THE CABIN CREW ROLE IN REDUCED FLIGHT CREW OPERATIONS

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ABOUT THE AUTHOR

Trevor Jensen was a graduate (1969) of the Qantas Cadet Pilot Scheme and between 1984 and 1996 he held several senior management appointments included Superintendent Flight Safety and General Manager B747 Operations. Resigning from Qantas in 1996, he has since held "C" level appointments in large international and Domestic airlines, LCCs and freight airlines within Australasia, Asia, and Europe; these roles have included regulatory responsibility for AOCs and Certificates of Approval (Maintenance) issued by the Australian CASA, the New Zealand CAA, and the Myanmar DCA.

INTRODUCTION

Aviation is a truly remarkable story. The advances made since that very short flight in December 1903 that ushered in the era of aviation are impressive. From intrepid aviators battling the wind and rain in flimsy little biplanes, in an industry plagued by accidents, to the sophistication of today's global industry, commercial air travel is well accepted as the safest mode of transportation. Public opinion is that it needs to be. Safety is at the core of every airline's service offering. It is inherent to the commercial patronage of airline customers and is the de facto sponsor of social intolerance towards aviation accidents.

While air transport accidents are increasingly survivable, there is a strong perception that danger in the air will lead to loss of life. This perception has led the aviation industry and its regulators to a relentless pursuit of excellence. The standards we operate to are prescribed by law. Still, sometimes these standards are inadequate, while on other occasions, the issue is not the regulation itself but compliance and the desire (safety culture) to comply. The well documented 1987 "Herald of Free Enterprise" disaster at Zeebrugge, Belgium,[1] and, more recently, the Boeing 737 Max certification [2] process illustrate this.

The COVID-19 crisis has generated a plethora of loans, loan guarantees, wage subsidies, and equity injections, and as reported by the OECD, [3] this is

'raising concerns about competition and the efficient use of public resources.' Pricing is cutthroat, and once take-off thrust is applied, that flight's inventory (revenue-generating opportunity) has perished. One reason given for the continuing low cost of air tickets is the absence of a price on the *'negative environmental externalities'* of air travel.[4] In the wake of the Covid-19 crisis, some governments are now pursuing interventions that would remove cheap but energy-intensive options from travellers' decision-making entirely. For example, the French government announced that bailouts for Air France would be contingent on the airline ceasing to provide domestic flights for trips that could be completed by train in under 2 hours and 30 minutes. [5]

While airlines are resilient and resourceful, aggressive cost reductions to reduce overall expenses will be needed more than ever to ensure survival and reducing crew costs has always been on the ‘bean-counters' radar. In the cabin, for example, where staffing often exceeds the regulatory minimum number of cabin crew required, airlines have reviewed inflight service processes and simplified catering to reduce cabin crew numbers per flight. To date, reductions in pilot costs have primarily centered around roster productivity; however, technological advances now offer the 'carrot' of autonomous flight with associated reduced flight deck crew operations.

In June 2020, Airbus concluded an extensive two-year flight test program involving over 500 flights using onboard image recognition technology to achieve autonomous taxiing, take-offs, and landings on a range of their commercial aircraft. Airbus says its overriding aim is not to build a pilotless plane but instead *"to explore autonomous technologies alongside other innovations in areas such as materials, electrification and connectivity."* However, they believe that with the extra autonomy aircraft that currently use two pilots could operate with just a single "safety driver." [6] Boeing also believes in "self-piloted aircraft" that would enable a gradual reduction in the number of crew members. [7]

Human frailty coupled with competitive pressures raises, at the very least, concern that demand, scarce pilot resources, and the pursuit of cost savings may overwhelm safety considerations. [8]

NOT IF, BUT WHEN

A man who is trampled to death by an elephant

is a man who is blind and deaf.

African Proverb

The purpose of this paper is neither to support nor to oppose reduced flight crew operations. We must be tenacious in the guardianship of our enviable safety record and never forget that airlines conduct business in compliance with all laws and regulations for two fundamental reasons:

1. To provide a transportation service for passengers and freight
2. To grow and provide a return to their shareholders

The economic benefits that automation can provide (or is perceived to offer) has motivated considerable research and development on the technical capabilities of automation to the point that a highly autonomous passenger jet aircraft enabling a reduction in the number of pilots should be considered a realistic possibility.

There are many in the industry besides Airbus conducting reduced crew trials. Since 2017, the U.S. Defense Advanced Research Projects Agency (DARPA) has been trialling a robot copilot using a B737 simulator. [9] Sikorsky and FedEx are also reported [10] to be working on technologies to allow single-pilot operations on large commercial aircraft and have conducted flight tests using an ATR 42-300 at Waterbury-Oxford Airport in Connecticut. The program is part of a broader Sikorsky effort to develop autonomous systems for helicopters and fixed-wing aircraft. Closer to home, Cathay Pacific and Airbus are working on a system designed to allow reduced crew (single pilot) during cruise on long-haul A350 passenger flights. The program is aiming is to achieve certification by 2025. [11]

Regulators are often accused of being ‘behind the curve’ when it comes to dealing with new technology, however in the case of unmanned flight, the regulators are well aware of the situation and what work needs to be done. [12]. On 30 June 2022, the European Union Aviation Safety Agency (EASA) issued Notice of Proposed Amendment (NOPA) 2022-06 [13] relating to the establishment of a comprehensive regulatory framework to:

- address new operational and mobility concepts that are based on innovative technologies, like unmanned aircraft systems (UAS) and aircraft with vertical take-off and landing (VTOL) capability, and,
- foster and promote their acceptance and adoption by European citizens.

At para 4.3.2.1.1 of that document, they discuss VTOL-capable aircraft employed in emergency medical services and note, *"As the long-term intention of the manufacturers of VTOL-capable aircraft is to perform autonomous flights, VTOL-capable aircraft are not designed for operation with two pilots. Therefore, only single-pilot operation (with the support of an emergency doctor trained as technical crew) is possible and should be considered".* The NOPA goes on to say, '*The emergency doctor must be the pilot's 'second pair of eyes' when it comes to take-off and landing at unknown sites, possibly under the most adverse weather or visibility conditions. This requires training and checking as is today the case for HEMS technical crew members".*

While autonomous operations may result in a reduced flight deck complement, no revolution in smart vending machines or the use of Able-Bodied Passengers in a planned safety function should ever replace cabin crew on board aircraft. Just as EASA has proposed consideration of HEMS single-pilot operations being supported by a non-pilot, the emergency doctor, I would submit it is time for us to start thinking about what role our emergency doctor - the cabin crew - could play to support the future flight deck.

YIN AND YANG

The role of a flight attendant first appeared in the 1920s. In 1922, the British company Daimler Airways, a subsidiary of the Birmingham Small Arms Company (BSA) Daimler Company, hired 'cabin boys' to assist and reassure passengers during the flight. Ellen Church, a registered nurse and licensed pilot, was the first female flight attendant. She operated her inaugural flight for Boeing Air Transport (predecessor to United Airlines) from Oakland to Chicago in a Boeing 80A on 15 May 1930. Carrying 14 passengers, the flight took 20 hours and made 13 stops. As well as caring for the passenger's needs, she had to perform various other duties,

including cleaning the plane, loading baggage, selling tickets, and assisting with en-route refuelling. Reportedly, her tasks also included winding the cockpit clocks!

Employment as cabin crew is one of the most sought-after jobs in the world. Selection involves a highly competitive process, and of the hundreds of thousands of young people who apply to the numerous airlines across the globe each year, statistically, only 5% are selected.

Although there are always exceptions to the rule, cabin crew have excellent people skills. They enjoy meeting strangers, thrive in social situations, and are good at it. They can quickly size up a passenger and determine what they want, where they're from, and whether they will require extra patience, which they have more of than most of us!

While care and comfort of passengers is the most visible activity, the cabin crew's primary role and responsibility is the safety of passengers through the performance of cabin safety duties, including handling the emergency and abnormal situations that occur onboard aircraft every day. These range from life-threatening and highly time-critical to mundane and relatively trivial occurrences. Crew responses to some events are highly practiced during training. Other situations have never been practiced; they are so novel and unanticipated that no procedures have been developed to guide crews' responses.

We rely heavily on the training and skills of the crew as the last line of defence when other systems fail. The QF32 accident [14] is an excellent example of the crew making judgements in the face of competing priorities when procedures no longer exist and offer an appropriate solution. The ATSB QF32 report stated, *"... the safe outcome of the accident flight was not only contingent on the primary and supporting flight crew but also on the efforts of the CSM and cabin crew."* [15]

The cabin crew role has certainly evolved, and there may be more change. While the ground facility will provide human monitoring and, if necessary, intervention in a reduced crew environment, suitably selected and trained cabin crew members could support the pilot at appropriate times during flight in a 'fail active' role.

But cabin crew are different, aren't they?

While there is debate about the validity of the Myers-Briggs Type Indicator (MBTI) Test, it is used as an indicator of differing psychological preferences in how people perceive the world and make decisions. Most pilots who complete the test identify as ESTJ (Extraverted, Sensing, Thinking, Judging) personality types, while the cabin crew personality type is generally ESFJ (Extroverted, Sensing, Feeling, Judging). [16]

ESTJs are often described as logical, take-charge kinds of people. They are assertive and concerned with ensuring things run smoothly and according to the rules. People with an ESFJ personality type tend to be outgoing, loyal, organized, and tender-hearted and gain energy from interacting with others.

As EASA has proposed using the emergency doctor to support HEMS single-pilot operations, it may be of interest to note a study released in 2019 into personality preference research on medical students and physicians. The study reported that the most common personality types among the junior doctors were ESTJ (15.4%), INTP (Introverted, Intuitive, Thinking, Perceiving) (12.8%), and ESFJ (10.3%), while among the attending physicians, the most common types were ISTJ (23.7%) and ESTJ (18.6%). [17]

Pilots and cabin crew are generally different personality types, and just as most pilots would make poor cabin crew members, not all cabin crew would be suitable for or want to play an active role in a reduced flight crew operation.

WHAT PLANET ARE YOU FROM?

"The sound of you, it offends me. Abomination, I command you to be silent."

Thomas E. Sniegoski

In the early '80s, as Technical Director of the Australian International Pilot's Association (AIPA), I led a study to assist in our deliberations into whether we would accept the 2-crew B767 Operation proposed by Qantas. We met with many organisations, including representatives of Boeing and industrial associations representing pilots and flight engineers. Emotions were high, with some interviewed presenting sometimes ambiguous evidence interpreted in favour of their preconceived notions. U.S. ALPA and Europilote articulated their position in a booklet (circa 1980) titled, 'No Compromise with Safety: The Crew Complement

Question' [18]. They were adamant that *'pilots of the world would insist that all future generation aircraft must be flown by a crew of three in a properly designed cockpit*.' The publication listed four 'compelling' reasons (based on a study conducted on United Airlines B737 revenue services in 1968) as the rationale for this position:

1. The only comprehensive study of crew size in airline service found that safety required a crew of three.
2. An examination of pilot duties on existing two-crew member aircraft reveals a higher workload for the captain and first officer than found on three crew member aircraft.
3. The third crewmember has often saved the aircraft, passengers and crew by calling attention to conflicting traffic that the other crew members failed to see.
4. Pilot incapacitation can occur at a critical time without warning. This requires the presence of a third crew member to ensure a smooth transition of aircraft control and to complete the flight successfully. [19]

Biases are as old as humans. As I was preparing my report for the AIPA Committee of Management, I was reminded of what the philosopher Francis Bacon had noted in 1620, *"the human understanding, once it has adopted an opinion, collects any instances that confirm it, and although the contrary instances may be more numerous and more weighty, it either does not notice them or else rejects them, in order that this opinion will remain unshaken.*"

Reducing crew complement is one thing, but the proposition that a non-pilot could occupy a 'front row seat' will be difficult for many to comprehend, let alone consider. Bias will be rampant, but we should start addressing the 'elephant questions' using the best available resources; for example, if the onboard pilot requires assistance, can the cabin crew provide that? What form could that assistance take? And what training and regulatory changes will be necessary?

EFFECTIVE USE OF ALL AVAILABLE RESOURCES

Teamwork and communication are vital elements of flight safety. While both the Kegworth [20] and Dryden [21] accidents are cited in CRM training to illustrate how the lack of effective communication of safety-critical information between the cockpit crew and cabin crew contributed to these accidents, there are numerous

examples of excellent teamwork and communication during emergencies. The exceptional performance of the Cabin Service Manager in the QF32 accident and the role played by the Purser during the hijacking of TWA Flight 847 [22] serve to elucidate this.

While different crewing configurations and concepts have been proposed, the consensus is that reduced flight crew operations would see the pilot in command remain on the flight deck with the copilot being displaced to the ground to provide remote ground support during high workload situations. Schmid et al. [23] reported on a study using Cognitive Work Analysis (CWA) in combination with Social Network Analysis (SNA) to allocate functions in a reduced crew operation arising from pilot incapacitation and a possible data-link failure. CWA methodology analyses and evaluates complex systems but does not explicitly analyse the people-system communication interaction. SNA addresses the information needs of individuals, the team as a whole, and the communication between them. The Study noted, *'support by a remote copilot and possible other teams is essential to overcome the loss of redundancy of a second pilot on board.'*

The cabin crew must maintain a high degree of competence and be fully conversant with their duties and responsibilities in normal and emergency situations. Comprehensive training is provided; however, expectations during reduced flight crew operations may be different. For example, pilot incapacitation procedures require the crew to secure the incapacitated pilot and, if appropriate, remove them from the seat. In reduced flight crew operations, expectations of cabin crew in this event could include occupying a flight deck seat and carrying out radio communications.

Assessment of the requirement and extent of cabin crew support during reduced flight crew operations is needed using a Cognitive Work / Social Network Analysis or another appropriate methodology. If assistance is required, this work will enable the development of a person specification that will provide the personal attributes necessary for the tasks and the skills and experience needed.

Procedures considered normal today might be abnormal or critical tomorrow. A simple example is that pilots need to take a lavatory break. There are well-established procedures in multi-crew operations which in some companies includes

a cabin crew member sitting in the jump seat while a pilot is away from the flight deck. While the remote copilot will monitor the aircraft automation and take over in case of a system issue during the absence of the onboard pilot in a reduced crew, should the cockpit be occupied by a cabin crew member?

Deficiencies in cockpit-cabin coordination and communications have been identified in several accidents. As far back as 2002, in CAA CAP 719, a reprint of ICAO Human Factors Digest 1 [24], the importance of training to prevent communication errors, including the reinforcement of a standard language to ensure the error-free transmission of a message and its correct interpretation has been stressed. During an inflight emergency, such as cabin smoke or fire, the pilot's workload in a reduced flight crew operation will be very high. In this situation, should the 'communicator' be a cabin crew member with advanced qualifications to ensure appropriate and crisp communication? This could be of more significance in cross-cultural interactions, where those conversing have different mother tongues.

The impact of culture on flight safety is very well documented. Australians are resilient and vocal. Americans are straightforward, and the French are enthusiastic. We may sometimes mistake these characteristics as challenging and overbearing and even on the verge of being confrontational. During an emergency, the cabin crew must switch from their service role to their safety role, a role that requires assertive and decisive behaviour. For some cultures, e.g., Asian, cultural power-distance factors make it difficult for them to accept that being assertive is being proactive, not disrespectful. This knowledge must be applied to optimise cross-cultural performance should cabin crew from cultures with very low individualism rankings and high power distance be required to support reduced flight crew operations.

PHANTOM OF THE ANNEX

A man said to the universe:
“Sir, I exist!”

Stephan Crane, War is Kind and Other Poems

In the opening paragraph of their paper, *'The Legal Status and Liability of the Copilot'* [25], Captain Russell Kane and Tony Pyne noted, "*While there is a noticeable amount of legal literature concerning the status, legal position, duties, and liability of the aircraft commander of civil transport aircraft, only a few paragraphs have dealt with these issues in respect of the copilot."*

There are even fewer paragraphs concerning cabin crew.

ICAO Annex 2 defines a cabin crew member as *'A crew member who performs, in the interest of the safety of passengers, duties assigned by the operator or the pilot-in-command of the aircraft, but who shall not act as a flight crew member.'* A flight crew member is *'a licensed crew member charged with duties essential to the operation of an aircraft during a flight duty period.'*

A definition of Cabin Crew in Charge can be found in ICAO Doc 10002 Chapter 13, [26] *'The In-charge cabin crew member (also referred to as cabin leader, lead cabin crew member, onboard leader, senior cabin crew member, etc.) is a cabin crew leader who has overall responsibility for the conduct and coordination of cabin procedures applicable during normal operations and abnormal as well as in emergency situations for flights operated with more than one cabin crew member.'*

Given the changing legal and operational environment, I firmly believe it is time to recognise all key safety personnel in the legislation. Questions for consideration in any study of any role of the cabin crew in reduced flight crew operations could include:

- Do cabin crew need to be licensed?
- Is a described medical standard needed?
- Is level 6 language proficiency level required?
- Should the role of Cabin Crew in Charge be defined in Annex 2?
- Should the role of a cabin crew member supporting reduced flight crew operations be described in Annex 2?

CONCLUSION

The bounds the capabilities of technology can offer seem limitless. It can make life easier but also create complexity and uncertainty. It can transform the nature of human work.

With age, I have learned it is not only aircraft that fly. Today was yesterday's tomorrow. This paper has not sought to present solutions; rather, the intention is to promote discussion. There are many issues to consider, from technical to legal, to social, and of course, economic. Let us start the broader conversation about cabin crew support in reduced flight crew operations, and let's start it now. It may not be required, but along the way, we may rethink some of the legacy practices regarding the role of cabin crew and cabin management, which could also be a great outcome.

LIST OF REFERENCES

1. Sheen, Mr Justice (1987), *mv Herald of Free Enterprise: Report of Court No. 8074 Formal Investigation*, Crown Department of Transport, ISBN 0-11-550828-7

   On the evening of the 6th March 1987, the Herald of Free Enterprise, a roll-on/roll-off passenger and cargo ferry, capsized approximately 20 minutes after departing the Belgian port of Zeebrugge.

   The investigation concluded that crewmembers and the shipping company were responsible for the accident. While the direct cause was the negligence of the ship's crew, who failed to close the bow doors used for loading vehicles prior to departure, the investigation also found fundamental and grave shortcomings across the management level of the company operating the ferry. The executives and employees were unaware of their responsibilities concerning safety management and had not taken appropriate actions concerning their vessels' safety and safe operation. Before this event, the company-operated ferries had departed a port with the bow or stern doors open on at least five other occasions!

   191 passengers and crew lost their lives in this tragic accident.

2. U.S. House Transportation and Infrastructure Committee, *Final Committee Report : Boeing 737 Max,* 16 September 2020.

   The Congressional Report identified five broad problems:

   1. Production pressure to compete with Airbus and its new A320neo led Boeing to make production goals and cost-cutting a higher priority than safety.
   2. There were fundamental errors in assumptions made about the maneuvering characteristics augmentation system (MCAS).
   3. Boeing withheld crucial information from the FAA, customer airlines, and 737 MAX pilots. The Report cited Boeing's failure to inform pilots about the existence of the MCAS and the concealing of internal test data from the FAA.
   4. The FAA's oversight of Boeing was determined to be a conflict of interest, with instances reported of the FAA granting Boeing employees oversight authority, which left the FAA ignorant of important information.
   5. The Committee pointed to various documented instances where FAA management sided with a Boeing decision or recommendation, overruling the findings of an FAA technical or safety expert.

   In their final observations, the Committee stated, "This Report's main investigative findings point to a company culture in serious need of a safety reset. Boeing has gone from being a great engineering company to being a big business focused on financial success. Continuing on the same path it followed with the 737 MAX, where safety was sacrificed to production pressures, exposes the company to potentially repeating those mistakes and to additional reputational damage and financial losses. One of the first steps on a new path is understanding and acknowledging the problems that did occur, the technical mistakes that

were made, and the management missteps that led to the 737 MAX tragedies and the preventable death of 346 people."

3. OECD Policy Responses to Coronavirus (COVID-19) – *'COVID-19 and the aviation industry; Impact and policy response'*. 15 October 2020

4. The aviation industry has been relentlessly addressing environmental issues for many years; however, in common with other modes of transport, it creates adverse environmental impacts (environmental externalities) such as noise and emission pollution, which cannot be totally eliminated.

   Most European governments have adopted a 'polluter pays' principle requiring external costs to be reflected in costs incurred by the aviation industry. The imposition of carbon and noise taxes on passengers choosing to fly takes implicit account of the costs to residents affected by aircraft noise and emissions.

5. International Energy Agency, *"Changes in transport behaviour during the Covid-19 crisis"*, Paris, 2020.

6. Airbus Press Release, *'Airbus concludes ATTOL with fully autonomous flight tests'*, Toulouse, 29 June 2020

7. Steve Nordlund, Vice President and GM Boeing NeXt, reported in The Independent article by Tom Batchelor, '*Single-Pilot Passenger Planes Could Soon Take to The Skies, Says Boeing'*, Monday 10 September 2018.

8. In an article in U.S Air Force Times magazine dated July 19, 2022, the author, Rachel S. Cohen, reported that officials in the Air Force's Mobility Enterprise are considering amending rules to allow just two crew members on board the Boeing KC-46 Pegasus tankers during dangerous missions; one pilot and one refuelling boom operator. A spokesperson for

the Mobility Enterprise, said, "the command is reassessing minimum flight crew requirements as we explore and validate new tactics, techniques, and procedures oriented towards a dynamic, future fight'.

On July 15, 2022, a popular Facebook page with U.S. airmen posted an anonymous allegation that AMC had hatched the idea because of a pilot shortage at McConnell Air Force Base in Kansas. The Air Force spokesperson denied that the concept is connected to pilot retention.

9. Andrew Moseman, *“A Robot Copilot Just Flew - and Landed - a 737 Sim”*, Popular Mechanics, 16 May 2017

10. Various reports including theaircurrent.com and ch-aviation.com, February 2021.

11. RAeS Aerospace Journal, Volume 48 Number 8, August 2021

12. RAeS Aerospace Journal. Volume 48 Number 11 ‘*Creating a New World. Overview of the Global Urban Air Summit (GUAS)*', 2019

13. European Union Aviation Safety Agency Notice of Proposed Amendment 2022-06, 30 June 2022.

14. ATSB Report AO-2010-089. In-flight uncontained engine failure - overhead Batam Island, Indonesia - 4 November 2010 – VH-OQA, Airbus A380-842.)

15. It is beyond dispute that aviation's enviable safety record is linked to improvements in training and procedures that result from an honest investigation of accidents and incidents. The quality of an accident investigation report influences the learnings. In my opinion, the failure of the ATSB report to provide any discussion of the Cabin Service Manager (CSM) and cabin crew activities denied the industry significant learnings. Investigation of cabin factors needs to be mandatory in all RPT

investigations as understanding the actions and support provided to the flight crew by the cabin crew during an emergency or abnormal event will have even greater significance in reduced crew operations.

16. Vandermark, M. J. Should flight attendants be included in CRM training? A discussion of a major air carrier's approach to total crew training. International Journal of Aviation Psychology, 1, 87-94. (1991)

17. Chang, YC., Tseng, HM., Xiao, X. *et al.* '*Examining the association of career stage and medical specialty with personality preferences – a cross-sectional survey of junior doctors and attending physicians from various specialties'. BMC Med Educ* 19**,** 363 (2019).

18. '*No Compromise with Safety: The Crew Complement Question'.* Prepared by Europilote and U.S. ALPA. Circa 1980

19. Aircraft Accident Report 1/92, Report on the accident to BAC One-Eleven, G-BJRT over Didcot, Oxfordshire on 10 June 1990, Air Accidents Investigation Branch, Department of Transport, London, February 1992.

    BA Flight 5390 departed Birmingham International Airport at 07:20 hrs. on Sunday, 10 June 1990, en route to Malaga, Spain. Eighty-one passengers, two pilots, and four cabin crew were on board. Thirteen minutes after take-off and as the aircraft climbed through 17.300 feet, there was a loud bang, and the fuselage filled with condensation mist. It was apparent to the cabin crew that an explosive decompression had occurred. The commander had been partially sucked out of his windscreen aperture, and the flight deck door was blown onto the flight deck, where it lay across the radio and navigation console. The No. 3 steward rushed onto the flight deck and grasped the commander round his waist to hold on to him. The purser removed the door's debris and stowed it in the forward toilet.

The co-pilot immediately attempted to control the aircraft and, once he had regained control, initiated a rapid descent to FL110. Meanwhile, the purser re-entered the flight deck and, having hooked his arm through the seat belts of the fourth crew member's jump seat, which was located behind the left-hand pilot's seat, was able to assist the No. 3 steward in the restraint of the captain. The two men tied to pull the captain back within the aircraft, and although they could see his head and torso through the left Direct Vision window, the effect of the slipstream frustrated their efforts. The No. 2 steward entered the flight deck and he was able to relieve the No. 3 steward, whose arms were losing their strength as they suffered from frostbite and bruising from the windscreen frame. The No. 2 steward grasped the captain's right leg, which was stuck between the cockpit coaming and the control column, while his left leg was wedged against his seat cushion. The steward then strapped himself into the left jump seat and was able to grasp both of the captain's legs but not before he had moved a further 6 to 8 inches out of the window frame. He held him by the ankles until after the aircraft had landed.

The investigation found the left windscreen had been replaced and the task certificated by the same Shift Maintenance Manager (with the appropriate British Airways authorisation) 27 hours before the accident flight. The aircraft had not flown since its replacement. The replacement windscreen had been installed with 84 bolts whose diameters were approximately 0.026 of an inch below the specified bolts' diameters and six bolts of the correct diameter but 0.1 of an inch too short. The windscreen fitting process was characterised by a series of poor work practices, poor judgements, and perceptual errors, eroding the safety factors built into the method of operation promulgated by British Airways.

20. UK Air Accident Investigation Report 4/90, Boeing 737-400 G-OBME near Kegworth, Leicestershire, 8 January 1989

British Midland Airways Flight 092, a Boeing 737-400, crashed onto the motorway embankment between the M1 motorway and A453 road near Kegworth, Leicestershire, England, while attempting to make an emergency landing at East Midlands Airport on 8 January 1989. The aircraft was on a scheduled flight from London Heathrow to Belfast International Airport when a fan blade broke in the left engine, disrupting the air conditioning and filling the cabin with smoke. Several cabin staff and passengers noticed a fire in the left engine but did not convey this information to the flight crew.

The pilots believed the cabin smoke indicated a fault in the right engine as earlier models of the 737 ventilated the cabin from the right, and they were unaware that the 737-400 used a different system. The pilots mistakenly shut down the functioning engine and selected full thrust from the malfunctioning one, which increased its fuel supply, causing it to catch fire.

Of the 126 people aboard, 47 died, and 74 sustained serious injuries.

21. Commission of Inquiry into the Air Ontario Flight 1363 Crash at Dryden, Ontario (Canada) on March 10, 1989.

    On the 10th of March 1989, Air Ontario flight 1363 failed to become airborne on takeoff from Dryden, Ontario, and crashed into a forest, killing 24 of the 69 people on board. The investigation uncovered a tragic confluence of events that led to the Fokker F-28 taking off with ice on its wings. Among these was the reluctance of the cabin crew to communicate with the Flight crew.

    Although both cabin crew, and several passengers, including two off-duty airline captains deadheading on the flight, had observed the rapid accumulation of snow over the wings during the transit, they didn't notify the Captain as the Air Ontario cabin crew had been discouraged from bringing operational matters to the attention of the flight crew.

22. TWA Flight 847 was hijacked shortly after takeoff from Athens on June 14, 1985, by members of Hezbollah. The Flight Purser was instrumental in calming the hijackers during the 3-day ordeal, communicating between the flight crew, hijackers, and ground crew, and otherwise attempting to minimize the loss of life. Her calming effect in the face of imminent danger undoubtedly saved many lives.

23. Daniela Schmid, Bernd Korn, Neville A. Stanton. '*Evaluating the reduced flight deck crew concept using cognitive work analysis and social network analysis: comparing normal and data-link outage scenarios'.* Cognition, Technology & Work (2020) 22:109-124

24. UK Civil Aviation Authority CAP 719 '*Fundamental Human Factors Concepts',* page 3.3.3, 15 February 2002

25. Captain Russell Kane and Tony Pyne, *'The Legal Status and liability of the Copilot',* Air and Space Law, Vol. XIX, Number 6 ,1994

26. ICAO Doc 10006, Cabin Crew Safety Training Manual, Second Edition, 2020