

QF32: HOW IT WENT RIGHT

AN INTERVIEW WITH CAPTAIN RICHARD CHAMPION DE CRESPIGNY

When a normal day at work turns into an extraordinary day, where survival may depend on you and your team, you will need all of the elements that make up resilience. In this long read, **Steven Shorrock** interviews **Richard Champion de Crespigny**, Captain of QF32, about how things went right, when they could have gone so badly wrong.



It's the 4th of November 2010 and QF32, an A380, is taking off from Singapore bound for Sydney – a seven and a half hour flight for the 469 passengers and crew. There would normally be three pilots: Pilot in Command Richard de Crespigny, First Officer Matt Hicks, and Second Officer Mark Johnson. On that day, Richard was having an annual route check, and the crew were joined by Senior Check Captain Dave Evans, who was training, and Check Captain Harry Wubben. Richard briefed his other two pilots to focus on keeping the flight as safe as possible, and to not keep quiet or be distracted because it was a route check.

It was a flight that was characterised by many non-routine decisions and trade-offs. The first came after clearance to push back, when Richard noticed that that one of the Check Captains was occupying the seat that the second officer would occupy. After a short discussion, Richard ensured that a Second Officer sat where he normally would, in order to play his usual team role. *"It's vital in a team environment that every person feels psychologically safe to state concerns or in a critical situation, say 'stop!'"*

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Everything else was routine until four minutes after take-off, when engine number two exploded without warning, followed by a second explosion. *"It was louder than what I'd ever heard in the simulator. But it was obviously an engine failure."* At that point, Richard pressed the altitude hold button and pulled the heading select knob, reflecting the 'aviate, navigate, communicate' mantra that helps pilots to focus and prioritise. For the first 30 seconds or so, the crew concentrated on flying the aeroplane and got it under control, in the process discovering that the auto thrust had failed.

"We first concentrated on just flying the airplane", said Richard, "because it's vital in the first 30 seconds of a crisis to act habitually to avoid the startle effect of fight, flight or freeze. Stay alive, keep above the mountains, and maybe then communicate. It was probably after 40 or 50 seconds that I told air traffic control 'Pan, Pan, Pan, Qantas 32, engine failure, number two engine, maintaining 7,400 feet, maintaining current heading. Stand by for instructions.'"

ATC left the QF32 crew alone until the crew called for a new heading.

The damage

To those untrained in dealing with emergencies, the sense of calm control in the first half a minute may have seemed at odds the seriousness of the situation: 21 out of 22 aircraft systems were compromised – everything except the oxygen system, which was not needed because the aircraft was below 10,000 feet.

The damage list is extraordinary, and the full extent of damage and loss of capability was not fully known to the crew at the time. Electrics were down to 40 to 45%. Roll control was down to 35%. Brakes were down to 40%. There were holes in the wing and all of the leading edge slats and half of the spoilers were lost, increasing the stall speed significantly. The flight displays were in error. Anti-skid was broken.

None of the engines was operating normally. Two engines dropped down two layers of redundancy to the bottom layer. Engine number 3, which the crew thought was working normally, had dropped down one layer.

Critically, the aircraft was out of balance and leaking fuel quickly from the wing. *"We saw hydraulic pressure warnings and system failure warnings. The whole hydraulic system failed on the left-hand side. We had to shut down six out of eight hydraulic pumps."* Richard didn't find out until four months later that most of the warnings about the hydraulic and brake systems were wrong.

Around half of the computer networks had been compromised, and the lost

parameters affected other systems. *"When a complex black-box system fails, you may not know why and you may not even know if or how you can fix it. When one complex system, with all its interactions, takes out other complex systems, you quickly get an avalanche of other failures. When a 'black swan' event happens, the Swiss cheese model doesn't apply."*

ECAM armageddon

The electronic centralised aircraft monitoring (ECAM) system is a computer program that monitors the 250,000 sensors and parameters on an A380, an aircraft with four million parts. When a message goes into the network system that something's wrong, ECAM checks a database of around 1240 checklists. During the initial seconds following the engine failure, Richard and his crew ignored the ECAM, focusing instead on flying the aircraft. After a brief period, he informed the crew that the aircraft was at constant altitude, heading and speed, that the thrust was under control and the aircraft was safe. *"I then said, 'ECAM actions'", explained Richard. "That's a sign for co-pilot Matt Hicks to action the checklists. But that was probably 20 to 30 seconds after the engine had failed. There's no rush to go into ECAM. You absolutely must first get the aircraft under control."*

Richard compares ECAM to threat and error management (TEM), laid out in a linear progression. *"You first identify the threats and then you try to stop them. If you can't stop them then you try to fix them. If you can't fix them then you mitigate them. At the end of ECAM process, you know what systems have failed and you should have a mental model of the state of the airplane, how it will respond and how you're going to manage it."*

But 40 ECAM checklists queued up within the first second, followed by another 60 checklists over the next few minutes. Distraction was a major challenge to crew performance. *"The alarm bell was ringing continually. We cancelled it, and it came back. For every new warning, the master caution warning light illuminated and the aural alert sounded. These warnings pierced our senses. They're incredibly distracting."*



Another problem was the nature of interaction with ECAM. *“The overhead and lower panels were a sea of red lights. Checklists flooded the screens. We were running through nasty checklist after checklist without knowing how many more checklists lay underneath. And some of the checklists were not just wrong, but would have made our situation worse.”*

As a result, Richard said that he eventually lost the picture and became overloaded, with insufficient capacity to make sense of the information. *“All these checklists coming in were filling up my mental model. I'd lost all my free mental space. I couldn't absorb more failures and I'd lost the ability to create the complex knock-on effects in my mind. My mental model of the aircraft had failed.”*

The crew did around 100 ECAM checklists in the air and then another 20 or so on the ground. To put that into perspective, he said, a pilot in a simulator might do four ECAM checklists.

ECAM is prioritised but, as Richard explained, just like any computer system, ECAM caters for only the known situations that have been programmed into it, *“ECAM is generally designed to manage only the first layer of the failure. For instance, we lost 65% of our roll control and we had three increasing fuel imbalances that were each out of limits. ECAM doesn't combine those problems to predict whether we would retain control when we slowed and reconfigured to land. We'd lost 60% of our brakes but we were also landing 60 tons over our maximum landing weight. The computers couldn't calculate our correct landing performance. ECAM didn't warn us of a possible runway overrun.”*

To make matters worse, QF32 has lost many sensors and in many cases couldn't differentiate a 'no signal' (because of a severed controller area network bus wire) from a 'zero'. This is why ECAM became compromised and confusing, indicating that some systems were functioning better (brakes) or worse (hydraulics) than they really were. Officials at the Australian Transport Safety Bureau told Richard that the fuel system was damaged so extensively



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that ECAM checklists for the fuel system would never make sense. Other failure messages displayed and cleared quickly: *“We had a turbine overheat message that I didn't see because it came and went in a second.”*

Still, ECAM gave essential information. For instance, faults with the hydraulics, electrics and the landing gear meant that the crew had to put the gear down using gravity, with special actions for the brakes because leading edge slats, spoilers and anti-skid were compromised. ECAM advised to apply

the brakes only when the nose wheel was down on the ground, when there was less lift on the wings. The crew went through the ECAMs one at a time, building a shared mental model of the aircraft

and planned the approach, a process that took around an hour of the hour and 50 minutes that the aircraft was airborne.

The crew faced several dilemmas. If they stayed up too long, fuel leakages from the wings would take the aircraft further out of balance. If they landed too quickly, they wouldn't know what the aircraft was capable of doing or how it would perform on landing. *“Your priorities change depending on the situation. You need to keep a shared*

mental model and situation awareness of what's happened and what is happening, and make the best decisions for the future." As commander, Richard's sole concern and responsibility was the safety of the passengers.

But with the complexity of the situation and the loss of capability, the crew were concerned about control when they came in to land.

The control check

Controllability checks feature more in military than civil pilot training, and Richard credits this check with being critical to the safe landing of QF32. *"It's normal Air Force procedure that if your aircraft has a mid-air collision or has taken damage from an attack, and flight controls are affected, then you must determine the best configuration and the minimum speed that you need to land. I knew I had to do control checks at a safe height."* Flaps, slats and spoilers, as well as the landing gear, should behave as expected, so that the aircraft remains controllable while slowing down and configuring to land.

Richard explained that, while this procedure is habitual for military aviators, it wasn't documented in any Airbus manual or the airline's manual until after QF32.

He was aware that if hydraulics were lost, the flight controls could become saturated, with inadequate hydraulic power to move the controls quickly enough, or limiting the controls' effects. Either problem can induce a (rate-limited) pilot-induced oscillation. So while doing a controllability check, Richard monitored the flight control displays to determine that the flight controls were not saturated and were behaving as expected.

"The decision to do the control check was critical. I think it was the most important decision that I made on the flight." Recalling El Al 1862, he remarked that *"You need to study and learn from the past, so you don't repeat it."*

The Armstrong spiral

With fuel leaking rapidly, it was essential to understand the fuel situation. "If

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you can't guarantee fuel, you can't guarantee flight", said Richard. Both fuel computers failed and the fuel synoptic screens went blank. The crew reset the computers, but it didn't help. The fuel synoptic screen and ECAM made no sense. *"I said to the rest of the pilots, I'm looking at this fuel system and I don't understand it. Does anybody understand this fuel system? There was silence. At that point I realised that no one else understood the fuel system."*

Eight out of eleven fuel tanks were unusable. Both transfer galleries had failed. Half of the fuel pumps, including the jettison pumps and a jettison valve, had failed. With fuel control computer faults, the crew was unable to understand how the fuel system was working.

Fearing a loss of all the engines, Richard asked ATC for clearance to climb and for ATC to keep the flight inside 30 miles of the airport, to mitigate an all engine out approach to Singapore. He was positioning to enable the 'Armstrong Spiral', a procedure he named after Neil Armstrong's approach techniques in the X-15. The decision to climb to height was an intuitive reaction, Richard said, to thinking that the crew had lost the ability to monitor the remaining fuel.

Inverting the logic

Aircraft warning computers are 'glass half empty' machines: they tell you what is wrong. And on QF32 there were too many failures to diagnose and correct fully.

Richard decided to 'invert the logic'. He credits this idea to Gene Krantz, a NASA mission controller. *"During the Apollo 13 crisis, the mission engineers were melting down because they had lots of error messages. Nothing was making sense and the engineers were losing their mental model of the Apollo command module. So Gene Kranz yelled out, 'gentlemen stop wondering about what's failed and let's focus on what's working!'"* Gene Kranz

inverted the logic, and it worked. But to do that, you have to have a good foundation knowledge of your systems and the core layers of their technologies.

By inverting the logic, the QF32 crew turned a glass-half-empty approach to TEM into a glass-half-full approach. Instead of focussing on the myriad complicated failures, they focussed on the systems and services that remained. Richard reduced a complicated four million piece A380 down to a simple light aircraft. All they needed then, was enough fuel, wings, flight controls, wheels and brakes to land.

They had two and a half hours of fuel in engine one, and three and a half hours in engines three and four. That was enough. *"A great mantra in aviation is 'fuel gives you time and time gives you options'. You often have more time than you think, so in a crisis try to create time."*

Knowing that they now had two and a half hours to solve the many outstanding problems, the crew monitored the engines and fuel situation every five minutes. Every 10 minutes, they re-evaluated whether to stay airborne and continue ECAM checklists, or commit to and bracing themselves for an immediate landing.

The landing configuration

The crew now had to calculate landing performance, including where they would stop on the runway. Richard delegated the performance calculations to Senior Check Captain David Evans, who put all the failures into the computer. *"He put in about 12 failures. Normally, the most I've ever seen put in is two."* However, the computer would not calculate landing performance, even when David entered only the critical failures.

Richard was confident that the crew had the knowledge, training and experience to solve the known problems, and the decision-making and team skills to solve the unknown problems. *"I knew we had the tools and the brains on board to solve this. It didn't really worry me when Dave said it won't calculate it. In fact, I went off and gave a 10-minute public address*



to the passengers while Dave kept on working on it."

After the public address, David announced that he had a landing performance. It would give a 130 metre margin at the end of the four-kilometre Singapore runway. Richard wasn't worried. *"When I got told 130 metres I thought 'that's great'",* he said. Having researched the handling of big jets for a book, he knew how the A380 was certified and that the aircraft must be on the ground, touched down, within seven seconds from 50 feet. He was confident that the crew would do it. *"If you've done the research then all that knowledge, experience and training eliminates concerns that others might perceive as fears. This is why we must commit to a lifetime of learning. You must never stop learning."*

QF32 was on final approach, descending at 1400 feet per minute or 23 feet per second. The landing gear oleos are certified to a rate of 12 feet per second. There was now a choice of a hard and short landing, or flaring for a softer long landing that uses more runway.

"One of the pilots said to me during your approach, 'Rich, don't flare', because with a limited runway it's recommended to have a hard touchdown and just accept it – you can't float. But if I hadn't flared, I would have destroyed the oleos, the wheels would have gone up through the wing, and we'd be sliding down the runway with sparks around leaking fuel. I knew I had to flare."

The aircraft was slow to flare and then over-flared. As the wheels got closer to the runway, Richard thought they might hit the runway so hard as to risk destroying the landing gear. *"So I used a technique that is not practised in any simulator. If it's going to be a heavy landing, then at the last minute you push the stick full forward to lower the nose. That raises the wheels around its centre of gravity. That in turn gives you an extra half a second floating in ground-effect, a cushion of air."* The rate of descent at touchdown was 160 feet per minute, and QF32 touched down five seconds after 50 feet – giving more remaining runway than calculated.

Shutting down the engines

When QF32 stopped, air traffic control instructed the crew to shut down the engines and call the fire service on a dedicated fire frequency. On shutting down the engines, the crew expected the APU to provide electrical power and compressed air for the air conditioning. However, problems with the air data computers meant that the aircraft thought it was still in the air. Both APU generators were inhibited from coming online. The aircraft now had two car batteries of power remaining and had lost nine out of ten cockpit computer screens and six out of seven radios, including the radio that they needed to contact the fire controller.

The 20 or so internal and external wing leaks were even more of a problem now that the aircraft was level and the wing was flat. The holes that used to be above the fuel level were now below it. Around four tons of fuel was gushing out of the left-hand wing, close to very hot brakes. And with the radio problems, it took 30 to 40 seconds to contact the fire controller. *"When we did get in touch, we said 'Put water over the hot breaks, and put foam over the fuel'. They said, 'Well shut down the engines first.' And we said, 'We have!'"*

There was confusion about the status of the engine, Richard opened up the left-hand window and saw that engine number one was still turning. The crew tried more emergency shut down systems. None of them worked. *"I knew that there are two discrete sets of wires going to each of the high- and low-pressure fuel shutoff valves in the engine and the pylon. At that point, I realised they'd clearly been broken. Even the fire bottles, each with dual dedicated wire, didn't work. That wing must have been electrically destroyed. And then it sank in that the damage was far greater than we had thought."*

Evacuation or disembarkation?

On the ground, there were different perceptions in the cockpit about the best course of action, with fuel now pouring out on the ground near hot brakes, and an engine that wouldn't shut down. While the risk of fire was clear, the need for evacuation via slides,

rather than disembarkation via the stairs, was less clear. The door sill of the A380 upper deck is eight metres above the ground. With rescue slides angled at approximately 45 degrees, descending onto a hot runway at Singapore, the risk of injury had to be balanced against the need for rapid escape. Richard remarked that there were risks associated with people attempting to take objects from the cabin, slipping on kerosene, approaching a running engine, being run over by a fire truck, or – worse – accidentally igniting kerosene.

Richard recalled the A330 evacuation at Gatwick in 2012 following multiple smoke warnings, which turned out to be spurious. Over 300 people had to be evacuated. Fifteen passengers were hospitalised. *"Our threats were enormous",* Richard said, *"and this was now the longest most difficult decision that we had – whether to evacuate down slides and lose control of the passengers, or to let them go slowly down the stairs and keep control. The longer that decision took, the longer we stayed on the airplane, the more the brakes cooled down and more foam was put over the fuel."* After 10 minutes, the scene stabilised outside and the aircraft became inert for the next hour. The cabin crew were on alert to evacuate for the two-hour period after landing until the aircraft was fully deplaned – two hours of continuous decision-making. There were no injuries, which Richard also credits to the cabin crew: *"They were exceptional. That's what they trained for, and I am proud of them all."*

In his book, *FLY!*, Richard describes various ways to make decisions. *"The decision whether to evacuate or not was a really good slow decision. We used a decision model that is taught in the airline. It involves everyone's input. It's dynamic. You keep revisiting the decision, especially if things don't go to plan or if you find you're surprised."*

Briefing the passengers

After an accident, there are further decisions about briefing those affected, especially passengers. How much information do you give and how do you convey that information both while you're in the air and while you're on the ground?

For Richard, it was not a concern. *“Gene Krantz said when things are going well at NASA, you tell the media a whole lot, and when things go bad you tell them everything. Particularly today with social media, everyone with a phone is a reporter and they will be transmitting live as the incident happens. You can't try to hide it, and there is no longer a golden hour for companies to prepare for the media.”* Richard was aware that if you don't communicate the facts, as the most knowledgeable party, then the media will. *“Take control in a crisis, get the facts out there, shut down the fears and rumours, and become the single point of contact”* is his advice.

Richard made several public addresses using the NITS checklist: nature, intentions, time, special requirements. *“NITS stops fear and panic. Fear and panic are caused by people not knowing what's happening, not knowing why, not knowing what's going to happen, not having any control, and not knowing who to turn to. The other thing that I did was not in any of my company manuals. I told the passengers go to the terminal and wait there for me.”*

Richard followed the passengers to the terminal where he gave debriefs, with full and open disclosure, in two of the lounges. Each briefing lasted 45 minutes: 15 minutes of NITS, 15 minutes of group questions, and 15 minutes of individual questions. He gave passengers all the relevant facts

for two reasons. First, when involved in an incident or accident, people need to know the truth. Second, Richard knew that the media would be waiting, and wanted passengers to feel able to correct misreporting. He also checked on the passengers' wellbeing, and found that there were no injuries. *“I took all the elements that create fear and panic then slowly and systematically dissolved them.”*

The last thing Richard did was also not in any manual. He gave the passengers his personal mobile phone number in case they had questions or concerns. *“This is something that you would do if you had a daughter that you were leaving behind in a foreign country to go on a holiday. You would say, ‘Call me if you've got a problem.’”* He gave his personal guarantee to the passengers to provide full communication and attend to their needs. The combination of the full and open disclosure and the personal guarantee changed the perception of the incident outside the aircraft. *“I'm not aware of a single photograph of any QF32 passenger crying when they left the terminal. The passengers became the eighth team during the QF32 crisis. They took control of the media, delivered the facts, shut down rumours and protected my company's brand.”*

In 2011, Richard was awarded the Qantas Chairman's Diamond Award *“for valour and/or selflessness so extraordinary, that the reputation of the airline has been enhanced in the eyes*

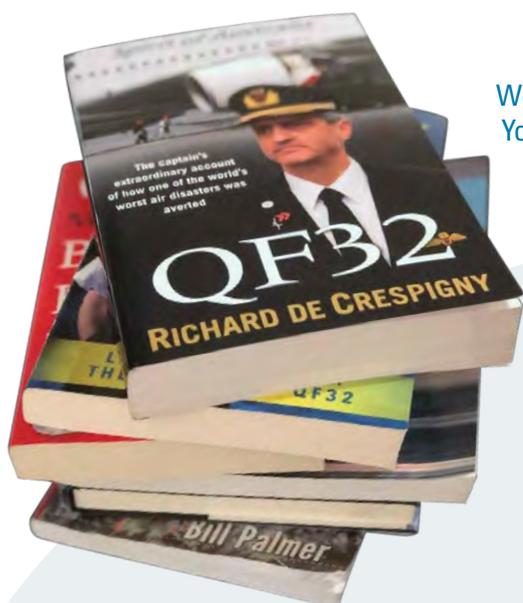
of other Qantas staff and the Australian public”.

People in control

The story of QF32 is one of success against the odds, borne of deep expertise not only in how to fly an aircraft, but in how to manage risks and make decisions as a team when procedures and checklists are not enough.

This is why humans must always remain in control of systems. Only people can make dynamic trade-off decisions that can't be programmed into a computer. Pilots are responsible for their passengers and controllers are responsible for traffic separation. So pilots must always remain in command of their flights and controllers must always remain in command of air traffic. This being the case, tasks, technology, and environments must be designed for people, and people must have the competency and expertise to handle situations that we can foresee and those we can't, like QF32. 📖

‘QF32’ was published by Pan Macmillan in 2012 (QF32.com). ‘FLY! Life Lessons from the Cockpit of QF32’ was published by Penguin Random House in 2018 (Fly-TheBook.com).



We must commit to a lifetime of learning.
You must never stop learning.