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Hunt for fatal flaw of Flight 38

An electronic systems failure is emerging as the prime suspect in BA's brush with disaster at Heathrow, report Richard Woods, Steven Swinford and Paul Eddy

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After 10 hours of flying, Speedbird 038 was almost home. First Officer John Coward was preparing to land the British Airways flight from Beijing to Heathrow. In front of him on the right side of the cockpit were three screens displaying flight, navigation and engine data; another three were arrayed in front of Captain Peter Burkill, who sat on the left.
Beyond, through the cockpit windows, Coward could see central London, one of the most densely populated areas of Europe, stretch into the distance. It was Thursday lunchtime and they were approaching Heathrow from the east. There is a preference for flights into the airport to cross the capital in this direction because it is quieter than having them take off over the city. Below them, millions of people were going about their business, never imagining that a plane might fall out of the sky.

HEATHROW CRASH-LANDING

A BA passenger jet made an emergency landing at Heathrow Airport on its return from China
Slide Show

At eight nautical miles from the airport, BA038 was down to about 2,400ft in a shallow glide. At 7½ nautical miles, the plane lined up with the instrument landing system that would guide it into Heathrow.

"At 2,000ft you lower the gear," said a former 777 pilot, referring to the undercarriage. "That's the procedure."

The plane was lining up for a "category one" landing in good weather, being guided in by two radio beams, one horizontal, one vertical. They were drawing the plane down a three-degree glidepath onto the southern runway, known as 27L, at Heathrow. Everything appeared normal.

The Boeing 777 is one of the most advanced passenger jets in the world, crammed with highly sophisticated electronics. Over 12 years it had established a remarkable safety record - more than 600 of the planes had gone into service and not one had crashed.

To Coward, a 41-year-old career pilot with BA, it was a routine flight and the plane was taking the strain. The autopilot and autothrottle were engaged and making the necessary adjustments.

"You can see the throttles moving themselves. It's as if they have a ghostly hand on them," another retired 777 pilot said. "The gear is down and the flaps are down. In most cases you'd see the runway at this point. The aircraft would be holding a speed or even slowing slightly."

As the plane approached, Coward, according to former pilots, would have announced: “1,000 radio. Man land 200.” This meant the plane was at 1,000ft, in its final approach, and that Coward was going to switch from autopilot to a manual landing at 200ft.

Once such a procedure was set, the plane would continue under automatic control until it reached an altitude of 250ft. Then a female computer voice would say, “Decide.”

“That’s decision time,” said a former 777 pilot. “The co-pilot would take the autopilot out. He’d say, ‘Man land 200, I have control’.”

At two miles out and 600ft up, the plane was “established on late finals” - it was less than a minute from landing. The crew and passengers must have thought that they would soon be inside the terminal.

As Coward stared at the controls, the autothrottle demanded more thrust. It was a normal procedure, a small adjustment intended to keep the plane at the correct speed and height. Nothing happened. The computer system again ordered more thrust. Again, no response.

In the central control displays of the 777 is a screen that shows the engine pressure rate (EPR). One indicator shows the “command EPR”, the level ordered by the pilot; another indicates the actual EPR. “The pilots would have noticed that the achieved EPR was drifting back,” said one former 777 flier. “That would have been one of their first indicators.”

Coward or Burkill - it is not clear which - tried to increase thrust manually. Still nothing happened.

At high altitudes, planes that lose power can glide for distances of up to 100 miles, according to Boeing, helped by starting at cruising speeds of more than 600mph. At less than 1,000ft and at much slower speeds, they can drop like a stone.

Yesterday Coward said the plane had suffered “catastrophic failure” in both engines and that he feared it would smash into the ground and disintegrate. He told a Sky News reporter that his “adrenaline kicked in”.

There were no drills for such a situation, no time to try to restart the engines. Pilots are taught how to recover from potential disasters at normal cruising altitudes, but not so close to the ground. “I was just focused on holding it up in the air for as long as possible, then keeping it straight,” said Coward.

Below 600ft the “ground proximity” warning is inhibited so that it does not distract pilots from an ordinary landing. But other signs and sounds would have rapidly filled the cockpit.

Through his clenched hand, Coward would have felt the control stick judder. “If a stall is imminent, the aircraft analyses its airspeed and gives a preliminary shake to the yoke,” said one former pilot. “It won’t let you miss it. We call it the ‘stick shaker’. An ‘airspeed low’ warning will also flash up on screen.”

Coward had only seconds to respond, only seconds before the plane would hit the ground.

Just 100ft or so below, Pym Reehal, whose house lies in the Heathrow flightpath, had gone outside to his car. He had an engine problem of his own and was trying to jumpstart the vehicle.

As he tinkered, BA038 hurtled overhead. “I had a quick glimpse and saw it was coming in at a very weird angle,” recalled Reehal. “It was sat at such a strange angle.”

A short distance away, John Rowland was driving his taxi just outside the airport perimeter fence. “It looked as though it was just missing the roof of my cab,” he said. “So low you would think you could lean out of the window and touch it.”

The plane skimmed the road and missed the perimeter fence by a few feet. Further down the Heathrow airfield another BA flight was preparing to take off. One of the air crew watched as BA038 hurtled towards the ground.

“I thought: oh my God, something’s terribly wrong,” said the witness, who asked not to be named. “The angle was all wrong. It just looked like it would be a disaster.”

Inside the cockpit of BA038 Coward and Burkill had no time to issue a Mayday, no time to warn passengers to brace. In the few remaining seconds they just fought to keep the plane flying.

The failure of the engines had cut the main power. The 777 does not have cables connecting wing flaps and rudder to the pilots' controls. It is all done by sending electronic signals. However, the plane has several back-up batteries that enable the instruments to work until the emergency power units kick in.

"If they had done nothing, the autopilot would have tried to fly the glide path," said a former pilot. The plane would probably then have stalled and crashed. "So they have to lower the nose to maintain speed, then lift it just before hitting the ground."

Coward, who lives in Valbonne in the south of France with his wife, said yesterday that he had thought it was "the end" for him - that the plane would land with an "almighty crash". He added that "some thanks has to go to the man upstairs for giving us that little lift at the end".

But he and Burkill, said one former pilot, did "a brilliant job". If the angle is right, a plane gets the benefit of "ground effect" - the wings in effect trap a cushion of air underneath them that softens the landing.

The Boeing 777 has the biggest landing gear of any craft, with six wheels instead of four on each assembly. As the plane slammed into the grass before the start of the runway, the landing gear on the left side smashed upwards through the wing; the right-side landing gear was torn off.

"It wasn't just one thud," said Coward yesterday. "It was a series of thuds."

The plane ploughed great gouges in the earth as it skidded hundreds of metres, skewed right and came to rest on the edge of the runway.

"I felt like I was in a washing machine," said Jason Johnson, one of the passengers. "The wings were making cracking sounds. You think of your family and your loved ones."

Others barely noticed that the plane had crash landed until oxygen masks fell from the overhead storage lockers.

The passengers fled down the emergency chutes that had been triggered when the crew opened the doors. Amazingly, nobody was killed and injuries were relatively minor.

How did one of the safest aircraft ever made come to crash-land, narrowly avoiding disaster, and why did both engines apparently shut down at the same time?

THE 777 is the first plane to be designed entirely on computers, with input from pilots from the outset. It is a long-range fuel-efficient workhorse. Since it started commercial operations in 1995, 777s have made more than 2m flights. Boeing claims that operators enjoy a "99% dispatch reliability rate". In other words, 777s rarely go wrong.

According to one database, there have been only a handful of recent 777 incidents – and two of those were hijackings. The only fatality had been that of an airport worker who was burnt to death when a refuelling operation went wrong in 2001 in Denver, Colorado.

The pilots got much of what they asked for in designing the plane, including a highly automated "glass cockpit" that does away with all analogue gauges and presents flight information on bright, software-driven LCD displays. Integrated into the software is EICAS (engine indication and crew alerting system) which monitors the two engines and alerts the crew to any abnormalities.

Nancy Novaes, an American pilot who flew 777s until she retired last year, said: "This is a great plane to fly. It's highly computerised, highly logical. It knows what it needs . . . and EICAS tells you what it wants."

However, the 777 and its computers are not infallible - as investigators knew before last week's crash.

Early in the evening of August 1, 2005, a Malaysia Airlines 777, en route from Perth, Australia, to Kuala Lumpur was climbing past 38,000ft towards its cruising level when the flight crew were confronted with

what the official report on the incident described as “a situation that had previously been considered not possible”.

On the EICAS screen a “low speed” warning appeared, suggesting the plane was approaching the speed at which it would stall. But almost simultaneously, the primary flight display screen warned exactly the opposite: that the aircraft was approaching the overspeed limit, the maximum speed at which it is designed to operate.

Too slow or too fast? Before the crew could decide, the autopilot pitched up the nose and the 777 climbed for 3,000ft, while the air speed dropped from 270 knots to 158 knots - at which point the stall-warning horn correctly sounded and the stick-shakers activated.

The pilot prevented disaster by disconnecting the autopilot and pushing the nose down. But then the autothrottle kicked in, commanding more thrust from the engines. The nose pitched up again and, of its own volition, the aircraft climbed another 2,000ft until it was brought under control.

The plane landed safely but, as the Australian Transport Safety Bureau report put it, the combination of a failed sensor and “a software anomaly” had created an “unexpected situation that had not been foreseen” and for which the crew had not been trained.

The sensor was a tiny “accelerometer” - a device used to measure the plane’s acceleration that is similar to those used in cars to deploy airbags.

Airlines were subsequently warned that they had to modify the plane’s software. Yesterday BA said it had received the directive and implemented it immediately.

Could a similar electronic or computer fault have occurred on flight BA038? Were the pilots not warned of engine failure or did a system erroneously shut down the engines?

One former 777 pilot believes that the accidental mechanical failure of both engines at the same time is unthinkable.

“There are separate autothrottles, a left computer and a right computer . . . everything is split. That is the philosophy of the plane,” he said. “For [both engines to fail] at the same time it has got to have been commanded. We are all aghast.”

In other words, it may have been an error in the computerised engine control systems. The Air Accidents Investigation Branch (AAIB) is examining all possibilities and downloading full data from the flight recorders.

Experts noted that its initial report said it would be “examining the range of aircraft systems that could influence engine operation”.

As investigators picked over the crash site, other hypotheses were being aired. One was that a “bird strike” had shut down both engines. The impact of large birds such as Canada geese hitting the fans inside the jet engine can cause engine damage; but no witnesses have recalled seeing any flocks of geese or other birds in the vicinity.

Authorities also monitor flocks by radar and said there were none on Thursday.

“The possibility of geese is remote at that height,” said one pilot. “And though they bend the blades, the engine keeps producing power.”

Pictures of the crashed plane also suggest that this was not the cause. The blades in the plane’s starboard engine were undamaged.

Turbulence is another possibility, particularly at busy airports. Sudden wind shear or even the wake left by powerful jets can damage the surfaces of planes, sending them out of control. But again there seem to be no signs that such forces were at work.

A fuel problem was another hypothesis. In the immediate aftermath of the crash, internet forums populated by pilots were rife with speculation that BA038 had run out of fuel.

Some airlines, although not BA, are known to run their planes with as little fuel as possible to reduce costs: heavier planes use more fuel. However, this policy can be problematic when planes face unexpected headwinds or delays in landing. BA had got its sums wrong, went the theory.

It holds little water, however. “It is well known that if all the engines snuff it, fuel is the most common cause,” said David Learmount, operations and safety editor at Flight International magazine.

“But fuel exhaustion is not the issue here because the AAIB report says fuel was spilt all over the [crash site]. Luckily it didn’t catch fire.”

Learmount suggested, however, that water could have got into the fuel, frozen at high altitude, thawed as the plane came into land and caused a slush in the tanks. This may have blocked fuel to both engines. Reports yesterday suggested that BA ground staff were warned to check the fuel mix in all its 777s.

Fuel starvation in certain tanks is another possible explanation, because large jets like the 777 have multiple tanks in both wings. Some aircraft have additional tanks in the belly and even the tail.

Transferring fuel between the tanks during the flight to maintain the aircraft’s equilibrium is a routine process, controlled by sensors, pumps and valves. Like all technologies, it is not infallible.

On February 7, 2005, a Virgin Atlantic Airbus 340, flying from Hong Kong to Heathrow, was passing through Dutch airspace when, without warning, one of its four engines - the outer engine on the port wing - went dead.

The crew quickly established from the Airbus’s sophisticated displays that the amount of fuel contained in the inner tank, from which the engine was feeding, registered as “0”. What they did not realise was that the automatic transfer system between the tanks had failed.

The outer engine on the right wing also began to lose power and the warning display showed that its tank contained zero fuel. The captain immediately realised there was a “fuel management problem” and opened the valves between the tanks to begin a manual transfer. It worked, but the crew still declared a Mayday and diverted to Amsterdam.

Some experts are sceptical that such a problem affected BA038. One former pilot on the 777 pointed out that during landing, fuel is going directly from tank to engine - there may be no transferring from one tank to another - and it is unlikely that both engines would suffer such a problem at the same time.

THE wreckage of the plane will be removed from the runway tomorrow and the airport will start getting back to normal. But crash investigators will not produce a definitive report into the cause of the accident for months. **Until then, suspicion is likely to remain with the avionics.**

So far other 777s have been allowed to continue flying, but the implications are serious. A senior airline industry source said: “I have heard that BA are going to have to check every single one of their 777s. They are not grounding them, but they will be checking every one because the AAIB has identified that it seems to be something connected with electrics and avionics coming from the flight deck to the engines, because the engines seem to be okay.

“They will go through the records of every single 777 flight looking for similar issues. They will go through all the engineering logs to find out if have had any similar problems between the flight deck and the engines.

“Each 777 will be brought in one by one for a maintenance check to look at whether there are any untoward signs. They will have to do that out of good practice as much as anything else.”

Whatever the cause of the accident, it was a remarkable piece of flying by Coward and Burkill and an extraordinary escape for their passengers.

The pilots, hailed as heroes, have been modest about their achievement. But Novaes, before she retired, had experienced the reality of crisis in the cockpit.

“These pilots have practised flying with limited controls,” she said. “They wouldn’t panic. Bravery is saying, ‘I’m afraid, okay, so deal with it’. Most pilots really only have to think about themselves. They are in the front. They are first on the scene. If they take care of themselves, everybody behind them is safe.

“But afterwards you feel a tremendous sense of relief. You are on the ground and you're almost giddy. The entire glut of emotions is probable.

“The pilot is a human being who may be better practised and controlled than others, but they’re still human.”

Why did both engines fail? The competing theories

Bird strike: A flock would have to have struck and stopped both engines. But there is no evidence this happened. Verdict: implausible

Pilot error: A mistake by those flying the plane must always be considered by air traffic investigators. But it is unlikely that BA would have allowed the pilots to be hailed as heroes if there were any suspicion that they had made a mistake. Verdict: highly unlikely

Running out of fuel: Last week pilots’ internet forums buzzed with speculation that the plane had run out of fuel. But the interim accident report said that “a significant amount of fuel leaked from the aircraft”, suggesting the plane was not short of fuel. Verdict: very unlikely

Fuel contamination: Reports yesterday suggested that investigators were focusing on the possibility that the plane’s kerosene fuel had been contaminated with water. A poor fuel mix has, however, never been held responsible for an air crash and one would expect other planes that were refuelled in Beijing to have been affected as well. No such problems have been reported. Verdict: unlikely

Fuel management problem: Fuel is transferred as required between various tanks in the wings and centre of large planes. In one incident, two engines on an Airbus 340 failed, even though the plane had plenty of fuel, because the transfer system malfunctioned. But it is unlikely to happen to both engines at the same time. Verdict: possible, but unlikely

Computer glitch: This happened with a Malaysian Airlines 777 and a former 777 captain told *The Sunday Times* that for both engines to fail at the same time “it has got to be commanded” - ie, it was computer error in controlling the engines. Verdict: possible and many experts’ prime concern

Boeing 777: how it measures up

- There are about 670 Boeing 777s in service around the world. Last Thursday’s crash was the first involving the plane, although in Denver, Colorado, in 2001 a member of ground staff was killed while refuelling a 777 when the fuel hose malfunctioned.

- It was the first plane to be digitally designed using 3D computer graphics. Its flight-control system also differs from earlier Boeings in using electronics to control the wing flaps and rudder, rather than mechanical systems such as cables.

- The 209ft-long plane can carry between 305 and 440 passengers at a cruising speed of 615mph with a range of up to 8,300 miles.

- When it came into service in June 1995 it became the first twin-engined plane permitted to fly three hours from the nearest runway. Until then, no twin-engined plane could fly more than 60 minutes from a landing spot. Airlines liked its reduced fuel consumption compared with four-engine planes. Double-engine failures are also rare.

- The Boeing 777s have, however, been involved in at least 12 incidents where electrical systems have overheated during or before flights, four of which resulted in “major damage” to the power panels involved in controlling the plane, according to Britain’s Air Accidents Investigations Branch. Single engine failure or forced shutdown resulting in an early landing has occurred on 11 known occasions.