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The Overall Approach to Cockpit Safety

The whole is the sum of its parts, and a smooth, safe flight is the result of a complex balance of human and mechanical considerations.

by

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Almost every aircraft has a master warning panel to warn of systems failures. Devices are installed to warn of pressure losses, temperature excesses, incongruities and loss of power in every critical system of the aircraft. When a problem triggers one of these devices, the pilot is immediately informed of the condition which, it is hoped, causes him to investigate the system at fault and apply his reason, training, knowledge and experience to coping with or correcting it. Many pilots are very good at this. Motivated by many different values and drives, they work, study, memorize and practice until they are so sharp they seemingly know the answer to any problem before other mortals see the problem. Such diligence is very good. Knowing the systems and checklists cold, in addition to providing the self-satisfaction the human ego requires, will serve any pilot well when his few moments of testing arrive. But is such a pilot fully prepared to meet the challenge of keeping his cockpit safe?

Recent study is teaching us that while being ready to cope with systems failures as presented typically in training goes a long way toward safety, it falls short of ensuring it — very short. What is being discovered is that an aircraft in flight is an incredible accumulation of interacting systems that go far beyond just the mechanical, hydraulic, pneumatic and electrical. When a pilot buckles his harness, a mechanic opens his screwdriver drawer, or a controller keys his mike, human systems are introduced that interact with and effect the proper operation of the whole aircraft. Just as the electrical system must supply appropriate voltage and current flow to the valves of the hydraulic system, so the human psyche must provide the human mind with the ability to reason and to operate the human motor system to apply that electrical potential to those valves at the appropriate times. It is all terribly complicated and heavily interdependent. The failure of the mechanical systems effects the human systems and vice versa.

Engineers have long recognized the need for reliable mechanical systems. Entire careers have been devoted to improving them, and the mechanical reliability of today's aircraft speaks well for their progress. But the importance and understanding of the human systems still has a long way to go to reach equal status. Small wonder that the percentage of accidents each year resulting from human failure is so high. It is for this reason that this area of study is so vitally important. The cost of not understanding the human parts of the whole of aviation safety is measured in lost lives.

Looking back on my experience, I can pick from hundreds of examples of situations where a pilot's systems knowledge and skill were not enough to keep him out of harms way. I was once told of a mature captain — a very capable aviator — who had flown a leg in fairly low weather with one of the young sharpies in his organization. This was a guy who was so sharp in training that he made you look bad even when you were good! It seems that they were making an IFR approach and all was completely routine until just after the copilot made his required “1,000 feet above minimums” call. The captain, concentrating on his flight director, caught in his peripheral vision a sudden movement of the copilot’s hands to the overhead panel, followed by the clicking of switches. His eyes started upward, but on the way, they stopped at a red light on the failure warning panel.

“Generator one failure,” he informed the copilot. “Let’s just leave it. We’re almost on the ground.”

“Not exactly,” came the unexpected reply. The captain looked to the right and found Sharpie pointing at the overhead electrical panel. He saw that the number one generator switch was off which did not surprise him since certain types of failures will trip the switch. He wondered what his copilot was getting at.

“Wha’d’ ya mean?” he asked.

“Already took care of it,” explained the copilot.

The captain, still unenlightened, looked back at the electrical panel and saw several switches off. “Oh, you downloaded. Okay,” he concluded as he went back to his instruments. Five hundred feet to go now, he thought. Little below glideslope. Better correct.

“Number one didn’t exactly fail,” the copilot was saying in an I-know-something-you-don’t kind of tone. Again the captain looked at the panel, getting edgy at his cohort’s guessing game and wondering what he was missing.

“Bus voltage okay?” he asked, not really knowing why.

“It’s all taken care of, Jim,” assured the young man. “It was just a little overvoltage. Watch your glideslope.”

The captain looked back at his instruments and eased the nose over to catch the glideslope.

The “field-in-sight” report that followed was a very welcome call. “All right,” the relieved captain replied, “let’s get this on the ground and worry about it then. Flaps final.”

As the last increment of flaps came out, a horn in the audio box set off an alarm in both pilots’ minds. “The gear!” they exclaimed in unison.

Well they got the gear down and landed without incident. What they did land with was confusion, a little embarrassment and, if they were wise enough to see it, an important lesson.

This very capable copilot was proud of his handling of the situation. It had been a minor aberration in the voltage output of the number one generator that had been going on for a long time. The captain, the copilot smugly noted, had not noticed it. On approach, it had finally crept up to the point where it bumped the number one generator off-line. The copilot had “solved the problem” within microseconds by securing the ailing generator and down-loading the electrical system.
I think that the copilot involved in this fictitious example would probably have said that he took appropriate action in view of the lack of time available. But what he did was handle a problem with a specific system failure without any communication or consideration for the effect of his actions on the whole issue of cockpit safety. This tunnel vision led to near catastrophe.

I wish that in every cockpit there could be a master-warning panel that looks something like this:

Communications	Aircraft Systems	Distraction
Physical Readiness	Knowledge	Proficiency

If we could somehow wire our human systems to this panel, a light would go off to warn us of problems not only with aircraft systems, but in other areas where failures can be even more deadly. It is hard to imagine a minor over-voltage in the number one generator causing an accident. But there should’ve been a very large and very red warning light labeled “communication failure” going off in the minds of both crew members, and they should have taken immediate action to extinguish it. They should have been trained to understand that this was where the real danger lay. The aircraft system problem was, in fact, corrected. But a human system remained impaired. Because of the way we are trained to believe that without an aircraft systems failure, everything is fine, one of these pilots didn’t recognize that a dangerous fault was still going unattended, and the one who did recognize it was at a loss to know what to do about it.

This is the clearest and most present danger facing aircrews today. Again and again we hear of tragic losses of life because the crew failed to recognize a serious degradation of safety due to human problems. In 1972, an L-1011 crew allowed their aircraft to pancake into the Everglades because of a distraction with an aircraft system. In 1977, a sotted captain simply flew his DC-8 into the water. And in 1978, a crew ran their DC-8 out of fuel in a holding pattern because the crew would not assert themselves enough to communicate with the captain. These are just the famous ones. Such things continue to happen and they demonstrate a dangerous lack of recognition of the relationship between the aircraft systems and the humans who operate them.

It is time for the corporate training companies to review their training strategies with this in mind. Fine examples of what is needed exist, but they are still mostly hidden deep in the syllabuses of a few major air carriers. What does a crew member do when he senses a slippage of safety due to high workload; or when the man a few feet away seems hopelessly distracted or unreasonably short; or when, in spite of himself, he just does not like his crew partner? The industry needs help on this. Some crews are getting it. But still, most crews are not.

A good beginning would be for pilots to modify their view of what it takes to be a truly excellent pilot. It is an admirable beginning to work hard and stay sharp on those NDB approaches and to know every nut and bolt of the aircraft systems — but only a beginning. An excellent pilot is one who goes beyond knowledge and skill and trains himself to recognize the remaining parts of the whole of cockpit safety. He or she is one who develops a mental master warning panel that sets off a light and horn whenever communication breaks down, when someone or everyone becomes distracted, when someone is overly tired or ill, or when any part of the crew lacks proficiency. An excellent pilot is one who works at communicating clearly and without abrasiveness, one who will not fly in a degraded physical condition, one who tries hard to put aside personal distractions or ill feelings about other crew members and one who maintains the highest possible level of knowledge and skill. Most importantly, he is one who recognizes the interrelationships of these factors and places them all on equal levels of importance; one who knows that human systems failures can kill you just as dead as an engine fire.

Such a pilot sees the whole problem that is laid out before him every time he takes the lives of others into his hands. He knows that being a "hot stick" is not enough. His desire for excellence runs deeper than that. His passengers may compliment him on the smooth flight and nice landing, and he accepts the praise gratefully, but he knows that it is unlikely they will ever know the rightful basis on which he should be judged. Only he knows what risk they were exposed to unnecessarily or what danger he was able to deflect. His approach to protecting their safety is holistic, not tunneled, and whether they liked his landing or not, they have been in the hands of an excellent pilot. ♦

Aircraft Performance

Trying to maintain heading with wings level and the ball centered is fine until you lose an engine and coordinated flight no longer is the easiest — or the safest — way to fly.

The U.S. Federal Aviation Administration once published a paper entitled "Engine Out Characteristics of Multi-Engine Aircraft" by Lester H. Berven that described important points in engine-out performance of multi-engine aircraft (particularly the so-called class of "light twins"). Because of its significance to persons who fly such aircraft, and to those who instruct engine-out maneuvers, some of its more important points are summarized here. Pilots who have been taught that coordinated flight is the only way to go may find that some of their previous assumptions are incorrect:

Misconception — When an engine fails, level the wings and keep the turn coordinator ball in the middle.

Correction — A five-degree bank into the good engine is vital to maintain aircraft control, but the ball with **not** be centered. In certification, aircraft are tested for minimum control air speed (V_{mca}), with five degrees bank and a constant heading held by full rudder deflection. In one example, 91 knots was the V_{mca} published for an aircraft. However, 115 knots was the airspeed at which control was lost during a subsequent test flown with wings level and the ball centered.

The "misconception" cited above is the correct technique for engine failure in single-engine aircraft. It cannot be applied to multi-engine aircraft. Some instructors, however, have taught that, to avoid stalling and spinning the aircraft, level wings and a centered turn coordinator ball are vital. This technique also is sometimes mistakenly recommended for minimum drag. It is not a valid technique. The following are the true factors in controlling V_{mca}.

- A decrease in weight increases V_{mca}.

- Moving the center of gravity aft increases V_{mca}.

- An increase in altitude (decrease in power) lowers V_{mca} but does not significantly change V_S (stall speed).

- Banking into the good engine lowers V_{mca} because of increased side slip angle, with less required rudder deflection.

- Decreasing bank angle away from the good engine (towards wings level) increases V_{mca} at the rate of three knots per degree of bank angle.

- In stabilized engine-out flight with a five-degree bank into the good engine, a pilot cannot judge or control side slip without instrumentation such as a simple yaw string or a flight-test sideslip vane.

- When flying at a constant altitude, constant heading and steady air speed, the ball indicates bank. There is no instrument in the cockpit to indicate side slip. Consequently, a pilot cannot seek to fly at zero side slip based upon instrument information.

- At zero side slip, the ball will give a large deflection towards the good engine.

- With wings level and the ball centered, the aircraft will be in a moderate side slip into the dead engine.

Berven's "bottom line" is reprinted below:

"If the pilot tries to hold the wings level in an engine-out situation, V_{mca} can increase as much as 20 knots. Thus, the aircraft could be uncontrollable at speeds as high as best single-engine speed (V_{yse}). This situation will exist if the pilot tries to maintain heading with the ball centered."

Your flight technique can benefit from this analysis. You may also note that banking towards the good engine requires less rudder pressure. Ease off the rudder, keep the bank into the good engine and watch your climb rate. It may be positive. ♦

[This article was reprinted from the March 1981 issue of Accident Prevention *in the interest of reinforcing within the aviation community safety topics of lasting interest. — Ed.]*

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