# Pilot Training in a Safety Culture: SMS and NextGen Demands

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History of airline safety includes both FAA economical and safety measures that have grown over the years. This paper not only provides a discussion of those safety trends, but includes a paradigm shift from reactionary strategies toward proactive measures of a safety culture, to include *reporting culture, just culture, flexible culture,* and *learning culture*. Identification of safety culture is the foundation for safety management systems (SMS), which will include the four pillars of safety: safety policy, safety risk management, safety assurance, and safety promotion. This article not only presents a timeline of safety history, but identifies aircraft automation challenges to include operational constraints and training challenges associated with economics, human factors, and training devices. These training challenges will be addressed, providing cost effective suggestions for improvement within an SMS framework supporting a safety culture.

Key Words: AQP, ASAP, ASRS, automation, complexity, human factors, fatigue, CRM, FOQA, LOSA, NextGen, pilot training, safety culture, simulator, SMS, and TEM.

## INTRODUCTION

A discussion of pilot training associated with safety culture, safety management systems (SMS), and NextGen would be incomplete without reviewing the history of aviation safety and regulatory processes (Adamski & Doyle, 2010; Gesell & Dempsey, 2011). Human factors research led to programs such as crew resource management (CRM), advanced qualification program (AQP), threat and error management (TEM), and line operations safety audits (LOSA), to reduce pilot error and improve safety (Patankar & Sabin, 2010).

Currently, airline safety is focused on an organizational safety culture as a mechanism to support safety management systems (SMS) in preparation for the implementation of NextGen (Stlolzer & Goglia, 2015). A strategic plan for the implementation of SMS into pilot training should follow, given that pilot procedures and actions in the flight deck are often the last defense preventing an accident or incident.

## AIRLINE SAFETY TRENDS

The early years of aviation saw many safety challenges resulting in regulatory change due to economics, more so than safety; yet, eventually the FAA became a dual gatekeeper of safety and economic protection (Adamski & Doyle, 2010; Gesell & Dempsey, 2011). The aviation industry expanded quickly and aircraft crashes were due, in part, to under-developed technology, the inability to avoid weather, and a paucity of ground support systems (Perrow, 1999). Early aircraft were unsteady, demanded continuous pilot input, and required unyielding attention due to unreliable external cues for navigation (Mosier, 2010). Aircraft technology evolved, and human factors specialists worked with engineering and flight crews to reduce cockpit workload. In the early 1970s CRM became the first regulatory mandate to deal with crew interpersonal and communication issues (Helmreich, Merritt, & Wilhelm, 1999).

### Crew Resource Management (CRM)

Crew resource management (originally termed cockpit resource management) was a movement to teach crewmembers interpersonal and communication skills in effort to reduce pilot error. CRM was not a one-time fix, but a process that evolved over five developmental generations during the 1990s—theory; teamwork emphasis; team expansion; AQP; and TEM (Helmreich, et. al., 1999). One of the greatest challenges with CRM was to convince pilots that they needed to improve their communication skills (Helmreich, et. al., 1999). However, once leadership understood that errors were unavoidable, but could be mitigated, corporate support was gained (Broyhill & Freiwald, 2012). CRM was mandated, and programs were developed and subsequently forced upon flight crews. Despite resistance from some, CRM took hold and became the way flight crews operated—CRM became embedded in airline culture (Broyhill & Freiwald, 2012; Helmreich, et. al., 1999; Valazquez & Bier, 2015). When CRM moved into simulator training in the form of AQP, operational training combined with interpersonal communication practice ensued.

**Advanced Qualification Program (AQP)**

AQP provided airlines an economic benefit by granting training departments the ability to reduce training footprints with a train-to-proficiency concept (FAA, 2006), notably reducing training expense. At the same time, airlines were required to track crew performance to ascertain training effectiveness, yet managers were perplexed how to accomplish this task (Nemeth, 2015). AQP also required the inclusion of CRM training, line oriented flight training (LOFT), and line operational evaluation (LOE) scenarios (FAA, 2006). These training/checking scenarios changed traditional processes where a pilot was trained and checked on individual performance, to training and checking crew-based performance (Helmreich, et. al., 1999). Line-oriented training processes not only enabled crews to learn how to manage the aircraft, but also worked toward improving team and communication skills. With the availability of highly reliable automated aircraft, designed to reduce workload and improve situation awareness (SA), training departments could achieve results quicker than ever before. CRM opened the door to exceptional communication, where crewmember briefings began with, "*Today the threats are…*"

**Threat and Error Management (TEM)**

TEM, the essence of fifth generation CRM, was developed to assist pilots with identifying operational threats in order to mitigate risk (Helmreich, Klinect, & Wilhelm, 2001; Mathew &Thomas, 2004). TEM began the bold shift from the reactive safety strategy of CRM, to a proactive strategy where the pilots assessed their environment (inside and out of the flight deck), and openly discussed potential threats (Helmreich, et. al., 1999). Accepting that errors would occur, and identifying areas of potential threat, created awareness and assisted pilots in not only anticipating those threats, but prepared them mentally for the unexpected event (Helmreich, et. al., 1999; Merkt, 2010). Trained observers subsequently joined pilots in the line environment to observe behavior.

**Line Operation Safety Audits (LOSA)**

Human factors' effort to improve flight deck management skills included line operation safety audits (LOSA). Trained observers monitored performance on actual flights, documented potential threats, and recorded scores on pre-established behavior criteria (Leva, Cahill, Kay, McDonald, 2010). TEM created the foundation of LOSA (Helmreich, et. al., 1999). However, multiple issues have posed concern with the efficacy of LOSA: [1] lack of continual feedback for flightcrew improvement, [2] inability to identify the *entire* chain of events, as an accident or incident is never one event, but many, [3] inability to assess pilots' understanding of the aircraft and operations, [4] how TEM connects to the LOSA process to mitigate risk is unaddressed, and [5] failure of data utilization to improve operational processes (Leva, et. al., 2010). The next generation of safety movements is underway with safety culture, SMS, and NextGen.

**Reactive to Proactive Safety Measures**

Executives readily accepted the human factors organizational problem that launched CRM (Broyhill & Freiwald, 2012). Change was forced upon flight crews, and pilots either learned appropriate behavioral skills, or they no longer fit the airline aviator profile. However, unlike CRM, safety culture is an *organizational* issue not necessarily a flight deck problem. Leadership may find that identifying safety culture issues within *their* processes more difficult than identifying behavioral issues within others in the organization, due to problem identification being more difficult with oneself than with others (Baumeister, Dale, & Sommer, 1998). CRM was a reactionary response to an industry issue. Whereas the International Civil Aviation Organization (ICAO) developed SMS to shift safety focus from reactionary problem solving to proactive measures, in order to mitigate risk and avoid unforeseen accidents (Leva, et. al., 2010). Somewhat akin to TEM with risk mitigation, but beyond the flight deck, SMS demands that the entire organization create processes to proactively look at operational practices and identify threats in order to mitigate risk. SMS must become an integral part of every organization's safety culture, not only to comply with FAA mandates, but for improved organizational safety (FAA, 2015a).

**Safety Culture**

The concept of safety culture was born in the wake of the 1986 Chernobyl disaster (Nejmedin, 1998), and grew with the airline industry when Continental Express Flight 2574 broke apart inflight (NTSB, 1992). Four years later, ValueJet crashed into the Everglades after an in inflight fire, due to an unsecured oxygen generator (NTSB, 1997). Both the Continental Express and ValueJet accidents were attributed to corporate culture of the airlines involved (NTSB, 1992; NTSB, 1997). Because of events like these, the concept of organizational safety culture has led airline management to revise attitudes, beliefs, actions, norms, rules, and acceptable levels of risk where safety of the organization is concerned, providing the foundation of safety culture (Mearns & Flin, 1999).

> Safety culture is the enduring value and priority placed on worker and public safety by everyone in every group at every level of an organization. It refers to the extent to which individuals and groups will commit to personal responsibility for safety, act to preserve, enhance and communicate safety concerns, strive to actively learn, adapt and modify (both individual and organizational) behavior based on lessons learned from mistakes, and be rewarded in a manner consistent with these values (Wiegmann et al., 2002, p. 8).

Reason (1997) further identified safety culture in terms of, "four critical subcomponents of a safety culture: reporting culture, a just culture, a flexible culture and a learning culture*"* (p. 196). *Just* and *reporting cultures* identify where open communication is not only encouraged, but *reporting* safety related information is rewarded (Reason, 1997; Stolzer, et al., 2015; Patankar & Sabin, 2010). *Flexibility* is essential for leadership to adapt and change from "a traditional hierarchy mode to a flatter professional structure, where control passes to task experts on the spot…" (Reason, 1997, p. 196). A *learning culture* is where people learn, grow and improve the system (Torres, 2008).

Delta Air Lines, CEO, identified the essence of a safety culture when he emphatically stated, "Every employee at Delta Air Lines has the right and authority on an unfettered basis to stop the operation at any time. *Every single employee* has the right*, the responsibility,* and *the duty* to stop the operation if *anything* is not right in the operation" (Anderson, 2015). A safety culture is the foundation of an SMS system; and an organization must live and breathe a safety culture *before* SMS will be effective (Stolzer, et al., 2008; Broyhill & Freiwald, 2012; Donghue, 2008).

**Safety Management System (SMS)**

SMS was designed to improve airlines' overall performance under the construct of safety culture through a *formal, top-down*, *organization-wide* system to manage risk and assure safety controls (FAA, 2015). Whereas human factors accidents launched CRM in a reaction to solving identifiable communication problems in the flight deck (Valazquez & Bier, 2015), proactive risk mitigation will propel SMS throughout the entire organization (FAA, 2015). Aviation safety has a history of being measured by the absence of accidents. However, a future trend of safety measurement will include risk mitigation with cross-organizational planning under SMS (Yantiss, 2008), and compliance will be mandated for all airlines by 2018

(FAA, 2015a).

## SMS and Training Challenges

For an SMS to operate effectively, the organizational safety culture must facilitate line employees' ability to implement SMS principles in their daily working tasks, while the organization implements measurement tools to assess performance, yet a *gap* exists (Chen & Chen, 2012). Flight operations and pilot training represent an organizational component managed by pilots who may represent a group with an attitude that Bent and Chan (2010) termed *organizational arrogance,* where those in the group feel that they do not need to change their values to SMS principles. Initial individual resistance of CRM with a stance—'I don't need to change'—may parallel organizational resistance to SMS with—'*we don't need to change*, *we comply with all regulations'*. Addressing pilot training, Bent and Chan (2010) argue, "Regulatory requirements are minimum requirements, but this does not mean compliance with the highest standard of operation" (p. 298). With regulatory mandates for SMS compliance required by 2018 (FAA, 2015), the question must be asked if airlines will be ready for SMS. More importantly, do they even have a safety culture to support an SMS system? Not unlike CRM, communication is an integral part of an SMS system.

The *just* pillar of a safety culture not only enables and encourages open communication, but should establish systems to take action with information, and encourage, empower, and reward all employees with a safety focus (Patankar & Sabin, 2010; Reason, 1997). At the 2015 Flight Safety International Air Safety Summit (IASS), Delta Air Lines' CEO stated, "Safety efforts must depend upon understanding human interactions with increasingly complex pieces of machinery. So the model has to move from a reactive safety management system to a predictive safety management system" (Anderson, 2015). Airlines worldwide will be tasked with integrating a safety culture philosophy of top executives that will spread throughout the entire organization, where all managers view safety as the first priority, in order to fully adopt SMS (Mearns & Flin, 1999).

Due to the direct link of pilot performance to operational safety, the remainder of this discussion will focus on pilot training and SMS. Flight crew training presents multiple economic and human factor challenges associated with technological growth, as the industry moves toward NextGen. Anderson (2015) believes, "The fixes have to be from a process standpoint, and it has to be transparent, and it's going to take a big behavior change". A true safety culture should lead airline executives to direct the integration of SMS into one of the most economically challenging departments in the organization—flight training. A focus of SMS in flight training will not only shift a training paradigm from historic reactive economic driven training strategies (FAA, 1996), but also adopt creative thinking for continued improvement in a learning environment. The learning culture emphasizes how the organization will grow and learn through its efforts to manage risk, and will in fact, "implement major reforms when their need is indicated" (Reason, 1997, p. 196). Recent airline accidents and FAA reports clearly indicated that need has arrived *(*FAA, 1996; FAA, 2013; ARAIC, 1996; BEA, 2012; NTSB, 2004; NTSB, 2010; NTSB 2014a; NTSB, 2014b).

### Training Metrics

In return for adopting an AQP footprint, airlines were required to establish a means to measure the effectiveness of AQP training programs (FAA, 2006). What transpired was a degree of confusion as how to gauge pilot performance, resulting in a lack of adequate measurement tools (Nemeth, 2015). Insufficient measurement techniques have been an area of concern since the onset of AQP (FAA, 1996). Today, current assessment methods do not necessarily identify if learning has taken place in the form of understanding, retention, and the ability to transfer knowledge to the aircraft (Walcott, & Phillips, 2013).

Technology and high automation reliability, with low pilot error rate, have created challenges in validating predictive models to assess the difference between technology induced pilot error, and conditional errors (Wickens, Sebok, Gore, & Hooey, 2012). Yet, accident reports continue to identify that training related issues contribute to a lack of understanding (ARAIC, 1996; BEA, 2012; NTSB, 2004; NTSB, 2010; NTSB 2014a; NTSB, 2014b).

Line operation safety audits (LOSA) and flight operations quality assurance (FOQA) data identify performance on the flight line, as do aviation safety reporting system (ASRS) and aviation safety action program (ASAP) reports, for potential regulatory violations resulting from performance issues (FAA, 2013). However this data has yet to be identified as a measurement of training effectiveness. Bent and Chan (2010) identify "sub-optimal training" as one of the two most "significant identified hazards today" (p. 306). Inasmuch as automated aircraft accidents have been attributed to lack of understanding and training issues, they have yet to be utilized as indicators of training program effectiveness. Pilot training should be a continual process for improvement, as "continual improvement is a characteristic of a learning culture that enables proactive risk management through process assessment and improvement" (Yantiss, 2008, p. 224).

**Automation Challenges**

Today, the industry has a growing issue with automation in the form of flight skill loss, complacency, complexity, and lack of understanding (Curtis, et. al., 2010; Franks, Hay, & Mavin, 2014; Geiselman, Johnson, & Buck, 2013; Haslbeck et al., 2012; Moll, 2012). However, this automation issue is of no surprise—five years after AQP was implemented, an FAA human factors team reported, "insufficient criteria, methods, and tools for design, training, and evaluation" attributed to weaknesses in "understanding, automation/mode awareness, and insufficient knowledge and skills" (FAA, 1996, pp. 23-24).

The FAA safety team (1996) furthermore reported (the report displayed bold font for emphasis), "**It is of great concern to this team that investments in necessary levels of human expertise are being reduced in response to economic pressures when two-thirds to three-quarters of all accidents have flightcrew error cited as a major factor**" (p. 24). Later in the report, the FAA (1996) further stated, "The HF Team is very concerned about both the quality and quantity of automation training flightcrews receive" (p. 33). A chair of the 1996 FAA safety report recently spoke at the 2015 Flight Safety IASS conference, as the FAA's chief scientific and technical advisor for flight deck human factors, and presented current operational challenges to include *flight skill loss, mode awareness, dealing with confusion,* and *guidance versus control* (Abbott, 2015).

In spite of the FAA (1996) report, recent studies (FAA, 2013), and numerous LOSA, ASRS, incidents, and accidents, resulting in present day concerns over flight crew proficiency in the operation of highly-automated aircraft, these challenges have yet to be addressed in training, and are of heightened concern (Abbott, 2015). In contradiction to suggested solutions (FAA, 1996), further reductions in formal training programs have occurred to support economic concerns. These reductions include train-to-proficiency under AQP with fewer simulator sessions, at home training programs, and computer based assessments (FAA, 2006). The many benefits of AQP that incorporated CRM training cannot be overlooked (Valazquez & Bier, 2015); however, neither should the unintended consequences of reduced training in automated aircraft (ARAIC, 1996; BEA, 2012; NTSB, 2004; NTSB, 2010; NTSB 2014a; NTSB, 2014b, Palmer, 2012).

Technology was designed to reduce workload and improve safety; however, issues with complacency, skill loss, and increased mental overload have not gone unnoticed by industry leaders and regulators alike (Curtis, Jentsch, & Wise, 2010; FAA, 1996; Haslbeck et al., 2012; Wickens, Sebok, Gore, & Hooey, 2012). Added complexity without associated understanding impacts cognition, and the resulting overloaded working memory reduces situation awareness (SA), limiting pilots' decision-making ability (Endsley, 1995). The new generation of accidents may be attributed to the lack of understanding—an unintended consequence of shortened training programs under the structure of AQP.

Based on research that indicate crews' inability to make a transfer to better understanding, Pons and Dey (2015) contend that Air France Flight 447 (BEA, 2012) crashed due to cognitive processes versus lack of knowledge. However, prior to the

AF447 crash, numerous pilots had experienced a comparable instrument loss, without a similar reaction of pulling the aircraft into a stall (Palmer, 2013). In a safety culture environment, with SMS in place, the cause of prior incidents would have been communicated and pilots warned of the potential instrument loss, trained accordingly, and technicians provided the data to address equipment issues.

**Operational Challenges**

How pilots fly airliners has shifted drastically with the advent of fly-by-wire technology. Pilots no longer fly with skill, they manage the aircraft with cognition (Harris, 2012). Technology has enabled aircraft to fly longer routes requiring double flight crews, limiting pilots' time in the seat during takeoff and landing (FAA, 2008). Reduced vertical separation minimums (RVSM) mandate autopilot usage at cruising altitude (FAA, 2015b). Due to a reserve system, pilots may only see the inside of a flight deck in the simulator every 90-days for a recency, per Federal Aviation Regulation (FAR) 121.439. Moreover, recency training—three takeoffs and landings in a simulator—does not require flight deck setup, in-flight operational procedures, navigation, takeoff or descent profile planning, but fulfills a minimal requirement (GPO, 2015).

NextGen pilots will have even less opportunity to manually fly due to regulatory pilot-managed separation, and automated arrivals (Darr, Ricks, & Lemos, 2010; FAA, 2015c). Due to NextGen, a paradigm shift is in process where hand flying skills may become archaic due to NextGen demands (FAA, 2015c), yet still essential. Thus, the need to understand and manage the automated aircraft, with or without the autopilot engaged, remains a key issue in merging an automated aircraft into the NextGen automated environment (Casner, Geven, & Williams, 2013; Franks, et. al., 2014; Geiselman, et. al, 2013; Haslbeck et al., 2012; Kole, Healy, & Fierman, 2010; Moll, 2012.)

Despite limited opportunities to practice hand flying skills in modern day aircraft, even with the autopilot disconnected, the pilot is still managing an array of complex systems in concert with automatic features and multiple levels of computer operations defined as flight control laws. A suggestion that flight skill loss is a contributing factor of modern day accidents (Haslbeck et al., 2012) is multifaceted, and one that could be addressed in training (FAA, 1996).

**Communication Challenges**

American Airlines Flight 587, an Airbus A330, crashed after an incorrect rudder response during a wake turbulence encounter. The crash was attributed to incorrect training in a high-fidelity full-flight simulator (NTSB, 2004). In the wake of this crash, numerous documents surfaced—a memo from Boeing concerning over use of rudder control in simulators; a letter detailing a similar experience with wake turbulence prior to Flight 587; a letter to the chief pilot from American's technical flight operations manager, expressing concern regarding the training procedure; a letter to Airbus from an A330 technical pilot, regarding concerns with rudder over use in simulator training; followed by a response from an Airbus representative expressing concern for excessive rudder control (Fraher, 2015). Four years *after* the preceding documents surfaced, Flight 587 crashed. This lack of response to safety related correspondence is clearly indicative of flight operations' and training departments' lack of communication and information sharing, and is in direct contradiction of *informed, reporting*, and *learning* cultures, essential to the safety culture that supports the SMS system.

American Airlines Flight 587 final NTSB report cited eighteen findings and provided eight recommendations; yet, the report did not address the necessity for an improved communication network, information exchange within the organization, or collaboration between American, Airbus, and design engineers (Fraher, 2015). Improper training, followed by non-response to expressed safety concerns, resulted in an accident that killed 260 people and could be indicative of a systemic problem within the construct of training departments not fully embracing the safety culture required for SMS.

**Training Challenges**

**Economic factors.** One of the greatest threats in aviation safety today is *sub-optimal training* (Bent & Chan, 2010). Training footprints were shortened due to advanced qualification requirements (AQP) with a train-to-proficiency concept (FAA, 1991), versus train to competency where pilots perform efficiently with full understanding, versus a minimum standard. Pilots are self-taught aircraft systems at home, and their knowledge is assessed via computer-generated tests, versus extensive oral examinations (FAA, 2006). Corporate pressure to reduce training programs, as cost saving measures, has become an industry standard (Dahlstrom, Dekker, van Winsen, & Nycy, 2008).

**Working memory and fatigue**. The idea that reduced training is adequate, because aircraft systems assist in problem identification and provide direction to problem solving, may be valid when all systems are operating normally. However, when the aircraft malfunctions, and a pilot does not have the resources to search his/her long-term memory for assistance, the result becomes an overloaded working memory ripe for human error, followed by reduced SA preventing sound decision-making (Endsley, 1995; Maurino, 2000; Wickens et al., 2004). Fatigue also impacts cognitive function, overloads working memory, and reduces situation awareness (SA) (Endsley, 1995). Sleep deprivation further decreases pilot performance (Gonzalez, Best, Healy, Kole, & Bourne, 2011). If a pilot is fatigued during training, data transfer will not occur, and an overloaded working memory will prohibit learning and memory formation (Endsley, 1995; Maurino, 2000; Wickens et al., 2004).

**Unknown events**. One notable training challenge has been the difficulty to train for unexpected events, identified as surprise or startle factors (Casner et al., 2013*)*. In the training environment, pilots anticipate malfunctions and the emergency is expected, but on the line the opposite is true, where pilots expect reliability.

**Training device.** Go et al. (2003), with FAA support, conducted an experiment to determine the necessity of motion simulators for training pilots in complex aircraft. Utilizing a Boeing B747-400 simulator, results indicate that pilots trained *without* motion, significantly outperformed their counterparts in training conducted with motion (Go et al., 2003). One recommendation in the American Airlines Flight 587 final report was to "minimize automation use, and consider flight training with non-motion simulators" (NTSB, 2004, p. 160).

**Understanding.** The optimal goal of training is understanding, retention, and the transfer of performance from the training environment to the aircraft (Kole, Healy, Fierman, & Bourne, 2010). However, training may be resulting in "narrow, memorized understandings of problem situation that do not generalize well to situations that do not match the ones they see in training*" (*Casner, 2013 p. 478). It appears a disparity exists between completing a type-rating program (training) and effectively working (operations) as a pilot, in terms of managing the automated aircraft (Dekker, 2000, as cited in Harris, 2012). This automation problem was not identified as an issue of aircraft management per se, but rather understanding what the automation was doing in conjunction with aircraft control. Without understanding, the pilot has difficulty managing the automation effectively (Wood & Huddleston, 2007, as cited in Harris, 2012). In addition to the human factors safety audit (FAA, 1996), the FAA sponsored working group identified lack of understanding, overuse of automation, and pilot training concerns, to be among contributing factors in 734 U.S. ASRS reports, 9155 LOSA observations, and numerous interviews (FAA, 2013).

**Confidence.** Confidence correlates with competence, and represents a key feature in operational success and safety (Johnson & Fowler, 2011), and is "critical to safe and effective operations" (Kern, 1998, p. 146). A pilot who understands the aircraft, resultant from in-depth training, feels confident in their ability and will carry that confidence to line operations with improved performance (Bandura, 1997). On the contrary, training programs that result with a pilot questioning his or her ability will reduce confidence and increase stress (Cuevas, 2003). If stress is unmanageable, flight performance will suffer (Henderson, et. al, 2012; Blouin, et. al, 2014).

Competency requires confidence to ensure performance will realize a positive outcome (Hattie & Timperley, 2007), resulting from the experience of line flying or simulator training.

## RECOMMENDATIONS

Since the SMS component of *safety assurance* features process improvement as one of the pillars of safety (FAA, 2015a), the incorporation of SMS principles into training should be a logical step, designing and ensuring that safety objectives are being met. The Human Error and Safety Risk Analysis (HERSA) tool identified failure modes with associated risk utilizing SMS *likelihood and severity scales* resulting in HERSA risk priority classifications, whereas three of the five categories—moderate risk, high risk, and extremely high risk—recommended safety action to include training (Sawyer, Berry, & Blanding, 2011). In practicality, all four pillars of SMS—safety policy, safety risk management, safety assurance, and safety promotion—could be applied to training processes to mitigate risk and improve safety. The FAA (1996) human factors team report expressed economic concern for implementation of improved training and checking practices, however, there are many opportunities to improve training without increasing cost as outlined below.

### Pillar 1: Safety Policy

**Assessment**. Flight operations personnel and training managers must develop policies to exceed standards versus meeting the minimum. Surveys could be a useful tool in identifying the extent and effectiveness of SMS throughout an organization (Chen & Chen, 2012). Interviews could assess safety culture, develop safety policy, and begin a culture change. Qualitative analysis could assess pilots' level of aircraft understanding. Utilize in-house resources.

**Flight training management.** A training department culture with an open door policy should encourage all pilots to feel confident and comfortable in sharing concerns and operational issues, and receive support to improve their performance. Unwritten subculture policies, such as a chain of command, contradict this philosophy and should be removed to facilitate open communication. If a pilot feels the need to improve performance, training professionals and chief pilots should take whatever measures necessary to get the pilot a training event, or on a flight without threat or fear of reprisal. Zero cost.

**Departmental goals**. Dispatch, scheduling, and flight operations have on time requirements goals as the highest priority. However, a culture shift must take place with safety as the primary goal, where an employee is not fearful to cancel a flight if the only option would place a fatigued pilot onboard, or to move an aircraft that is broken, but legal. Shared responsibility and open discussions identifying potential risk must take place under the construct of SMS. Zero cost.

### Pillar 2: Safety Risk Management

**Recency training**. Recency training could be expanded to operational practice, beyond merely filling the minimum requirement (GPO, 2015). Pilots who have not flown, or have not received their required takeoffs and landings, should be provided the opportunity to fly departures and full arrivals to missed approaches, followed by manual landings. In addition to not receiving three takeoffs and landings within 90-days, there may be pilots who have not been in the seat during takeoff and landing for an equal period. Additional tracking should identify such pilots, with an opportunity to perform start and taxi procedures during recency training. Normal operations will improve confidence, enable pilots to practice energy management, and practice manual flight skills. Zero cost—this training could be conducted during the current time allotment.

**Scheduling simulator sessions.** The nature of the job, of long-distance flying on the backside of the clock, is beyond operational control, however, scheduling training is not. A pilot who has not flown for 90 days and in need of a recency should never be scheduled a training event with a report time of 0230 their body clock. Providing an opportunity to train when rested will improve learning. Zero cost

**Pillar 3—Safety Assurance**

**Knowledge assessment**. Operational style orals to assess understanding should be reinstated. Passing a test does not mean that learning has occurred (Shepard, 2000; Smith & Fay, as cited in Casner, 2013), especially if teaching to the test in lieu of comprehensive understanding is standard practice. Minimal cost—training professionals on staff who could conduct this event.

**FOQA data transparency.** FOQA data is immediate and downloadable and could be used for personal reflection and learning. Pilots could assess their performance, identify how close they were to the landing zone, or stability of their approach, with a metric for improvement and continued growth. Data provides the opportunity to "move from reactive to predictive, and from compliance based to risk based," (Anderson, 2015). A philosophy of shared data provides opportunity to establish proactive measures. Zero cost with maximum benefit.

**Understanding assessment**. When an accident or incident flags a performance issue, standard procedures are to train for the particular inadequacy, thus reverting to a reactionary strategy. Under the construct of SMS, (FOQA, LOSA, ASRS, and ASAP) data could be utilized as a proactive assessment measure of an AQP training program. An enhancement to the aviation safety action program (ASAP) (FAA, 2105d), where pilots voluntarily report incidents, could include operational and system issues that arise during line operations. A pilot may comply with an ATC clearance, but is confused how to manage the flight management system, could be provided an opportunity to add to the body of knowledge in a safe manner with a simple reporting system in place. Currently, if an event does not transfer into a potential violation, the experience and learning tool is lost. Leva, Cahill, Kay, & McDonald (2010) promote pilot journaling to enable crews to report threats during the flight in an ongoing manner, as a way to identify and mitigate risk, however, utilizing the ASAP program with a training enhancement (ASAPT) would provide quick and efficient means of sharing knowledge. Under SMS and information sharing, this data could be utilized to improve training and create a growing database to improve overall operational understanding. Zero cost.

**Pillar 4—Safety Promotion**.

**Fixed-base simulator.** Utilizing the right tool for the job is a key component to risk mitigation, through understanding. Fixed base simulators—that emulate full motion simulators but without motion—are a cost effective means to meet an airline's and FAA's economic and safety balancing act. Training footprints could be increased, with time spent in repetition and learning complex features of the aircraft in a fixed-base simulator. Time spent in a full motion simulator where the autopilot is engaged is waste in resources. Price difference in equipment is approximately $3 million for fixed base simulator versus $30-$40 million for full motion simulator, with lower operating costs and improved learning (Go et al., 2003). A fixed base simulator could be placed at each airline base, providing unlimited access for pilots to maintain competency.

**Full-motion simulator**. In response to the challenge of how the industry should address skill loss due to automation (Abbott, 2015), airlines worldwide have full motion simulators. These devices emulate the aircraft and should be utilized for flight skill development to practice hand flying skills (Dahlstrom, et. al, 2008), versus practicing fatigued in foreign, congested airspace, on the back side of the clock, with passengers on board. Invaluable.

**Instructors.** Instructors must understand that as powerful as a training device is, it is not an aircraft. Utilizing line pilots as operating instructors provides the benefit of understanding with an operational perspective. However, at the very minimum, simulator *only* instructors must understand operational standards, and incorporate safe operating practices in the simulator, not what is easiest to teach. During the course of American Airline's upset recovery training that induced the rudder failure of Flight 587, Airbus expressed the concern that the simulator was not representative of the aircraft, yet instructors' response was, "but it works in the simulator!" (Wainwright, 1996:6 as cited in Fraher, 2015).

## CONCLUSION

The NextGen/SMS Airline Training Safety Model (Figure 1) displays a history of cause and effect of industry change, as the FAA balanced the dual challenge of safety with economics. Airplanes flew, which resulted in first generation accidents, and encouraged the creation of CRM per reactionary safety measures. The safety side of the FAA house created CRM, and economics fostered AQP. Under AQP, training was reduced and subsequently the new generation of automated accidents occurred. Today, economics are driving NextGen, and the FAA is proactively working toward safer skies with proactive measures via safety culture and SMS mandates.

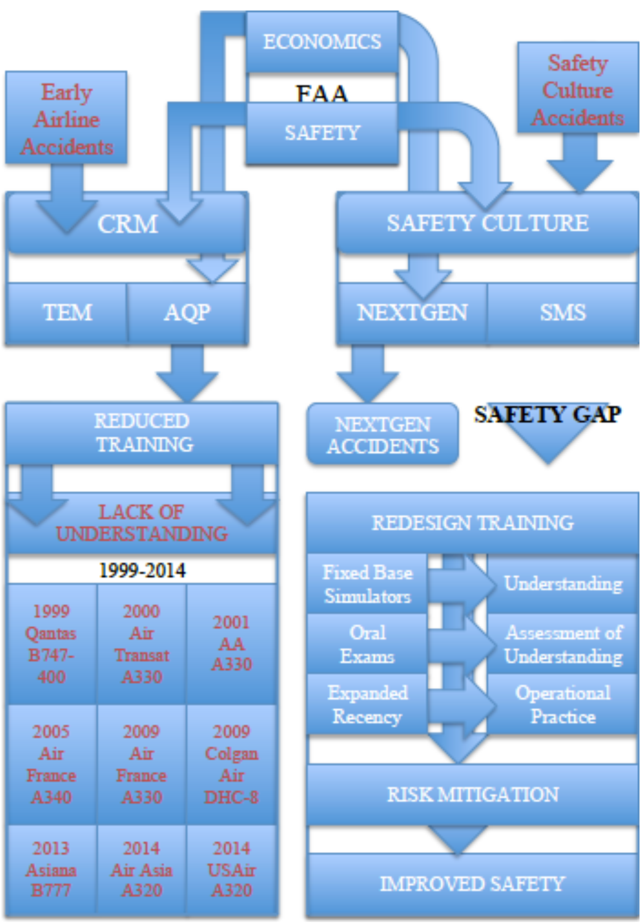


*Figure 1.* NextGen/SMS Training Safety Model. Created by Petitt, K, 2015

Safety culture is the foundation of SMS and facilitating a safe environment for next NextGen operations. However, a gap may exist between the entire safety culture concept with SMS and NextGen, due to training issues not being addressed. Without closing the safety gap, the industry may deposit an automation problem into the automated infrastructure of NextGen, resulting in the next generation of accidents. A proactive stance of SMS incorporated into pilot training could assist the NextGen transition by mitigating risk and reduce the possibility of NextGen related accidents.

## The Future of Aviation Safety

### Future Research

Airlines should consider conducting a qualitative analysis to assess pilots' level of understanding of their automated aircraft, and utilize that data in conjunction with LOSA, ASRS, ASAP, and FOQA data, and NTSB reports to understand *why* errors are made. Gathering qualitative data could provide a clear picture of understanding and provide a direction for learning, and identify where training is needed, in addition to improved methods of assessment. This qualitative assessment could begin the data collection process required to identify the efficacy of AQP training. A qualitative data analysis could also provide a benefit of identifying and assuring a safety culture, prior to SMS mandates (FAA, 2015).

### NextGen Demands

When aircraft and system complexity increase due to NextGen, a critical look at current technology and pilot training processes must be visited with an SMS focus to prepare for the transition. Systems and profile management must be understood in the event of component failure with deviations beyond a preprogrammed flight plan. In preparation for NextGen, the question must be asked if pilot training and checking practices have adapted to the demands of automated aircraft, where *understanding* aircraft systems and associated operations have become a challenge due to aircraft complexity. Automated aircraft operations are accomplished with flight deck management skills, thus, understanding aircraft complexity and operations is a critical survival tool when an aircraft component malfunctions. Addressing this automation issue prior to NextGen, where automated aircraft will move into an automated infrastructure, is essential to airline safety. NextGen will not only increase pilot responsibility, but will also expose aircrews to potential overload when the unexpected occurs (Wickens, Sebok, Gore, & Hooey, 2012).

## SUMMARY

The focus on safety culture and SMS implementation in pilot training may require a paradigm shift in order to address automation challenges—flight skill loss, complacency, complexity, and lack of understanding. In that human error in automated aircraft is likely to increase if pilots are not trained properly (Skitka, Mosier, Burdick & Rosenblatt, 2000), a clear focus on problem identification, operational constraints, training devices, and alternative solutions to meet both economic and safety goals are crucial. Extending SMS into the training department with organizational goals in alignment with safety policy, risk management, safety assurance, and safety promotion may provide opportunities to improve overall aviation safety.

NextGen will create yet another challenge, where automated aircraft will operate within an automated infrastructure. If these automation challenges are not addressed prior to this transition, the industry may experience the next generation of accidents. With emphasis on safety culture and SMS, airline training departments should be directed to operate within an SMS framework.

Human error has been identified as the primary cause of airline accidents, with the ultimate responsibility for safety belonging to the pilot in command (Gesell & Dempsey, 2011). Interpersonal issues and poor communication launched CRM, and CRM was incorporated into simulator training along with AQP. However, the question must be asked if AQP in present form is adequate for pilot understanding of automated aircraft, and if appropriate measures have taken place to validate the efficacy of such training.

History reminds us, that anytime new technology is introduced, an area of instability develops in association with the learning curve, creating an environment ripe for catastrophe (Salas, Maurino, & Curtis, 2010). NextGen will introduce ten new pieces of technology into the flight deck, creating more operational complexity in an already complex environment (Krosi, Piccione, and McCloy, 2010). If pilots do not have a solid understanding of their aircraft, with both cognitive and physical skills, the added challenges of NextGen may just increase that level of instability with added distractions of NextGen (Darr, Ricks, & Lemos, 2010).

SMS is a proactive means to address safety, and if incorporated into pilot training could be the solution to the reduction of aviation accidents and incidents, by mitigating risk as the industry moves into NextGen. If industry action is not taken, sooner than later, the following pre-departure brief may become industry standard, "*Today the threat is that I don't understand the airplane, keep me out of trouble…*" (A330 Captain, Personal communication, 2015).

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