Sidestepping Operational Complacency

From one Challenger to another

BY **JAMES ALBRIGHT** james@code7700.com

NASA

Like most people my age, I can recall exactly where I was on Jan. 28, 1986, when I heard the news that the space shuttle Challenger had exploded and broken apart just 73 sec. after liftoff, killing all seven crewmembers. I was driving onto a U.S. Air Force base getting ready for instrument instructor pilot training. The guard at the gate asked if I had heard. I didn't even realize there was a launch that day. The shuttle launches had become, in a word, routine.

Most space aficionados of the time could give you exact details of the O-rings used to seal the three sections of the solid rocket boosters (SRBs) and the temperature tolerance of the rings (no colder than 53F) and the temperature at the moment of launch (36F). They could tell you that the manufacturer (Morton Thiokol) designed the SRBs without meeting the temperature range of the space shuttle itself (31F to 99F). All that is true and is interesting in and of itself. But I remember there was much more to it than that. NA SA had been steadily reducing the minimum temperature for launch since the first orbital mission in 1981. I also recall that NASA had established as a goal for 1986 that the shuttle was to become "operational." Gone were the days of test flights. The space shuttle was to become a viable commercial enterprise. Space travel, the agency said, had become routine.

After the Challenger explosion, the initial focus was on the SRB's O-rings. Theoretical physicist Richard Feynman demonstrated the fragility of the O-rings at cold temperatures during a televised hearing by simply dropping a sample of the material into a glass of ice water. The O-ring lost all of its resiliency. I didn't fully understand the real cause of the Challenger disaster until 10 years later, when I read The Challenger Launch Decision: Risky Technology, Culture and Deviance at NASA by Diane

Black smoke from an O-ring seal in the right solid rocket booster of the space shuttle Challenger, Jan. 28, 1986.

ROBERT FROLA

A "high-tech" cockpit in the year 2000, Challenger 604.

Vaughan, a professor of sociology at Columbia University. Managers at NASA had learned to accept deviations from their own Standard Operating Procedures (SOP) from the very start of the program and increased those deviations with just about every launch until that fateful day in 1986. If 53F was the stated limit, going a few degrees lower should be OK. Until it wasn't. The O-rings were installed in pairs and both were required by SOP for redundancy. No O-ring damage was allowed. Until it was. Slowly but surely, NASA moved the goal posts to the very SOPs they had designed.

Vaughan coined the term "The Normalization of Deviance" to describe what happened at NASA. That makes her book an excellent case study for all pilots, even those of us who confine our aviation to the atmosphere.

Since that day in 1986 I have added many more type ratings and with each new aircraft I noticed my tendency to normalize my own deviance after I had become, well, bored with the novelty of the new jet. It is a tendency I have only recently learned to anticipate and sidestep. All of this self-discovery happened in the five years I flew my own Challenger, the Bombardier Challenger 604. That five-year span seemed to be a moment of discovery for many Challenger pilots.

Step One: Accepting Unanswered Questions

In the year 2000, the Challenger 604 had one of the sexiest cockpits I had ever seen. There was glass — and lots of it. The switches and buttons all turned black when everything was good; I had never seen a flight deck that more fully embraced the idea of a "dark cockpit." I felt fortunate that my first civilian job was flying this airplane and I showed up at FlightSafety International Tucson, Arizona, energized and motivated to learn. That was on day one.

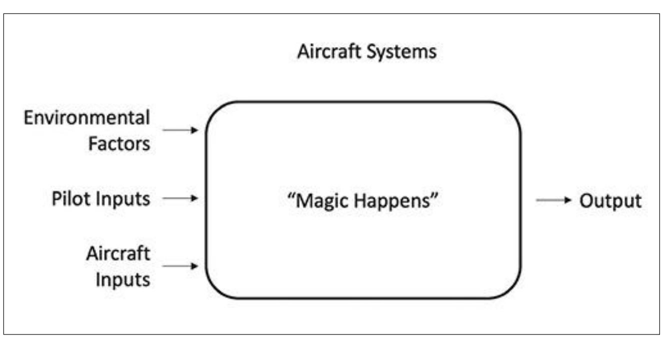
As ground school progressed, I realized the classroom was paced for the proverbial "lowest common denominator" and the course objective was aimed more toward passing a type rating evaluation than it was learning to master the airplane. While the most challenging part about flying this Challenger was the avionics, all that was left for when we got to our flight departments. I finished school with my new CL-604 type rating with a list of unanswered questions and theories that ran contrary to what I had learned in school. All of this, I knew, was par for the course. As I finally became operational in the jet, I expected to have all of these questions answered and to be proven wrong about many of my preconceived notions. That is what happened, except for four of my complaints.

Complaint No. 1. I left initial training with a long list of complaints, the first of which was the superficial coverage of the aircraft systems. We were taught the bare minimum to understand and with some success to troubleshoot the aircraft. You might as well explain that "magic happens" when the subject gets too deep to teach. For example, the CL-604 has more fuel tanks — eight of them — than any two-engine aircraft I've ever flown. Fuel loading and consumption patterns were not a part of the curriculum. Relax, I was told, that's something you will learn once operational.

But out in the field the questions only got worse. I was fortunate to start my 604 career in a large flight department with pilots and mechanics who had several years of experience with the jet. But even these experts were often stumped. Why can't the airplane continue fueling under some conditions when the fuel truck pauses? Don't know. Why is fuel ejected from the wingtips when it is nowhere close to full? Don't know. I started combing through the maintenance manual but came up empty. After a while I stopped asking and like the rest of our pilots, accepted the quirky fuel system as just "one of those things" we pilots had to accept in the "magic" category.

Then, on Oct. 10, 2000, the Challenger 604 world was given the biggest fuel system mystery of them all. How can fuel that is properly loaded prior to takeoff suddenly shift aft so quickly that pitch control is lost? Don't know.

Two Bombardier production test pilots, flying Challenger 604 C-FTBZ, discovered the problem while demonstrating aft center of gravity takeoffs from Wichita-Mid-Continent Airport (KICT). The pilot lost control of the airplane during takeoff, stalling it, rolling it on a wing, and killing all three people on board. The Transport Canada accident report blamed fuel migration from the forward auxiliary tank, to the center auxiliary tank, to the aft auxiliary tank, exceeding the test pilot's ability to maintain pitch control. The 604 had been operational for five years at this point and this had never before happened. Bombardier immediately placed narrower CG limitations on the airplane while we operational CL604 pilots were left wondering about those fuel tanks. Reading the report, we for the first time learned those tanks were unbaffled and the pipes between each allowed rapid fuel migration. None of us operational pilots had ever heard about the problem, but none of us had ever felt such a shift in CG, either. A part of the puzzle was missing. We had no choice but to accept the curtailed CG and move on. I moved on.



A general idea of how aircraft systems are taught.

Step Two: Accepting Non-Standard Procedures

Complaint No. 2. My second complaint centered around non-standardized stick and rudder procedures. However, having grown up in large Boeing 707s and 747s, rotation rates were critical to avoid tail scrapes and wing stalls. Of the eight pilots in my new flight department, the three Air Force veterans all used the same 3-deg.-per-second rate. Two of the other pilots favored a slower rate to keep the nose lower to scan for traffic. The three remaining pilots insisted a much faster rate was needed to get away from the ground, where the danger awaited. Nobody seemed to care that the operating manual specified the 3-deg. rate. This, too, I learned to accept as "one of those things."

One year later, a Boeing BBJ sliced into one of our parked 604's horizontal stabilizers, damaging it beyond repair. Bombardier replaced the stab for us and agreed to have one of the company's test pilots fly the airplane provided I sat in the right seat. On initial takeoff the pilot snatched back so hard on the yoke I felt the wing shudder. I took the airplane with the "I've got it" honed from years as an Air Force instructor pilot and the test pilot immediately let go of the yoke, as if he had a lot of practice doing that. After the flight, I asked the pilot why he was so aggressive with the pitch, especially given our newly installed stabilizer. His answer, "That's the way I fly," was hardly sufficient.

I thought that would rekindle our flight department debate, but the rapid rotation pilots assured the rest of us that they were doing it safely, had been doing it safely for years, but thanked us for our concern. They were our most experienced pilots, each having flown the airplane since its first year of operational service, nearly five years earlier. I had yet to attend my first recurrent. Once again, I decided to move on.

Step Three: Ignoring Common Sense

Complaint No. 3 . . . well, perhaps the word "complaint" is too strong. I was uncertain about deice/anti-ice procedures

Twenty-Five Case Studies Worth Your While

(1) Air Canada Flight 797, June 2, 1983, cabin fire, NTSB AAR-86/02.
(2) Air Cargo Carriers Flight 1260, May 5, 2017, complacency, NTSB DCA17FA109.
(3) Air France Flight 296, June 26, 1988, complacency, Bureau d'Enquetes et d'Analyses (BEA) published April 1990.
(4) Air France Flight 447, June 1, 1990, loss of control, BEA published July 2012.
(5) Alaska Airlines Flight 261, Jan. 31, 2000, improper maintenance practices, NTSB AAR-02/01.
(6) American Airlines Flight 965, Dec. 20, 1995, CFIT, Flight Safety Foundation's Flight Safety Digest, May-June 1998.
(7) Bombardier BD-700 C-GXPR, Nov. 11, 2007, eye-wheel-height, Transportation Safety Board of Canada (TSBC) A08A0134.
(8) Bombardier Challenger 600 N370V, Feb. 2, 2005, weight and balance, NTSB AAR-06/04.
(9) Challenger 604 C-FTBZ, Oct. 10, 2000, complacency, NTSB AAB-04/01.
(10) Challenger 604 N90AG, Jan. 4, 2002, icing, U.K. AAR 5/2004.
(11) Colgan Air Flight 3407, Feb. 12, 2009, improper stall recovery, NTSB AAR-10/01.
(12) Comair Flight 5191, Aug. 27, 2006, situational awareness, NTSB AAR-07/05.
(13) Eastern Air Lines Flight 401, Dec. 29, 1972, crew resource management, NTSB AAR-73-14.
(14) Gulfstream GIII N303GA, March 29, 2001, CFIT, NTSB AAB-02/03.
(15) Gulfstream GIV N121JM, May 31, 2014, intentional noncompliance, NTSB AAR-15/03.
(16) Gulfstream GV N777TY, Feb. 14, 2002, NTSB MIA-02LA060.
(17) Learjet N47BA, Oct. 25, 1999, hypoxia, NTSB AAB-001/01.
(18) Pilatus PC-12 N128CM, March 22, 2009, complacency, NTSB AAR-11/05.
(19) Pinnacle Airlines Flight 3701, Oct. 14, 2004, intentional noncompliance, NTSB AAR-07/01.
(20) Qantas Flight 72, Oct. 7, 2008, crew coordination, Australian Transport Safety Bureau AO-2008-070.
(21) Sabreliner N442RM and Cessna N1285U, Aug. 16, 2015, midair collision, NTSB WPR15MA243A/B.
(22) Southwest Airlines Flight 1248, Dec. 8, 2005, situational awareness, NTSB AAR-07/06.
(23) Southwest Airlines Flight 1455, March 5, 2000, situational awareness, NTSB.
(24) Swiss Air Flight 111, Sept. 2, 1998, cabin fire, TSBC A98H0003AAB-02/04.
(25) United Airlines Flight 173, Dec. 28, 1978, crew resource management, NTSB AAR 79-7.

▶ Australian Transport Safety Bureau reports are available at **https://www.atsb.gov.au/**
▶ BEA reports are available at **https://www.bea.aero/index.php?id=17&no_cache=1**
▶ Flight Safety Digest is available at **https://flightsafety.org/aerosafety-world/publications/flight-safety-digest/**
▶ NTSB accident reports are available at **http://www.ntsb.gov** under the "Investigations" tab.
▶ TSBC reports are available at **http://www.bst-tsb.gc.ca/eng/aviation/index.html** under the "Investigations" tab.
▶ U.K. accident reports are available at **https://www.gov.uk/aaib-reports**

for the Challenger 604 because I had never been taught and I never had the experience. By the time I attended my first recurrent I had yet to need a deice truck when operating the 604. During my first recurrent at the simulator, the syllabus item was considered complete if I managed to notice the synthetic snow blowing across the synthetic ramp and called for some synthetic deice. After the sim period, I asked, "How does she fly with ice on the wing?" The question was considered a strange one. "Why would you do that?"

I heard from another instructor that a brand-new Challenger 604 flunked its initial airworthiness test flight because it rolled rapidly to one side during full flap stall checks. The only thing wrong with the airplane was a 6-in. strip of paint left on the leading edge of a flap. They removed the paint and the roll tendency went away. I decided that any contamination on the Challenger 604's wing should not be taken lightly.

I finally got my chance in Anchorage, Alaska, where, with a full coat of Type IV anti-ice fluid, the airplane seemed to fly without complaint even in lightly falling snow. A month later I was in Seattle where an overnight freeze left my wings with a sandpaper-like coating of frost. The other pilot got his vote in early. "It's nothing a little sunrise can't take care of." I was the pilot in command, but he was senior to me. I asked for a truck with Type I. As we taxied from the ramp I noted, with no small degree of self-satisfaction, that the other aircraft were still frost covered. When we got home the chief pilot asked me about the bill, which was around $400. I explained the frost situation. "OK," he said. "But keep in mind we don't waste the client's money just to make ourselves feel good."

I was thinking about this one month later, the day of President George W. Bush's inauguration on Jan. 20, 2001. We had flown into Washington Dulles International Airport (KIAD), Virginia, the previous night. It had been snowing heavily, but all that had turned to rain the next day. When it was time to leave, our wings appeared clean from a distance but there was clearly a coating of frost on the leading edges. We had two 604s parked side-by-side and the other three pilots agreed the frost wasn't going to be a problem. I was in the process of talking myself into doing something I knew was wrong when the other aircraft's passengers showed up. We watched as they attempted and failed to start their engines. A pool of frozen water in both engines kept both spools of their engines from rotating. I crawled onto our frost-covered wing and discovered the same problem in our airplane. We towed both aircraft into a warm hangar to thaw out our engines; my frost on the wings argument was postponed.

I managed to avoid frost until the next winter, when another Challenger ended the debate once and for all. On Jan. 4, 2002, Challenger 604 N90AG took off from Birmingham International Airport (EGBB), U.K. Both pilots commented about the frost on their leading edges, even as other aircraft were deicing for amounts of frost reported to be between 1 and 2 mm. Immediately after takeoff the 604 rolled sharply to the left, despite the crew's application of full opposite aileron and rudder. Six seconds after liftoff, the bank angle reached 111 deg. as the aircraft impacted 13-deg. nose down; both pilots and all three passengers were killed.

The accident surprised everyone in our flight department. Half of us wondered why two pilots would blatantly ignore the flight manual limitation requiring a wing clear of any contamination, including frost. The other half wondered how these pilots lost control of the aircraft when they had seen the airplane fly just fine with a little frost. The answers to both questions were surprising. Both pilots were suffering from the combined effects of jet lag and a nonprescription drug. While one of the pilots appeared to be concerned about the frost, he didn't take any steps other than commenting. But why did they lose control immediately after takeoff? The accident report speculates that the hot APU exhaust melted the frost on the right wing only. The aircraft it seemed, had enough lift to fly but not enough roll authority with frost on one wing only. Our chief pilot issued his first ever "all hands" email. We were instructed that under no conditions would we be allowed to take off with anything less than a clean wing.

With three years of operational experience, nearly all of my complaints had been answered. I had learned to accept that I would never understand the fuel system and that stick and rudder procedures were more about technique than procedures in this airplane. It was an unhappy result, but I had learned to accept both unhappy answers.

The next year, the NTSB reopened the investigation into the Wichita fuel migration crash. In 2004, it concluded this second accident investigation and determined that although fuel migration was a problem, the crash was caused by the pilot's aggressive rotation of 9.6 deg. per second. Had the pilot observed the operating manual's 3-deg.-per-second procedure, the crash would not have occurred. This served only to solidify positions in our flight department and, in the end, no positions had changed.

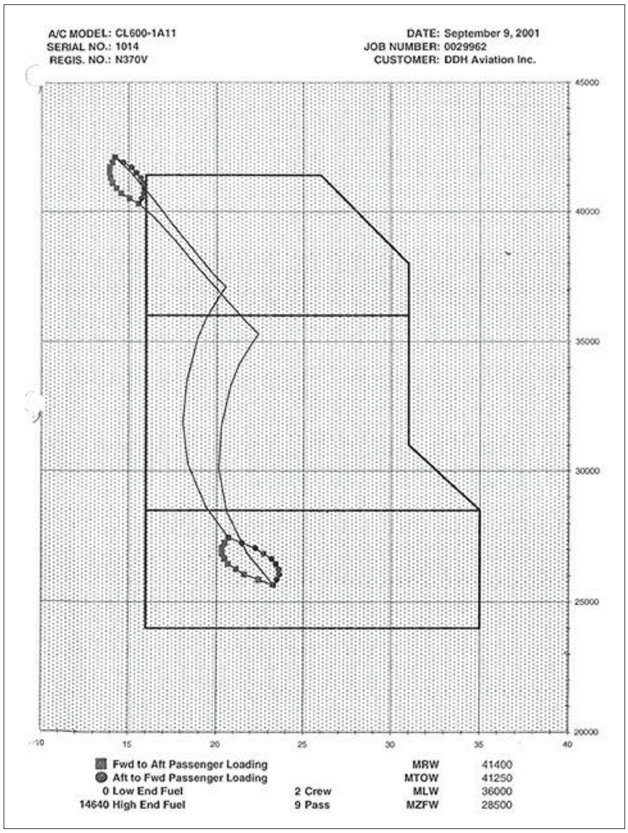
Step Four: Learning the Hard Way

Complaint No. 4. The last remaining complaint was really the first I had noticed during training: None of our pilots had a firm grasp on the airplane's weight and balance. During initial training the instructor handed us a workbook with step-by-step instructions that we used during an open book exam. I used the workbook to complete the exam and forgot about CG problems until given the task of cleaning out our cockpits of anything extraneous. I found something buried underneath the many manuals, charts and checklists in the cabinet meant for such things. The mystery item was a piece of metal with three holes cut out meant for a weight and balance chart.

A few of the older pilots recognized the piece of tin immediately and we found the paper chart meant to go with the template. One of the pilots taught me to use it and I realized it did what it claimed. The template allowed us to trace the impact of loading passengers, bags and fuel onto the chart without any math at all. "Why don't we use this?" I asked. "It isn't necessary," the veterans said. We never had a CG problem, so using it was a waste of time. Everyone agreed we needed to keep the template in the cockpit, in case anyone asked, but we shouldn't use it because the paper charts cost money. I stuffed one template and one paper chart into envelopes and ensured each aircraft had a set. That task done, I returned to the business at hand: flying the Challenger 604 all over the world.

As my fifth and last year of flying the 604 opened, I was starting to feel bored with the jet, despite still having a few unanswered questions about aircraft systems and procedures. I was no longer troubled with my less than perfect state of knowledge. In fact, most of my effort was steered toward finding another jet to become excited about. But before I could do that, I was reminded about one of my complaints that I had dismissed and forgotten.

On Feb. 2, 2005, the crew of a Challenger 600, N370V, failed to rotate from Runway 6 at Teterboro Airport (KTEB), New Jersey. The aircraft ran off the departure end of the runway at



NTSB

The weight and balance envelope for Challenger 600, N370V.

a ground speed of about 110 kt. through an airport perimeter fence, across a six-lane highway (where it struck a vehicle), and into a parking lot before impacting a building. The two pilots were seriously injured, as were two occupants in the vehicle. The cabin aide, eight passengers and one person in the building received minor injuries. The airplane was destroyed by impact forces and postimpact fire.

Of course, we Challenger pilots were concerned and speculated about something falling between the pilots' seats and the yoke, or perhaps a control jam. Early accident reports focused on the nature of the operator's charter business and the aircraft's CG. It took more than a year for the official accident investigation to conclude, and in that time, I left the Challenger world for a return to Gulfstreams. While the fate of the Teterboro Challenger was old news to me, the findings served as a wakeup call about my path to operational complacency.

The pilots of N370V did not compute their takeoff weight and balance for their flight from Teterboro to Chicago-Midway Airport (KMDW). The planned fuel and passenger loading would have been within limits, but the pilots asked for a fuel "top off," as is a common practice in the airplane when stopping distance isn't


NTSB

Challenger 600, N370V crash site

a concern. What these Challenger pilots didn't understand was that the Byzantine layout of their fuel tanks meant their CG tended to migrate forward once a certain amount of fuel was uploaded. Going from their planned fuel load of 13,900 lb. to 14,600 lb. not only put the aircraft above its maximum allowable takeoff weight but also moved the aircraft's CG well beyond its forward limit.

Reading the report, I realized that I could have been guilty of the same offense many times during my Challenger 604 career. Asking for a full load of fuel wasn't uncommon in the limited range jet. As many fighter pilots have said over the years, "You can never have too much gas, unless you are on fire." When I started flying the airplane, one look at the fuel tank layout and the weight and balance chart told me I needed to get smarter on the subject. The fun and excitement of actually flying the airplane — being operational — allowed me to forget my list of complaints and get on with the business of flying. I had become complacent and my complacency grew with each year of operational flying. It was a pattern I was guilty of many times over the years.

Step Five: The 'Sidestep' — Anticipate It Before It Happens

As with many who have come face-to-face with repeated failure, I vowed to do better. I thought that the causes of my operational complacency were inevitable, they were headed my way no matter what I did. What I needed was a way to get out of the way, to sidestep the causes before they had a chance to damage my psyche. My method has taken shape over the 15 years that have elapsed and seems to work for me. You might give it a try as a starting point.

(1) Approach initial training with an open, but skeptical mind. Make note of things you learn as an instructor's opinion until you can get verification from a manual or actual experience. Keep notes and keep a record of unanswered questions.

(2) Treat operational experience as another learning opportunity. Your fellow pilots, mechanics and other technicians are instructors of a sort. Make notes of what you learn "out there" while also keeping track of who said what. You will soon learn who is espousing reliable knowledge and who is just making it up.

(3) Develop a network of like-minded peers who value understanding aircraft systems and procedures as much as you do. Trade questions and answers. Collect source material.

(4) Study accident case studies with a few questions in mind: How would this problem manifest itself in my aircraft? What would I have done in that situation? What resources do I have in the cockpit to deal with these issues? Go beyond a cursory mind game; dig into your manuals and follow the checklists to become familiar with them and to spot problems where you might need a little more knowledge. See the sidebar, "Twenty-Five Case Studies Worth Your While" for a good place to start.

In the years since my Challenger weight and balance epiphany I've upgraded airplanes four times. I've managed to avoid the boredom that has plagued me in the past, though I've probably bored some of my peers with my incessant questioning about aircraft systems and procedures. I am no longer flying a Challenger, but with every new airplane I've learned to accept each challenge and remain motivated to learn. Even operationally, the learning never stops. BCA