MACH 2

Concorde magazine

Improving on excellence
Concorde modifications

Concorde watch
Latest news from Duxford

Celebration for G-AXDN
50th anniversary event

Issue 35
August 2022

Introduction

Many of us lay readers may be unaware that Concorde continued to evolve as the aircraft entered airline service. In our main feature, British Airways Flight Engineer David Macdonald looks at a couple of the changes made during and just after the certification process, as well as instances of fine-tuning as Concorde entered service with British Airways and Air France.

In the present day, Concorde's capabilities still astonish visitors who see the aircraft at museums. Just as amazing are the recollections of the pilots, engineers and others who worked with the aircraft during development and service. On 13 June the Duxford Aviation Society hosted an illustrious gathering of these men to commemorate the 50th anniversary of G-AXDN's maiden flight; we report on that fascinating day.

We also report on the aviation memorabilia fair held by The Aviation Society at Manchester Airport, under the wings of Concorde G-BOAC, and we bring news of the latest restoration work carried out on G-AXDN by Heritage Concorde at Duxford.

In this issue

Editor: Katie John

Cover: British Airways Concorde in the maintenance bay at Heathrow, 2003. Photo: John James

Improving on excellence

After more than six years of development, with thousands of hours of flight testing, Concorde entered airline service on 21 January 1976. However, that was not the end of the evolution process; the manufacturers and airlines continued to fine-tune the aircraft for optimal performance. BA Flight Engineer David Macdonald *recalls the adjustments made to optimise Concorde's already-spectacular capabilities.*

It is with some trepidation that I dip my toe into the pond labelled 'Modifications' – hereinafter, 'mods'. After all, if an aircraft is perfect, why set about changing it? Your esteemed editor's initial suggestion was received with a shudder, but in fact it is an opportunity to highlight how an airline's Engineering & Maintenance and Flight Ops teams work closely with a manufacturer's Design/Product Support/Flight Test departments. Being lucky enough to bag a place on the first Conversion Course in January 1975, I was well placed to participate in the final few months of flight test and the tumultuous years following Entry into Service (EIS).

It has been said before, many times – but I think to fully appreciate this piece it is necessary to restate – that there had never before been an aircraft designed to fly at high supersonic speeds for hour after hour, year in year out, at 60,000 feet in a 400 Kelvin environment.*

*The Kelvin scale is used in engineering: I first met it during Applied Thermodynamics at Tech College. Subtract 273 from the Kelvin figure to give the familiar 127°C.

The latest Airbus or Boeing, for example, whilst including innovations, will still be a typical subsonic airliner. It will fly at the same speeds as pioneered in the late 1950s; its systems, aerodynamics and handling descend directly from the first swept-wing airliners of the 50s and 60s. By contrast, Concorde was new. Concorde was different. Keep this in mind as you read on.

Preparations for service
7 July 1975: Concorde G-BOAC makes a preliminary visit to the British Airways hangars at Heathrow, during the final preparations for certification and service.
Photo © Steve Fitzgerald

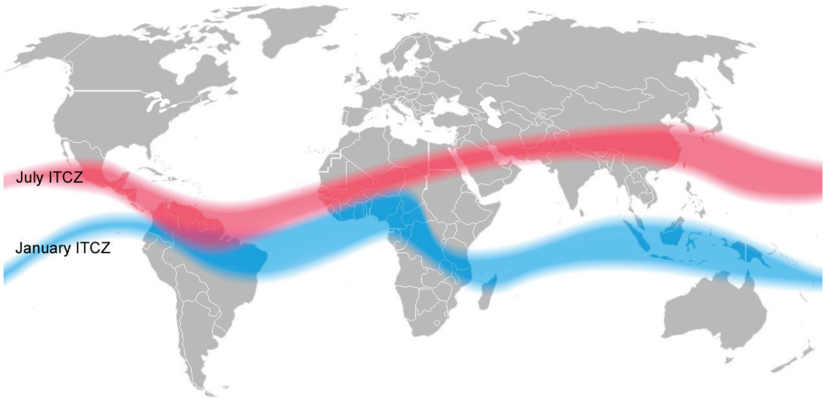
From flight tests to service

Here, we shall look at only post-EIS mods, or to be more precise only those mods incorporated after the Type Certificate of Airworthiness was awarded in 1975. We will begin with an in-depth examination of two 'crossover' mods, identified during the summer '75 endurance flights but not incorporated until after EIS.

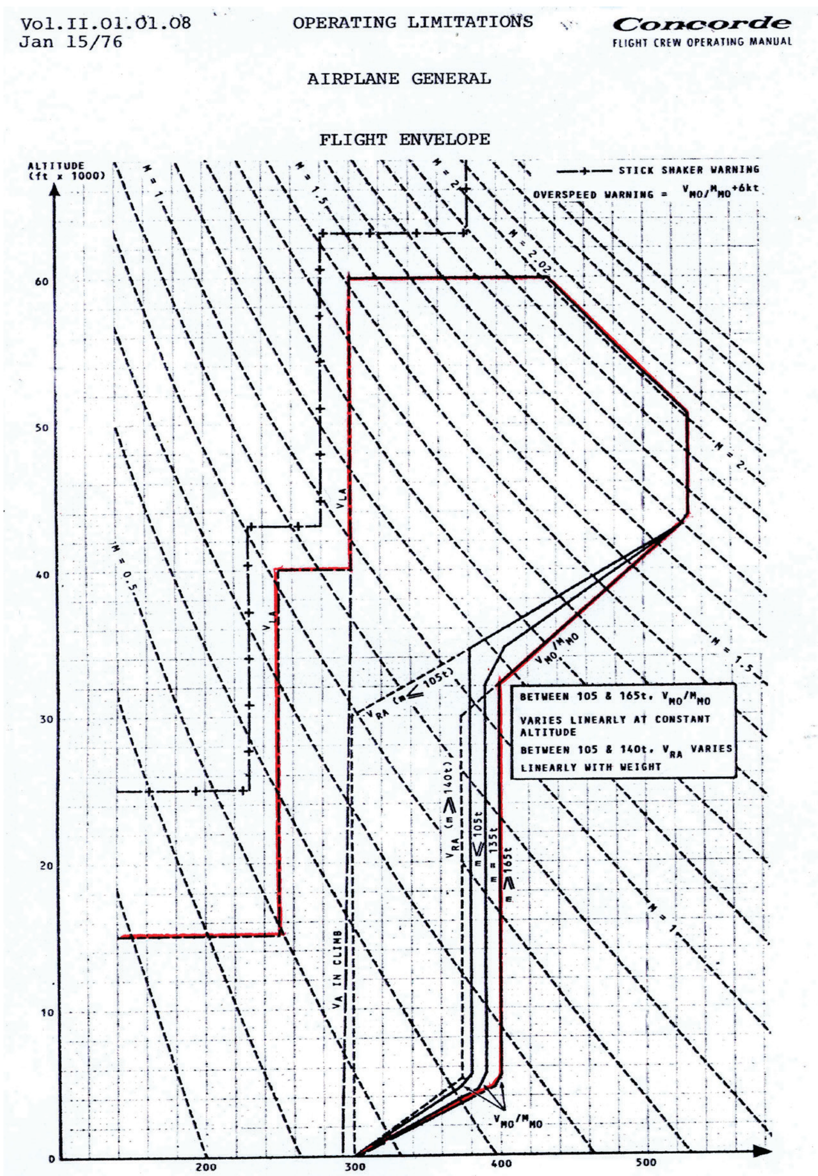
The 6 years and 5,500 hours of flight testing since the prototype's first flights had spawned many improvements and changes – for example, the introduction of digital electronics to the engine intakes or reshaping of the wing leading edges. Now those 5,500 hours were divided between six aircraft, with the lead aircraft only amassing around 340 hours of supersonic flight. This is perfectly reasonable, but there comes a time when one has to stop testing and start producing. However, as supersonic hours built up after EIS, waiting for us just a few years down the line were the twin nemeses of temperature and vibration.

Far-East weather

From July to September of 1975 my colleagues and I participated in the last 750 hours of flight test, planned to emulate a typical airline operation. Initially we were based in Bahrain, operating through Bombay, Singapore and Melbourne. Weather manuals will describe June to September as the Indian monsoon



The Intertropical Convergence Zone
This image shows the location of the Intertropical Convergence Zone and its shift in position from January to July.
Artwork: Mats Halldin / Wikimedia Commons (CC BY-SA 3.0)



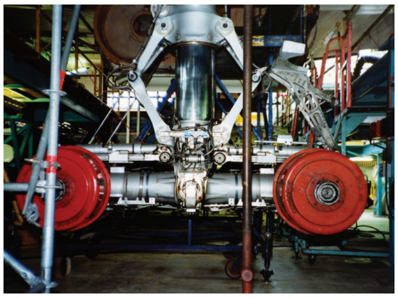
Flight envelope
The diagram on the left is taken from BA's Concorde operating manual. The red line indicates the outer limits of the flight envelope.
Photo: David Macdonald

period – interesting! The next chapter of the manuals might introduce the Intertropical Convergence Zone (ITCZ) stretching from Pakistan to Singapore, a meeting of airflows from the south and the north that drifts northwards rather like the monsoon itself.

The towering cumulonimbus clouds reaching up beyond 50,000 feet were not a real problem, but the converging airflows at different temperatures soaring up to our operational heights certainly were. Being new to Mach 2, we spoke of rapidly changing atmospheric temperatures when, in fact, it was our rapid progress – 1,300 mph – that created the problems.

At this point we need to look at the 'flight envelope'. This is shown in the graph to the left. On the left of this graph is minimum allowable speed; on the right is maximum allowable. For a subsonic aircraft, cruise speed will be somewhere between the two, but Concorde is a high-performance aeroplane we fly flat out following that maximum allowable line, all the time – that is where we find maximum efficiency. Our pilots learn to stick to that line assiduously; deviating below the line loses efficiency and draws a rap on the knuckles, while beyond that line is a 6-knot margin before the overspeed warning shouts at you. Speak to any Concorde pilot and you will find that such a precision operation becomes second nature and part of flying's pleasure.

Imagine now the Far East scenario: above 50,000 feet in supercruise, engines at max cruise power, autopilot holding Mach 2 and the aircraft gradually drifting upwards as weight reduces with fuel consumption, a speed of about 1,300 mph, everything stable … until we



Main landing gear
Above: The main landing gear.
Photo: John Dunlevy
Right: Concorde landing, showing the pressure that the gear had to bear.
Photo: Jetinder Sira

hit a patch of colder air. The speed of sound varies with temperature – the hotter the air temperature, the higher the speed of sound. Thus in hot air, Mach 2, 1,300 mph, all is stable; however, cross into cold air and at that point 1,300 mph becomes considerably above Mach 2. The overspeed warning goes off, autopilot pitches the aircraft upwards to regain Mach 2, and engines are throttled back manually to assist. There were considerable height changes and Mach number excursions between M 1.8 and M 2.1 before stability could be restored. Clearly something had to be done.

As these flights were still part of the test programme, everything was recorded and sent back to base. Design responsibility rested with Aérospatiale; they drew up a mod that basically allowed the auto-throttle system to be engaged in a 'standby' mode, ready to work with the autopilot the instant any over-speed was detected. Aircraft 201, F-WTSB, fitted with the new kit, was dispatched to Kuala Lumpur on 24 October 1975. Sixteen flights, including over 40 hours supersonic, were flown, proving that the mod would be a success.

French authorities awarded Concorde the Type Certificate (Air-worthiness) on 9 October, knowing that a solution to the above had been defined and would be incorporated in a satisfactory time scale. However, although certainly linked to the above, I have never fully understood why, under pressure from a British Airways source, the British Type Certificate was delayed until 19 December.

Runway undulations

Still in the Far East – yet another phenomenon to challenge flight crew. For this period our base was transferred to Singapore to facilitate operations south to Melbourne and west to Bahrain. In 1975 Singapore bore little relationship to today's overgrown, overblown city state (the same can also be said of Bahrain). The airport was still the 1950s' single-runway Paya Lebar.

At this stage I will introduce a quote from A.C. Kermode's magnum opus, *Mechanics of Flight*, that may not read too well. Here goes: "The more one understands about aircraft, the more one realises that an aeroplane is, from beginning to end, a compromise."

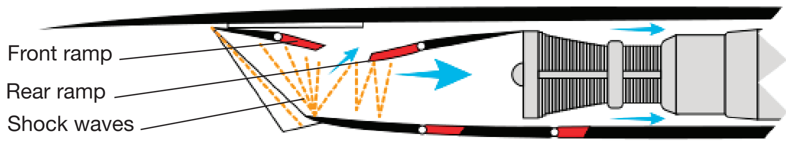
My heart may see perfection, but my head knows of compromise!

Concorde's general shape, and that of the Tupolev Tu-144 (and of every nascent design since), is a slender delta – that way efficiency lies. In this case the long, narrow fuselage (high fineness ratio) is at odds with, of all things, the landing gear – in particular, the main landing gear, which is in fact one huge shock-absorber; it has to deliver a smooth, comfy ride whilst taxying round airfields, support 185 tonnes of fully loaded Concorde at the point of rotation and, on the day that something unpleasant happens and an aircraft has to make an immediate return, accept 180 tonnes bearing down at 207 knots! That's the background.

The Singapore runway had undulations – nothing dramatic looking – but it was built on a swamp, after all. During a heavyweight take-off, just as we were beginning to really motor, we met a slight, but long depression; there was just enough time to make the 100 knots 'power check', before an up-and-over undulation – and that did it!

The stiffness of the main landing gear allowed the forward fuselage to go into vertical and lateral oscillation at the fuselage's natural frequency; the effect would continue for as long as the aircraft's weight rested on its undercarriage, only ceasing when we were airborne and the weight was now borne by the wings. On the flight deck one certainly felt the undulations, but the vibration made it more than a little difficult to read the instruments. It was certainly a relief to get airborne.

Special flight recorders were set up and once again data transmitted back to Headquarters. The above was not an entirely unknown phenomenon, and so we come back to compromise. In this case the main gear units had been designed to a particular degree of stiffness, perfect for most runways but not for those with a less than perfect surface; therefore, the main gear internals were modified to soften the spring rate and ease the friction, thus effectively preventing the vibration. Since we visited something like 375 airfields worldwide, the mod was well worth while.



Engine intake ramps in action
The front ramp is hinged at the front, and the rear ramp is hinged at the rear. They operate up and down together: fully up until Mach 1.3, thence as required to control the shock waves (shown here in yellow).
Artwork: MacMoreno / Wikimedia Commons (public domain)

Post-EIS modifications

The following modifications were made during the early years after entry into service.

Combustion chamber

The combustion chamber of Concorde's Olympus engine is one large annulus (ring-shaped structure); think of it as a cylinder within a cylinder. It contained 16 vapourisers spraying fuel into the chamber. In the search for efficiency and power, turbine entry temperature would be as high as metallurgy allows. The Olympus 593-610 is unique in that for hours at a time air temperature at the intake is around 120°C, with additional heat raised by the combined compression ratio of 80:1!

We began to see the twin-arm vapourisers cracking and shedding pieces that could result in off-centre flame impinging on the chamber sidewall. Rolls-Royce were soon on the case; however, new, stronger vapourisers were not the complete answer. Borescope checks (the same endoscopic technology that medics use to carry out internal examinations) were introduced at each return to London. In addition, a Sharp calculator with an engine temperature monitor program loaded was issued to Flight Engineers for in-flight use to detect both compressor and combustion deterioration. Thus we lived with the condition until the final solution – a totally new combustion chamber; revised cooling; improved shape; and judicious use of new materials. The new chamber came in at 40 lbs heavier than the original, but a much more efficient combustion more than compensated. It was a long haul but we got there.

Engine intakes

After about a year in service, a hawk-eyed maintenance colleague making a routine inspection found an incipient crack on the inner face of an intake sidewall in the vicinity of the rear ramp hinge line. A repair was made and the finding passed on to Product Support at Filton. Out came the ubiquitous flight recorder, finding a space in the rear wardrobe; the intake was wired up, and the aircraft returned to service. Such a small beginning.

Part of the rear ramp's function is to slice off a portion of the air entering the intake, pass it into the engine bay for cooling purposes, then use it to help shape the jet efflux to optimise thrust – nothing is wasted! This being so, it would seem practical to give the rear ramp a sharp leading edge. But the recorder told us of a stagnation point along the leading edge, becoming unstable between about M 1.6 and M 1.8; the resulting vibration was amplified by the rear ramp, then fed into the hinge structure. Top marks to 'Hawkeye' for spotting the issue.

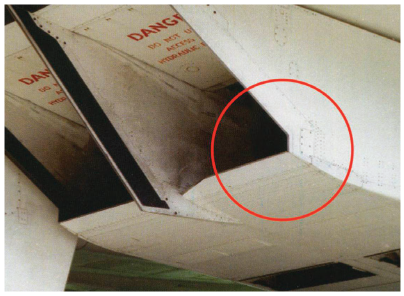
The attack on the problem was threefold. Straightaway, the Filton I-team (I for Intakes – read Ted Talbot's book *Concorde: A Designer's Life – the Journey to Mach 2*) gave us temporary operating instructions to alleviate the buzz whilst they worked on a change of control laws within the 'black boxes'. Within a week or so, revised Intake Control Units began to be fitted. These were named 'Super TX'. What a fabulous name! To this day I have no idea what it means; suffice it to say they did their job wonderfully well. Coming up to M 1.6 they deliberately ran the ramps off-schedule until the vibration zone was passed, and then gradually brought them back to max efficiency. This again was expediency, awaiting stage three – a revised profile to the rear ramp leading edge.

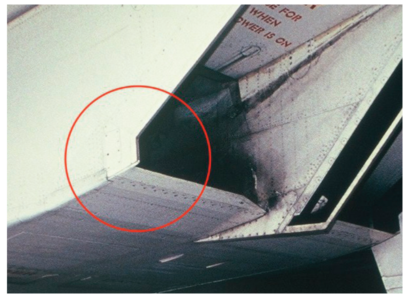
Beyond perfection

The first two of the post-EIS mods have one thing in common – both raised because of in-service problems. There were other modifications, though, that were purely 100% product improvements – we are about to meet one.

In parallel with the above, Concorde 202, G-BBDG, had been booked to fly-out an intake mod full of wonderful promise. It was called 'The Thinned & Lowered Lower Lip'. A bit of a mouthful and so it became the 'Thin Lip' mod. (See also Mach 2, February 2022.)

It had been noted by Filton's analysts that atmospheric conditions across the North Atlantic were such that the intake ramps were not taking up their most efficient positions. And the analysts had an idea. Make the intake capture area a bit bigger, give it the potential to swallow more air, adjust the electronics and Bob's your uncle. Sounds simple? Possibly: but the I-team knew very well that in this field the smallest changes can have a huge impact – you have to get it right.





Change to intake lower lip
Right: the pre-modification lower lip. The area ringed in red shows where the lip exactly meets the side wall of the engine nacelle.
Far right: the post-modification lower lip, set back a little way from the base of the side wall.
Photos: David Macdonald

The intake lower lip was cut back, replaced by a thin, sharp-edged lip sitting further back and lower. It is a challenge to examine photographs and deduce pre-mod or post-mod intake! By now aerodynamicists had designed a 'D-section' leading edge for the rear ramp, and so Delta Golf took to the air, multi-tasking, flying-out the new shape to the rear ramp together with the Thin Lip. It all worked beautifully.

Next time you visit Delta Golf or any of the production airliners in whatever country, do have a look and give a nod to the I-team. And it was true – the mod cut about 1500 kgs off fuel use for a transatlantic flight.

Kilo Whisky vibration

Feel like some more vibration? Don't say I didn't warn you!

Let's go back to February 1980. Events had conspired to leave us short of capacity for our burgeoning workload. British aircraft 214 (eventually registered as G-BOAG) had been completed as a Concorde 191, the factory standard model, and was parked at Filton awaiting a friend. As soon as a short-term lease was agreed, I spent a couple of days at Filton cataloguing differences both in the flight deck and in the cabin. On 6 February we did an acceptance flight, on the 7th we did the delivery flight, and on the 8th the aircraft went into service, registered G-BFKW – Kilo Whisky.

Within the first month, crews were beginning to report a mild low-frequency vibration/buffeting felt in the flight deck during initial climb-out in the 6,000 to 16,000-feet height band. The effect could be 'switched off and on' by varying no. 1 engine power.

This engine, engine number 057, had only recently been changed. There had been a couple of minor anomalies earlier in its life. During test-bed running it had been towards the top end of acceptable vibration, and so the decision was taken to give it a complete strip, inspection and rebuild at our in-house overhaul facility near Cardiff; it passed with flying colours.

In July, 057 was fitted to Alpha Foxtrot no. 1 position, with symptoms as above. It was removed and sent to Cardiff, where the low-pressure compressor was fitted, and once again it passed the test run. November found 057 fitted to Alpha Echo no. 4 position. By now the engine had its own dossier. To supplement crew reports that flight recorder was dusted off once again and pressed into service, and lo and behold there it was – a strong 18-Hertz vibration in the vicinity of the flight deck. At this stage a couple of other engines began to exhibit similar symptoms. Was something going round?

Now the engineering detectives got to work, synchronising the above with data from the 'built-in' main flight recorder to find a correlation with the actual fuel flow to the engine. Breakthrough! The vibration only occurred when the second-stage pump (SSP) was running.

To provide adequate fuel flow to both engine and reheat there are two pumps, one shaft-driven running all the time and a 'Second Stage Pump' that cuts in when required. The SSP is bolted on to the Flow Control Unit (FCU) – the metering device. They form one assembly, usually only separated in workshops.

Once more we turned to our good friends at Filton and aircraft 202; what would we have done without 202? Engine 057 was trucked down the M4 to Filton, and 202 was wired up to record the subject vibration, stress effect, engine parameters and fuel data. A minor 'ripple' was discovered in the SSP output pressure, which translated into minute thrust fluctuations too small to be seen on engine instruments; there was no adverse effect on structural life.

By now we had three 'suspect' SSP/FCU assemblies. All were separated, stripped down, inspected, measured and rig-tested by their manufacturers. Nothing was found to be wrong; not the slightest anomaly. What we did know, though,

Location of the SSP and FCU
Detail from a display specimen of the Olympus 593 engine. The large, light-coloured component just below the right-angled pipe, just right of centre in this image, is the Flow Control Unit (FCU). The Second Stage Pump (SSP) is behind and attached to the FCU.
Photo: Nimbus227 / Wikimedia Commons (CC BY-SA 4.0)

was that a 'suspect' SSP could be mated to a known 'good' FCU and it would perform perfectly; likewise, a 'suspect' FCU mated to a 'good' SSP. Sometimes one just has to take a pragmatic view, so nothing further was done – except that each suspect unit had a red spot painted on it and for the next 23 years there was just one rule:

NO RED-SPOTTED UNITS SHOULD FORM AN SSP/FCU ASSEMBLY.

Will Shakespeare knew a thing or two when his Prince of Denmark mused, "There are more things in heaven and earth, Horatio, than are dreamt of in your philosophy …"

And what of engine 057? It was a tease, giving trouble-free flying for months on end and then high oil consumption, but with no leaks detected. Return to service followed by the above was ultimately a step too far, and so engine 057 was dismembered down to its constituent 12 modules, to be used as spares.

An ignominious end? No; 057 had the last laugh. The following July, Alpha Fox arrived at New York with only half a tank of oil in no. 4. Records showed that one of 057's modules was part of that engine: the module carrying two of the main bearings and their protective labyrinth seals, one of which had unusual wear … Finally. R.I.P. 057.

This was truly a saga – so much work, and in the end the only 'modification' came from a simple pot of red paint.

Hydraulic systems seals

And so to temperature. I imagine every design decision considered temperature: it was omnipresent.

Concorde has three hydraulic systems. Between them they power all the flight controls; raising and lowering of the nose and visor, and similarly of the landing gear; brakes and steering; intake ramps and spill doors; a couple of fuel pumps; even an emergency generator – pretty important stuff.

Whenever there is a system involving liquid, such as the hydraulic fluid, there are seals; and here we revisit 'compromise'.

To certify a supersonic transport aircraft (SST) as airworthy, one must also examine its subsonic flight endurance; its ability to withstand a cold soak as well as the supersonic heat soak. Thus, seal material was chosen that would fulfil both tasks. It would have been about 1982 when we began to see one or two hydraulic drips, mainly from intakes and flight controls, that would cease when the systems were pressurised. Rectifications were made, but it became an epidemic. Analysis showed seals to be hardening due to the high-temperature environment in which they worked.

It was decided to choose a different material, one better able to withstand the heat, although at the expense of low temperature properties – a shift in the compromise. The new seals were manufactured from Viton GLT. (The name amuses me; it still sounds like a 1970s car – Vauxhall Viton GLT!)

Wheels and tyres

Outside of the two main problem areas of temperature and vibration came 'wheels and tyres'. Between 1979 and 1982 Dunlop made us some stronger main wheels and reinforced tyres. The originals were 22-inch wheels with tyres to match, while the new ones came in at 22.1 inches. The new wheels were anodised blue and tyres given a prominent blue patch, to prevent confusion. As part of this package Aérospatiale produced a Tyre Deflation Detection System.

A trouble-free flight
From 1981 to the end of service, the engines had no further problems like those experienced with engine 057, as long as the suspect Second Stage Pumps and Flow Control Units were never used together. *Photo: Jetinder Sira*

Finally – something quite different

Question: At what stage of flight do you think engines experience the highest stress?

Here, possibly, is a new term for most readers – 'Group A Rotating Parts'. Our engine specialists use it to describe the very substantial solid discs attached to compressor/turbine shafts, and into which the compressor and turbine blades slot. Every now and then you may read of a blade or two breaking – all engine casings must be designed to contain such failures, and they do. However, the discs have so much weight and mass that it would not be feasible to contain a failure; therefore, they must not be allowed to fail. (To see why, I recommend you look up the Sioux City DC-10 accident of 19 July 1989.)

When a new type of engine is introduced, its discs will arrive with a fairly conservative 'life'. As time progresses, discs will be sampled and if all is OK they will gain a modest increase in life – an on-going process. It came as a bit of a shock, then, in the early 1980s, when Rolls-Royce announced a probable reduction in disc lives.

It transpired that the Olympus 593 experiences its highest stress towards the end of flight, after we have throttled-back the engines for deceleration and descent and just at the point when we bring the power back up under autothrottle control to level off for a short subsonic cruise; who would have thought it!

This is what's happening. At this corner of the operation, significant temperature differences between a disc bore and rim will develop, leading to thermal stress. As the autothrottle increases power to level off, it always overshoots – it is a little coarse – leading to mechanical stress that is additive to the thermal effect. If you want to challenge me – could I as a Flight Engineer do any better? You bet your bottom dollar I could!

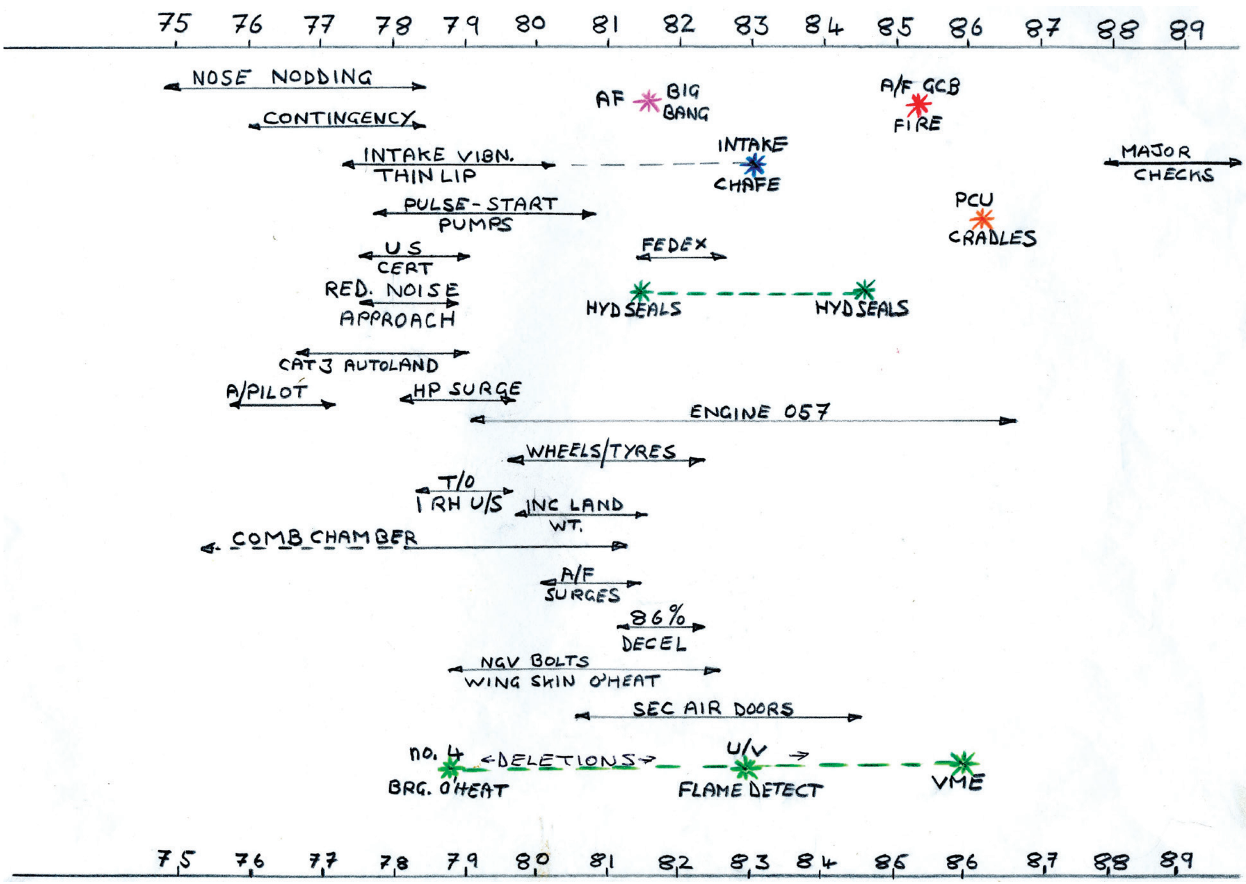
In conjunction with Rolls-Royce and the British Aircraft Corporation (BAC), a revised procedure was developed whereby we would always level off temporarily at 41,000 feet; as deceleration reduced to M 0.97, the Flight Engineer would gently increase power to 86% N2 (N2 being the speed of the high-pressure compressor, used as a measure of engine power) and with small adjustments maintain exactly 86% N2 for 60 seconds to balance the bore-to-rim temperatures, thus negating thermal stress, then descend as required by Air Traffic Control. Result! Problem solved; disc life assessment back to normal.

Conclusion

This has been but a snapshot of the 'Concorde Project', with engineers and flight crews working together to take care of the aircraft; there have been many more mods of varying sizes, reinforcing my view that at least the first ten years could be termed 'post-EIS development'.

It may also validate the quote from Brian Trubshaw's book *Concorde, The Inside Story* when he opines, "Most problems arise after an aircraft is finally placed in the hands of the operator".

Tongue in cheek, I think!



Timeline of modifications
This chart shows the modifications made to improve and fine-tune Concorde's performance in the first 10 years of operation, from certification to the start of the first Major checks.
Image: David Macdonald

Happy anniversary, G-AXDN!

On Monday 13 June 2022 the Duxford Aviation Society (DAS) held a commemorative event to mark the 50th anniversary of Concorde G-AXDN's maiden flight. The event had been postponed from November 2021 due to Covid-19 restrictions, but DAS did a wonderful job of celebrating G-AXDN. Katie John *reports on the day.*

Still looking gorgeous
G-AXDN with nose and landing lights reactivated.
Photo: Katie John

THE ATTENDEES for this day of celebration included people who had been involved in every stage of Concorde's history – from those who helped to develop and build Concorde, to former pilots and engineers who worked on the aircraft during service, to some of the volunteers who work on Concorde preservation today.

Peter Archer of DAS welcomed everyone to the event. We then had a chance to explore the hangar. Bill Darroch of DAS and Graham Cahill of Heritage Concorde gave me a tour of the new museum on the Hermes fuselage beside Concorde. DAS volunteer Alan Longworth later described the Hermes display as "a walk back in time …" For example, it gives a clear view of the Hermes cockpit, with ample accommodation for a five-man crew: two pilots, flight engineer, navigator, and radio operator. The display includes a section on Concorde; DAS plans to install part of Concorde's original cabin fittings and seats here.

Graham pointed out the new decals – exact replicas of the originals – that DAS had had applied by a local signwriter, plus the replica "bonkers" on the tail and wings. G-AXDN is looking in fantastic condition – a tribute to DAS and their painstaking care.

At 12.15, we had a demonstration of G-AXDN's current capabilities. After audio of an engine start-up, Simon Peachey of DAS carried out a nose move (prompting a gasp of excitement from some watching schoolchildren). The navigation, anti-collision and taxy lights were also switched on to provide a full "back to life" display.

Peter Archer explained the cycle – first preparation to "take off", then the visor lowering and the nose drooping, and the taxy lights coming on, for a "landing". He also invited former Concorde engineer John Dunlevy, now of Heritage Concorde (HC), to give

New decals
Below and right: The original decals on the airframe have been replicated exactly.
Photos: Heritage Concorde

some impressions of his working life with the aircraft. For example, John described the "incredible noise" that resulted from putting the visor down when Concorde was at Mach 2.

John was followed by Graham Cahill, head of HC, who gave a brief history of the team's work with G-AXDN from the start of the project in 2012 to the present day. He touched on some of the challenges they had faced in restoring the aircraft – the most difficult being to remove dried M2V from the hydraulic system, where it had congealed to become "like earwax"! He thanked the rest of the HC team and the volunteers at DAS for everything they had done for Concorde.

Peter concluded the demonstration by saying that Concorde was "the best aircraft ever built, and still looking gorgeous 50 years after she first flew".

A wealth of knowledge

During the delicious lunch, I had the chance to talk to some of the men who had worked with the aircraft since her earliest days. Engineer Bill Burridge had been with G-AXDN in Tangier for the heat trials, and had gone on to work with the British Airways Concorde fleet from entry into service until the 1990s. One of the highlights he mentioned to me was his involvement in the charter flight to New Zealand in 1986 to observe Halley's Comet.

Chris Morton was another engineer who had been in Tangier with G-AXDN, then in Bahrain to prepare for Concorde's entry into service; he was later responsible for the British Airways Concorde simulator throughout Concorde's time in service, until 2002. (He observed to me that "*most* of the tales being told here today are true …) I also spoke with DAS volunteers Alan Longworth and Phil Miles. It was a pleasure to listen to everyone's stories of their experience with Concorde and their life in aviation. Looking around the room, I guessed that there must be centuries' worth of aeronautical knowledge held in the minds of all those present at this event – an awe-inspiring thought.

John Hutchinson's talk

After lunch, Concorde captain John Hutchinson gave a talk on "Celebrating Concorde 101's first flight". He began by thanking DAS and the Imperial War Museum for organising the day's celebration. He noted Concorde's enduring popularity with the public; he gives

Honoured guests
Concorde captain John Hutchinson (right) joins (from left) engineers Bill Burridge, John Dunlevy, Carl Percey and Roger Blake beneath G-AXDN.
Photo: DAS

talks about Concorde on the Queen Mary 2, and on a recent journey to New York, the ship's lecture theatre was full for his talk.

John paid tribute to Concorde's beauty as "a fusion of art and technology into a sublime creation". He quoted the words of Sir Hugh Casson, former head of the Royal Institute of British Architecture, who described Concorde as "a piece of 20th-century sculpture".

John also pointed out that "Concorde" was not just the aeroplane – it was all the people who worked with her, whether flight crew or cabin crew, ground engineers, dispatchers, check-in staff, and many others. He especially commended the work of the ground engineers, and the professionalism of the cabin crew who delivered a "seamless" service in Concorde's rather restricted space.

John participated in various publicity events with Concorde. He took part in the four-ship formation flight over the West Country in December 1985 (see Mach 2, Xmas 2015), and was one of the crew with G-BOAG for the famous photograph of Concorde flying with the Red Arrows and the QE2 (see Mach 2, August 2018). He described the challenge of getting into formation with the ship; the Navy initially refused permission for them to cross military airspace over Portland – but they relented as long as Concorde and the Red Arrows would overfly HMS *Illustrious* for their family day! He also paid tribute to Arthur Gibson, the photographer who had taken that iconic image from a Hawk aircraft.

John went on to recall some memorable passengers, including a lady who had had her first plane flight with Louis Blériot in 1911; he noted that her flight with Blériot had been

A remarkable assembly
A gathering of the men who have worked with Concorde, from those involved with the earliest development to the volunteers doing the preservation and restoration work today.
Photo: DAS

only 23 miles per hour, and now there she was in Concorde, flying at 23 miles per minute! He himself had started his flying career in 1955, and as a young pilot would never have imagined that just 22 years later, he would be flying a supersonic airliner.

In conclusion, John said there would be a successor to Concorde, with new technology and materials – but Concorde led the way. He finished with "Thank you, Concorde!".

There followed a series of questions from the floor. In response to one about the Concorde conversion course, John said this was extremely rigorous, much longer than those for other aircraft types, and the standard was very high indeed; in the ground school course candidates had to get over 90% in every exam. He described Concorde as "a joy to fly", and very safe due to having so much reserve capacity – but also very demanding. You could not afford to be "behind the aeroplane" at any point. In answer to a question about engine failures, John said there were very few – but he did recall a flight in which Concorde started "shaking violently" due to an engine surge. Flight Engineer Bill Brown managed to resolve the problem, but on landing at Heathrow John found that the passengers had "drunk the aircraft dry", draining Concorde's substantial and excellent supply of alcohol.

Exploring the museum

After Peter Archer had thanked John for his fascinating talk,we ended the day by having a good look around the museum, including the recently-arrived BAe 146 from the Royal Flight (now with a time-expired engine for display next to the aircraft). We were even treated to an impromptu flying display by a Vampire and a MiG-15! This brought the day to a wonderful conclusion, as we admired the exhibits and enjoyed glimpses of aircraft undergoing renovation (such as the Victor undergoing work in the conservation area).

Many thanks to the Duxford Aviation Society for putting on such a wonderful day to commemorate G-AXDN. For further details of their work, please visit their website: https://www.duxfordaviationsociety.org

Presentation to DAS

Heritage Concorde had four Olympus engine compressor blades signed by 12 of the former engineers on G-AXDN who were at the event; it was remarkable to have so many of the engineers in one place. Heritage Concorde donated the blades to DAS for display on board the aircraft.

Presenting the signed blades
Graham Cahill of Heritage Concorde donates the blades to members of DAS on board G-AXDN.
Photo: Heritage Concorde

Aviation memorabilia fair

The Aviation Society (TAS) at Manchester held an aviation fair in the hangar with Concorde G-BOAC, on 23–24 July. Heritage Concorde attended and were given a stall beneath Alpha Charlie's nose. Report by Katie John.

The weekend seemed to be very well attended, with visitors of all ages and backgrounds enjoying the event, although it was a little quieter on the Sunday due to the bad weather.

There was a wide range of aviation-related memorabilia, with a significant proportion of items to do with airliners and airlines; it was good to see so many pieces connected with civil aviation. The offerings ranged from artwork and models to items used in airline service and even components from aircraft. One stall had cutlery and souvenirs from British Airways' Concorde service, as well as very attractive glassware commemorating Concorde.

Heritage Concorde did a brisk trade in items collected in the course of their preservation and restoration work. Popular items were the emptied cans of M2V, the hydraulic fluid used for Concorde while the aircraft was in service and now utilised for activities such as nose moves, and old lightbulbs taken from Concorde's cabin and flight deck. There were more unusual and valuable pieces of memorabilia on offer as well, including a framed circuit board, components from the test equipment formerly carried on board the British prototype Concorde 002, and compressor blades from Olympus engines.

Over the weekend, Heritage Concorde raised more than £800; this money will go towards the restoration work planned for G-BOAC's aft cabin.

For more information on the activities of TAS at Manchester Airport, see their website: https://www.tasmanchester.com

Details on events at the Runway Visitor Park, including Concorde tours, can be found on the RVP site: https://www.runwayvisitorpark.co.uk

G-BOAC nose moves

Nose moves on Alpha Charlie are performed as part of the Concorde Platinum Tour, which includes a full tour of the cabin and flight deck. For further information, please see the RVP's web page on their Concorde tours: https://www.runwayvisitorpark.co.uk/bookings/book-a-tour/

Under Concorde's wings
A view of the stalls around and underneath Alpha Charlie. The TAS stall can be seen to the right of this image.
Photo: Heritage Concorde

Heritage Concorde memorabilia
The Heritage Concorde stall offered a wide range of items, from prints and stamps to components and M2V cans formerly used on Concorde or replaced in the course of restoration and maintenance work.
Photo: Heritage Concorde

Concorde watch

Concorde G-AXDN British pre-production aircraft

Location: Imperial War Museum, Duxford, UK
Reporter: Graham Cahill **Date:** 24 June / 26 July 2022

Since the last edition of Mach 2, the restoration team has been relatively busy on G-AXDN at Duxford. We visited on 24 June and 26 July with a team of 4 and 2, respectively; here is a breakdown of work completed.

1. Nose and visor

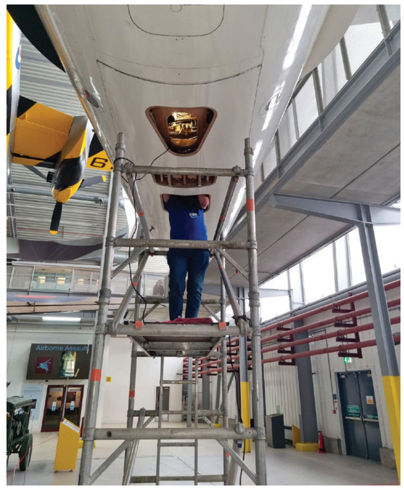
We are still trying to diagnose the slow nose raising problem on 101 relative to G-BBDG, G-BOAC and G-BOAF. We have a few suspicions. One involves the first component in the fluid path from the pump: the Visor Selector Valve (VSV). As Concorde 203 (F-BTSC) and later use a different hydraulic system set-up, our spare VSV is the only known spare of the correct type.

If you have been following the work on G-BBDG, you would have seen that the Concorde 202 team at Brooklands overhauled the VSV on 202 a few years back due to intermittent performance issues caused by dried/congealed M2V. Our refurbished component was ready to be swapped on to 101 at the next engineering visit. It was hoped that this spare valve would solve or improve the situation – only one way to find out!

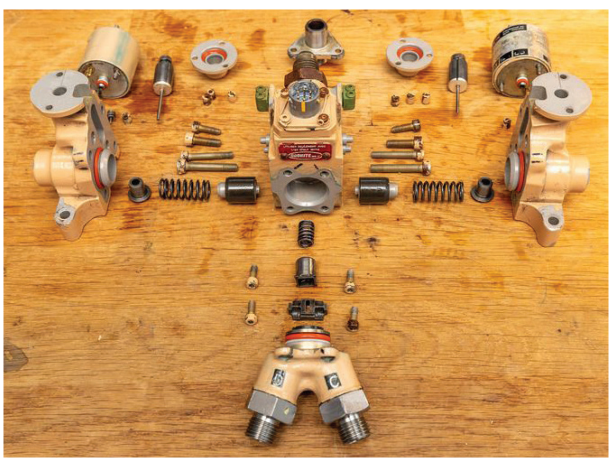
On 24 June we fitted the refurbished valve, but because of an adjustment problem the valve failed to operate correctly. However, although the visor did not raise during the test we did hear significant reduction in noise from the nose system. We are definitely on the right track so will continue with the investigation. The original visor valve was refitted so nose moves would not be affected. Further photos of the valve stripdown are available at http://www.concorde-photos.co.uk

2. Hydraulic system leaks

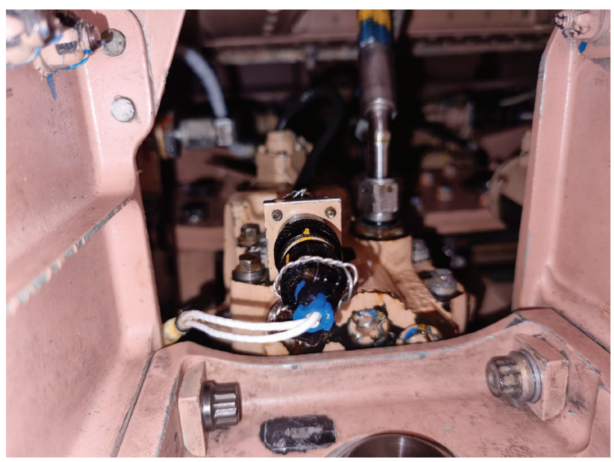
A small leak developed on the nose system; the leak was quickly solved by tightening of a connection to the nose jack on the 12.5 degree side. (In the case of G-AXDN it is literally the 12.5 degree side of the jack, as production aircraft have a 7.5



Nose system
Peter Ugle fixing the connection on the nose jack to stop the leak.
Photo: Heritage Concorde



Components of the Visor Selector Valve
The spare Visor Selector Valve, stripped down with refurbished components ready to be reassembled.
Photo: James Cullingham (concorde-photos.co.uk)



Nose system leak
The 12.5 degree nose jack; the vertical pipe just right of the centre of the image was the one that had the leak fixed.
Photo: Heritage Concorde

degree side and both aircraft have 5 degree jacks.)

G-AXDN has also had a small hydraulic leak to the rear of the aircraft. This is caused by the return alloy pipes having a pin hole in them. We have come across this problem before on G-BOAC at Manchester; there isn't a lot we can do about this other than repair the leaks as they occur. However, we will look at protecting vulnerable pipes with some sort of treatment to try to prevent further occurrences.

Flight test observer's station
John Dunlevy replaces light bulbs on the flight test observer's station in the cabin.
Photo: Heritage Concorde

3. Cockpit lighting

As outlined in the previous edition of Mach 2, we were completing improvements to G-AXDN's general visitor lighting in the cockpit. We had already completed the dash panels; this time, the engineer's panel has also been completed. The finished product looks great in comparison to what was there before. We have copied original lighting locations as per their appearance when the aircraft was powered.

4. Observers' desk and cabin lights

Regular maintenance of the observers' desk has been completed. We go through 15 to 20 caption bulbs each time; we do this because the desk is in constant operation for general visitors. We are also in the process of replacing and repairing cockpit bulb holders and various other failed lighting components in the cabin.

5. Hydraulic pump

The new pump location on board G-AXDN (as covered previously in

Cockpit lighting
Heritage Concorde engineer John Dunlevy checks the lighting on the pilots' instrument panels.
Photo: Heritage Concorde

Flight engineer's instrument panel
John Dunlevy adjusts the lighting on the instrument panel to look the way it did when G-AXDN was in operation.
Photo: Heritage Concorde

Mach 2) is working very well, and other than the small nose system leak outlined above in point 2 the hydraulic oil is not being lost or dropping. We are happy with the progress made here but will check oil levels each time we visit.

6. Brake accumulator

We found in the rear of the aircraft a brake accumulator that was still holding 150 bar of pressure. It has been 40-odd years since G-AXDN retired and we were surprised to find this still charged after such a long time, but for safety reasons no original pressurised containers are required on the aircraft and part of the decommissioning practice is to remove or discharge such vessels. We were sad to do this, but we safely discharged the accumulator (following the procedure from the maintenance manual) once the museum had closed.

7. Main cabin lighting

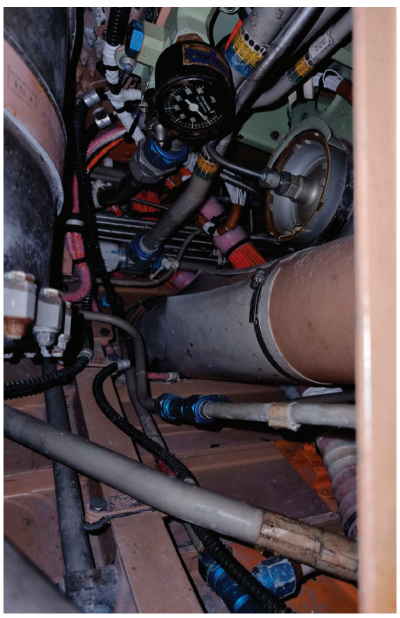
The main lighting in the cabin was repaired. This was a quick 5-minute job as it was just a plug that had worked loose from a run of lights.

8. On-board visitor displays

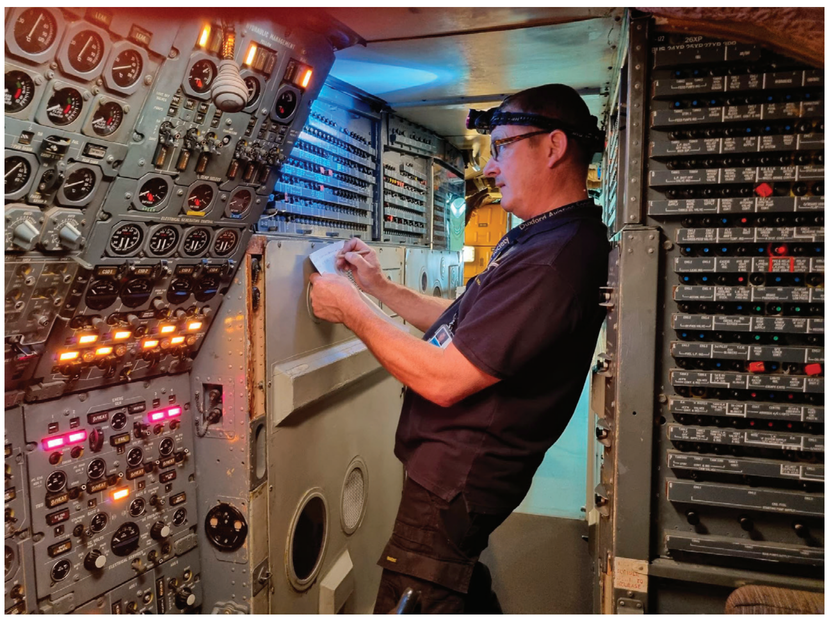
Regular maintenance of the displays on board G-AXDN was carried out. The most significant was repair of the tape unit, which had become faulty. The unit is a copy of a data recorder used to save data to a tape during test flights, and as it has moving parts it requires regular work. The tape unit can now be switched on daily. This work all adds to the visitor experience.

To learn more about Heritage Concorde and support their restoration work, you can find them on Facebook or visit their website: https://www.heritageconcorde.com

Data recorder unit
The replica tape recorder unit in the cabin; this unit would record data from test flights for analysis after landing. The unit can be switched on to show how it would have worked during the test flight programme.
Photo: Heritage Concorde



Brake accumulator
The brake accumulator in the rear of the aircraft, with the power being discharged; the unit has now been made safe.
Photo: Heritage Concorde



Maintenance checks
Graham Cahill at work outside the flight deck, listing circuit breakers for DAS. Heritage Concorde carried out this task in order to produce engineering notes (so DAS will be able to maintain the nose if Heritage Concorde is not available).
Photo: Heritage Concorde

