Air and Space this Week

Item of the Week

IF THE ENGINES FAIL

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BtOn extremely rare occasions, a commercial airliner has an engine failure. Usually, the pilots can handle the situation without much difficulty. But what happens if ALL of the engines fail? If the pilots keep their cool, like Captain Sullenberger did, the aircraft and people aboard might still be OK. If the pilots have experience flying sailplanes, like Sully, the odds get even better.

Why sailplanes? While I was thinking about that question, I looked out of my office window. USAF Academy cadets were on training flights overhead, and I could see several sailplanes aloft over the valley. The Air Force knows that its pilots need to be very familiar with gravitational potential energy (altitude) and speed, and how they can be traded one for the other (with frictional losses, of course). There is no better way to drive the point home than to have cadets fly an aircraft with no propulsion capability.

Forty-four commercial airline flights were forced to glide at some point while they were in the air! Five of the most famous ones are described below.

IT MUST HAVE BEEN SOMETHING THEY ATE

The most recent, and famous, incident where an airliner had all of its engines fail simultaneously was US Airways Flight 1549 on January 15, 2009, but it most certainly wasn't the first. The Sullenberger plane was downed when it struck a flock of geese after takeoff, and the engines were destroyed as a consequence. There wasn't anything Sully of FO Jeff Skiles could have done to avoid the geese, but their cool action saved the day. You all remember this event, and can find out more about it here, so I won't go into it in detail. Two other examples of engine indigestion failure follow.

British Airways Flight 009

On **June 24**, 1982, **42 years ago this week**, British Airways Flight 9, a B747-236B, was flying from London to Auckland, New Zealand, with a number of intermediate stops along the way. Its route would take it over Indonesia at night.

The plane was still over the Indian Ocean when the flight crew noticed what appeared to be St. Elmo's Fire in front of the cockpit, a phenomenon related to static electrical charges. The radar

showed clear weather ahead, so the pilots activated their de-icing equipment as a precaution. The flight crew began to smell smoke, but that was back in the days when tobacco smoking was permitted on passenger flights, so nobody took particular notice.

That part of the world has many active volcanoes, and Mt. Galunggung, in West Java, was in full eruption. It had spewed a huge cloud of volcanic ash, but it was difficult to see at night, and because the ash was dry, the plane's radar couldn't see it, either. BA-9 flew right into the cloud. Volcanic ash is hard and has sharp edges, and jet engines don't last long if they encounter it. All four of the 747's engines began surging and then all of them flamed out over a period of only a few minutes, and at first, the pilots did not know why.

The damaged plane was just over 100 miles from Jakarta, and the now-gliding pilots aimed for it, hoping to get the engines re-started. A quick calculation showed that they could glide only part of the way, so more power was needed to make the field, especially since there were mountains in their path to Jakarta. The pilots and flight engineer would have to try to get engines re-started at a higher altitude than recommended; they tried repeatedly, and failed.

The passengers knew something was up, and were likely not reassured by the pilot's overly-stiff-upper-lip announcement on the plane's PA, which was punctuated by the oxygen masks dropping from overhead. The engines not running meant that the planes' pressurization could not be maintained. The Senior First Officer's mask had broken, and maybe not every passenger's mask would work properly, so the Pilot descended quickly to an altitude where breathing was more normal, which shortened their potential gliding range even more.

A decision would be required soon: Land in the jungle southeast of Jakarta or the ocean? They had little chance of a good outcome either way. They tried to re-start again. Engine 4 finally started up, followed a few minutes later by Engine 3. That stopped the descent and made Jakarta within reach. The other two engines re-started before the landing, but Engine 2 began surging again and had to be shut down. When the lights of Jakarta started to appear, the flight crew realized that their cockpit windows were badly frosted. The landing was difficult, but they made it safely.

The problem's cause, engine ingestion of volcanic ash, was quickly determined. Engines 1, 2, and 3 were junk, replaced at Jakarta, as were the cockpit windows. The fuel had gotten contaminated by the ash, so the fuel system had to be purged. Engine 4 was the least damaged, it was fixed up a bit and made it back to England and was then scrapped.

Since 1982, there have been other, less serious occasions where volcanic ash caused flight problems, but now there are better warning systems and policies in place to keep planes out of volcanic zones.

TACA Flight 110

TACA International Airlines, in one form or another, has operated for a long time in Central America; it's now part of Avianca S.A. On May 24, 1988, TACA Flight 110 was travelling from San Salvador to New Orleans. It was a brand-new B737-300 airliner, with 38 passengers and 7 crew aboard. Pilot Carlos Dardano, only 29, was highly experienced and capable, in spite of

having lost an eye when his plane was hit by gunfire flying into El Salvador during its civil war. The First Officer was highly experienced, too, and there was an instructor pilot aboard also.

The flight out of San Salvador going north was uneventful, but as the pilots began the descent into New Orleans they were faced with a "substantial" thunderstorm in their path. The on-board radar showed medium-level precipitation, with several cells of more severe weather ahead. As they passed 16,500 feet, the pilots throttled back as planned, and they entered a zone of very heavy rain, turbulent winds, and large hail. Both engines flamed out. The pilots managed to get the Auxiliary Power Unit running, restoring on-board electrical power and the hydraulic system. But the engines resisted re-starting; worse, adding fuel to them for trying increased the chance of a catastrophic engine fire, which could bring the plane down.

The pilots were flying a glider now. And no airport was within their reach.

The area below them was marshy; perhaps a pancake landing there would minimize risks to those on board. Then the pilots saw the Intercoastal Waterway, and began thinking about a pre-Sullenberger water landing on it. The pilots configured the aircraft for a water landing.

At the last minute, the First Officer noticed that the levee bordering the Waterway was broader than usual (it actually had at one point been a primitive WWII-era airstrip at NASA's nearby Michoud Assembly Facility). They might be able to make a wheels-down landing on it!

The problem was that they were too high and going too fast. What to do, what to do?

Fortunately, Captain Dardano had experience flying sailplanes. They also tended to come in high and hot on their landing approach, since they had no good way of regaining altitude. Their pilots often use a tactic called "side-slip," to lose speed and altitude more quickly once they are sure they have the field made. Basically, the pilot applies rudder to turn the aircraft one way, but uses the stick/wheel to move the ailerons to turn the other. The result is that the aircraft turns at an angle to the line of flight, greatly increasing drag.

Captain Dardano slewed the aircraft ~40°, and straightened up in time to make a beautiful landing. Nobody was hurt, and the aircraft wasn't damaged!

But the aircraft was now on a levee. How would *it* be rescued?

One plan was to remove the wings and barge it to a repair facility. Instead, both engines were replaced on the levee, a small amount of fuel was put on board, and two pilots flew it off the levee to Moisant Field (now Louis Armstrong New Orleans International Airport). The aircraft continued in service with a string of companies until December 2, 2016.

[A similar problem, but with a less nice ending, happened with Southern Airlines Flight 242, a DC-9, on April 4, 1977. Both engines failed in a heavy thunderstorm. The pilot attempted a highway landing, but hit a gas station and exploded. Seventy-two of 85 aboard perished, and another 9 were killed on the ground.]

OUT OF FUEL!

A number of mechanical or other problems can bring down an airplane. The most ridiculous, because it is so avoidable, it to run out of fuel. Pilot negligence, ground management negligence, or mechanical failure are pretty much the only possible causes. All three are on display, one each in the three examples below.

United Airlines Flight 173 – Pilot Negligence

UA 173 was a December 28, 1978, flight from JFK in New York to Portland, Oregon, with an intermediate stop in Denver. The aircraft was a ten-year old DC-8, 60 series, with four jet engines. There were 189 passengers and 8 crew aboard. The flight to Denver was uneventful, as was the take-off from there.

They were approaching Portland at dusk, and when they prepared for landing by lowering flaps and wheels, a bump was felt by all and the aircraft yawed a bit. Worse, the landing gear indicator light for the starboard gear did not illuminate.

What had happened was that the right gear had lowered when the bump was felt; a piece holding it in place when retracted had broken and the gear free-fell into position. It actually was locked, but the micro-switch that powered the cockpit light was damaged when the gear dropped, and did not work. The pilot requested and received ground control permission to circle in a holding pattern so the crew could assess the situation.

Situational awareness went out the window, and cockpit resource management wasn't a "thing" yet. The pilot was totally distracted by the landing gear problem and preparing for an emergency landing. To a lesser extent, the others in the cockpit were not fully-focused either. They stayed in the holding pattern, with the wheels down and the flaps half-down, too, with the extra drag burning fuel at a much-greater rate than usual.

The pilot kept dithering over the situation, and became oblivious to the input the FO and engineer were giving him. One of them had gone into the passenger cabin and visually observed the tell-tale pin that protrudes from the top of the wing when the landing gear is in the down-and-locked position and reported it to the pilot, to no avail. He and others began warning the pilot about the fuel state, to no avail. In those days, the pilot-in-command was king, and others were not encouraged to provide input. That would soon change.

The pilot finally realized the peril when his engines started flaming out from fuel starvation. They weren't high enough to glide all the way to the airport, and were faced with an emergency landing in a major urban area. Not only was the plane and those aboard at great risk, there was an excellent chance of people on the ground getting killed.

The pilot may have had his head elsewhere, but he was quite a capable flier. He managed to find a small area in the dying light that seemed to be open. It was wooded, but the only one within reach that wasn't heavily built up. Alas, the pilots had not seen the taller apartment building in the way….

Superb flying allowed the airliner to barely miss the building, and be set down "gently" into the trees, dodging them as the plane bored in. The news media actually got to the crash site before the First Responders did.

Unfortunately, two crewmembers and eight passengers were killed; another 23 had serious injuries, and everyone else was more than a bit shaken up.

Post-crash investigation revealed the problem with the landing gear, and the problem with the crew. The pilot was a broken man, and never flew again. The FAA researched how flight crew can be better managed, including the empowerment of junior members to provide important input to the command pilot. "Cockpit Resource Management" training for all pilots was the result.

The "Gimli Glider" – Ground Support Negligence

Perhaps the most ridiculous situation was that of Air Canada Flight 143. On July 23, 1983, AC 143, a B767, took off on a routine flight from Montreal and Edmonton, with 61 passengers and 8 crew aboard. The airplanes fuel gauge was out-of-order, a fact known to both Air Canada and flight crew, but they (thought they) had taken aboard more fuel that would be necessary for the flight, so the busted gauge was not thought to be an issue.

What happened next is really stupid. The B767 was an all-metric airplane, one of the first in Air Canada's fleet. One version says the fuel was ordered in gallons but delivered in liters, making the fuel added at Montreal much less than needed. Another said it was a mass-to-volume conversion error (probably the correct explanation). In either case, the ground folks and crew thought the aircraft had more fuel than needed. They were wrong.

Flight 143 ran out of fuel over Red Lake, Ontario, at 41,000 feet. The left engine failed first, and the flight crew started planning to divert to Winnipeg, not realizing yet that they were running out of fuel. The right engine failed shortly thereafter, and the plane became a glider. Such an emergency was "unthinkable," and no flight crew had trained for it before. Fortunately, Captain Robert Pearson was a recreational sailplane pilot. The bad news was that the B767 needed engine power to operate its electrical and hydraulic systems. The B767 control surfaces are too large for the pilots to move them manually, so they deployed a ram-air turbine from the bottom of the aircraft. Its spinning from the airflow provided enough hydraulic power to operate the flight controls. However, only a few basic flight control instruments and the radio had battery power back-up. One of the non-operating instruments was the vertical speed indicator; with it out, Pearson and crew had no way of figuring how far Flight 143 could glide.

The Red Lakes, Ontario, area is not exactly replete with airfields big enough for the B767. Pearson would need all his glider experience (and his recollection of the MacCready Speed Ring) to stretch their glide to the maximum. He was ably assisted by First Officer Maurice Quintal, who by working with air traffic control was able to determine that their glide ratio was about 12:1 (twelve miles horizontally for every mile descended). No operational airfield was in range, but Quintal was heartened to realize that the now-out-of-service Royal Canadian Air

Force base at Gimli, at which he once served, *was* within reach. It was their only chance to get down in one piece.

What Quintal, Pearson, and air traffic control did not know that after the base was closed, it was converted into the Gimli Motorsports Park, a race track complex that used part of the base's former main runway as a drag strip. Alas, races were being conducted at the same time that Flight 143 approached. The area around the Park were full of people, cars, and campers.

Pearson was stretching his glide as much as possible, hampered by the fact that, as the airplane slowed, the ram-air turbine produced less hydraulic power, making the aircraft increasingly-difficult to control. There wasn't enough hydraulic oomph left to forcibly lower the landing gear, so the pilots had to use gravity to drop the gear and lock them in place. The main gear went down and locked successfully, but the nose gear only dropped – it did not lock.

Pearson had to come in high and fast to ensure he had enough speed to make it to the runway. As they approached, he realized that they were too high and too fast, but not so much that they could make a circle to drain off speed/altitude without stalling.

Here's where Pearson's glider experience saved the day.

He used the same slip technique sailplane pilots use routinely, the one that Captain Dardano used successfully at the levee, to put the aircraft into position to land. Good thing, as it was getting dark.

It was then that they noticed that the runway was not clear and there were a lot of people around. Consternation in the cockpit!

Imagine the consternation on the ground! The B767 was gliding, making almost no sound. The noise of the race activities and crowd noise were high, and the B767 got quite close before people on the ground noticed it. I would imagine the linen soilage rate was rather high at seeing a big plane, close and approaching fast, flying half-sideways! Especially for the two boys riding bikes down the part of the old runway not being raced on where the airliner was about to land.

Pearson straightened the aircraft at just the right time and set it down quite smoothly. His skill had gotten them this far. Now they needed a little luck to avoid disaster. They'd get it, twofold.

The nose wheel not being locked down actually helped. They had essentially no brakes and no thrust reversers, so the friction between the nose of the plane and the runway pavement was the only significant retarding force in play. They probably would have still run off the end of the runway had it not been for the second stroke of luck that evening.

When the main airstrip had been converted into a drag strip, a stout low wall had been built down the middle to keep the dragsters from hitting one another if either driver lost control. Pearson had put the plane exactly on the runway center line, and when it slid into the section of the runway-now-dragstrip the nose of the aircraft was impaled on the wall, bring the plane to a safe, if abrupt, final stop. A few passengers suffered minor injuries using the escape slides

at the rear of the aircraft because of the angle of the plane with its nose on the ground made that drop steeper. But nobody was hurt seriously, on the plane or on the ground.

The second most-ridiculous thing about the story of the "Gimli Glider," as the flight became known, was that Air Canada demoted Pearson and suspended Quintal (along with the refueling team involved, who arguably were more deserving). In 1985, saner heads prevailed and both men were awarded the first-ever Fédération Aéronautique Internationale Diploma for Outstanding Airmanship!

A number of other pilots have tried to make a safe landing in simulations of the Gimli Glider emergency. Every one of them crashed with what would have likely been fatal results for all.

The aircraft was fixed up enough at Gimli to be flown out to Winnipeg where it was repaired fully and returned to service. It remained in commercial use until its last flight on January 1, 2008. Pearson, Quintal, and three of the six flight attendants who flew the Glider flight were on board.

Pearson and Quintal successfully appealed their punishments, put their award diplomas on their wall, and also returned to service for full careers. Pearson retired in 1995 and Quintal passed away in 2015.

Air Transat Flight 236 – Mechanical Failure

Air Transat Flight 236 was an Airbus A330 flight from Lisbon to Toronto, on August 24, 2001, with 293 passengers and 13 crew aboard. Its initial problem wasn't due to pilot error or ridiculous oversight, and it had left Lisbon with plenty of fuel aboard.

Four hours into the flight, a major fuel leak developed in the plumbing feeding the right-hand engine. Pilots noted a drop in oil temperature and high oil pressure in that engine right away. The combination of readings was perplexing, and after consulting with Air Transat's maintenance facility, the pilot took a wait-and-see approach to the potential problem.

Now comes the pilot error(s). Concern in the cockpit rose when a message popped up that showed fuel consumption was unusually high. The crew had not been monitoring the fuel situation as closely as they should prior to this message. Then their control panel showed a fuel imbalance, with tank feeding the right engine lower than that on the left. Instead of following the proper procedures and checklist, the crew opened a cross-connect valve from left to right, allowing fuel from their good tank to be leaked out of the right engine, too. Fuel was used to cool engine oil in this model aircraft, and the rapid loss rate resulted in the low oil temperature but high oil pressure that the pilot had been ignoring for some time.

The pilots belatedly realized they had a fuel problem, declared a flight emergency, and asked to be diverted to Lajes Air Base in the Azores, one of the only bits of land in that part of the Atlantic. When they got 170 miles from Lajes, the right-hand engine flamed out due to fuel starvation. The pilot descended to 33,000 feet, as per procedure when losing an engine, and called a Mayday. Thirteen minutes later, the left-hand engine ran out of fuel.

They were still 75 miles from Lajes. They had very limited battery power, and had to deploy the ram-air turbine, just as the Gimli Glider had to do. But 75 miles, all over ocean, was daunting. The pilots needed every foot of altitude they had, and five minutes after the left-hand engine quit, the oxygen masks popped out due to the depressurization of the aircraft.

The military flight controllers at Lajes gave the pilot excellent guidance, and the pilot was very good at stretching his glide. He came in very high over Lajes, which had a rather short runway for a plane that size with no thrust reversers. He did a series of maneuvers to descend and bleed off speed, including a side-slip (the pilot had sailplane experience!). It was a hard landing. The anti-skid braking system was inoperative, so all eight wheels locked up, shredding the tires and then the wheel rims.

Post-flight inspection showed that "(T)he fuel leak resulted from fitment of an incorrect part to the hydraulics system by Air Transat maintenance staff as part of routine maintenance. The engine had been replaced with a spare engine, lent by Rolls-Royce, from an older model which did not include a hydraulic pump. Despite the lead mechanic's concerns, Air Transat authorized the use of a pump from a similar engine, an adaptation that did not maintain adequate clearance between the hydraulic lines and the fuel line. This lack of clearance, of the order of millimeters from the intended part, allowed chafing between the lines to rupture the fuel line, causing the leak." (source)

A series of Airworthiness Directives were issued in response to the errors on this flight and its maintenance. The aircraft was returned to service in December, 2001, and would remain in service for 20 more years.

The air crew made several serious errors in diagnosing and then reacting to the problem without following established procedures. In spite of that, the pilot was awarded the Superior Airmanship Award by the Airline Pilots' Association.

CODA: One of the passengers on this flight was a post-Doctoral psychology student on her honeymoon. "She and her colleagues recruited 15 other passengers in a study of post-traumatic stress disorder (PTSD), published in the academic journal *Clinical Psychological Science*, which compared details recalled by passengers with PTSD with those recalled by passengers without PTSD and with a control group."

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