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The Three Critical Success Factors

Flight crew members who possess specific attributes that strengthen their ability to excel are less likely to become involved in pilot-preventable accidents.

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After many years of observing pilots in training and line operations, it is apparent that some flight crews seem to perform measurably better than others, especially during abnormal or emergency situations. Most professional pilots experience similar initial and recurrent training programs. They receive equivalent simulator training and similar (within each company) checkrides. What makes one pilot or one flight crew perform better than another?

Statistics indicate that approximately 80 percent of all aircraft accidents are caused by some type of flight crew error. Therefore, the reasons behind excellent performance versus merely acceptable performance of pilots is of vital concern to the aviation industry.

It is a simple matter to list the mistakes pilots make during training and checkrides. After all, pilots are human, and all human beings make mistakes. However, in reviewing flight crew performance, it is more productive to examine the attitudes and performance of those pilots and flight crews who distinguish themselves by excellence during training and line operations.

Demonstrated excellence in a training environment is no guarantee of excellent performance during a true emergency; however, pilots who display this quality during training and normal line operations will most likely repeat it during actual abnormal and emergency situations.

Three Critical Success Factors Produce the Excellent Pilot

Excellent pilots and flight crews share certain attributes and attitudes that are present at all times during the individual's life. In our organization, these qualities were researched, analyzed and summarized as the "Three Critical Success Factors." They are:

- An intimate knowledge of the business
- A professional attitude embracing continual skepticism, time-dependent situational awareness, and a conservative response to challenge
- The Development — and use — of standard operating procedures (SOPs)

An Intimate Knowledge of the Business Is the First Consideration

Highly successful aviators have pride in thorough knowledge of their business — much more than just the minimum required for a training cycle or a checkride. They spend time reading and reviewing the Airman's Information Manual (AIM). They are very familiar with proper operating procedures and techniques, both for their aircraft and for operations within the air traffic control (ATC) system. They are also well-versed in company policies and procedures.

These pilots are very knowledgeable about the information available to them on en route and approach charts. They know the symbology. They are familiar with the definitions of the different segments of an instrument approach, and the vertical clearances afforded them on each segment by terminal instrument procedures (TERPS). These pilots are students of aviation and thirst for more knowledge.

These pilots make mistakes, but their mistakes are fewer, less serious, and more quickly discovered and corrected than those made by other pilots.

What part, then, does this intimate knowledge of the business play in the day-to-day activities of the excellent aviator? The answer is deceivingly simple.

Pilots constantly make decisions. During the judgment phase, the brain processes information very much like a computer; that is, the more accurate the information we input into the human computer, the better the results. This process includes analysis of past experiences and current information. With a wide range of data available, there is a better opportunity to make the best decisions.

The best decisions seem to be made by those pilots who know their jobs the best. When important information is lacking, the results can be disastrous.

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In December 1974, a Trans World Airlines Boeing 727 Flight 514, made a premature descent while on a VOR/DME (very high frequency omnidirectional range/distance measuring equipment) instrument approach to runway 12 at Washington Dulles International Airport (Figure 1). The aircraft flew into the top of Mount Weather (elevation 1,670 feet) killing all aboard. In its investigation, the U.S. National Transportation Safety Board (NTSB) determined that "...the probable cause of the accident was the crew's decision to descend to 1,800 feet before the aircraft had reached the approach segment where that minimum altitude applied."

The NTSB's investigation also cited numerous contributing factors, including deficiencies in ATC procedures causing "confusion and misinterpretation of air traffic terminology" and the fact that the aircraft was cleared for the approach while still 44 miles from the airport. The report concluded, "Nevertheless, the examination of the plan view of the approach chart should have disclosed to the captain that a minimum altitude of 1,800 feet was not a safe altitude."

The term "knowledge is power" is a familiar one. In aviation, knowledge is safety. Had the captain of Flight 514 (or other flight crew members) been more knowledgeable about the information presented on the approach chart, this accident probably would not have occurred.

A Professional Attitude Embraces Continual Skepticism, Time-Dependent Situational Awareness, and the Conservative Response to Challenge

Professional pilots must be professional skeptics. They cannot accept the status quo, because the status quo changes quickly at jet speeds. The best pilots are alert and ask themselves, "What if...?"

When a hydraulic pump fails, excellent aviators are prepared to plan not only the use of the backup pump, but also the course of action to be taken should the backup pump fail. During instrument approaches, the missed approach procedure is always accepted as a possibility, even in fair weather.

This quality of professional skepticism allows excellent pilots to detect abnormalities sooner than their peers. Potentially hazardous situations are anticipated, and therefore, avoided. Those that do occur are identified quickly and dealt with effectively.

A time-dependent situational awareness is one of the most important aspects of the three critical success factors. Most professional airmen are familiar with the term "situational awareness." Pilots with good situational awareness always know their airspeed, altitude, heading, next navigation waypoint, how much fuel they have on board (a time-dependent item) and, above all, their present location with regard to some ground reference point. Simply put, situational awareness is knowing the aircraft's location with regard to time, space and terrain.

It is common for pilots of jet aircraft in the United States, for example, to navigate from waypoint to waypoint for periods of several hours without knowing what state they are flying over. A catastrophic electrical failure would leave these pilots guessing at their position. They would, at best, know their location within a hundred miles or so — not the best situation to be in under those circumstances.

Accident files contain too many reports about professional airmen who have lost situational awareness with tragic results. In December 1972, the crew of Eastern Airlines Flight 401, a McDonnell Douglas L-1011 on a flight from New York City, N.Y., U.S. to Miami, Fla., U.S., lost situational awareness after becoming distracted. The nose gear light failed to illuminate after the landing gear was extended prior to landing and the flight crew became immersed in the problem of how to ascertain that the nose gear was extended. Instead of properly dividing the cockpit workload, so that one pilot was always responsible for flying the airplane (thereby maintaining situational awareness), the captain ordered the second officer to put the airplane on autopilot.

While all three crew members were absorbed in efforts to resolve the light bulb crisis, the autopilot inadvertently switched modes and the aircraft began a descent from its assigned altitude of 2,000 feet. So complete was the flight crew's loss of situational awareness, that they were unable to take corrective action to prevent the accident even though they became aware that something was wrong with their altitude fully seven seconds before impact.

The final seconds of the voice recorder show how complete the crew's loss of situational awareness had been:

First Officer: "We did something to the altitude."

Captain: "What?"

First Officer: "We're still at 2,000 [feet], right?"

Captain: "Hey, what's happening here?"

Sound of Impact.

The final part of the second critical success factor is conservative response to challenge. A challenge is anything that occurs during a flight that could potentially affect safety. An aircraft system or component failure would be considered a challenge, as would a line of severe storms ahead. Both represent possible compromises to safety.

A conservative response is any action taken that preserves or enhances the current level of safety. This means deviating early and often where severe weather is concerned, or acting promptly to discontinue a flight when major problems arise. The pilot does not allow himself to be pressured to continue a flight when conditions are deteriorating. The first goal of any flight is survival — getting from point A to point B is a secondary goal. The excellent pilot is aggressively conservative.

The first goal of any flight is survival … .

The Development — and Use — of SOPs Is the Third Critical Success Factor

Most professional pilots fly for companies that have developed a complete set of SOPs. Some pilots rely on them more than others; some take them for granted; and some ignore them completely. If a pilot is asked why SOPs are important, he might reply, "So everyone will do things the same way." That is correct, but there is much more to it than standardization.

First, SOPs provide a structure for flight operations. This structure gives crew members the ability to anticipate each other's actions. Most pilots would agree that the most important task of the pilot-not-flying (PNF) is to monitor the adherence to procedures and clearances by the pilot-flying (PF), but if no standards for monitoring exist, how effective can monitoring be?

Most SOPs call for a standard altitude callout when within 1,000 feet of an assigned altitude during a climb. The proper callout may be, "One thousand to go," or "Out of three six zero for three seven zero." No matter how it is said, the SOP gives the flight crew a standard for monitoring and, in this case, helps assure proper altitude vigilance. In the absence of such an SOP, deviations from assigned altitudes would occur more frequently.

Second, SOPs provide flight crews with time-tested, consistent and safe methods of accomplishing many normal (and abnormal) tasks. Standard operating procedures help flight crews avoid the surprises that might occur if there were no prescribed methods for dealing with the unexpected.

Third, and perhaps most important, adherence to SOPs helps to keep pilots operating in long-term planning. There are two types of planning in aviation: long-term and short-term. Long-term planning is any action taken for which there is an anticipated procedure or response. By this definition, even an engine fire on takeoff would be considered long-term planning. After all, it can be anticipated (and practiced), and there is a set procedure for dealing with it. SOPs provide pilots with those anticipated responses and procedures, and excellent pilots embrace their use. Other examples of long-term planning include:

- Federal aviation regulations
- Company SOPs
- Checklists (normal and abnormal)

- Minimum equipment lists
- Training
- Testing

Failure to use established long-term planning tools such as SOPs can have disastrous results. In December 1977, the crew of a United Airlines DC-8 cargo aircraft, Flight 2860, from San Francisco, Calif., U.S., to Salt Lake City (SLC), Utah experienced loss of the number one generator en route. They were unable to re-power the inoperative generator's electric bus. The power failure caused the loss of the number one VHF navigation radio, number one communications radio, landing gear position indicator lights and hydraulic pressure and quantity gauges.

The weather at SLC was reported as "1,700 broken, 2,000 overcast, visibility 15 miles in light rain." During their VOR approach, the crew extended the landing gear. Although the gear extension process appeared normal, no gear-down indicator lights illuminated. The crew broke off the approach and requested to hold at the SLC VOR. ATC issued incomplete and ambiguous holding instructions to the flight and the crew failed to question the clearance. As a result, the captain believed he was supposed to hold north of the SLC VOR, when in fact he was told to hold northwest. To the north was the Wasatch mountain range, to the northwest was Great Salt Lake.

The flight crew requested permission to leave the frequency on which they were communicating with ATC "...for a little minute," using the only communication radio that was operable, while they conferred with their San Francisco maintenance base about the electrical problem.

Even with the incorrect clearance, had the flight crew flown a normal holding pattern, there would have been no problem, but they ignored normal holding procedure and flew a 10-mile outbound leg instead of the prescribed four miles. Seven and one-half minutes after leaving the frequency, they returned to the SLC approach control frequency. The controller, who had watched on radar as the aircraft approached the mountains during its holding pattern while the flight crew was on another radio frequency, immediately told the flight "… you're too close to terrain on the right side for a turn back to the VOR, make a left turn back to the VOR," and less than a half minute later to "climb immediately to maintain 8,000 [feet]."

The crew responded too slowly. They had to be told twice to climb to 8,000 feet before they acknowledged the transmission. Within seconds, the aircraft struck the top of a mountain peak killing all aboard. The NTSB cited the controller for his "incomplete and ambiguous holding clearance," but also placed blame on the flight crew for its "failure to adhere to prescribed impairment-of-communications procedures and prescribed holding procedures."

Many times, pilots do not do well when the need arises to be creative in the cockpit.

Short-term Planning Requires A Different Approach

Short-term planning involves reacting to an existing situation for which there is no plan. The crew of United Airlines Flight 232 became involved in short-term planning after all three hydraulic systems failed and caused the loss of all normal flight controls on their McDonnell Douglas DC-10 in July 1989 [see "United 232: Coping with the 'One-in-a-Billion' Loss of all Flight Controls," June 1991 FSF *Accident Prevention*]. There was no book procedure (long-term planning) for the loss of all hydraulic systems. That situation was never anticipated by the aircraft's manufacturer. The flight crew members were on their own — they had to create a set of procedures to fit the situation.

Many times, pilots do not do well when the need arises to be creative in the cockpit. In this instance, however, the crew members exhibited excellence by developing procedures that allowed them to partially control their crippled aircraft and save many lives when they crash-landed at Sioux City, Iowa. This crew exemplified all the critical success factors.

Critical Success Factors Are Easily Validated

It is easy to validate the importance of the three critical success factors. An analysis of NTSB accident reports reveals that every crew-preventable accident occurs because of a failure of the flight crew to adhere to one or more of the three critical success factors. Crew preventable is used rather than the term "pilot error" because it implies there is something pilots can do to prevent the accident. TWA 514 descended too early because of the flight crew's lack of understanding of instrument approach charts. Eastern 401's crew lost situational awareness. United 2860's pilots did not adhere to established SOPs.

There are other dramatic examples. The captain of Delta Flight 191, a Lockheed L-1011, did not respond conservatively to the challenge of a thunderstorm directly in his flight path while on final approach at Dallas/Fort Worth International Airport, Tex., U.S., in August 1985. The aircraft was forced down by a microburst and slammed into a water storage tank with extensive loss of life. The captain of Air Florida Flight 90, a Boeing 737 taking off on a snowy day from Washington, D.C., U.S., failed to respond successfully to several challenges. There were known accumulations of ice on the aircraft's wings and control surfaces; the first officer voiced repeated concerns about disturbing engine readings during the takeoff roll, and, finally, the stick shaker activated immediately after rotation. A conservative response to any of those challenges probably could have prevented the accident. The aircraft failed to climb after takeoff and struck a bridge less than a mile from the runway before sinking in the Potomac River. There were 78 fatalities.

The lessons learned by observing excellent crew members is clear. The three critical success factors can be a pilot's checklist for safe, efficient flight and a long and successful career. But, like any checklist, to realize its benefits, it must be used. ♦

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Lawrence I. Schuman is an advanced airmanship instructor with SimuFlite Training International at Dallas/Fort Worth International Airport, Tex., U.S. He teaches flight deck management and other advanced training programs. Previously, he was a first officer for Braniff Inc., and worked in the training department, writing flight standards in addition to flying duties on Boeing 727 and 737 aircraft.

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With more than 8,000 flight hours logged, Schuman holds an airline transport pilot certificate and has type ratings in the Boeing 737, Learjet and Nord 262. He is rated as a flight engineer in the Boeing 727 and is a certificated flight instructor-instruments.

Schuman earned a bachelor of science degree in aeronautical studies from Embry-Riddle Aeronautical University in 1974, graduating cum laude.

Aftermath of a Tragedy

Accident report raises safety issues and offers recommendations to prevent runway collisions.

(Adapted from U.S. National Transportation Safety Board accident report)

On January 18, 1990, at approximately 1904 hours, an Eastern Airlines Boeing 727 Flight 111, while landing on the runway in night visual conditions, overtook and collided with an Epps Air Service Beechcraft King Air A100, N44UE, on a runway at the William B. Hartsfield International Airport, Atlanta, Georgia, U.S. The King Air had landed prior to the airliner and had not yet cleared the runway. The Boeing 727 sustained substantial damage, but none of the 149 passengers or eight crew members on board were injured. The King Air was destroyed as a result of the collision. The pilot of the King Air sustained fatal injuries, and the copilot, the only other occupant, sustained severe injuries.

The U.S. National Transportation Safety Board (NTSB) determined that the probable causes of this accident were the failure of the U.S. Federal Aviation Administration (FAA) to provide air traffic control procedures that adequately take into consideration human performance factors such as those which resulted in the failure of the north local air traffic controller to detect the developing conflict between the King Air and Eastern Flight 111, and the failure of the north local controller to ensure the separation of arriving aircraft which were using the same runway.

Contributing to the accident, according to the NTSB report, was the failure of the north local controller to follow the prescribed procedure of issuing appropriate traffic information to the airliner, and failure of the north final controller and the radar monitor controller to issue timely speed reductions to maintain adequate separation between aircraft on final approach.

The safety issues raised in this report include:

- Air traffic controller procedures and compliance with requirements for final approach separation and clearance to land

- Conspicuity of airplane lighting

- Limitations of the "see and avoid" principle in the night landing, final approach environment

- Effectiveness of airport surface detection equipment (ASDE), the airport movement area safety system (AMASS) and airport surface traffic automation (ASTA) to preclude similar runway incursion accidents

As a result of this investigation, the safety board made five recommendations to the FAA intended to prevent runway incursion accidents:

- Develop an air traffic bulletin and provide a mandatory formal briefing to all air traffic controllers on the importance of, and the need for, giving traffic information when issuing an anticipated separation landing clearance.

- Amend the *Air Traffic Control Handbook 7110.65F*, paragraph 3-127, to preclude the issuance of multiple landing clearances to aircraft outside of the final approach fix. Also establish a numerical limit so that no more than two landing clearances may be issued to successive arrivals.

- Expedite efforts to fund the development and implementation of an operational system analogous to the airborne conflict alert system to alert controllers to pending runway incursions at all terminal facilities that are scheduled to receive upgraded ASDE-3 airport surface detection equipment.

- Conduct research and development efforts to provide airports that are not scheduled to receive ASDE systems with an alternate, cost effective system to bring controller and pilot attention to pending runway incursions in time to prevent ground collisions.

- Incorporate into the training syllabus at the FAA Academy at Oklahoma City, Oklahoma, U.S., the importance of, and the need for, giving traffic information when issuing and anticipating separation landing clearance. Stress that this information will enhance pilot awareness and visual acquisition of preceding traffic, thereby providing and redundancy in separation assurance for controllers and pilots. ♦

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