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Historical Research and the case for a Fifth Component of SMS

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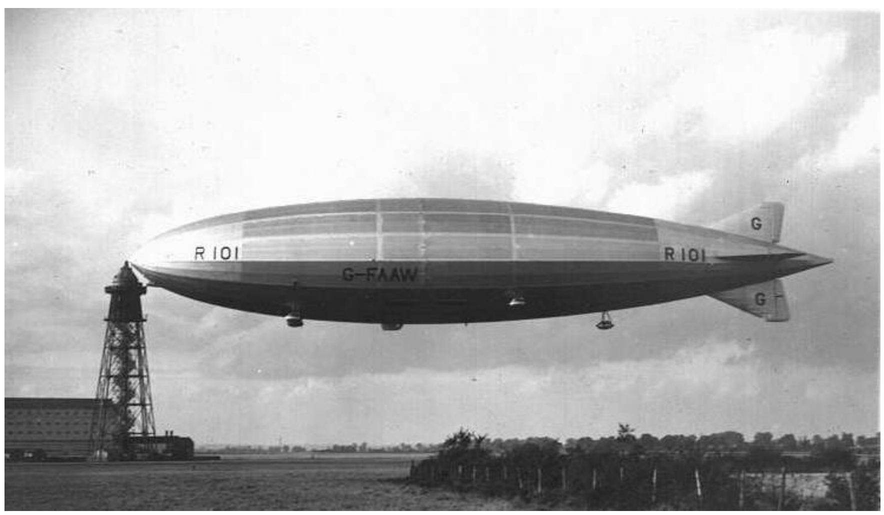
The research conducted and reported here examines three high-profile events that have shaped aviation, now seen through the lens of safety reporting systems and safety culture. This research used qualitative methods of Historical and Case Study research. Historical research "attempts to systematically recapture the complex nuances, the people, meanings, events, and even ideas of the past that have influenced and shaped the present" (Berg & Lure, 2016). "Case Study research continues to be an essential form of social science inquiry. The method is appropriate when investigators desire to (a) define topics broadly and not narrowly, (b) cover contextual conditions and not just the phenomenon of study, and (c) rely on a multitude and not singular sources of evidence" (Yin, 1993). The research conducted examined three aviation events, spanning a total of 90 years, and employed the strict procedures of Historical and Case Study methodology. The method has several steps, but in summary, "when multiple cases are chosen, a typical format is to provide a detailed description of each case and themes within the case called a *within-case analysis,* followed by a thematic analysis across the cases, called a *cross-case analysis*, as well as assertions or an interpretation of the meaning of each case" (Creswell, 2013). This research method concludes with a "lessons learned" section that led to the recommendation of a fifth component to be added to the FAA's current Safety Management System (SMS).

The Airship R101

Narrative source material: Gwynne, S. C. (2023)*;* Davidson, P. (2015); Rope, L. D. (2019).



The R101 got a late start on the day of departure, not slipping away from the mooring mast in Cardington, England until 6:36 PM on October 4, 1930. The R101 was, at the time, the world's largest flying machine with a length of 777 feet - more than two football fields. The R101 was larger by volume than the *Titanic*. The R101 had a steel frame and gasbags with a combined capacity of 5.5 million cubic feet – all filled with hydrogen. By design, the R101 was supposed to weigh 90 tons and be able to lift 150 tons, but when completed the airship was overweight and as the airship released from the mast, Captain Herbert "Bird" Irwin had to immediately order the dropping of 2.5 tons of ballast water out of the nose of the ship to avoid hitting the ground. The R101 was bound for Karachi, India, with one stop (and a state dinner) in Ismailia, Egypt. The R101 had completed only a few flight trials and none of those trials had taken place in a strong wind, or in heavy rain, or at night. This flight had all three – but despite those conditions, the flight set a course to fly over London, across the English Channel, then over France, to the Mediterranean, and on to Egypt. At 9:30 pm, the R101 passed Hastings and flew out over the English Channel - flying sideways to counteract a 50-knot quartering headwind. By 2:00 in the morning the airship was flying over the French countryside approximately 90 miles north of Paris and trying to hold an altitude of 1,000 feet above the ground. At 2:05, the R101 experienced a sharp dive of about 30 seconds in duration and then leveled off. George Hunt, the chief coxswain, in charge of watching the riggers of the airship's massive rudder and elevator, oddly left the Control Cab and passed Arthur Disley on his way to the crew quarters. Disley was the radio (wireless) operator and Hunt said to Disley, "We are down, lads." But the ship was not down and at the moment the ship was level. We only know what Hunt said because Disley was one of only six survivors (out of 54 onboard). Then at 2:09, the R101 pitched down again, twenty degrees below the horizon. Arthur Bell and Joseph Binks were engine mechanics. The R101 had five engine cars, each carrying an eight-cylinder, inline Beardmore Tornado diesel engine capable of 650 horsepower. Together the engines were to propel the R101 through the air at 70 miles per hour. The engine cars were not actually inside the airship but were pods hanging well below the fuselage. The only way to access the engine cars was to climb down a rope ladder, through thin air, and into the side door of the car. There was an engine mechanic in every engine car, watching the engines at all times, but at 2:09 both Bell and Binks were together in the car because Binks arrived late to start his 2:00 shift. The two mechanics felt the dive but could do nothing. The nose of the ship hit the ground – but not with a violent impact. Binks called it later a "crunch." But the impact and probable sparks ignited the hydrogen gas. The engine car, where Bell and Binks rode, struck the ground and became dislodged from the rest if the ship. The floor of the car collapsed and flames shot into the compartment. There was no way out. Both men were on fire – but then a ballast container full of 250 gallons of water inside the ship ruptured and the water spilled down drenching the mechanics and putting out the fire. The men ran for their lives. Of the 54 men onboard the R101, eight survive the crash, but two died from burns in the next few days. The rest were burned beyond recognition and their remains were buried in a mass grave back at Cardington on October 11.

So why was the R101 in such a hurry to leave, having very little flight testing done? The driving force behind the trip to India and back was Christopher Birdwood Thomson who was the British Secretary of State for Air. His official title was Lord Thomson and he found himself in his position largely because of his friendship with the British Prime Minister Ramsey McDonald. He was in charge of all aviation in the entire British Empire, which at the time included India, Australia, and Canada, to name only a few. Thomson had created the Imperial Airship Scheme which, in his vision, would link the far-flung dominions of the British Empire. Changing travel months at sea to weeks in the air. An Imperial Conference was set, hosted by King George V, and all eight empire Prime Ministers had been summoned to travel to London in late October 1930. Lord Thomson's plan was to fly to India and back on the R101 and return just in time for the Conference, where he would make a grand speech claiming the success of the Imperial Airship Scheme. The King would then name Thomson to be the Viceroy of India where he would command 150,000 British troops, rule over 300 million citizens of India, and live in the largest diplomatic mansion in the world. Thomson's motivation was all about empire, prestige, and power – not the delays and concerns about the R101. The R101 had to leave in early October to allow time for the trip to India and the triumphant return.

But before the fatal flight of the R101 there was Michael Rope. In the summer of 1930, Rope was a Supervising Engineer of the R101 and during a routine inspection he discovered that sections of the airship's outside fabric covering were rotting. A substance called "dope" was routinely painted on aircraft fabric to make the fabric draw up and taut across the frame and waterproof. To save time, the fabric of the R101 was “pre-doped.” The dope was added to the fabric before the fabric was applied to the frame, instead of doping in place. Rope saw that cracks had occurred in the dope causing the fabric to be torn and this was allowing moisture to invade the airship. The fabric must be replaced. Rope wrote a memo to his bosses, Reginald Colmore and Chief Designer Vincent Richmond. In the memo Rope wrote that due to the deterioration of the fabric “there is no margin for safety for flight in a rough atmosphere,” and recommended a six-month delay for the flight to India. Colmore and Richmond knew that a six-month delay would not work for Thomson’s schedule. They ignored Rope’s memo and never told Thomson about it. Then on September 23, Frederick M. McWade, the Chief Inspector for the Air Ministry’s Aeronautical Inspection Division wrote his own memo. The R101 would need a Certificate of Airworthiness before it could legally fly to India, but McWade, who could issue the Certificate, refused. McWade found that instead of replacing the damaged fabric that Michael Rope had found, the R101 had been patched. The patches were applied using a rubber solution, but that solution interacted with the existing dope and cause more severe deterioration. The danger with weak fabric was that the gas bags were housed just inside the fabric. If the fabric tore away the gas bags would then be exposed to the elements and the gas bags were so thin and fragile that anything could rupture them. Highly flammable hydrogen was used because it was cheap and readily available. The non-flammable helium gas would have been safer, but provided only half the lifting force as hydrogen and it was scarce – the only source of helium was in America. When Colmore found out that McWade was not signing off on the R101’s Certificate of Airworthiness, he went over McWade’s head. He contacted Air Vice Marshall Hugh Dowling. Dowling was new to the position in the Air Ministry and had extensive experience with military aircraft, but no experience with airships. Colmore convinced Dowling to push the Certificate of Airworthiness through the Airworthiness of Airships Panel – but that panel was comprised of several engineering professors who had consulted on the R101. In the end, the inspectors were the same people who built the R101, and the Certificate was rushed through – but the actual Certificate had not been written on the day the R101 departed for India and the R101 took off without the Certificate of Airworthiness. McWade did not travel on the R101 on October 4, but Michael Rope did. Rope as well as Lord Thomson, Vincent Richmond, Captain Irwin, George Hunt and Reginald Colmore, all perished in the R101 crash and are buried together - not knowing whose remains are whose.

Note: The final report of the R101’s Court of Inquiry indicated that the outer fabric of R101 forward upper surface had torn away and gas started to escape, which lowered the nose. It was not until 2014 that Dr. Bryan Lawton of Cranfield University conducted thermal and stress tests on the R101’s elevator cable and discovered that it had snapped before the airship hit the ground. In 1930 it was believed that the crash and fire had snapped the cable. Did George Hunt, coming from the control car, know the cable was broken when he said, “We are down, lads.” The airship lost lift in the forward section due to torn fabric and the loss of gas. With no elevator cable the airship’s nose could not be raised and the R101 hit the ground.

The Challenger

Narrative source material: Harwood, W., Navias, R. (1986); The Report of the Presidential Commission on the Space Shuttle Challenger Accident (1986); Cook, K. (2021); Berkes (2016; Berkes (2021).

On the cold morning of January 28, 1986, the seven astronauts entered Challenger's crew cabin and were strapped into their launch couches. There were three rows of seats. Commander Dick Scobee was in the seat typical of a captain – front left. Pilot Michael Smith in the front right. The middle row is where Mission Specialists Ellison Onizuka and Judith Resnik sat. Resnick looking straight forward between Scobee and Smith while Onizuka was offset behind Smith's right shoulder. Ronald McNair sat back row left, Gregory Jarvis, back row middle and in the back right couch was "Teacher in Space" Christa McAuliffe. When the countdown reached zero and the solid rocket boosters ignited Judy Resnik shouted out on the flightdeck intercom, "All Right!" As the first vertical movement was recorded, Mickael Smith yelled back, "Here we go!" Launch commentator Hugh Harris, on NASA television said "Liftoff of the 25th space shuttle mission, and it has cleared the tower." Eight seconds into the flight, Dick Scobee called ground control with "Houston, Challenger. Roll Program." Astronaut Dick Covey was on the ground and talking with Challenger. He confirmed, "Roger Roll, Challenger." The roll turned the shuttle "heads down" and on a trajectory out over the Atlantic Ocean. Smith said, "You go mother!" and Resnik responded "(expletive) hot!" Nineteen seconds into the flight, Smith said, "Looks like we have a lot of wind up here today" and Scobee said, "Yeah," and Smith, "There's 10,000 and Mach point five." At this point the speed and the thickness of the atmosphere together places great stress on the shuttle, so they bring the power of the liquid rocket booster back. At 43 seconds, Scobee reported, "OK, we're throttling down." Between 45 and 48 seconds into the flight, a tracking camera picks up the sight of three quick flashes along the Shuttle's right wing. At 52 seconds, ground control reports, "Velocity 2,257 feet per second, altitude 4.3 nautical miles, downrange distance 3 nautical miles..."From the tracking camera, the first visual evidence of flame is seen on the right side solid rocket booster at 59 seconds. At 60 seconds, Smith shouted, "Feel that mother go!" and an unidentified astronaut yelled back, "Woooo Hoooo!" A bright, sustained glow is photographed on the side of the external fuel tank at 64 seconds. The Shuttle is now high enough so that the atmosphere is no longer causing significant drag and it's time to bring the power back up. At 69 seconds, Covey signals, "Challenger, go at throttle up," and Scobee confirmed, "Roger, go at throttle up." On the intercom Smith said, "Uh oh."

At 72.284 seconds into the flight the Challenger explodes.

The crew cabin does not itself explode. The cabin remained intact and was blown free of the main explosion. Researcher and author Kevin Cook confirmed that the crew survived the initial disaster and "were conscious, at least at first, and fully aware that something was wrong." The remains of the astronauts and the crew cabin were eventually recovered. There was no sign that the cabin had lost pressure rapidly, meaning they were probably conscious. Investigation concluded the jump in G-force was “survivable, and the probability of injury is low.” Toggle switches on the right control panel had been moved indicating that Pilot Michael Smith was working, after the explosion, to restore power to the cabin. Each astronaut had emergency air packs, but due to the limited space on the flightdeck, the packs were located behind each seat and that required the astronaut sitting behind to switch on the packs. That is why the seating arrangement was so important. It was found that three of the air packs had been switched on. This confirms that the crew survived the explosion, were conscious, and were actively working to save themselves. But, the situation was hopeless. After the explosion, the crew cabin continued upward for 20 seconds, but then began a 12-mile fall to the Earth, crashing into the ocean at 200 miles an hour.

But before the fatal flight of the Challenger there was Bob Ebeling. Ebeling was an engineer at NASA contractor Morton Thiokol. The twin solid rocket boosters that were attached on either side of the Space Shuttle were made by his company. The boosters were tall cylinders, but they were not made from one piece. To allow for flexibility and stress during a launch, the boosters were a series of smaller cylinders stacked one on the other. That meant there were joints between each cylinder and that joint was secured with rubber “O-rings.” Ebeling knew that the O-rings were only capable of sealing the hot burning gases inside the cylinder when the rubber of the O-rings were flexible. And the O-rings were only flexible when they are warm. The temperature is usually warm in Florida at the Cape Canaveral launch site, but on that January morning the temperature was only 28 degrees and the O-rings had been sitting in the cold the night air as the temperature dropped to 22 F. Ebeling and the Thiokol engineers had never tested the O-rings at temperatures colder than 38 degrees. Seeing the temperature forecast, Ebeling contacted his supervisors at Thiokol and NASA and disparately set up a teleconference with NASA managers. Just hours before the launch, Ebeling told NASA about his concerns about the O-rings and to delay the launch. One NASA manager on the call fired back, “When do you want me to launch — next April?” Recalling the meeting to National Public Radio, Ebeling said, "There was more than enough [NASA officials and Thiokol managers] there to say, 'Hey, let's give it another day or two, but no one did." The NASA managers refused to delay the launch. There is no evidence that Challenger Commander Scobee was told of Ebeling’s warning. Ebeling's daughter, Leslie Serna, told National Public Radio, "He said, 'It's going to be a catastrophic event ... The Challenger's going to blow up." On January 28, Ebeling sat in a conference room, surrounded by Morton Thiokol executives, powerless, and watched the Challenger explode on a big-screen TV. "Had they listened to me and wait[ed] for a weather change, it might have been a completely different outcome," Ebeling told the reporter.

Alan McDonald was also an engineer at Morton Thiokol and was, in fact, in charge of the solid rocket booster program, but unlike Ebeling, McDonald was in Florida for the Challenger launch. As director of the program, McDonald had to make the final sign-off to approve a launch using his rocket boosters. In 2021, he told National Public Radio, "I made the smartest decision I ever made in my lifetime. I refused to sign it. I just thought we were taking risks we shouldn't be taking." But even though McDonald never approved the launch, Morton Thiokol executives, under intense pressure from NASA, overruled McDonald.

So why was NASA in such a hurry to launch that day? Why did NASA ignore the warnings? NASA was under a great deal of pressure to maintain a launch schedule that they had proposed to Congress. They needed to prove their vision of routine Space Shuttle flights, some as frequent as one every month. But the biggest motivator for NASA on the morning of the launch was that President Ronald Reagan was set to deliver the State of the Union address to a joint session on Congress and the world that very night. NASA officials had every signal that Reagan would include NASA's achievements during the speech, especially since there was going to be a teacher in space. NASA was thinking about their launch schedule plan, their prestige, the President's approval, and the politics of their budget – they had no time to worry about cold weather and O-rings.

After the explosion, Reagan postponed the State of the Union speech and two days later signed the Executive Order creating the Presidential Commission to investigate the Challenger Accident. Former Secretary of State William Rogers was appointed chairman of the commission. But the Commission was not free to follow the facts wherever they may lead. Before the Commission began its work, Reagan gave Rogers his orders: "Whatever you do, "don't embarrass NASA." The Chairman opened the session by declaring, "We are not going to conduct this investigation in a manner which would be unfairly critical of NASA, because we think—I certainly think—NASA has done an excellent job, and I think the American people do." Allan McDonald was asked to attend the commission meeting but was not scheduled to speak. After hearing an executive from Morton Thiokol and NASA managers provide the commission members with, what he thought was a very misleading version of the decision to launch – he spoke up. He raised his hand from the back of the room and was recognized by Chairman Rogers. "Mr. Chairman," McDonald said, "we recommended not to launch." Chairman Rogers said, "Would you please come down here on the floor and repeat what I think I heard?" And Rogers added, "If I heard what I think I heard, this will be in litigation for years to come." McDonald told his story and Bob Ebeling's story to the Commission. This, of course, really angered the Morton Thiokol executives, so after McDonald returned home – they demoted him. They ignored McDonald and Ebeling and now were punishing the Congressional whistleblower. When the demotion of McDonald became public information, Representative (now Senator) Edward Markey, a Massachusetts Democrat, introduced a resolution that would forbid Morton Thiokol from getting any future NASA contracts. The resolution passed.

Note: In its final report, the Rogers Commission concluded that a contributing cause of the Challenger explosion was the failure of both NASA and Morton Thiokol to respond adequately to a design flaw in the O-rings, that they had known about since 1977. The final conclusion: "The Challenger disaster was an accident rooted in history."

The 737 Max 8

Narrative source information: Preliminary Accident Investigation Report (2018); Potlin, F. (2019); Lanfermeijer, S. (2019); March, R. & Wallace, G. (2019); Campbell, D (2019); Baker, S. (2020).

Lion Air First Officer Harvino, who went by only one name, received an unexpected call at 4:00 am on the Morning October 29, 2018. A Lion Air crew scheduler had a mix-up and needed Harvino to fill in for a flight later that morning – but he would have to hurry. At 5:18 am, Harvino entered the flight deck of the Boeing 737 Max 8 and was greeted by Captain Bhavye Suneja. Captain Suneja was originally from India and had been flying for Lion Air for over seven years. Harvino was flying on very little rest and Suneja told his First Officer that he had the flu and coughed repeatedly.

A third Lion Air employee, an engineer, arrived on the flight deck and tells Captain Suneja that he will be riding along on the flight, and interestingly he mentioned that he had not had any training yet on the 737 Max 8. At 6:20 am, Lion Air Flight 610 took off with Suneja flying the airplane and Harvino on the radio.

Immediately after takeoff, Captain Suneja's stickshaker started vibrating. Air Traffic Control verified radar contact and cleared Lion 610 to 27,000 feet. Suneja asked Harvino to verify the airspeed and together they saw that there is conflicting airspeed information between their two indicators. An Angle of Attach sensor is now sending faulty data to the flight computer which makes the airplane think it is too slow and losing lift. To resolve this problem, the nose must come down. The elevator trim started to move the trim tab to a position to force the nose down. But, in fact, the airplane was not dangerously slow and does not need the nose to drop – but the trim motor forced the nose down anyway. Captain Suneja struggled to pull the nose up against the trim-down force and told Havino to ask ATC for somewhere to go so they can work the problem. Havino asked ATC if Lion 610 can go "to some holding point." ATC inquired the reason for this unexpected request and Harvino said, "flight control problem," and that they were trying to fly the airplane manually. Pilots train in flight simulators for the "runaway trim" scenario all the time. In the runaway condition, the trim, primarily the pitch trim, starts to move the trim tab without command. The fix for this problem is to turn off the electricity that is powering the electric trim motor. The traditional way to do this is to disengage the autopilot or pull the trim motor circuit breaker. What the pilots didn't know is at that moment it is the Maneuvering Characteristics Augmentation System (MCAS), unique to the Max 8 airplane, that is sending the down-trim signals to the trim tab and MCAS does not shut off in the traditional way.

Captain Suneja called out, "memory item" but didn't specify which memory checklist he was asking Harvino to start reciting. Not sure which checklist to use, the sound of pages being turned are picked up on the Cockpit Voice Recorder – Harvino disparately looks through the quick reference handbook. “Where is the?...no airspeed,” Harvino shouts, “Airspeed, airspeed!” and more pages are turning. Captain Suneja then remembered that he has an engineer on board and asked a flight attendant to bring the engineer to the flight deck. The flight deck door is opened and the engineer entered. The Captain asked the engineer to help with shutting off the trim motor. Now the engineer and Harvino are both looking through manuals. It was confirmed later that the MCAS Software information was not included in the onboard manuals – they were looking for something that they would never find. ATC calls and said that Lion 610 is no longer climbing and is descending through 1,700 feet. Captain Suneja reported to ATC “we have some problem.” ATC asked what assistance they can provide and asked that Lion 610 climb to 5,000. The Captain responds, “Five Thou-“ but the trim motor has now overpowered the pilots. An excess speed warning sounds on the Cockpit Voice Recorder. Harvino said, “fly up!” Two computerized voice alerts are heard: “Terrain, Terrain” and “Sink Rate.” Captain Suneja remained silent. First Officer Harvino calls out “Allahu Akbar!” which is Arabic for “God is greatest.” Radar contact with Lion 610 is lost. All 181 passengers and seven crew members are killed on impact with the Java Sea.

In the following investigation it was discovered that the airplane that crashed had a similar problem the day before with a different crew. Passengers on that flight reported heavy shaking and a smell of burnt rubber inside the cabin. The ride was “like a roller-coaster.” The Captain of that flight called ATC and reported, “Pan-Pan.” The call of Pan-Pan is the international call when a problem in flight presents an “urgent” situation. This is one step down from a “May-Day” call which would signal immediate danger. Ironically, as would take place the next day as well, another employee was on the flight and was called to the flight deck after the Captain called “Pan-Pan.” The NTSB later confirmed that the third person was an off-duty pilot who had received additional training on the Boeing 737 Max 8. There are no recordings of the previous day’s cockpit conversations, but soon after the third pilot arrived, the Captain rescinded the Pan-Pan call. Speculation is that the third pilot knew how to disengage the MCAS and did so. No mention of this was relayed to Suneja or Harvino. The aircraft's maintenance logbook revealed that the aircraft suffered an “unspecified navigation failure” on the captain's side, while the First Officer's side was reported to be in good condition. The chief executive officer of Lion Air, Edward Sirait, said the aircraft had a "technical issue," but this had been addressed in accordance with maintenance manuals issued by the manufacturer. Engineers had declared that the aircraft was ready for takeoff on the morning of the accident.

But before the fatal flight of Lion Air Flight 610, there was Edward Pierson. Pierson is a former Boeing employee who wrote several warnings about the 737 Max program before the crashes of Lion Air 610, and four months later, Ethiopian Airlines 302. Pierson urged his managers, including Boeing CEO Dennis Muilenburg, to shut down production of the 737 Max 8 production line because an overly ambitious schedule was creating mistakes and corner cutting. Pierson warned of “potential airplane risk due to the unstable operating environment within the factory.” But Pierson said, those warnings were ignored.

So, why was Boeing in such a hurry to bring the 737 Max 8 to the market? The pressure started when Airbus showed up at the 2011 Paris Airshow with the A320neo (new engine option). The A320 competed with the Boeing 737 for airline sales in the narrow-body jet transport market – but the A320neo burned 6% less fuel and that was a game changer. Boeing had to respond quickly or lose the market. Boeing could not allow that to happen. But a brand-new airplane would be years and billions of dollars away, so the decision was made to upgrade the 737, an airplane whose original design was over 50 years old. The 737 Max 8 was a stop-gap airplane needed to buy time. The 737 Max 8 had to deliver fuel savings, but Boeing also had a plan to make the 737 Max 8 more affordable to airlines by cutting out the need for additional pilot training. The three previous versions of the 737 all had the same "type rating." In other words, pilots could fly any of those models interchangeably without any additional pilot certificates. The Boeing plan was to just include the 737 Max 8 in the existing type rating and all airlines who purchased the Max would not have extra pilot training and flight simulator time to pay for. Boeing Chief Pilot, Ed Wilson, announced that any pilot who was rated to fly the previous 737 models could switch to the Max 8 and fly by taking an online course, "two and a half hours of computer-based training." But as time went on it became more apparent to Boeing engineers that the 737 Max 8 was not the same airplane as previous 737 models and really should have its own type rating – but of course, that would derail the sales pitch of a more affordable airplane. In order to match, and beat, the fuel efficiency of the A320neo, Boeing switched engines. The LEAP-1B engines could reduce fuel consumption another 8%, but there was a problem. The LEAP-1B engines are larger than the previous engines and when mounted to the underside of the wing they would nearly touch the ground. There was not enough clearance for takeoff. The only way to use that engine on that airplane was to move the mount of the engine further forward and higher – but this changed the aerodynamics of the airplane considerably, especially in steep climbs. There had to be some fix to this problem that would avoid these aerodynamic changes and more importantly avoid the need for a different type rating and all the expensive training that would come with it. That is where the MCAS came in. The MCAS would receive pitch information from the Angle of Attack sensors and slightly and automatically trim the airplane in climbs so that no difference could be perceived. The MCAS was a stop-gap system to save a stop-gap airplane. But pilots of the 737 Max 8 did notice the difference and before the crash, Lion Air contacted Boeing and asked Boeing to provide more pilot training, including flight simulator training. That is the last thing Boeing managers (and sales force) wanted to hear. In an internal memo revealed through litigation and reported by Bloomberg and Forbes, one Boeing employee called Lion Air "idiots" for wanting additional training and said their request is "because of their own stupidity."

Why didn't the FAA step in and require a different 737 Max 8 type rating? Because in the 737 development, the FAA largely delegated the certification process back to Boeing. After the accident Boeing and the FAA defended the decision to allow the aircraft manufacture to also become the aircraft inspector. FAA said they would need 10,000 more employees to do all the certifications needed, and they don't have the budget for that. Boeing defended the process as well: "The system of authorized representatives — delegated authority — is a robust and effective way for the FAA to execute its oversight of safety," a spokesperson reported. But former FAA employee Michael Collins said that he witnessed senior FAA managers side with Boeing. In one case, Collins reported that the FAA overruled "13 engineers, one project pilot, and four managers." During the certification process of the Max, FAA employees believed there needed to be a change to the rudder's design, but as Collins told it, the FAA backed down: "As the certification date neared, and Boeing had not made a design change, FAA management decided not to require that Boeing redesign the 50-year-old rudder control design."

NOTE: Edward Pierson testified before the US House Transportation and Infrastructure Committee on December 11, 2019, and later interviewed with the International Consortium of Investigative Journalists. There he said that there had been much investigation of pilot training and the MCAS, "but there was no investigation of production, there was no one looking into what could have happened. These problems are going to reoccur."

Historical Case Study Research Method applied: Common Threads & Themes

How can the findings of a Historical Case Study find their way into practical use today? Like any other research method, the findings of Historical Research are discovered through data collection and analysis, followed by conclusions and recommendations. The recommendations, if adopted, can make a direct impact on the practice. The data analysis method is a deep dive into the complexities of the cases involved. “One analytic strategy would be to identify issues within each case and then look for common themes that transcend the case” (Yin, 2009). How are “common threads & themes” identified? “The researcher peruses the collected data in search of general themes that seem to “pop out” as being important considerations in the phenomenon under investigation” (Leedy & Ormrod, 2019). So, what general themes “pop-out” from the three Case Studies just reviewed? Looking back across all three stories there emerges several common threads or themes:

First, and the most obvious commonality between all three cases, is the tragic loss of life in aircraft that could have been prevented.

The second theme revealed is that in all three cases, a safety threat was discovered by individuals who worked inside the organization and were involved in the manufacture and operations of aircraft. R101 engineer Michael Rope and aircraft inspector Frederick McWade discovered that pre-doping the canvas outer covering of the R101 was a faulty procedure which lead to cracks, rotting and imminent failure of the covering needed to protect the gas bags inside the R101 steel frame. Morton Thiokol engineers, Bob Ebeling and Alan McDonald concluded that the spongy O-rings that sealed the Space Shuttle Challenger’s solid rocket booster, would not provide protection when they were cold. The O-rings had never been tested below 38 degrees F. but the Challenger was set to launch having stood on the launch pad as the temperature dropped to 22 degrees F. the night before the launch. Boeing employee Edward Pierson and FAA inspector Michael Collins both urged the shutdown of the 737 Max 8 production due to an unstable operating environment within the Boeing factory and design flaws.

The third theme present across all three cases is that after the engineers and inspectors discovered safety issues, they did not become whistleblowers – at first. Instead, they reported their findings and concerns to their supervisors. They followed the chain-of-command. Rope and McWade reported their safety concerns to their managers including the Chief Designer of the R101. Ebeling and McDonald wrote memos and held teleconferences with managers from both Morton Thiokol and NASA. Pierson and Collins reported to Boeing managers, including the CEO of Boeing.

The next apparent themes is that all the safety reports, conversations, and memos in each of the three cases – were ignored, or downplayed, or rationalized, or overruled, by decision-makers that were up the chain of command. Several tactics were used by the upper-level decision-makers including pressure, coercion, misinformation, and withholding information. In all three cases, information that could have made the difference was withheld from the person who is supposed to be the final decision-maker: The Pilot in Command. Captain Irvin (R101), Commander Scobee (Challenger), and Captain Suneja (737 Max 8) were all kept in the dark about known problems with their own aircraft. The responsibility and authority of Pilot in Command is defined by the FAA as: “The pilot in command of an aircraft is directly responsible for, and is the final authority as to, the operation of that aircraft” (CFR, Chapter 1, Subpart A, Part 91.3). In these case studies, the actions of organizational decision-makers robbed the Pilot in Command of information they needed to fulfill their regulatory requirement to be the final authority. In these cases, the final authority was not the Pilot in Command, but instead members of organizations who allowed outside pressures, other than safety considerations, to influence their decisions.

Another theme to "pops out" is the fact that in all three cases, the organizations were inspecting themselves. Initially the R101 did not earn a Certificate of Airworthiness for the inspector, but when that decision went up the chain to the British Air Ministry, the inspector was overruled. The British government had funded the R101 construction, and it was the British Government (Air Ministry) that ultimately approved the R101 for flight. The NASA managers, overruling the engineers at Morton Thiokol, made the decision to launch the Challenger. NASA and the US Government were in charge of the Shuttle launch schedule as well as the Shuttle inspection process. Boeing took advantage of the fact that the FAA did not have the manpower or expertise to properly inspect the 737 Max 8. Boeing built the Max and also inspected the Max. It appears that allowing an organization, with vested interest in a project's success, to inspect itself, opens the door for decisions to be made that do not place safety as the highest priority (despite what the organization might say otherwise).

The final theme identified is that the individuals that discovered a safety threat, and reported that threat, were ignored, and eventually became compelled to depart from the chain-of-command and become whistleblowers. This action came at great risk to these individuals. The personal risk was increased because of the "high profile" nature of the situation. The individuals whose moral compass made it impossible for them to remain silent had their lives forever changed. Some were demoted, some ridiculed, and made to be public figures when they never wanted to be. On the 30th anniversary of the Challenger explosion, Bob Ebeling said that he had experienced extreme grief and lamented, "I could have done more. I should have done more." Edward Pierson retired early from a career he spent his life building. Michael Rope was himself killed in the R101 crash.

Decision Making Interference

What "outside pressures" could have been so powerful that normal safety decision-making was overridden? In the three cases we saw decision interference. In the three cases we saw combinations of these pressures reoccurring:

1) The Plan. In each case upper-level managers were following a plan that they had a vested interest in – in some cases these managers were the architect of the plan. Failure of the plan would be seen as their personal failure and this would have negative ramifications to their career.
2) Pride. The typical definition of pride is a feeling of deep satisfaction derived from achievements, and the organizational managers in the three cases certainly sought great achievements, but their actions seemed to go beyond this simple definition. The senior managers that made fatal decisions had a blind ambition. They could not fail, and they could not "lose face." Nothing else mattered regardless of the cost to safety.
3) Prestige. The idea of a person, or a company, or a country having prestige is one of reputation achieved through success, influence, power, or wealth. In the cases examined, upper-level decision-makers were influenced, some blinded, by the hope of prestige or the perceived loss of prestige should their plan be delayed or fail.
4) Politics. In this example politics is not a person running for an elected office or the voting for a candidate – this idea is more the art of "playing" politics. Lord Thomson saw his plan as a fulfillment of the United Kingdom's destiny of empire. NASA managers were mindful that the President of the United States would deliver his State of the Union address just hours after the Challenger launch and they wanted to give him something to brag about. Boeing was making every attempt to keep American aircraft building at the top against rival Airbus.

5) Profits. Probably the greatest common theme among upper-level decision-makers is to make as much money and possible or lose as little as possible. Profits are not always dollars however, profit also comes in the form of budgets allocated by governments. The British Air Ministry wanted more money from the government to build more airships and the R101 would prove the airship's worth. NASA wanted the next year's budget allocation from the US Congress to be greater than the previous year and maintaining an ambitious launch schedule would show Congress that NASA was up to the challenge. Boeing had to bring the 737 Max 8 to market quickly facing competition from the A320neo or lose global market share and profits.

In each of the three cases examined, the upper-level decision makers allowed one or more of these distractors: Plan, Pride, Prestige, Politics and Profits (five P's) to cloud their otherwise sound decision making, with disastrous results. They overruled safe decision making by allowing "situational ethics" to intrude. Situational ethics is a line of thinking that rejects prescriptive safety rules that were thought out in advance. Situational ethics allows non-safety factors to enter into the decision-making process, because, at the time, other factors (the five P's) were considered more important.

Safety Management System

So, what can be done to remove powerful non-safety distractors from the decision-making process 100% of the time? How can we ensure that situational ethics does not contaminate, divert, or coerce safety decision-making? Stolzer and Goglia (2016) defined SMS as "A dynamic management system based on quality management system principles in a structure scaled appropriately to the operational risk, applied in a safety culture environment." The Federal Aviation Administration, in Order 8000.369C, defines SMS as, "the formal, top-down, organization-wide approach to managing safety risk and assuring the effectiveness of safety risk controls" (2020). The FAA established four functional components of SMS: (1) Safety Policy, (2) Safety Risk Management, (3) Safety Assurance, and (4) Safety Promotion.

1. **Safety Policy** — *Establishes senior management's commitment to continually improve safety; defines the methods, processes, and organizational structure needed to meet safety goals.*

This component of SMS assumes that senior management will always act with safety as their highest priority, but we have seen evidence that this is not always the case. The FAA's Safety Policy statement paints the picture of a world where there are no outside safety-distractors present and assumes senior management will always be "honest brokers" who are impervious to outside pressures. But a world where there are no outside pressures is not the real world. There is a hole in this safety net. If senior management does not resist the temptations from any of the five P's and succumb to forces outside of "pure" safety considerations, then this component loses its effectiveness.

2. **Safety Risk Management (SRM)** — Determines the need for, and adequacy of, new or revised risk controls based on the assessment of acceptable risk.

In the case studies we saw that the "assessment of acceptable risk" was a moving target. The risk that is acceptable was altered based on outside factors. A senior manager who is distracted by non-safety informed forces can apply situational ethics, or even "situational corruption" to a situation and assume more risk than would have been accepted without outside pressure. Situational corruption of the safety protocols is an intentional action, taken in the moment or as part of a larger scheme, by a person in authority, to address a situation where outside distractors filter away from pure safety decision making.

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3. **Safety Assurance (SA)** — Evaluates the continued effectiveness of implemented risk control strategies; supports the identification of new hazards

This component is based on a level of trust that employees have in their senior leadership. This component assumes that employees are confident that senior managers will do the right thing – and most of the time they do. But, as we have seen, managers do not always "support the identification of new hazards" and instead try to ignore, downplay, or rationalize newly identified hazards. These upper management personal, are not ordinarily "bad actors." If fact, they normally act in good faith and in accordance with their own stated safety practices – gaining the confidence of others – that is why it is so hard to confront them when an occurrence of situational ethics or situational corruption is initiated. This corruption of the Safety Assurance component typically is a rare event when outside pressures and filters can override what otherwise is consistent adherence to safety policy. The pressure in a specific situation tempts the management to "look the other way - just this one time." That situation is a momentary lapse, but, as we have seen in the case studies, the departure from safety standards sometimes is not a "one-off" occurrence, but part of a grand scheme with many co-conspirators.

4. **Safety Promotion** — Includes training, communication, and other actions to create a positive safety culture within all levels of the workforce.

This component relies on effective communication. Much work has been done to promote anonymous safety reporting by employees. The fear employees have is that if they point out a flaw or safety concern to upper management, they will get blamed for it. They fear repercussions and therefore they are reluctant to report. But a safety "culture" relies on employees believing that there will be no repercussion for reporting and reporting really is in their best interest. But even though this component mentions "all levels of the workforce" there is little emphasis placed on what upper management does with safety reports once they receive them. If reports are made but little or no action is taken, employees will soon see no need to report. The safety culture dissolves and whistleblowers emerge. Worse, when employees discover that managers have departed from their own SMS concepts, they lose all confidence in SMS. This "failure to lead by example" destroys employee confidence in the system.

The Hole in the Safety Net

Part of the FAA's definition of SMS is that the system uses a, "top-down" approach. This means that senior management buys-in to the system and will always follow its components. SMS is a well thought out and effective safety tool – when it is used. But case studies have shown that there can be a hole in the SMS safety net if the people in power, the ultimate decision-makers, succumb to outside pressures. The top-down approach only works when the ones at the top act with integrity within the system.

Recommendation

If people deliberately subvert a system for reasons of their own choosing, then making more guidelines, components, and components won't stop them, but can we fill in the gaps in the current safety net? Can we add another component to the current SMS that is specifically designed to prevent the departures from safe practices that we saw in the case studies? The recommendation from this research is to patch the hole in the safety net by including a fifth components to the current SMS:

5. **Safety Integrity** — *Establishes a network of both internal and external checks designed to counter any senior management departure from the first four components of SMS.*

Essentially the Safety Integrity component is a guard rail that would attempt to halt an organization's shift in their decision-making toward decisions influenced by Plan, Pride, Prestige, Politics, and/or Profits. The structure of this guard rail comes from the findings of this research. "At the simplest level, we collect data about events and try to discern trends" (Stolzer & Goglia, 2016). Using this Historical Case Study analysis, several trends or themes "popped out." Among these themes was a breakdown in the "bottom-up" safety reporting system. The current SMS reporting system should remain in place and employees should use that system as their first line of defense. But if safety concerns are ignored after following the in-house reporting procedure, employees need another avenue to share concerns and send alerts. Employees who report safety concerns that they discover or witness sometimes can be ignored or downplayed even though they followed the established reporting procedure up the chain-of-command. Of course, this does not happen in every case, but if it can ever happen, then a problem exists. Part of the Safety Integrity component is to establish an employee reporting system that takes a path outside of the organization and bypasses senior management. This would prevent senior management from blocking a safety concern or suppressing an alert. The receiver of these safety reports would not be the media – this is not a whistleblower recommendation. The receiver would need to be an independent body with no conflicts of interest. The sole role of this body in the process is to collect safety information and anonymously publish that information to the public. The Aviation Safety Reporting System (also known as the "NASA Forms") is already conducting a service like this. The "ASRS captures confidential reports, analyzes the resulting aviation safety data, and disseminates vital information to the aviation community" (ASRS, 2023). The Safety Integrity component establishes a NASA Form-type reporting system, where employees can bring safety concerns to light that are not being addressed appropriately through the regular in-house reporting system.

One of the themes discovered from the case studies was that senior management can get away with non-safety motivated decisions, if they set up a system whereby, they are inspecting themselves. The Safety Integrity component establishes a system of routine supervision and inspection from individuals outside the organization. This could take the form of an outside Advisory Board or a safety consultant conducting an independent safety audit on a periodic basis. An "attorney-client" type relationship would be established between the employees and the consultant to guard against exposing any market information that the organization does not want to disclose, but without compromising safety reporting. The Safety Integrity component establishes policies and procedures that prevent a situation where the organization is the sole inspector of itself.

Employees should not have to become whistleblowers to save lives. Employees should not have to make a choice between damaging their own careers and the safety of the public. We need a system that prevents the need for whistleblowers in the first place. We need a safety net to catch senior management's departures from non-safety motivated decisions. We need Safety Integrity built into the system. It is too late for the victims of the R101, the Challenger, and the crashes of the 737 Max 8, but identifying the core themes that contributed to those tragedies and taking steps to expose and mitigate those themes will hopefully save the next tragedy from happening.

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