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SMS Implementation: System Safety Tools for Improving Part 135 Operators' Safety Culture

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On May 15, 2017, N452DA, a Learjet 35A operated by Trans-Pacific Air Charter, LLC, departed from Philadelphia to Teterboro, New Jersey and crashed south of Teterboro Airport (TEB) on a positioning flight under 14 Code of Federal Regulations Part 91 (Part 91) in Visual Meteorological Conditions (VMC). While circling to land Runway 01 after executing the Instrument Landing System (ILS) Runway (RWY) 06 approach, N452DA stalled and crashed one half mile south of the approach end of runway 01. The flight records indicated that the crew committed numerous errors prior to the accident, including deviations from air traffic control (ATC) clearances, company standard operating procedures (SOP), stabilized approach criteria without initiating a go-around, all of which contributed directly to the outcome. While the National Transportation Safety Board (NTSB) investigation issued several recommendations to the Federal Aviation Administration (FAA) and one recommendation for a change to the company's SOP, using a group of practitioners' perspectives, the authors used Fishbone Ishikawa Analysis and Fault Tree Analysis to discover upstream contributing factors followed by SMS implementation to improve the safety culture.

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Introduction

Trans-Pacific is a 14 CFR Part 135 (Part 135) operator, N542DA was flying from Philadelphia International Airport (PHL) to Teterboro (TEB), New Jersey under Part 91 as a positioning flight with no passengers on board. For this specific flight, the crew's third of the day, the PIC filed a flight plan for a 28-minute flight at a cruising altitude of flight level (FL) 270 and a cruise speed of 441 knots true airspeed (KTAS).

The NTSB (2019, pp. 1-7) accident report indicated that the straight-line distance from PHL to TEB is about 80 nautical miles (NM), but the flight plan indicated a less direct route. PHL cleared the aircraft for takeoff shortly after 1500 (all times given in local time). Soon after takeoff, ATC cleared the aircraft on a different, shorter route via the waypoint MAZIE. ATC also limited the aircraft to an altitude of 4,000 feet above Mean Sea Level (MSL). At 1509, ATC issued temporary vectors away from the revised route for traffic sequencing. The aircraft exceeded the Part 91.117 airspeed limitation of 250 knots indicated airspeed (KIAS) below 10,000 feet MSL. Cockpit dialog indicated a complacent attitude from the pilots. The PIC requested a higher altitude a few minutes later, a request that ATC did not grant. About 10 minutes into the flight, the crew checked in with New York approach, and the approach controller provided vectors for the TEB ILS RWY 06 approach, circle to land runway 01. Forty-eight nautical miles from TEB, the PIC commented to the SIC that they were hundreds of miles from TEB. Less than a minute later, the controller instructed the crew to descend to 3,000 feet MSL to intercept the localizer for runway 06. While attempting to join the localizer, the SIC mistakenly identified Newark International Airport (EWR) as TEB and told the PIC that he had the runway in sight. The aircraft flew across the correct localizer course, and a short time later, the controller noted this error. The crew then followed the controller's instructions to correct their course, turning left to intercept the TEB localizer and flying toward the VINGS waypoint.

While N542DA was inbound to VINGS, the SIC tried to transfer the controls to the PIC, but the PIC did not respond, so the SIC continued to fly the approach. The circle to land maneuver would consist of a right turn followed by a left turn onto the extended center line of runway 01. About 08 miles prior to VINGS, the approach controller cleared N452DA for the approach. Contrary to company policy, the pilots did not conduct an approach briefing, and instead, the PIC continued to coach the SIC through the speed and altitude requirements for the approach (NTSB, 2019).

At 1526 the approach controller instructed the crew to do three things – contact TEB tower, cross the next waypoint DANDY at 1500 feet MSL, and initiate the circling maneuver at the final approach fix TORBY located 3.8 miles from runway 06. The flight crew acknowledged these instructions but neglected to do all three. The PIC had become so preoccupied with coaching the SIC through the approach that both pilots lost situational awareness. The crew did not contact TEB tower; they crossed DANDY at 2000 feet MSL, and they did not begin the circling approach at TORBY. About two minutes later, ATC again instructed N542DA crew to contact the tower, and the PIC continued to coach the SIC, instructing him to descend to the circling minimum of 760 feet. When the crew did establish contact with TEB tower, the controller cleared the aircraft to land on runway 01. When N542DA was about one nautical mile from the approach end of runway 06, the tower asked the aircraft if they were going to start the turn. N542DA banked hard to the right. While the airplane was in the right turn, the SIC turned over the controls to the PIC. The PIC took the controls and directed the SIC to watch the airspeed, and began a left turn to runway 01 at a high bank angle. During the turn, the SIC called airspeed four times; the PIC called out stall, and the SIC agreed, repeating airspeed twice more. In less than 30 seconds, the aircraft impacted the ground in an industrial area just south of the airport.

Final NSTB Accident Report

In the final report, the NSTB found the probable cause as the PIC's attempt to salvage an unstabilized visual approach, which resulted in an aerodynamic stall at low altitude. The NTSB concluded that the PIC's focus on the visual maneuver of aligning the airplane with the landing runway distracted him from multiple indications of decreasing stall margin. Despite the SIC call-outs, the PIC did not add power or reduce the aircraft's angle of attack during the left turn. Further, the PIC's decision to allow an unapproved SIC to act as pilot flying, the PIC's inadequate and incomplete preflight planning and the flight crew's lack of an approach briefing, and the PIC's decision to allow the unqualified SIC to fly all contributed to the outcome (NTSB, 2019).

The NTSB's citation of ineffective or non-existent company safety programs among its final contributing causes resulted from an extensive analysis of the company's existing policies and practices. The existing policy did not contain necessary measures to make the company aware of the kind of deviations or issues associated with the accident crew. Beyond the initial identification of these issues and the resulting categorization of each pilot, this policy contained no measures to provide surveillance of or updates on the performance of the lower category pilots. The company also had no check airmen qualified on the Learjet 35 and depended on the FAA for the administration of line check flights. This practice precluded the effective monitoring of regulatory and SOP compliance by company pilots.

Furthermore, the company's crew resource management (CRM) training also did not address SOP compliance or the "influence of planning, briefing, and decision-making on workload and time management" (NTSB, 2019, p.49), issues of particular importance during the accident flight. The CRM program addressed the responsibilities of a PIC as a team leader only in the most general terms. The NTSB also identified that the PIC had never received any form of leadership training prior to his designation as a PIC.

The company's director of operations served as the safety officer and acted on the informal safety information that he received, including performance deficiencies reported by the training provider regarding both the PIC and SIC. This awareness, however, did not prevent the assignment of these two pilots to fly together, as an effective progressive qualification policy might have. The company indicated that it had initiated the implementation of an SMS at the time of the accident, but still had not done so two years later (NTSB, 2019, pp. 44-51).

Risk Management Analysis – A Case Review

Confusing Assignment of Flight Crews

For most of the flight, the PIC did not maintain sufficient oversight of the crew and aircraft operation instead of instructing the SIC in basic flying of the airplane. His resulting inattention to his Pilot Monitoring (PM) duties resulted in multiple regulatory and procedural deviations, as well as numerous missed radio calls. To summarize, the PIC's decision to allow the SIC to act as Pilot Flight (PF) placed both pilots in roles they did not routinely perform and for which neither prepared adequately. Thus, neither performed their assigned duties competently during the flight (NTSB, 2019).

Situational Awareness

Further, the PIC seemed to lack overall awareness of the flight environment in both his preflight planning and his in-flight assessments. By filing for a cruise altitude of FL270 and later stating that the aircraft was "hundreds of miles from [TEB]," he demonstrated that he did not understand that the flight would only cover approximately 80 NM. Given that normal ATC practice would require the aircraft to be at 3,000 feet MSL approximately 10 nautical miles and three minutes before landing, the available distance to climb from takeoff to FL270 and back to 2,000 feet MSL would have been only 70-80 NM, flown in approximately 24 minutes. The climb and descent tables available to the crew indicated that this combined climb and descent would have required 80.7 NM and 13.7 minutes (computed for a typical aircraft takeoff weight of 15,000 pounds at standard pressures and temperatures) (FlightSafety International, 2011, p.23, p.54), as well as integration of the accident aircraft into the traffic arriving and departing from TEB and the other airports in the vicinity.

Latent Factors

While these failures would not have resulted in an accident in many circumstances, the crew operated this flight in some of the most congested airspace in the country, where they should have anticipated rapid changes of frequency, multiple changes of routing, numerous other radio transmissions, both for their aircraft and others, which the crew should have tracked to maintain necessary levels of situational awareness, and the requirement in VMC to maintain a constant visual scan outside the aircraft for other traffic. Such a short flight, approximately 28 minutes from takeoff clearance until anticipated landing, would require the crew to perform its normal checklists and procedures more rapidly than normal, even while dealing with the issues associated with the congested airspace, creating a demanding operating environment for even an experienced professional crew (NTSB, 2019).

These demands placed an even greater premium on both preflight preparation and the assignment of suitable duties to each crew member. During a long flight, the crew would have had time to prepare for the arrival and approach while in the later stages of cruise flight, after collecting weather, arrival, and approach information for the destination. In the absence of adequate preflight planning, time pressure exaggerated the crew's high workload and precluded any such preparation. The resulting disorientation proved fatal (NTSB, 2019).

Internal Supervision vs. Organizational Culture

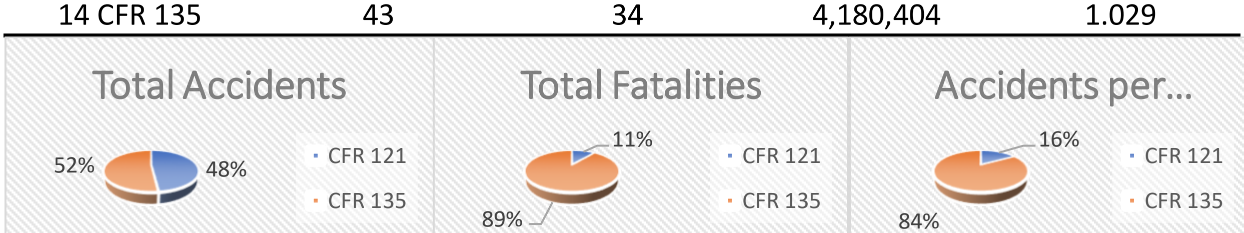
At the most important level, an effective safety program would have established a safety culture that would have identified many of the hazards that the crew encountered and mitigated the associated risks, which include reporting, just, informed, and learning cultures (Lu, 2011). While absent from the NTSB report's solid conclusions, the executives created a major impediment to the company's safety culture. In fact, most directors of operations could not have provided an independent assessment of the safety issues associated with their own operations. Per the "Hawthorne Effect" theory, this director's supervisory responsibilities over the pilot workforce would also have had a chilling effect on independent or anonymous safety reporting by his subordinates (Lu, 2021). This salient conflict of interest is attributable to a failure of the flight crews before and during the flight. Evidently, reporting culture was not shaped as well as most SMS components.

FAA SMS Policy

The FAA's Part 121 Air Service Providers SMS mandate listed a compliance deadline of March 2018 (FAA, 2019 March); therefore, 2019 was the first year to compare Part 121 safety statistics with Part 5 against Part 135 Air Taxi safety statistics without a mandatory requirement. The statistical analysis from the NTSB's 2019 national database (NTSB, 2020) was conducted. According to the number of accidents, it did not differentiate between Part 135 operators utilizing an effective SMS from those operators who did not. However, Part 121 carriers logged roughly four and half times more flight hours than Part 135 operators; thus, the authors focused on the accidents and fatalities rate (one hundred thousand hours and departures data) for a common neutralized data comparison showing Part 135 had encountered a much higher accident rate than that of Part 121 (NTSB, 2020).

Table 1
2019 NTSB Accident Statistics: Accidents per 100,000 Flight Hours

US air carrier operating rules	Accidents	Fatalities	Flight Hours	Accidents per 100,000 Flight Hours
14 CFR 121	40	4	19,786,547	0.202
14 CFR 135	43	34	4,180,404	1.029

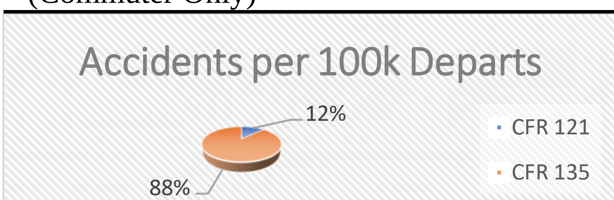


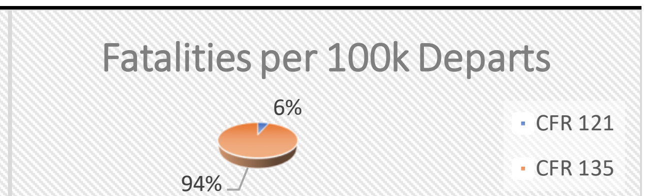
Source: NTSB (2020). Data and statistics.

In addition, as the NTSB's data indicated, the Part 135 operators' accident rate per 100,000 flight hours was approximately five times higher. This statistic created the illusion that Part 135 operators were five times more likely to have an accident, but a deeper review comparing the total number of departures was necessary. Taxi, takeoff, and landing are statistically the most dangerous phases of a flight, not the cruise flight portion that comprised most flight hours (Boeing, 2012). To enhance the meaningfulness of data analysis, the authors also compared the total number of departures between Part 121 and Part 135. Unfortunately, the NTSB only recorded the total number of departures for Part 135 commuter operations and omitted the Part 135 on-demand departures, which might have misled the readers. However, even some Part 135 (on-demand air taxi) operations were not recorded by the NTSB, the table below (Table 2) remained strong, showing accident rates of Part 121 and Part 135 service providers. This data indicated Part 135 commuter operators had approximately seven times more accidents in 2019 than Part 121 carriers (NTSB, 2020). This analysis simultaneously highlighted a safety gap that the NTSB and FAA have been seeking to close.

Table 2
2019 NTSB Accident Statistics: Accidents per 100,000 Departures

US air carrier operating rules	Accidents	Fatalities	Departures	Accidents per 100,000 Departures
14 CFR 121	40	4	19,786,547	0.202
14 CFR 135 (Commuter Only)	9	2	632,793	1.422





Source: NTSB (2020). Data and statistics.

FAA Advisory Circular AC 120-92B

On January 8th, 2015, the FAA published Advisory Circular AC 120-92B, which required air operations under Part 121 to adhere to Part 5 SMS requirements (FAA, 2015 January). The deadline to comply with this regulation was March 2018. The FAA Safety Team broke Part 5 down into six subparts which outlined the FAA's expectations of a compliant airline SMS as shown in Figure 1 below:

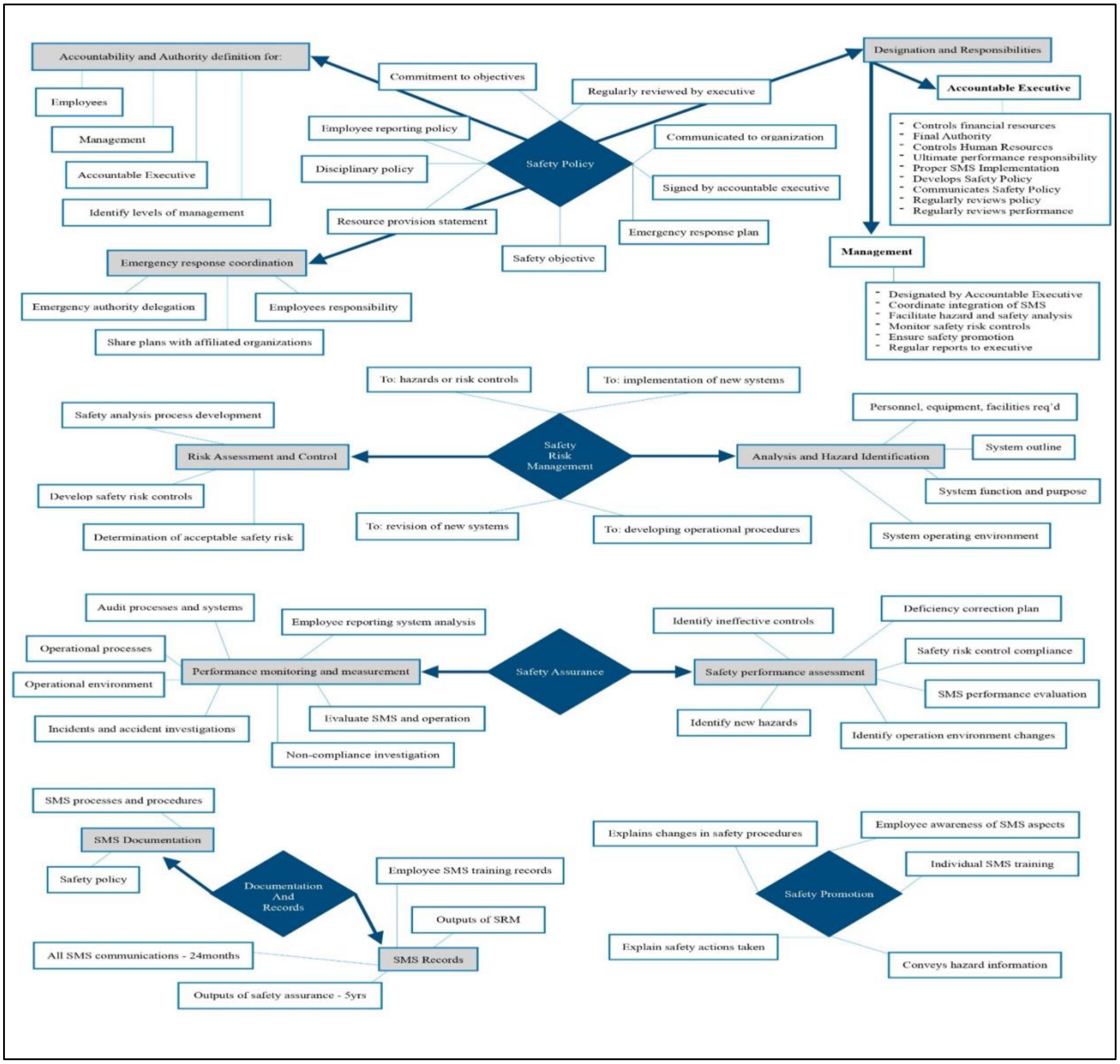


Figure 1. 14 CFR Chapter I Subchapter A Part 5 – an SMS Visual Aid

Source: FAA (2015). AC 120-92B SMS for aviation service providers.

The FAA's voluntary SMS implementation guidance for Non-121 Air Operators, MROs, and Training Organizations was an excellent web resource that we referenced during our abbreviated outline of a Part 5 compliant program. 14 CFR Chapter I, Subchapter A, Part 5.3 (a) stated, "The SMS must be appropriate to the size, scope, and complexity of the certificate holder's operation" (14 CFR, n.d.). The number of safety professionals needed to develop and maintain an SMS was, therefore, dependent on the size of the operation. The organization had to identify an accountable executive, whose responsibilities were outlined in Part 5.25(a). The accountable executive would then identify the safety team and place that group within the organizational hierarchy, where they would then work within Part 5 requirements to design, implement, and maintain an SMS.

Methodology - Risk Management Tools

This systemic analysis attempted to isolate the organizational issues that either led or permitted the crew to act in this manner, based on the assumption that neither pilot was aware that they were placing themselves in mortal peril through their decisions and actions. During stage one of this study, the authors used Fishbone Ishikawa Analysis and Fault Tree Analysis (FTA) that helped reveal contributing factors of the accident and shed light on areas most in need of improvement. Stage two of the study provided an additional level of safety analysis and recommendations to emphasize the need for an SMS program to prevent future accidents and improve the company's safety culture.

Ishikawa Fishbone Analysis

As the first step in accident analysis, the Fishbone Ishikawa Analysis allowed the research team to see an array of all inputs to the outcome. Brainstorming activities following SHELL, 5Ms, or HFACS would later shape a visual fishbone diagram indicating root causes of the undesired event. This effort provided the foundation for the subsequent use of another analytic tool to determine the accident's root cause (Ishikawa, 1990).

Fault Tree Analysis

Fault Tree Analysis (FTA) is a system analysis that is used to determine the root causes and probability of occurrences derived from a specific undesired event. FTA is useful for evaluating large, complex, and dynamic systems in order to understand problems better and implement mitigation strategies (Ericson, 2005). Through its graphic depiction of the relationships between component failures within an overall system (Lu, 2021), Fault Tree Analysis (FTA) proved most useful in the team's analysis of the N542DA accident, even without knowing the mathematical values associated with the probability of each subordinate failure. Given the choice between a deductive approach, which listed the possible causes of a system failure as a means of discovering the possible system failures, or an inductive approach, which began with the undesired outcome and retraced the causal failures throughout the system, the team chose the inductive approach (Vincoli, 2014). If, however, one had applied the deductive approach before the accident, a frank appraisal of the circumstances would have led the team to an accident as the likely outcome.

Validity and Reliability of Analysis

Reliability is the capacity of a test or report to "perform in the future as it has in the past" (Lu, 2020 March). This would mean that multiple renditions of a study would result in the same outcome. While the minimum method error (tool selection) and trait error (researcher conditions) yield the maximum reliability, the triangulation process helps ensure analytical consistency. The inter-rater technique was applied by the authors to secure reliability (Goff, 2005). For validity, the authors found convergence among multiple sources of information to form themes or categories in a study. The bias of each researcher was eliminated by adopting triangulation methods when conducting research (Creswell & Miller, 2000).

Research Questions

Q1. What are contributing factors of the N452DA Learjet crash in 2017, according to Ishikawa Fishbone and Fault Tree Analysis?

Research Hypothesis: Beyond the NTSB's probable causes of the accident, there are upstream contributing factors leading to the N452DA Learjet crash.

Q2. What mechanisms of Safety Management Systems can be used by FAA FAR Part 135 Air Taxi service providers?

Research Hypothesis: There are practical SMS for the budget-constrained FAA FAR Part 135 Air Taxi service providers.

Results

The information in the NTSB report of the accident investigation portrayed a relatively clear accident scenario, two pilots acting in unfamiliar roles with limited or no competence attempted to operate a high-performance business jet in the country's most congested airspace, lost situational awareness, and failed to recognize the imminent low-altitude loss of control until recovery was no longer possible. The report, however, alluded to an unsafe operating environment involving hazardous attitudes (FAA, 2016, p. 2-5) within the company. FAA did little to support and protect these employees or the company's equipment.

Q1. What are contributing factors of the N452DA Learjet crash in 2017, according to Ishikawa Fishbone and Fault Tree Analysis?

Ishikawa Fishbone Analysis & Fault Tree Analysis. In the Fishbone Ishikawa Analysis, each branch represented a different area of the flight where one or more failures were apparent. Specific contributing factors (flight phases including preflight, en-route, and approach) and latent factors (environment, management and equipment, and training) were selected to be analyzed. Contributing causes of each selected factor were also provided based on group discussion and triangulation. Please see Appendix A.

Fault Tree Analysis. FTA diagram is provided in Figure 2 using two branches: PIC and SIC. Full-size diagrams are available in Appendixes A and B. The cut-sets included [SIC's violation to SOPs, Weak PIC airmanship, lack of inflight briefing, inexperienced SIC], [SIC's violation to SOPs, Weak PIC airmanship, lack of preflight, inexperienced SIC], [SIC's violation to SOPs, Weak PIC airmanship, the unwillingness of obtaining information, inexperienced SIC] regardless of the failure probability associated with each root cause. Please see Appendix B.

Contributing Factors

Hazardous Attitudes. On the FTA's left-hand branch, five basic tree initiators contributed to the PIC's distraction involving Anti-Authority, Impulsivity, and Macho attitudes. All five events point to a poor safety culture within the company's flight department. First and foremost, the first officer was performing PF duties for all but the last thirty seconds. Not only was the SIC less experienced, but his participation as PF also exhibited a blatant disregard for company policy. The NTSB's report also mentioned that it was likely not the first officer's first time acting as the PF, further showcasing a systemic lack of rule adherence, namely antiauthority. The first officer's lack of airmanship and attitude of resignation likely overwhelmed the PIC, leading to additional distraction. As a result of the PIC's distraction level, the PIC suffered a complete loss of situational awareness (SA) throughout the flight. This event began when the crew failed to perform their pre-flight duties and chose to depart without the current Teterboro weather and on an unrealistic flight plan, which was one of the operational pitfalls – neglect of flight planning (FAA, 2016, p. 2-22).

CRM issues. During the flight, despite attending the FAA mandatory crew resource management (CRM) training for Part 135 operators, the crew exhibited a disregard for proper checklist and briefing criteria written in the company's General Operating Procedures (GOPs). This combination led to the crew's poorly understanding of the elements of the circle-to-land procedure, which caused a further loss of situational awareness upon entering the terminal environment, which showed the lack of information management. Further compounding this loss was the PIC's inability to ascertain his position throughout the flight, a skill-based error (Reason, 1997). Not only was the PIC lost, but he also displayed an arrogance (a mixture of macho and invulnerability) that hindered his urgency from regaining SA. With the absence of a strong safety culture, lack of communication, teamwork, and workload distribution, the situation exposed the PIC's weaknesses as a pilot when the distracted captain reluctantly accepted the flight controls for the final airborne moments of the flight.

Training and Airmanship. The company's policy clearly stated that the SIC of this flight was prohibited from performing pilot flying duties due to his low total flight time. Several factors attributed to the SIC's inability to aviate without the assistance of the PIC. At the forefront of his shortcomings was his lack of experience in turbine-powered aircraft, namely both knowledge and skill-based errors. Additionally, CAE, the simulator flight training company that administered the SIC's initial training noted several training deficiencies during his initial course. One of those training deficiencies included difficulty performing circle-to-land maneuvers like the Teterboro approach. While on the line, investigative interviews discovered the SIC's line performance to be "hit or miss," yet no corrective action was taken, further highlighting the need to improve pilot qualification training and safety culture.

Non-punitive Reporting System. Without a non-punitive reporting system or working safety system in place, management's ability to identify underperforming crew members was almost non-existent. While a non-punitive reporting system at the company was almost non-existence, many hidden problems were covered up and undisclosed. As if that situation were not troubling enough, the FAA exhibited low levels of safety oversight and a lack of interest in expanding those levels of support due to the lack of legal basis. Worst of all, the NTSB's investigation noted the FAA's Principal Operations Inspector (POI) presiding over the company had never performed an inflight check on a Part 135 carrier.

Q2. What mechanisms of Safety Management Systems can be used by FAA FAR Part 135 Air Taxi service providers?

Even though the language of NTSB safety recommendation A-16-36 only asked that the FAA mandate that Part 135 carriers maintain an SMS, the researchers chose to use 14 CFR Chapter I Subchapter A Part 5 as it demonstrated the FAA's expectations of an SMS. To simulate how Part 5 would challenge Part 135, safety teams, the researchers created Figure 1 to demonstrate a Part 5 compliant SMS' complexity and examined Part 5 with the help of the FAA's voluntary SMS guide for non-121 air operators, as well as the International Civil Aviation Organization's (ICAO) SMS publication, dubbed Annex 19.

The researchers reflect on this accident and its lessons to understand the importance of a focused cockpit, how quickly situational awareness eroded, and the dangerous consequences when it did. A reporting system shall be created to allow anonymous reports, comments, and safety alerts. In fact, the NTSB final report did indicate that, aside from the plan to implement a safety management (which did not occur) and third-party safety audits, little else happened before the accident. A company cannot simply tell its crews not to make the same mistakes and expect that the same circumstances will not recur. Without a change in the company's safety culture starting from a hazard reporting system, the company could have no expectation of significant, lasting change in its safety performance (Leib & Lu, 2013).

Benefits of SMS Implementation

Given the availability of free, voluntary FAA programs for both SMS and data participation, USAIG and Global Aerospace offer a policyholder dividend equaling 5% and 10.6% of the premium, respectively (USAIG, 2021; Global Aerospace, 2021). The greatest benefits, however, will not be financial. As noted by the International Business Aviation Council (IBAC, 2021), an effective SMS would offer enhanced operational safety, a means of measuring safety performance, improved operational performance, improved stakeholder confidence, and improved teamwork, as well as enhanced pride, among the company's employees (ICAO, 2016).

Safety vs. Budget Constraint

Given the small size of the company and the age of the aircraft, a comprehensive FDM program would not be possible, as the original CVR and flight data recorder models did not yet collect enough discreet data or retain it for a long enough period to allow collection and evaluation, not to mention Flight Operation Quality Assurance (FOQA) program (FAA, 2004). Our research also noted that the company was not the owner of any of the aircraft that it operated. According to the broker, the company, therefore, could only recommend conversions to an aircraft's owner(s) if it were so inclined. The Part 135 management and charter of these privately owned aircraft would become far less lucrative if the owners faced an FAA mandate to install FDM equipment costing more than one-quarter of the aircraft's value that would also not increase the value of the aircraft at resale.

However, with the availability of the FAA's Aviation Safety Information and Sharing (ASIAS) program, the company can both learn from the safety information and contribute to safety improvement throughout the industry. To present early concerns on known risks, the FAA designed ASIAS to accept all forms of safety data, including an SMS' manual hazard reporting or other methods that did not necessarily rely on the high-technology methods that would be impractical for companies facing budget constraints at this time. ASIAS' deidentified aggregate safety-related data are available to the airline industry for cross querying, and lessons learned purposes (FAA, n.d.). The FAA has also indicated that it cannot use ASIAS data against operators participating in the program, which will protect the company from enforcement actions based on information submitted directly to the program by the company or its employees.

Mechanism of Safety Management Systems

Commitment. As noted earlier, a successful SMS begins with a commitment from the top management through its safety policy. Given a corporate aviation company's history and its relatively small size, the chief executive officer/president (CEO) should sign this policy and announce the beginning of this program to the employees and other stakeholders in the company. Besides showing visible supports to the program, safety policy should also designate a different employee as the safety program manager, thereby eliminating the current conflict of interest posed by having the director of operations serve in that role.

Reporting and Informed Cultures. As a counterintuitive example, an increased number of safety reports indicates positive safety system performance and an improving reporting culture rather than greater risks to the company. The content of those reports may serve as an unknown risk indicator, e. g. multiple reports of pilots continuing unstabilized approaches beyond the limits prescribed within the company SOPs. The safety committee should then track each safety, incident, and accident report, including the actions taken in response to the report and follow-up assessments of the effectiveness of those actions to shape the informed culture.

Just Culture. The non-punitive policy should come with the establishment of a company safety committee comprised of a representative from each department of the company and chaired by the safety program manager. Embracing the "just" concept, the safety committee would be responsible for recommending safety policies to company management, reviewing incidents, accidents, or other safety reporting, and conducting safety training within members' respective departments. At the outset and with the guidance of the risk management team, the safety committee members would participate in the development and implementation of the SMS.

Learning and Adaptive Culture. Also, for the learning culture, it is essentially rooted in safety assurance. The company must solicit both authored and anonymous safety reporting for continuous safety education and promotion. Continuous Gap Analysis. Part 5, ICAO Annex 19 (2016), and the various SMS audit standards provide comprehensive lists of those policies and activities that will be mandatory subjects of the gap analysis, but committee members should also include other practical activities with potential hazards. This gap analysis would identify and document the current activities that the department performs to mitigate identified risks, in effect taking credit for work already completed, and it would identify and document those hazards and associated risks that the department has either not identified or identified and not addressed.

Continuous Risk Assessment. After compiling the routine gap analysis, the committee members should assess the company's existing and anticipated risks regarding both their severity

(S) and their probability (P), rating in a Risk Matrix as a low, medium, or high risk, according to a rubric adopted by the committee. The committee should also determine the actions necessitated by each level of risk and, after the application of those actions to mitigate the initial risk, rate the residual risk. This risk assessment system must also include the company's policy on conducting activities based on their residual risk rating, e. g. the company might choose not to conduct any activities with a high residual risk rating, activities with a medium residual risk rating might require CEO or director of operations approval, and no action may be necessary for activities with a low residual risk rating. In each area of the company's activities, committee members should also establish a way to measure leading indicators of potentially increased risk or positive safety system performance.

Safety Promotion and Assurance. The participation of each department's representatives in these processes would then become the first stage of SMS promotion within the company. The company should also develop initial and periodic SMS training for its employees, managers, and safety committee members. Senior management should consider the development of a company safety newsletter or regular email, which should include reporting highlights, information of particular interest from the ASIAS database or NASA Aviation Safety Reporting Program (ASRP), and other relevant safety subjects. Many corporate aviation companies also develop incentives for employee contributions to the SMS, and the safety committee would recommend the award of these incentives to the CEO.

Leadership Visibility and Involvement. At each step, employees and other stakeholders should see the senior managers embrace the SMS, especially the CEO. Without the CEO's overt and active support, the SMS would be little more than paperwork and meetings. This engagement would reform the foundation for the company's safety culture. The combination of senior-level engagement, floor manager support, and SMS training/other forms of SMS promotion will begin to create a shift in employee attitudes, leading them to trust that the system exists for their benefit, rather than a mechanism for employees to report each other or managers to punish employees. While an effective SMS does include sanctions against employees who refuse to comply with company policies, including its SMS policy, employees should see the system's more positive outcomes much more frequently in order to remain engaged.

Conclusions

FAA FAR Part 135 air taxi service providers are not required to implement SMS, yet taking proactive action to ensure safety is recommended. While cost is a significant hurdle impeding air taxi providers to implement many optional programs, the cost is much lower than restoring the company's good standing and reputation with its customers, shareholders, insurers, regulators, and, most of all, its employees after a severe accident like the crash of N452DA Learjet in 2017 in Teterboro, New Jersey.

By virtue of the researchers' close analysis of the NTSB accident report using Fishbone Ishikawa Analysis and FTA in conjunction with decades of industry's experiences in air operation and safety, the benefits of SMS toward the improvement of the corporate aviation safety culture are significant. The authors assembled a plan to invigorate the company's safety program and begin rebuilding its safety culture on the solid foundation of safety policy, risk analysis, safety assurance, and promotion. To succeed, the plan requires that top managers demonstrate positive supports and commitment as well as the buy-in from employees and safety committees and the employees' involvement in developing the safety program. This means full involvement is critical to making a safety program successful, while a successful non-punitive hazard reporting system is the starting point.

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