, revising Regulation (EU) No 1321/2014 regarding the continued airworthiness of electric and hybrid-propelled aircraft, as well as other non-conventional aircraft. Commission Regulation (EU) No 1321/2014 establishes the requirements for aircraft's continued airworthiness, including the qualifications and licenses of personnel responsible for returning products to service after maintenance, but previous versions of the regulation did not fully cover all eVTOL aircraft types.**

**According to the new rule:**
"By considering all tilt-rotors as complex motor-powered aircraft, Regulation (EU) No 1321/2014 was not commensurate for the simplest ones as stringent requirements applicable to any complex motor-powered aircraft was also applicable to the simplest tilt-rotors, for which less stringent requirements should apply by comparison with simple aircraft of other categories, namely aeroplanes and helicopters. Therefore the definition of complex motor-powered aircraft should therefore be amended."

The new rule broadly brings eVTOLs within the umbrella of EU rules covering maintenance and support of all EU-registered aircraft. For example, eVTOL operators will need to ensure their maintenance programs have been approved by the competent authority in accordance with point M.A.302 of Annex I (Part-M), due maintenance has been performed and certified in accordance with point 145.A.48 and 145.A.50 of Annex II (Part-145), and an airworthiness review has

In this context, a new category has been added to aircraft maintenance licenses: B1.E - (MTOM ← 5,700 kg).

Modules Required for B1.E License

Aircraft maintenance engineers who want to have a B1.E license must successfully complete the following modules:

- Module-1: Mathematics
- Module-2: Physics
- Module-3: Electrical Fundamentals

- Module-4: Electronic Fundamentals
- Module-5: Digital Techniques/ Electronic Displays
- Module-6: Materials and Hardware
- Module-7: Maintenance Practices
- Module-8: Basic Aerodynamics
- Module-9: Human Factors
- Module-10: Aviation Regulations
- Module-11: Aircraft Aerodynamics, Structures and Systems (B1.E)
- Module-17: Propeller
- Module-18: Electric Power Plant (Newly Added Module)

This new module is specifically designed for aircraft maintenance engineers who will perform maintenance on electric and hybrid propulsion aircraft. The content consists of the following headings:

- 18.1 Fundamentals
- 18.2 Engine performance
- 18.3 Engine structure
- 18.4 Electrical energy system
- 18.5 Engine display systems
- 18.6 Engine Assembly (Installation)
- 18.7 Engine monitoring and ground operations
- 18.8 Engine storage and protection

**Exam Information**

For Category B1.E: 76 multiple choice questions

Exam duration: 95 minutes

No written questions (essay).

Electric and hybrid propulsion aircraft are becoming increasingly important in line with sustainable aviation goals. This new license will enable aircraft maintenance engineers working in the sector to gain competence in this field.

The relevant regulation link: https://www.easa.europa.eu/en/document-library/regulations/commission-implementing-regulation-eu-2025111

Ömür CANİNSAN
Part -147 Type Training Instructor

# OPTIMIZING AIRCRAFT MAINTENANCE: CONCEPTS, DETAILED METHODOLOGIES, AND FUTURE DIRECTIONS

**Aircraft maintenance optimization is at the heart of modern aviation, balancing safety, operational efficiency, and cost management. With increasing fleet sizes, stringent regulatory requirements, and the rising complexity of aircraft systems, maintenance optimization has evolved from simple reactive repairs to sophisticated data-driven strategies.**

This paper delves into the evolution of maintenance methodologies, the contributions of Reliability-Centered Maintenance (RCM) and the Maintenance Steering Group (MSG) frameworks (MSG-1, MSG-2, MSG-3), and the integration of advanced technologies like Airplane Health Monitoring (AHM) and digital twins. Furthermore, it discusses future directions and the critical role of artificial intelligence (AI) and machine learning (ML) in predictive maintenance.

**From Corrective to Reliability-Centered Approaches**

Aircraft maintenance has evolved significantly from its early days of reactive repairs to today's highly structured and reliability-focused methodologies. Initially, the industry operated under a "fix-it-when-it-breaks" philosophy, known as corrective maintenance. While straightforward, this approach proved costly, inefficient, and posed significant safety risks. As jet aircraft became more complex in the mid-20th century, the need for structured maintenance programs became evident.

By the 1960s, preventive maintenance became the dominant strategy, with components overhauled at fixed intervals based on historical failure data. However, this often resulted in unnecessary maintenance of fully functional components, leading to increased costs and operational inefficiencies. To address these challenges, the 1970s saw the introduction of Reliability-Centered Maintenance (RCM), which revolutionized aircraft upkeep by systematically analyzing failure mechanisms. RCM prioritizes critical systems affecting safety and operations, identifies failure modes and their consequences, and tailors maintenance tasks to mitigate failures cost-effectively. Today, RCM remains a fundamental principle in modern maintenance optimization,

ensuring reliability while aligning with operational and economic goals.

**The MSG Frameworks**
The Maintenance Steering Group (MSG) methodology was developed to standardize and refine maintenance practices, integrating Reliability-Centered Maintenance (RCM) principles. Over time, the framework evolved through three generations—MSG-1, MSG-2, and MSG-3—each adapting to the increasing complexity of aircraft systems and improving maintenance efficiency.

The first iteration, MSG-1, introduced in 1968, provided a structured maintenance planning framework that categorized tasks into three types: Hard Time (HT), which required scheduled overhauls; On Condition (OC), involving inspections and performance tests; and Condition Monitoring (CM), which used operational data to determine maintenance needs. Despite its structured approach, MSG-1 was heavily reliant on fixed intervals, often leading to inefficiencies.

By 1970, MSG-2 built upon these foundations by emphasizing Condition Monitoring (CM), allowing real-time performance evaluations. This advancement reduced unnecessary replacements, as components were serviced only when they failed to meet operational standards, introducing greater flexibility in maintenance strategies.

The most significant shift came with MSG-3 in 1980, transitioning from a component-based to a system-centric approach. This framework embedded RCM principles and introduced key advancements, such as prioritizing hidden failures that might not immediately impact operations but could have severe consequences, adopting a task-oriented approach tailored to specific system needs, and utilizing a top-down analysis methodology for a more holistic assessment of aircraft maintenance requirements.

Today, MSG-3 remains the industry standard, shaping how modern maintenance programs are developed and ensuring optimal balance between safety, reliability, and cost-effectiveness.

| MSG-2 | MSG-3 |
|---|---|
| **Analysis**<br>• System<br>• Structure | **Analysis**<br>• System<br>• Structure<br>• Zonal, Enhanced Zonal Analysis Procedure (EZAP)<br>• L/HIRF |
| **Bottoms-Up Approach**<br>• Hard Time (HT)<br>• On-Condition (OC)<br>• Condition Monitoring (CM) | **Top Down Approach**<br>• Airplane<br>• System<br>• Part Number<br>• Component Serial Number |
| Analysis at the **lowest** manageable level | Analysis at the **highest** manageable level |

**Modern Maintenance Optimization Practices**
Technological advancements have driven maintenance optimization beyond traditional MSG frameworks, leveraging data analytics and predictive modeling to enhance efficiency. Today, real-time monitoring systems, digital simulations, and data-driven optimization techniques play a pivotal role in shaping modern maintenance strategies.

**Airplane Health Monitoring (AHM)**
Airplane Health Monitoring (AHM) systems integrate sensors throughout an aircraft to collect real-time performance data. These systems track critical metrics such as engine performance, oil pressure, and environmental stress, enabling Condition-Based Maintenance (CBM)


by scheduling tasks only when data indicates potential failures. This predictive approach reduces unscheduled downtime, enhances operational efficiency, and optimizes fleet utilization.

**Digital Twins**
Digital twins replicate physical aircraft within virtual environments, allowing operators to simulate real-world conditions. These virtual models predict component failures and wear, optimize maintenance intervals based on usage patterns, and test different operational scenarios without affecting actual aircraft. For instance, a digital twin of an aircraft engine can simulate its performance under varying loads, providing early insights into potential maintenance needs and improving lifecycle management.

**System Analysis and Safety Monitoring Optimization (SASMO)**
System Analysis and Safety Monitoring Optimization (SASMO) tools utilize historical maintenance records and operational data to refine task intervals. By identifying inefficiencies and trends, these tools help extend non-critical task intervals and optimize critical inspections to enhance safety and reliability.

**AHM in Practice**

| Metric | Example Sensor | Purpose |
|---|---|---|
| Engine Health | Vibration Sensors | Detecting early-stage wear. |
| Hydraulic System Pressure | Pressure Gauges | Monitoring for leaks. |
| Electrical Systems | Thermal Sensors | Identifying overheating risks. |

SASMO methodologies enable data-driven decision-making, ensuring that maintenance actions align with operational demands while minimizing costs and resource usage.

The integration of these advanced maintenance optimization techniques represents a significant shift from reactive to proactive strategies, ensuring improved aircraft reliability, reduced operational disruptions, and greater cost efficiency across the aviation industry.

**Statistical Insights into Maintenance Optimization**
The adoption of advanced maintenance practices has led to measurable improvements in safety, cost savings, and operational efficiency.

**The Future of Maintenance Optimization**
The next stage in aircraft maintenance optimization lies in the integration of artificial intelligence (AI) and machine learning (ML), which

promise enhanced efficiency, cost reduction, and improved safety. These technologies offer a transformative approach by automating processes, improving predictive accuracy, and dynamically adapting maintenance schedules.

**Key Innovations in AI-Driven Maintenance**

**Predictive Analytics:** AI can process vast datasets to forecast failures with greater accuracy than traditional methods, enabling more precise maintenance planning.

**Autonomous Inspections:** Drones and robotic systems can conduct rapid, high-precision inspections, reducing human workload and minimizing inspection times.

**Dynamic Maintenance Scheduling:** ML algorithms can adjust maintenance schedules in real time based on operational demands, weather conditions, and aircraft usage patterns, ensuring optimal resource allocation.

**AI in Predictive Maintenance**

One of the most promising applications of AI in maintenance is predictive maintenance, where AI-powered systems analyze sensor data to detect microfractures in engine components before they lead to catastrophic failures. This proactive

**Maintenance Cost Trends**

| Year | Avg. Maintenance Cost per Flight Hour (USD) | % Change Over Decade |
|---|---|---|
| 2000 | 1,200 | — |
| 2010 | 900 | -25% |
| 2020 | 700 | -22% |

**Operational Benefits**

| Metric | Traditional Maintenance | Optimized Maintenance |
|---|---|---|
| Aircraft Downtime (Hours/Year) | 120 | 85 |
| Avg. Maintenance Cost (USD/Year) | 3.5M | 2.8M |

approach allows operators to replace parts preemptively, reducing unscheduled downtime, minimizing costs, and extending the lifespan of critical aircraft systems.As AI and ML continue to advance, their integration into maintenance strategies will revolutionize the aviation industry, making aircraft maintenance smarter, more efficient, and highly responsive to real-world operational challenges.

As outlined above, aircraft maintenance processes have undergone a significant transformation from traditional, rigid schedule-based methods to data-driven and dynamic approaches. The MSG-3 maintenance framework, Aircraft Health Monitoring Systems (AHM), and digital twins have enhanced maintenance strategies, making fleet management more precise and efficient.The future of the industry will be shaped by the widespread adoption of predictive maintenance tools powered by artificial intelligence (AI) and machine learning (ML). These innovations will provide real-time monitoring, autonomous inspections, and adaptive maintenance planning, reducing costs while enhancing safety and operational efficiency. With continuous technological advancements, the aviation industry will continue to move towards smarter, more proactive, and more reliable maintenance processes.


**References**

Boeing Maintenance Planning Documents (MPD), 2023.
International Air Transport Association (IATA), Maintenance Cost Task Force Reports, 2021.

Airbus, "Digital Twin Technology in Aircraft Systems," Technical White Paper, 2022.

GENDER DIVERSITY IN AVIATION:

# CHALLENGES AND PROGRESS

**Aviation is a highly technical and dynamic industry, yet it has remained predominantly male-dominated for decades. Women face significant barriers to entry and career advancement across various aviation roles, from piloting to maintenance and engineering. Despite global efforts to promote gender diversity, the industry still struggles with representation and inclusivity.**

**Gender Disparity and Challenges in Aviation**

Women continue to be underrepresented in key aviation roles, with only 5.8% of commercial airline pilots, less than 2% of aircraft maintenance professionals, and around 10% of aerospace engineers being female (IATA, 2023). A lack of visible female role models, workplace biases, and societal stereotypes discourage many women from entering technical and operational fields.

One of the biggest challenges is the historically male-dominated culture in aviation. Women often have to work harder to prove their competence, particularly in maintenance and repair operations, where outdated perceptions persist about their technical abilities. Additionally, the physically demanding nature of certain jobs has contributed to these misconceptions.

Work-life balance is another barrier, as aviation jobs frequently involve irregular hours and extensive travel. Many companies lack adequate parental leave policies and childcare support, making it difficult for women to sustain long-term careers in the industry. Moreover, the gender gap begins early, with fewer female students encouraged to pursue STEM-related education, leading to a smaller talent pool for aviation careers.

**Efforts to Promote Gender Diversity**
Various organizations have launched initiatives to address gender disparities in aviation:

**Women in Aviation International (WAI):** Established in 1990, WAI provides scholarships, mentorship programs, and networking opportunities for women in aviation.

**International Society of Women Airline Pilots (ISWAP):** Focuses on increasing the number of female pilots by offering career resources and professional support.

**ICAO's Gender Equality Program:**
A global initiative launched in 2022 to promote gender balance across all aviation sectors through policy recommendations and collaboration with industry stakeholders.

**Building a More Inclusive Aviation Industry**
To close the gender gap in aviation, proactive measures must be taken at multiple levels:

**Encouraging Women in STEM and Aviation:**
Outreach programs, scholarships, and mentorship initiatives should be expanded to attract more women to aviation careers.

**Creating Inclusive Work Environments:**
Airlines and MRO organizations need to enforce anti-discrimination policies and implement more flexible work arrangements to support career longevity for female professionals.

**Increasing Female Representation in Leadership:**
Setting gender diversity targets and promoting successful women as role models can inspire the next generation and ensure more inclusive decision-making within the industry.

The aviation sector has made progress in promoting gender diversity, but significant challenges remain. By fostering a culture of inclusion, investing in education, and eliminating structural barriers, the industry can create an environment where talent, not gender, defines success. With continued efforts from organizations, airlines, and regulatory bodies, aviation can move toward a future where opportunities are equally accessible to all.

# TRUMP'S SECOND PRESIDENCY AND THE FUTURE OF AVIATION: LIGHTSPEED AHEAD?

**Donald Trump's re-election in 2024 will change the global economy, trade relations, and regulatory policies in significant ways that will not spare the aviation sector either. His first term (2017–2021) had a profound impact on industry, from combative trade policy to deregulation and tax cuts.**

Now, with Trump back in the White House in 2025, the pieces in aviation are set for another round of changes. Will these changes fuel the industry's expansion, or will they create new challenges that might fracture global aviation networks?

**Trump's First Term and What That Means for Aviation**

Reflecting on Trump's first presidency, he made his mark primarily with economic policies that were all about slashing corporate taxes and minimizing federal regulation of what American businesses do. The Tax Cuts and Jobs Act of 2017, allowed for a significant tax break for corporations which lowered the corporate tax rate from 35% to 21% serving as a substantial boost for airlines and manufacturers in the aerospace industry. Americans Airlines utilized these tax breaks, which subsidized Boeing, into growing their fleet, modernizing their infrastructure, and boosting shareholder dividends. However, these benefits were reaped until the dual crises of the 737 MAX safety scandal and COVID-19 pandemic altered the entire landscape.

In an effort to fortify the American airline industry during the pandemic, Trump's administration enacted the CARES Act, which as a part of the plan allocated billions in funding to the domestic airlines. While this kept the airline industry from totally collapsing, Trump's trade policies put a strain on international relationships. His administration's trade wars with China and the European Union resulted in increased tariffs and retaliatory action that impacted demand for aircraft and the supply chain. Boeing saw a decrease in orders as China abandoned them as a primary customer in favor of Airbus, which was expected. European imports of aircraft into the USA also faced higher tariffs, creating friction in the Atlantic relations of aviation.

Policies regarding the environment have also undergone change as Trump was elected for his first term. He opted out of the Paris Climate Agreement and made cuts to a range of rules that were aimed at cutting down on carbon emissions. This meant that the aviation industry faced less motivation to adopt changes


such as the use of sustainable aviation fuel (SAF) and other green initiatives. While Joe Biden's government returned to the focus of sustainable aviation policy, Trump's return raised concerns that economic and industrial focused policies would once more overrule environmental regulations being prioritized.

**Aviation in 2025 and Beyond: What to Expect Under Trump's Second Term**

With Trump back in office, several key areas in aviation are very likely to undergo some changes, and they each bring with them a unique set of opportunities and challenges for the sector.

**The US-China Trade War: Issues and Boeing's Prospects**

Trump's trade position on China is perhaps the most worrying thing for the aerospace industry. Trump's campaign rhetoric would suggest that he intends to introduce a 60 percent tariff on Chinese imports, while at the same time placing a 10 percent tarif on all other imports. If these statements were put into action, China would increase retaliatory measures, and especially in the area of aviation.

The Boeing company has had its work cut out for it as it re-establishes its business in China post the 737 MAX crisis. Boeing's most recent challenges might stem from China increasingly leaning towards Airbus at the expense of Boeing. It doens't help that the COMAC, which is supported by the state of China, is building the C919 to serve as an alternative to so many Western planes. Should tensions between the two countries extend, China might very well speed up its strategies towards becoming self-sufficient in aerospace fueling the Boeing challenge because this market is one of the most important aviation industries in the world.

Trump's administration likely means a hike in tariffs for the European Union and that could mean a new term in the trade war between Boeing and Airbus. Trump used his first term to place tariffs on European made Airbus aircraft as a continuation of unresolved issues with WTO. If the U.S. chooses to approach the issue the same way, U.S. carriers like Delta and JetBlue might find it tougher to operate because of the reliance on Airbus aircraft and the increased costs could mean a change in strategy when it comes to the buying of aircraft.

**Fuel Prices and Aviation Economics**

One of Trump's most popular policies is energy autonomy which means increased drilling for oil domestically and loosening restrictions on fossil fuels. If these policies succeed, the prices of fuel could fall and that would be beneficial for airlines. Jet fuel is one of the biggest operational expenses for an airline, and fule price decreases would free up capital. Lower fuel prices could enable airlines to lower ticket prices.

The industry's transformation to green aviation could be hindered by the excessive concentration on conventional energy sources. At the start, the Biden administration brought forward green aviation policies which enhanced SAF adoption. This effort however was expected to be undone by Trump's policies which overshadowed these efforts. As a result, green aviation across all regions of the United States faced the possibility of being financially unworkable and airlines may push their sustainability investments on the back burner. This puts airlines under the risk of receiving global regulatory scrutiny from various sources such as the ICAO or the Fit For 55 program initiated by the EU.

**Aviation Defence And Space**

The aerospace industry with the focus on propulsion for example, is another one that was predicted to undergo significant changes within the Trump era. During his first tenure as President, Trump actively lobbied for greater military investment. As a result, he founded the Space Force, which happens to be America's sixth branch of military, during his previous term. Additionally, these

policies should also benefit defense firms such as Boeing and Lockheed Martin on the drone and military aircraft side. It should enable more research on sophisticated military planes and unmanned aerial vehicles.

Policy shifts were also expected to occur for Trump's return to the moon or long term stations: the Artemis program was set to be supported more vigorously. The focus however under the Trump era was expected to be set towards Space X, Blue Origin, and Boeing's starliner projects. Depending on budget allocations, some government-backed initiatives may be scaled back in favor of commercial partnerships.

**Airport and Infrastructure Investments**

Aviation infrastructure has been one of the key points in the general economic vision by Trump. Throughout his first term, Trump constantly decried U.S. airports as compared to Asia and the Middle East. In 2025, his administration may advance the ball on megaproject modernizations at core hubs like New York's JFK, Chicago's O'Hare, and Los Angeles' LAX. Yet sources of funding remain unclear, as Trump has long opposed major government spending bills unless the projects are yoked to private partnerships.

If the America First mentality trickles down to his administration's infrastructure development policy, international investment into U.S. airport projects could become thinner on the ground. In some instances, that could slow modernization projects that have long relied on foreign capital.

**Final Thoughts: Challenges and Opportunities for Global Aviation**

With Trump back at the reins of power, it's a potentially transformative moment of truth for aviation. Airlines might benefit from low fuel prices, corporate tax cuts, and infrastructural investments, but on the other side, they also risk getting severely disrupted from trade conflicts, reduced sustainability initiatives, and different defense priorities.

For Boeing, the stakes are particularly high: if China hastens its pivot away from US aircraft manufacturers, Boeing could lose a vital market to Airbus and COMAC. US airlines could face higher tariffs on imported aircraft, which would alter their fleet strategies.

Environmental concerns will also continue to be a contentious issue. While lower fuel prices may ease short-term operating costs, a weakened commitment to

sustainability could put U.S. airlines at odds with global regulatory standards.

Ultimately, of course, whether Trump's aviation policies prove successes or failures hinges on how effectively the industry modernizes to navigate new trade dynamics, fluctuating fuel prices, and shifting geopolitical landscapes. For 2025, airline chiefs, manufacturers, and global policy thinkers will observe with interest as Trump's second term reimagines the flight path of aviation.

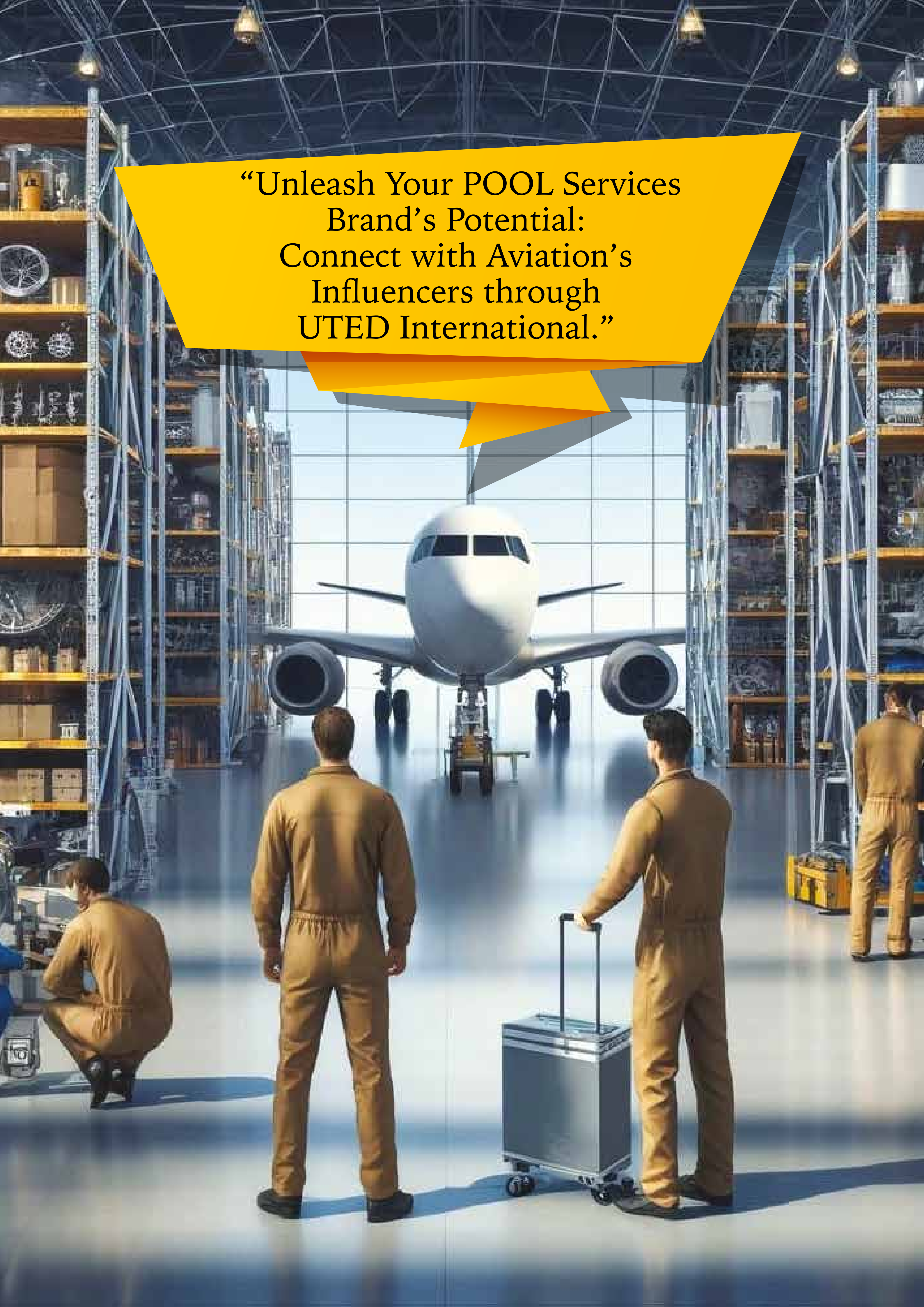
**References**

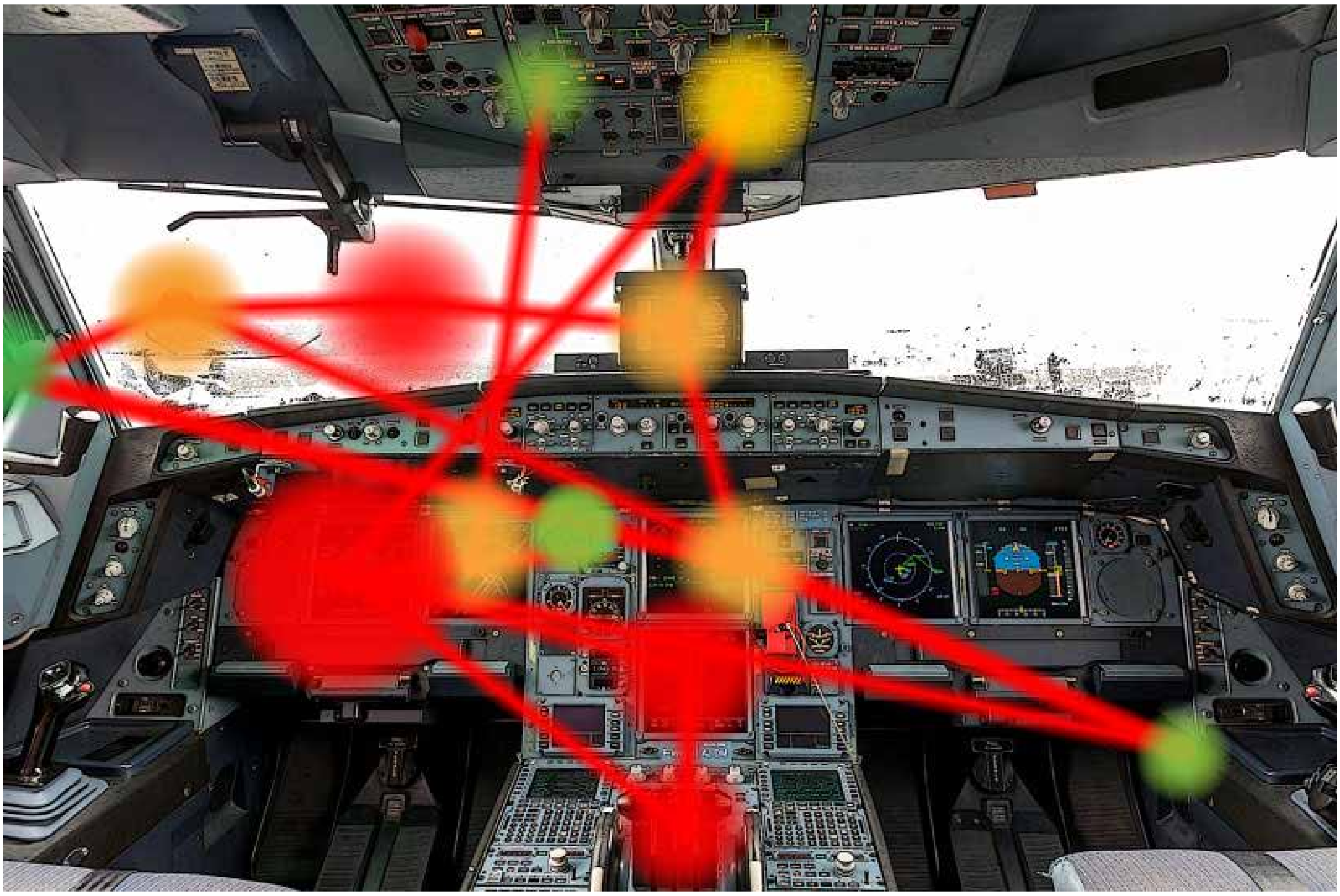
Financial Times (2024). What the US election means for corporate America.

Forbes (2024). How Trump's trade policies could impact Boeing and Airbus.

The Economist (2024). The future of aviation under Trump's second term.

ICAO Reports (2024). Sustainable Aviation and Regulatory Challenges.


“Unleash Your POOL Services Brand’s Potential: Connect with Aviation’s Influencers through UTED International.”



# BITE TEST:
# THE EYES AND EARS OF AVIATION MAINTENANCE

**In a modern aircraft cockpit, hundreds of buttons, screens, and systems work together to ensure a safe flight. But how do we know if each of these systems is functioning correctly? Detecting faults in avionics systems before they escalate into major issues is a critical aspect of aviation maintenance. This is where BITE (Built-In Test Equipment) testing comes in, playing a crucial role in keeping aircraft systems operational and ensuring flight safety.**

**The Origins of BITE Testing: Why Was It Developed?**
In the early days of aviation, troubleshooting faults relied heavily on manual inspections and visual checks by technicians. However, as aircraft became more complex—especially with the introduction of jet engines and sophisticated avionics—these traditional methods proved insufficient.

By the 1960s, military aviation recognized the need for automated diagnostic systems to minimize maintenance time and quickly detect system failures. Military jets, designed for rapid deployment and operational readiness, required self-diagnostic capabilities to identify malfunctions without extensive manual inspections. This necessity led to the development of BITE systems, which could conduct internal system checks and provide real-time feedback on potential issues.

**The Evolution of BITE Testing in Commercial Aviation**
Following its success in military aircraft, BITE technology was integrated into commercial aviation. By the 1980s, aircraft manufacturers such as Boeing and Airbus began incorporating built-in test capabilities into their avionic systems.

Modern aircraft, like the Airbus A320 and Boeing 737, come equipped with advanced BITE systems that constantly monitor avionics, flight control, and engine health. These systems can detect and diagnose issues ranging from minor sensor malfunctions to critical failures in electronic components.

**How Does BITE Testing Work?**
BITE testing is essentially an onboard diagnostic system that runs self-tests on aircraft components. The process involves three main functions:

**Fault Detection:** Identifying anomalies or deviations from standard performance.

**Fault Isolation:** Pinpointing the exact component or subsystem responsible for the issue.

**Fault Reporting:** Storing diagnostic data for use by maintenance crews, allowing them to assess the issue quickly.

When a BITE system detects a problem, it generates a fault code, which is recorded in the aircraft's maintenance log. Technicians can then use specialized diagnostic tools, such as a Central Maintenance Computer (CMC), to analyze these fault codes and determine the necessary corrective actions.

### Applications of BITE Testing in Modern Aviation

**1. Routine Maintenance and Pre-Flight Checks**

BITE tests are regularly conducted as part of pre-flight and post-flight inspections to ensure that all critical systems are functioning properly. Airlines rely on these tests to minimize the risk of in-flight failures and to comply with aviation safety regulations.

**2. Troubleshooting System Malfunctions**

When pilots report a system malfunction during flight, BITE diagnostics provide the first line of troubleshooting. For example, if a navigation display fails, a BITE test can confirm whether the issue stems from the display unit itself, a faulty data connection, or an underlying software error.

**3. Predictive Maintenance and Data Analytics**

With the rise of big data and predictive analytics, BITE testing is no longer just about identifying current faults—it is also used to predict potential failures before they occur. By analyzing trends in BITE data over time, airlines can proactively replace components that are likely to fail, reducing unplanned maintenance and improving aircraft availability.

**4. Compliance with Aviation Regulations**

Regulatory agencies such as the FAA (Federal Aviation Administration) and EASA (European Union Aviation Safety Agency) require periodic system checks, many of which rely on BITE diagnostics. Ensuring compliance with these regulations is essential for maintaining aircraft certification and operational safety.

### Challenges and Limitations of BITE Testing

While BITE testing has revolutionized aircraft maintenance, it is not without challenges:

**False Positives & Negatives:** Sometimes, a BITE system may generate an error code for a problem that does not exist (false positive) or fail to detect an actual issue (false negative).

**Complex Interpretation:** Modern aircraft systems are highly interconnected, making it difficult to interpret some BITE test results without further manual inspection.

**Dependence on System Health:** If the BITE system itself malfunctions, it may not accurately report issues, leading to potential misdiagnoses.

### The Future of BITE Testing: AI and IoT Integration

As aircraft become increasingly connected through the Internet of Things (IoT), BITE testing is evolving into a more advanced predictive maintenance tool. Future advancements include:

**Artificial Intelligence (AI)-Driven Diagnostics:** AI can enhance BITE testing by learning from historical data and identifying subtle patterns that may indicate early-stage system degradation.

**Remote Monitoring & Cloud-Based BITE Analysis:** Airlines are exploring real-time, cloud-based monitoring of BITE data, allowing maintenance teams to assess aircraft health while in-flight and prepare for necessary repairs before landing.

**Augmented Reality (AR) for Maintenance Crews:** AR could provide technicians with visual overlays of BITE test results, helping them quickly locate and resolve faults.

### Conclusion

BITE testing has become an essential part of aviation maintenance, enhancing operational efficiency, safety, and reliability. What began as a tool for military aircraft has now become a standard feature in modern commercial aviation, ensuring that every flight is as safe as possible. As technology continues to evolve, BITE systems will play an even greater role in predictive maintenance, reducing downtime and keeping aircraft in peak operational condition.

With advancements in AI, IoT, and data analytics, the future of BITE testing is set to redefine how airlines approach aircraft maintenance—proactively addressing potential failures before they occur and making air travel even safer than ever before.


## MID-AIR TRAGEDY OVER THE POTOMAC:

# ANALYZING THE AMERICAN EAGLE AND BLACK HAWK COLLISION

**On the evening of January 29, 2025, a devastating mid-air collision occurred over the Potomac River near Washington, D.C. This tragic event involved an American Eagle regional jet and a U.S. Army Sikorsky UH-60 Black Hawk helicopter, resulting in the deaths of all 67 individuals on board both aircraft. This incident marks one of the deadliest aviation disasters in recent U.S. history and has sparked urgent discussions about air traffic control management, military and civilian flight coordination, and regulatory oversight failures.**

**Details of the Incident**

American Eagle Flight 5342, operated by PSA Airlines, was a Bombardier CRJ-701ER regional jet flying from Wichita Dwight D. Eisenhower National Airport to Ronald Reagan Washington National Airport (DCA). The flight carried 60 passengers and four crew members. Meanwhile, the Black Hawk helicopter was on a routine training mission involving airspace maneuver drills near restricted military airspace, carrying three military personnel. Preliminary investigations suggest that the collision occurred at approximately 8:47 p.m. EST, just as Flight 5342 was making its final approach to DCA. The Black Hawk, reportedly flying at an altitude of around 3,000 feet, entered the jet's flight path, resulting in a catastrophic mid-air explosion. Witnesses described seeing a fireball over the river before both aircraft plunged into the icy waters.

**Air Traffic Control and Communication Failures**

One of the key elements under scrutiny is the role of air traffic control in managing conflicting flight paths. Initial findings indicate that there was only one controller on duty at the time of the crash—a situation that deviates from standard FAA protocols requiring at least two controllers for monitoring both military and civilian airspace. Moreover, reports suggest that the air traffic control supervisor had left their post early, leaving the tower understaffed during a critical period.

Additionally, questions are being raised about whether the helicopter crew had received timely clearance or whether they were operating in a known civilian corridor without proper coordination. The FAA is reviewing recordings of all communications between air traffic controllers and both aircraft to determine if miscommunications or delays played a role in the crash.

**Investigating the Role of Surveillance and Avoidance Systems**

Modern air traffic management relies on a combination of radar surveillance, Automatic Dependent Surveillance–Broadcast (ADS-B) systems, and Traffic Collision Avoidance Systems (TCAS). Commercial aircraft like the Bombardier CRJ-700 are equipped with TCAS, which automatically alerts pilots to potential conflicts. However, military helicopters, particularly those on training missions, may not always be required to have active transponders enabled, reducing their visibility to civilian aircraft.

Investigators are examining whether the Black Hawk had its transponder activated and if the American Eagle crew received any TCAS alerts prior to impact. If the helicopter's transponder was off or malfunctioning, this could have significantly reduced the regional jet's ability to detect and react in time.

**Potential Contributing Factors**

**1. Airspace Management Issues**

The Potomac River region is known for its complex airspace, which includes restricted military zones, high-density commercial flight corridors, and helicopter operations for law enforcement and government agencies. While military aircraft are allowed to conduct training exercises near civilian airspace, strict coordination is required to prevent conflicts.

**2. Weather Conditions**

Meteorological data at the time of the crash indicated clear skies but freezing temperatures, which may have contributed to challenges in emergency response and recovery efforts. However, weather conditions do not appear to have played a direct role in the collision itself.

**3. Human Factors**

The possibility of human error on multiple levels—from air traffic control staffing issues to pilot situational awareness—is a major avenue of investigation. Fatigue among controllers, potential misinterpretations of instructions, and pilot reactions under time-sensitive conditions are all being evaluated.

**4. Regulatory Oversight and Military Protocols**

The National Transportation Safety Board (NTSB) and the FAA are reviewing whether there were lapses in regulatory compliance, including whether military training protocols were adhered to in terms of flight planning and coordination with civilian air traffic controllers.

**Community Impact and Mourning**

The tragedy has deeply affected numerous communities. Among the victims were members of the figure skating world, including former champions and young aspiring athletes. The Skating Club of Boston and other organizations have held vigils in memory of those lost.

Nationally, the incident has reignited concerns over aviation safety and airspace management near densely populated urban centers. Families of the victims have begun demanding answers from the authorities, with some advocating for stronger oversight of military-civilian air traffic coordination.

**Moving Forward: Safety Recommendations**

As investigations progress, several safety recommendations are expected to emerge:

- Mandatory transponder activation for all military aircraft operating near civilian corridors.
- Enhanced air traffic staffing requirements to ensure proper monitoring of high-traffic airspace.
- Improved real-time coordination protocols between the FAA and military operations.
- Regular joint training sessions for civilian and military pilots to improve situational awareness.

The collision between American Eagle Flight 5342 and the Black Hawk helicopter serves as a sobering reminder of the complexities and risks inherent in modern airspace management. While mechanical failures have not been indicated as primary causes, systemic issues—ranging from air traffic control oversight to procedural failures—are at the heart of the ongoing investigation.The final NTSB report, expected within a year, will provide definitive conclusions, but immediate policy changes and safety enhancements may be required long before then to prevent a similar tragedy from occurring in the future.

# ENGINE MRO INVESTMENTS AND DEVELOPMENTS

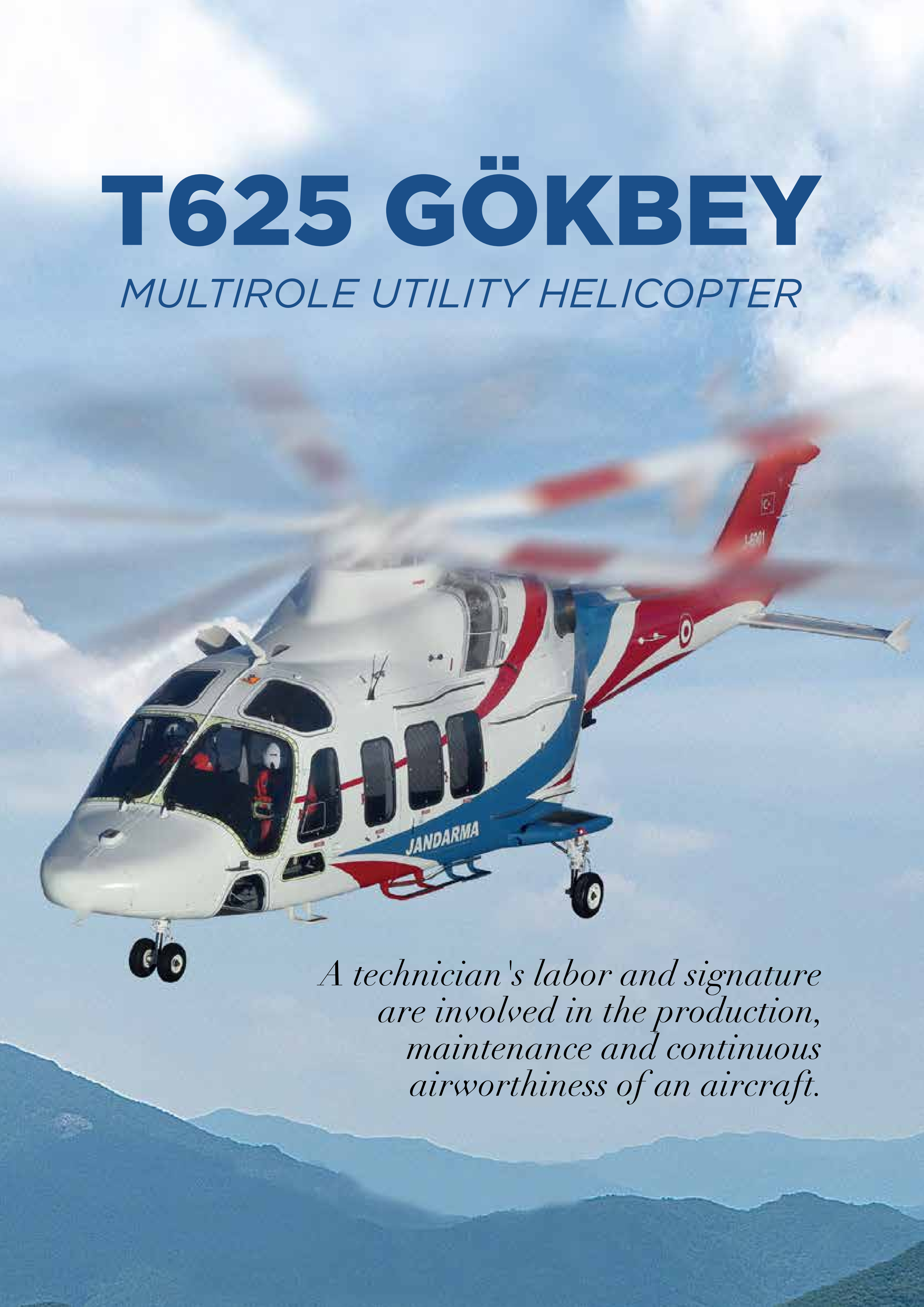
Despite easing production issues in 2025, significant investments in next-generation engine repair networks continue.

**Pratt & Whitney Geared Turbofan (GTF)**
Operating within a closed network, Pratt & Whitney's GTF program faces durability challenges, with 600-700 engines scheduled for early repairs by 2026. MRO demand is expected to grow from 100 events in 2025 to 750 by 2028. Expansion efforts include a 40% capacity increase at its Florida site and a $150 million upgrade at its Christchurch Engine Center. Pratt & Whitney plans to have 30 GTF MRO facilities by 2030.

**GE Aerospace GEnx**
The GE Aerospace GEnx, introduced in 2011, is seeing increased shop visits. The GEnx aftermarket, projected at $5.9 billion in 2025, continues to grow as the engine gains market share against Rolls-Royce. GE Aerospace, along with providers such as Sanad, MTU Maintenance, and AFI KLM E&M, is expanding MRO capabilities, including a potential joint venture between AFI KLM E&M and Saudia Technic for GEnx repairs in Jeddah.

**CFM International Leap**
The Leap engine program is projected to generate $238.5 billion in MRO spending over the next decade, surpassing the CFM56 by 2029. Safran and GE Aerospace plan to increase Leap shop visits to 1,725 in 2025, with further expansions in Brussels, Morocco, India, Mexico, and France. CFM has eight licensed MRO shops, with Lufthansa Technik (LHT) and StandardAero leading the network. LHT has completed over 60 Leap engine events, focusing on modifications like the Reverse Bleed System (RBS) to improve performance. New Leap repair facilities are emerging in Cyprus, Israel, and Portugal, while CFM anticipates adding 3-5 more MRO suppliers to meet growing demand.

**Rolls-Royce Trent 1000 & XWB**
Rolls-Royce is expanding its aftermarket operations to support Boeing 787 and Airbus A350 engines. Investments of £55 million in Derby, UK, and Dahlewitz, Germany, will increase Trent 1000 and XWB capabilities. A £1 billion enhancement package aims to improve engine durability. Joint ventures with Lufthansa Technik (N3) and SIA Engineering Co. in Singapore will boost Trent engine output, while a new partnership with Air China (BAESL) will add capacity by 2026.


T625 GÖKBEY
MULTIROLE UTILITY HELICOPTER
JANDARMA
A technician's labor and signature are involved in the production, maintenance and continuous airworthiness of an aircraft.

INCREASED MAINTENANCE INTERVALS FOR ATR DE-ICING COMPONENTS FOLLOWING EASA DIRECTIVE:

# A BROADER LOOK AT INSPECTION REQUIREMENTS IN AVIATION SAFETY

**The European Union Aviation Safety Agency (EASA) has mandated more frequent inspections of the pressure regulator and shut-off valves (PRSOV) in ATR turboprops, following a design review conducted with ATR. These valves play a crucial role in regulating engine bleed air for airframe and engine de-icing, ensuring safe operations in icing conditions. The directive, effective as of January 24, 2025, reduces the intervals between functional tests to mitigate the risk of losing anti-icing protection for the engines' air intakes.**

According to the directive, functional checks must now be performed at intervals ranging from 650 to 1,050 flight hours, depending on the ATR model. All ATR aircraft are required to undergo their first inspection within the next six months. ATR has proactively communicated updated maintenance procedures to all operators, ensuring that the functional testing of affected components is performed in accordance with regulatory guidelines. The manufacturer has also stated that there have been no reported in-service failures related to this issue.

**Lessons from the Voepass Linhas Aéreas Flight 2283 Incident**

The push for increased inspection intervals and enhanced maintenance protocols has been reinforced by the fatal accident of Voepass Linhas Aéreas Flight 2283 in August 2024, which involved an ATR 72-500. The aircraft was operating in severe icing conditions, and preliminary investigations by Brazil's Center for Research and Prevention of Aeronautical Accidents (CENIPA) indicated that its ice detection system had been triggered multiple times before the crash. Cockpit voice recordings captured crew discussions about significant ice accumulation shortly before the aircraft lost control.

While the final report on the accident has not been issued yet, the incident has highlighted the critical importance of de-icing system functionality in ATR aircraft and turboprops in general. It has also reignited discussions on whether

current de-icing protocols and maintenance schedules are sufficient in the face of extreme weather conditions.

**Expanding Inspection Frequency to Other Critical Systems**
The increased inspection requirements for ATR de-icing components reflect a broader trend in aviation safety regulations, where frequent and proactive maintenance practices help prevent catastrophic failures. Several other aircraft components and systems have also been subject to revised maintenance schedules due to safety concerns, including:

Flight Control Systems – Issues with stabilizer trim, rudder movement, and aileron actuators have led to the need for closer monitoring of hydraulic and electrical components in recent years.

- **Engine Components and Oil Systems**
  Uncontained engine failures and oil degradation risks have prompted regulatory bodies to mandate more frequent borescope inspections and engine oil analysis to prevent failures.

- **Landing Gear and Brake Systems**
  Extended wear-and-tear from frequent operations has resulted in new requirements for shock absorber inspections, hydraulic line checks, and brake wear monitoring.

Electrical and Avionics Systems – As modern aircraft become increasingly dependent on automated flight control and electronic systems, regular software updates and functional tests have become necessary to prevent failures in navigation and communication systems.

**The Importance of Proactive Maintenance in Aviation Safety**
EASA's latest directive underscores a fundamental principle in aviation safety: maintenance should be preventive rather than reactive. By implementing shorter inspection intervals and more rigorous testing of critical components, aviation authorities can detect early signs of component failure before they become safety risks.

With increasingly unpredictable weather conditions due to climate change, it is expected that aircraft will encounter more severe icing conditions, turbulence, and temperature fluctuations in the coming years. Airlines and operators must remain adaptable and prioritize compliance with updated maintenance directives to ensure the safety and airworthiness of their fleets.

The ATR PRSOV inspections serve as a crucial reminder of how seemingly minor component failures can have severe consequences. By addressing potential issues before they escalate, aviation regulators and manufacturers continue to uphold the highest standards of safety in global air transport.

**References**


Centro de Investigação e Prevenção de Acidentes Aeronáuticos (CENIPA). (2024, September 6). Preliminary Report on the Accident Involving Voepass Linhas Aéreas Flight 2283. Retrieved from dedalo.sti.fab.mil.br

European Union Aviation Safety Agency (EASA). (2025). Airworthiness Directives & Maintenance Bulletins. Retrieved from easa.europa.eu

# LIST OF MAJOR AVIATION EVENTS WORLDWIDE IN 2025

Important aviation events will be held worldwide throughout 2025. Among them, events such as MRO Middle East (Dubai, February 10-11), WTW Aviation Conference (Muscat, February 11-13), and IATA World Legal Symposium (Shanghai, February 18-20) stand out, bringing together industry professionals. Organisations like World Aviation Training Summit (Orlando, April 7-10) and 7th International Flight Training Exhibition (Istanbul, May 9-11) will also shape the developments in aviation training. Additionally, prestigious exhibitions such as Paris Air Show (June 16-22) and Dubai Air Show (November 17-21) will showcase the latest innovations in the aviation industry.


MRO MIDDLE EAST **DUBAI** FEBRUARY 10-11, 2025


WTW AVIATION CONFERENCE **MUSCAT** FEBRUARY 11-13, 2025


IATA WORLD LEGAL SYMPOSIUM **SHANGAI** FEBRUARY 18-20, 2025


MRO SOUTH ASIA **NEW DELHI** MARCH 26-27, 2025


AIRCRAFT INTERIORS EXPO **HAMBURG** APRIL 8-10, 2025


WORLD AVIATION TRAINING SUMMIT **ORLANDO**, APRIL 7-10, 2025


MRO AMERICAS **ATLANTA**, APRIL 8-10, 2025


**TEKNOFEST** ERCAN HAVALİMANI 1-4 MAYIS, 2025


EAMTC 82ND GENERAL ASSEMBLY **MILANO**
MAY 5-7, 2025

7TH INTERNATIONAL FLIGHT TRAINING EXHIBITON
**ISTANBUL** MAY 9-11, 2025

MRO BEER **PRAGUE** MAY 14-15, 2025

EBACE25 **GENEVA** MAY 20-22, 2025

55TH INTERNATIONAL AIR SHOW **PARIS**
JUNE 16-22, 2025


WORLD AVIATION FESTIVAL **LISBON**
OCTOBER 7-9, 2025

MRO EUROPE **LONDON** OCTOBER 14-16, 2025


19TH AIR SHOW **DUBAI** NOVEMBER 17-21, 2025


AIRSPACE ASIA PACIFIC 2025 **HONG KONG**,
DECEMBER 09-11, 2025

THE 15TH AVIATION FORUM **HAMBURG, GERMANY**
DECEMBER 10-11, 2025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