MACH 2

Concorde magazine

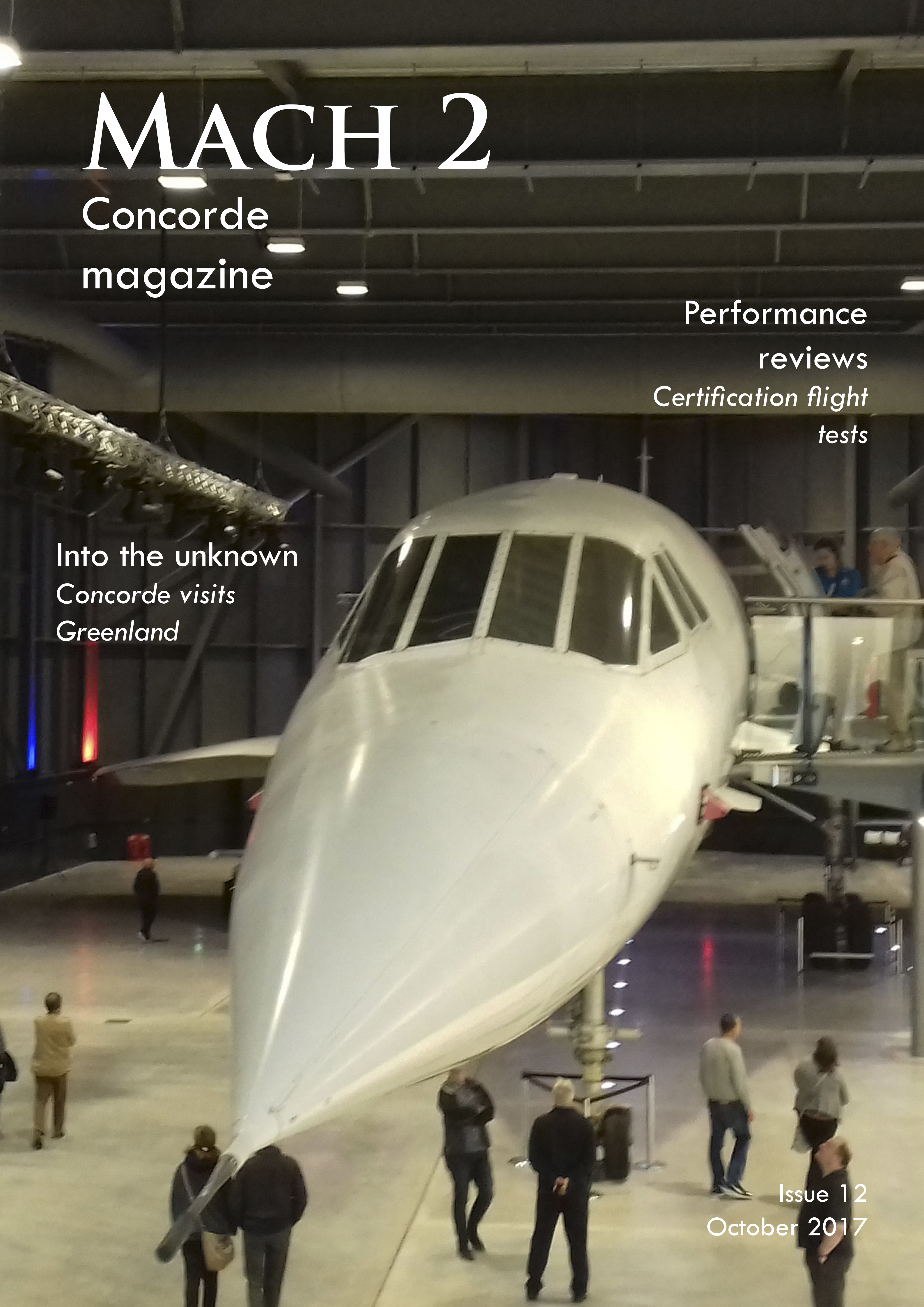
Performance reviews

Certification flight tests

Into the unknown

Concorde visits Greenland

Issue 12
October 2017



Introduction

This month we offer a detailed insight into two major aspects of Concorde operations. In our first article, British Airways Flight Engineer David Macdonald and Fleet Shift Manager Pete Comport go through the procedure for Concorde certification flights – an essential requirement to keep the aircraft airworthy. Charter flights were another important part of Concorde services, and also required special management; Philip Cairns describes his experience of taking care of Concorde on her inaugural charter flight to Greenland.

We also have news of recent visits to Concorde museums. Katie John reports on a highly productive meeting between Concorde preservation groups at Duxford, and Nigel Ferris gives us an insight into the final preparations at the Aerospace Bristol museum.

In this issue

Editor: Katie John
Contributing editor: Nigel Ferris

Cover: Concorde G-BOAF in the new Aerospace Bristol hangar at Filton. Photo: Nigel Ferris

Concorde flight testing

Pete Comport in conversation with David Macdonald

In order to maintain Concorde's airworthiness, the aircraft had to undergo regular certification tests. Here, former British Airways Flight Engineer David Macdonald and Fleet Shift Manager Pete Comport talk us through each stage of this complex, meticulously planned process.

All commercial aircraft need to have a Certificate of Airworthiness (C of A). In order to maintain the certification, each Concorde was required to complete regular flight tests at scheduled intervals, throughout its life in commercial operations, to ensure that the aircraft operated as per the design. The flights are designed to confirm the aircraft's operational standards as set out by the manufacturer and certified by the governing airworthiness authority.

A C of A flight would both test flying skills and confirm engineering excellence. These events were special to all in Engineering and Flight Operations as they provided an opportunity to test fly the aircraft to the edge of the design, operating, and engineering limits – something extraordinary for all involved.

In this article we go through the procedures carried out for all phases of a typical C of A test flight.

Pre-departure

Whereas the standard British Airways crew complement for Concorde is Captain, Co-pilot, and Flight Engineer, a C of A renewal presents an opportunity for our Civil Aviation Authority (CAA) friends to enjoy a little flight time. Thus, a typical test crew would comprise CAA pilot in the left-hand seat, CAA Observer behind him in the 4th seat, British Airways Flight Manager in the right-hand seat – but in command of the flight – and two British Airways Flight Engineers, one to operate and the other to "conduct": i.e., to orchestrate the smooth flow from one test to the next, particularly the often complex configure/de-configure routines. (One such "conductor" mentioned that the 5th seat, mounted on the bulkhead at the back of the flight deck, allowed only a view of backs of heads – a kitchen stool behind the 4th seat was much better!)

Although several specialists, drawn from the hangar, will accompany the flight, it is still necessary to load bagged shingle ballast into the front hold, to enable the aircraft to explore the full Centre of Gravity (CG) envelope – and beyond.

Preparations for flight

The aircraft departs from the engineering base. It is fuelled to the maximum tank capacity to ensure that the 4+ hour schedule can be completed (a typical commercial flight time was only 3.5 hours). Catering is ordered (just tea and coffee and some sandwiches) and stowed in No 1 galley. Paperwork and briefing complete, the operating crew ready themselves and the aircraft.

The flight test schedule requires several different operating heights and operating speeds, to ensure that each part of the flight envelope is tested. This means that airspace clearance and control would be unusual for air traffic control (ATC). Crew will therefore meet well in advance of the flight, to go through the flight profile in depth.

Pre-take-off testing (additional to the normal pre-take-off checklist) involves the following tasks:

- Testing of crew seats for operation
- Engine power indication
- Take-off configuration warning
- Manual control of the engine intake ramps and spill doors
- Testing of wheel brakes and nose wheel steering using emergency hydraulic "Yellow" system.

Pre-flight preparations
Concorde G-BOAB being fuelled in readiness for a C of A test flight.
Photo: David Macdonald

(Concorde has 3 systems – Blue, Green, and Yellow – with pressure supplied by 6 engine-driven pumps, and an emergency RAM Air Turbine (RAT) – see below.)

Staying ahead of the game is vital. For example, preparations for cabin pressure tests begin before take-off, so that 25 minutes later we can move into them without delay.

Take-off

Take-off from LHR follows the normal procedures for routine flying, but with some additional checking of engine control features designed to increase the low pressure RPM (N1) power at idle throttles once we are airborne.

The unique feature of holding back #4 engine to 88% N1 until the aircraft reached 60 knots is tested, to confirm an engine design need to limit high engine RPM at low airspeed.

The aircraft is flown between predetermined waypoints, with testing completed along the route.

Subsonic testing phase 1

Standby instruments

With the aircraft trimmed to a centre of gravity (CG) of 54.5%, using fuel transfer managed by the Flight Engineer, the aircraft accelerates to the Vmo (Velocity Max Operating). This test is performed at between 15,000–20,000 feet; its purpose is to test the standby instruments for accuracy against the Air Data Computers. Standby instruments are designed to function using only sensors and piping attached to the skin of the aircraft (such as the famous nose pitot probe).

Testing the indicated airspeed system (IAS) means trimming engine power with the flying controls set for level flight at the maximum safe airspeed for that altitude.

Air Data Computers and flying controls – high speed

Individual testing of the speed warning systems provided by the two Air Data Computers follows. Such is the complexity of the aircraft's fly-by-wire control systems (designed for "fail safe" operation) that individual tests for each speed control and warning are tested, with each Air Data Computer powered down in turn to test the other.

This testing ensures correct control of the outer elevons. It is essential to ensure that the elevons are locked out above Vmo, to ensure no violent movement at high speeds, and re-engage them once the aircraft has decelerated below the maximum operating airspeed. Testing of the middle and inner elevons for smaller scales of travel will follow.

Concorde
FLIGHT CREW OPERATING MANUAL

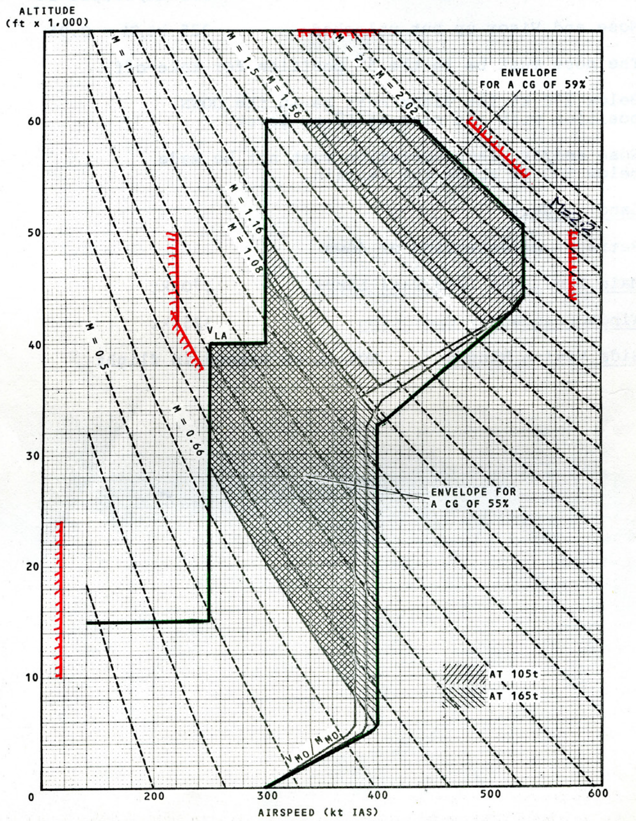
OPERATING LIMITATIONS

Vol.II.01.01.09
Jan 15/76

AIRPLANE GENERAL

MACH/CG

Mach number limitations vary with CG position and, to a lesser extent with weight, (see pages 01.01.05 and 01.01.06). For example, the envelopes associated with supersonic and subsonic cruise, at CG positions of 59% & 55% Co respectively, are shown on the following figure:-



Failure Cases

The limitations are given with the associated procedures.

Flight envelope

A page from British Airways' Concorde operating manual. The thick black line shows the normal flight envelope. The hand-drawn red lines show the highest, fastest, and slowest that Concorde has ever flown during factory certification testing, 1969–75. *Source: David Macdonald*

The artificial feel placed on the controls with the increase in speed is tested, as well as the indicated airspeed warning on the airspeed indicators.

Concorde operates at maximum allowable speed – not a bit under, but at maximum. To protect against control reversal at very high speeds in the vicinity of Mach 1, the outer elevons are driven to a zero-degree neutral position. This function is checked by accelerating to 40 knots beyond the normal high speed limit, noting the "plus 6 knots over speed warning". This is a duplicated system; both systems are checked.

Rubber jungles

Whilst the above systems are under test, the aircraft is being progressively de-pressurized as part of the process of climbing. Oxygen for all will soon be needed!

The cabin excessive altitude warning (10,000 feet) will sound and flash on the central master warning panel on the centre console glare shield.

Next, the passenger cabin will soon look like a rubber jungle of oxygen masks; all 4 air groups that provide fresh conditioned air into the cabin are turned to OFF, and at a cabin altitude of 14,000 feet, passenger oxygen system breathing masks deploy above each seat row, cabin crew seats, and all toilets. Warnings, operational indications, and announcements are tested. (The passenger address system auto-announces what to do when the passenger oxygen is deployed.)

Oxygen supply
Flight test engineers John Allen, Pete Holding, and Mike Addley wear bone domes, oxygen masks, and parachutes on an early Concorde test aircraft. Oxygen masks were also needed for the de-pressurization testing phase on C of A test flights.
Photo: David Macdonald

As soon as it is safe so to do, our on-board tech staff will check that all oxygen masks have deployed and, as a matter of honour, will re-stow 100+ masks, all before landing.

Aircraft/engine performance and low-speed relights

Two performance climbs are conducted with the utmost accuracy. During development and certification testing, every four-engine aircraft type must demonstrate an ability to achieve a particular climb gradient following an engine failure during take-off at maximum weight, and similarly to maintain a climb gradient on two engines in prescribed circumstances. Data gathered from our two tests is used to calculate what those critical gradients currently are and whether in-service deterioration has occurred.

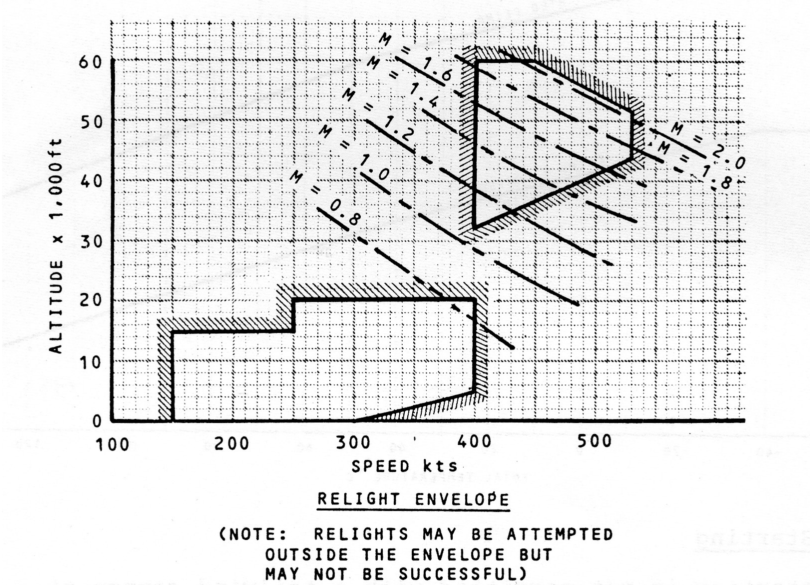
First comes the take-off case: with one engine shut down, the remaining three at reheated take-off power, landing gear up, nose at 5°, beginning at 5,000 feet, and flown at 215 knots precisely for 3 minutes. (Note: 215 knots is an extremely low "high drag" speed for Concorde.)

Second is what may be termed an "en-route climb". Beginning at 10,000 feet, the configuration landing gear up, nose and visor up, two engines on the same side are shut down, with the others at maximum continuous power, and reheats off. The climb is flown at Vmo, 400 knots at this altitude, for 4 minutes.

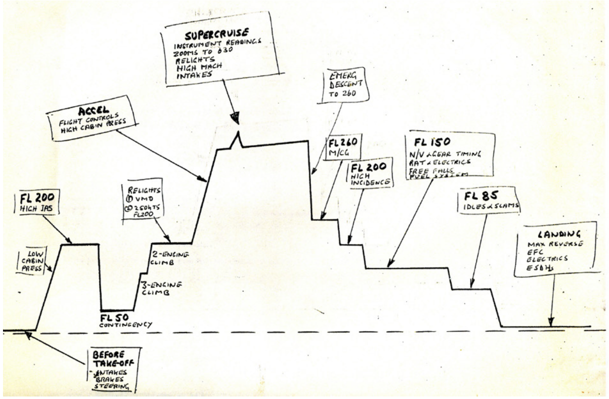
On each climb the aircraft must be flown on a constant heading, clear of cloud and with anti-icing systems off. Weights, altitudes, trim settings, temperature, and engine data are recorded.

Engine relights

Relighting the engines come next. Generally, on any aircraft type, it must be demonstrated that an engine can be relit at any point in



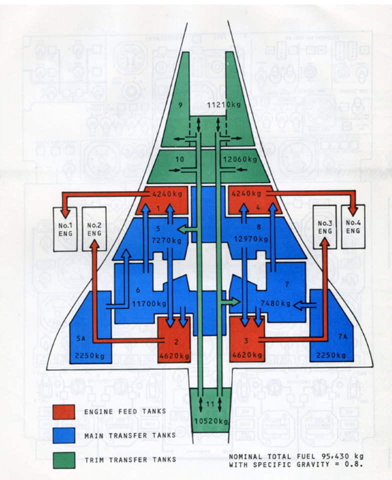
Relight envelope
A page from the BA flight operations manual showing the "relight envelopes". On most aeroplanes the engines must be able to be relit at any point in the flight envelope, whereas on Concorde, uniquely, you can relight either high and fast *or* low and slow, but there is a big gap in the middle.
Source: David Macdonald



Flight profile
A flight profile hand-drawn by David Macdonald for the C of A renewal ahead of one of the early flights; the pilots liked to have a profile to hand. *Source: David Macdonald*

the flight envelope. For Concorde there is an extended transonic region where shock waves are developing, but have not reached a point of stability, and in which a relight cannot be guaranteed.

Each engine is relit in turn, looking at the edges and corners of the relight envelope to verify no deterioration. No. 1 engine relight test is conducted with speed still at Vmo. For No. 2, speed is reduced to 250 knots and height set to 20,000 feet. These two tests seek to establish satisfactory relights at the high-speed and then the low-speed edge of the relight envelope. Records are made of time to light-up and time to reach idle RPM. Each engine's exhaust gas temperature (EGT) is checked and recorded, to make sure that the engine is not getting too hot; EGT must not exceed 550°C.



Concorde fuel tank layout
Engine feed tanks are shown in red, main transfer tanks in blue, and trim transfer tanks in green.
Source: David Macdonald

Supersonic testing

Starting

Start over the usual supersonic transition point, close to Lundy Island

Prior to starting this test, the aircraft's CG must be managed to within a 3% operating margin (55%–58%). This task is managed by the Flight Engineer operating the trim tank fuel pumps, thereby moving the fuel across the centre of gravity between tanks 9, 10, and 11 (known as trim tanks). This is a manual process. It is a clear safety requirement to maintain the centre of gravity and centre of pressure in equilibrium and between a defined margin as the aircraft accelerates; if this is not achieved, the centre of pressure would move rearwards, resulting in an excessive amount of nose-up trim and associated high drag that would preclude further acceleration beyond Mach 1.15.

Aircraft acceleration flying control tests and maximum cabin pressure testing

And so to the acceleration and Mach 2 with flying control checks on the way. Did we remember to set the cabin altitude down to sea level after the rubber jungle, in preparation for max differential checks? Yes we did! There are systems in place to prevent the cabin structure from being overstressed in the event of pressurisation malfunctions, and these systems are tested at this stage of the flight.

The first test undertaken is for supersonic climb acceleration whilst flying at Vmo, to test flying control systems. The test schedule describes the procedure as a "normal supersonic acceleration" – in other words, a routine element of any Concorde passenger flight. Reheats are applied two at a time: inners (numbers 2 and 3), then outers (1 and 4). The shock wave passing over the speed and altitude sensors causes a brief pressure blip on the instruments.

Tests include auto-stabilisation, artificial feel system tests (two of each are fitted, both being needed due to the flying control loads and speed of flight), and testing of the 3 discrete flying control systems, one at a time. (Two of these systems are fly-by-wire signalling, known as the blue and green control systems; the other is a mechanical signalling system using linkage and electrical sensor.) When these tests are started, most other aircraft would be at their cruising height!

44,000 feet maximum cabin pressure testing

There are two cabin pressure control systems and both must be tested. The test ensures that the controllers individually control the pressure to no more than 11.1 PSI. This is significantly more than for subsonic aircraft; Concorde's cruise altitude of up to 60,000 feet means that the airframe is designed to withstand much higher differential pressures.

Next comes the overpressure warning. This involves shutting down 2 of the 4 air conditioning groups (systems) that provide air into the cabin and then testing 2 discrete systems that protect the cabin from over-pressure. One system warns you at 11.4 PSI, and the other safety valve controls at 11.6 PSI. You must never go over 11.7 or damage may well occur.

Captain's instruments
The airspeed indicator is seen in the top row of the panel, second from left, with the striped needle clearly visible.
Photo: David Macdonald

Turn left at the end of Cornwall above 51,500 feet, level flight at Mach 2

Flight instrument and CG readings

Here we record flight instrument readings – Captain's and Co-pilot's altimeters on both normal and standby feeds, the standby airspeed indicator, both main airspeed indicators on normal and standby feeds, plus their Vmo readings.

Looking at the flight envelope, Vmo begins at 300 knots at sea level, increasing to 400 knots by 5,000 feet, then holding at 400 knots until 33,000 feet, then out to 530 knots between 44,000 feet and 50,000 feet where it becomes Mach 2. This profile is calculated by the Air Data Computers and presented as a striped needle on the airspeed indicators.

Finally, Centre of Gravity (CG) readings are taken from each of the three CG computers. CG is vital information, hence a triplicated system. Before flight the Flight Engineer will have inserted weight and payload data into the system. The three CG computers are pre-programmed with the moment arm of each fuel tank; thus, feeding the instantaneous readings of all 13 tanks to the CG computers will enable CG to be calculated. The fuel quantity indicators (FQIs) have a duplicated system of measuring probes; sharing duplicated quantity information between these and a triplicate CG system created initially quite a few in-service headaches! (Note that the fuel tank architecture is designed to keep the aircraft in equilibrium with fuel loads forward and aft of the centre of gravity at any given time of flight; this maintains the CG to a operation tolerance correlated to speed.)

Zoom to above 63,000 feet (just under 12 miles high) flying NOT less than Mach 1.5 high altitude and low speed – refer to the flight envelope

There follows a beautiful little corner of the high speed/high altitude envelope; the reader should keep a finger on that graph. The top of the authorised envelope is 60,000 feet; we are going to use the aircraft's weight and speed to "zoom" climb ("zoom" is a technical term in the Mach 2 world), pop out of the top of the envelope, and note that the stick shaker operates at 63,000 feet. (Yes, the same stick shaker that traditionally warns of an approach to the stall, only this time all it wants you to do is to descend back to where you should be).

Back inside the envelope and after the shaker has stopped, take a deep breath, throttle the engines, and slide gently out of the left-hand side of the envelope towards 260 knots to check that once again the stick shaker fires off. This time it is telling you that you are going too slow. Recover by pushing the nose down to just over 6° pitch attitude and accelerate; note that the shaker stops **and the high speed warning begins!** How can that be? Well, 150 tonnes of Mach 2 aeroplane has such a lot of energy, and stuffing the nose down without a care could get you into trouble.)

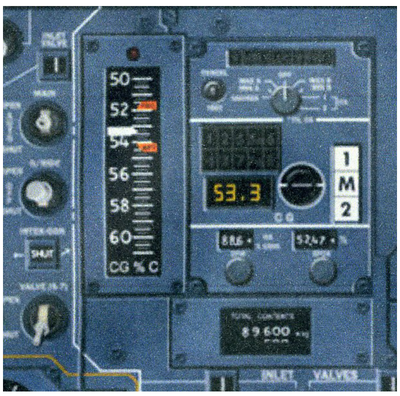
Now do it all over again using system 2.

More engine shutdowns

The aircraft is accelerated back to Mach 2. Now, no. 4 engine is shut down using the high pressure (HP) valve (fuel shut-off switch).

The response is quite unusual. A yaw and rolling action to the right would be expected; however, corrective rudder is applied automatically, thus minimising yaw, and – although not part of the test – we observe the wings rolling in the opposite direction, to the left. This latter feature is due to the intake spill door, in the floor of the intake, opening and dumping unwanted air – air that has been compressed by passage through the intake shock waves and the convergent nozzle formed by the front intake ramp. (This is unique in supersonic flow; a convergent nozzle means pressure increase.)

The aircraft is decelerated to 400 knots, the very edge of the relight envelope, to check satisfactory engine 4 relight.



CG readings
A detail of the Flight Engineer's fuel panel; the vertical gauge shows the CG as a percentage.
Photo: David Macdonald

This segment is repeated with no. 3 engine shutdown and with system no. 2 auto rudder in play.

High Mach number warning

This task completed, the testing continues by re-accelerating to Mach 2. On some of these occasions, NATO fighter aircraft would enter Concorde's airspace having used Concorde's test schedule to practice interception procedures. Look out for military aircraft practising intercepts when testing for high Mach number warning!

To complete the high Mach number warnings, the aircraft is positioned to be level at 55,000 feet, the circuit breaker for overspeed warning no. 2 is tripped out, maximum continuous power is applied, and in a shallow descent we push gently out to Mach 2.1 but NOT to exceed 535 knots. Record the Mach number at which the overspeed warning occurs, taking the reading from the Captain's Mach meter. "Gently" is very much emphasised; the intakes are reaching their limit of control.

At this point we focus on the low pressure compressor RPMs (N1s), looking for N1 auto reduction – a slowing down of the LP compressor to prevent a shock wave array being drawn towards the engine, to prevent flow distortion and engine surge. Note that if the upper atmosphere is a little warmer than usual, the overspeed warning may occur at a total (on the nose) temperature of 134°C plus or minus 2°. Once again the test is repeated, using system 2 and taking the readings from the Co-pilot's Mach meter.

Going weightless

Supersonic testing continues with tests on the intake control system. These tests require the aircraft to be side-slipped at Mach 2, checking that the engines do not surge. A further unusual manoeuvre follows: pulling up, followed by a push-over of the control column, causing a period of weightlessness. Once again, no engine surge is allowed.

At this point supersonic tests have been completed.

Looking out of the flight deck you can see all of Portugal; turning right to come home, the aircraft has a turn circle of 250 miles!

Emergency descent

The emergency descent has no particular significance. It is simply a quick way of getting down for the next tests and a bit of practice for the pilots.

The procedure involves pitching down to 5.5° until 50,000 feet, then reducing pitch attitude to zero degrees to contain the speed within the flight envelope, then at 40,000 feet descending at Vmo, the max operating speed for lower levels, whilst bringing the CG forward quite quickly, using the fuel transfer override switch. Aircraft handling is assessed on the way down.

Subsonic testing phase 2

Below 10,000 feet above the English Channel, usually close to the Isle of Wight

Centre of gravity (CG) limits

After the deceleration and descent, the forward and aft CG limit warnings are tested. Concorde's CG is a dynamic thing. It is varied by crew action from 53.5% to 59% and back. (See "Supersonic testing", above.) The aircraft cannot achieve Mach 2 with CG at take-off position, and cannot be landed with CG at supercruise setting. During acceleration and deceleration the CG must be maintained within a defined – at times a fairly narrow – corridor.

For the aft limit, CG is set to 56.6% and the aircraft decelerated out past the aft limit to check both a red warning and operation of the stick shaker. (Yes – the same shaker that warned of going too high and going too slow at the high-speed end of things!)

Finally the stick shaker gets to do what we have always expected it to do: warn of too high an incidence. The generic term is "stall protection", although Concorde does not stall in the conventional sense. Nevertheless, the atmosphere in the flight deck does become a little more tense as speed is reduced at 1 knot per second, angle of incidence increasing – the stick shaker triggers at 16.5° – then even less speed, and even more incidence, until finally the stick wobbler, a sort of muted stick pusher, kicks in at 19°. At this point enough is enough; we draw comfort from knowing that real test flying proved the wing capable of controlled flight down to 119 knots.

Low-speed stability and warnings are verified "clean", with nose and visor and landing gear in the "up" position, and then again in the landing configuration – gear, nose, and visor down.

Emergency systems

This series of tests involves timing the nose and visor emergency "free fall" operating system, checking the Ram Air Turbine (RAT) deployment (the RAT supplies emergency hydraulic pressure), and then testing emergency landing gear extension. The latter test is scheduled last, as it results in losing a quantity of "Yellow system" hydraulic fluid as part of the process!

Landing gear and nose/visor systems each have 3 ways of being set to the down positions; they will all be tested. First to be tested are the Normal systems, using the Green hydraulic systems, then Standby Lowering, using the Yellow hydraulic system, and finally 'Free Fall' – entirely mechanical. The visor will be lowered and the nose set to 5° by operating a lever on the right-hand side of the centre console.

Ready for testing
A BA Concorde fresh from a Major check is prepared for C of A testing.
Photo: David Macdonald

For the landing gear, the Flight Engineer will locate and lift two squares of carpet, one in each cabin, to reveal the access panels to the landing gear free-fall controls. You may have wondered what two sets of red and green spots on the overhead hand baggage racks were; when time is of the essence, they indicate where the free fall panels are located.

To lower the nose gear, a rotary handle is rotated seven and a half turns – those inside the aircraft will clearly hear the doors opening and gear dropping into the slipstream. In the rear cabin a larger panel has a rotary control to isolate the hydraulics, and then a big lever to insert into a socket; a substantial heave to starboard will pull the upper locks open, allowing the gears to fall and push open the doors as they go. From leaving the flight deck to achieving 3 greens (gears locked down) should take about 2 minutes 45 seconds.

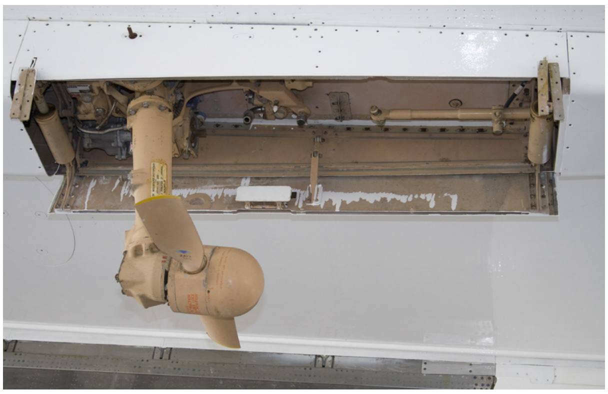
Landing gear free fall is always conducted close to Heathrow. If the flight has gone well and the aircraft is fully serviceable, then we reset the free fall controls to Normal and carry out a normal extension prior to landing. Resetting to Normal whilst airborne is quick and easy, whereas on the ground, in the hangar it is a protracted affair; either way it dumps half the Yellow hydraulic system contents, hence the precautions.

Concorde has an Emergency Lowering Ram Air Turbine (RAT). We check output from its 2 hydraulic pumps and their ability to power flight controls and the standby, hydraulically-driven electrical generator. Deployment is by one of two explosive bolts; thus, it cannot be retracted.

Idles and slams

The last tests before landing are tests on the fuel system cross-feed and engine electronic controls. These are performed at 8,500 feet, flying at approach speed (typically 155 knots) and with the independently variable low pressure compressor and primary nozzles set to a value that reduces noise.

Each engine in turn is set to idle, RPM is noted, then it is throttled up briskly to achieve maximum engine acceleration from idle to 100% RPM within 8 seconds. This test establishes that engine response during a go-around is satisfactory.



Ram Air Turbine (RAT)
The RAT is seen in its “deployed” position under the starboard wing.
Photo: David Macdonald

Landing

An auto-land is completed as required, although not mandated as part of the C of A.

The reverse thrust system is also tested to the fullest extent (beyond the usual selections), to test reverse N2 (and thus stopping power); this is required as a C of A test.

Post landing

On the ground, after landing, there are two final checks:
(1) Emergency Flight Control – a force sensor in the Captain’s control column responds to the force being applied should the column jam (a sort of “fly-by-thought”!).
(2) Each engine is finally shut down using the emergency shut-down handles. The same action also closes fuel LP valve, hydraulic shut-off valve, air bleed valves, and the nacelle fire flaps.

All the above is completed whilst performing the normal flight activities such as ATC clearances, fuel management, and the many duties completed on the Flight Engineer’s and pilots’ control panels.

Such is the nature of flight testing that the additional crew complement is indeed necessary!

Concorde Memories

Former Concorde engineer Philip Cairns recalls the trip of a lifetime as he accompanied Concorde on the inaugural charter flight to a highly unusual destination: Greenland.

My name is Philip Cairns, and I was a Licensed Aircraft Engineer (LAE) working for British Airways on the Concorde fleet. My authorisation covered Airframes and Jet Turbine Engines.

At work
Author Philip Cairns with Concorde at Heathrow.
Photo: Philip Cairns

Concorde did quite a lot of charter flights, and if it was sent to a destination that did not have an engineer with Concorde cover, the Concorde Control Centre would ask a Heathrow-based LAE to go with the aircraft to carry out the necessary transit checks at the foreign destination.

Preparing the way

In 1996 I was asked to go to Greenland to do the Concorde turn-round at a place called Kangerlussuaq. This would be the inaugural flight to Greenland, so I was thrilled to be asked. The charter was to take 100 passengers to Kangerlussuaq and bring back a further 100 passengers who had spent several days there.

I asked my manager if anybody had checked that the airport in Greenland had all the necessary equipment to handle a Concorde – steps, ground power, air starts, and the like. I was assured that a qualified person had been out there and checked that everything that was needed was there. I said that I was very happy to go as this involved me going with the aircraft there and back.

On the day of the trip, I seem to remember that our take-off time was around noon and that we would arrive in Kangerlussuaq before lunch, local time. I was delighted to be given a seat on the flight deck and would be able to see how the aircraft performed.

With all the passengers safely aboard, we left the stand for the short taxi to the runway. Take-off was brilliant as usual, and we were soon asking Shannon air control for permission to go supersonic. I'm a bit hazy about the flight time, but roughly 3 1/2 hours later we were on approach to the Kangerlussuaq runway, flying down a fjord with large hills on either side. The Captain told me that we would go out the way we had come in, saying there were mountains in the opposite direction that could get in the way of take-off. The Concorde was brought in to land beautifully, and the crew received applause and cheering from the passengers.

Creative problem-solving

The taxi to the terminal was stopped short, about 400 metres from the normal arrival finger, as the aircraft had to be towed by a tug into the departure point so we could refuel and Concorde be turned without the blast from her engines affecting the airport buildings. Aircraft steps and coaches arrived to remove the passengers from their epic trip and to take them to immigration and then on to their destination. In the meantime a tug and tow bar arrived, along with a Danish engineer who spoke good English.

The tow bar was a Boeing 707 type which, turned upside down, would fit a Concorde towing point. However, this tow bar turned out to be a military equivalent off a KC 135. It was heavily reinforced, and some of the stout brackets would not allow it to be fitted to Concorde. The Danish engineer said he would modify the tow bar and it would not be a problem. However, I couldn't refuel the aircraft or do all my checks without power being on; this would only be achieved after repositioning Concorde over the fuel hydrants, when a fuel bowser could then pump the fuel on to the aircraft. This problem could easily have led to an overnight stop.

The Danish engineer had to cut the heavy metal off using a gas acetylene torch. This he did twice, and then we were able to fit the tow bar and at last move the aircraft to the refuel hydrants. Ground power was then applied. The flight engineer came and told me the aircraft had arrived with nil defects, which is always good to know. I had done the aircraft walk-round previous to moving the Concorde, but I could now check the engine fronts and backs, check oil levels on the engines, and do all my other checks.

Pre-departure checks

The engineer stayed with me as he was keen to help in any way possible. I had started the refuel and so could leave my friend looking after the gauges whilst I finished my checks.

The cleaners had done a good job on the interior, the toilets had been serviced, and the catering company were waiting to replace all the food and drink trolleys. I had checked the flight deck instruments and gauges for serviceability and found that Green hydraulics needed topping up. We carried spare oil in the rear freight along with the manual pump gun for putting on the oil. The fuelling was almost complete, so I decided to do the hydraulic oils when we had finished. I had a nice plus on the fuel figures; the flight engineers were always happy with a little extra fuel, so I filled in the Tech Log with all the appropriate figures, and with the flight engineer happy with aircraft I signed the Tech Log to say that all was serviceable. I topped the hydraulics up. All was now complete, and with the passengers arriving we got ready to start the engines and connect the air starts.

My Danish engineer friend was happy to do the start-up, and as the Concorde would safely taxi away from its position I could remove my steering pin. I briefed my friend about engine start-up and all the other checks that had to be completed before the aircraft departed; with that done I said my farewells and thanks for his wonderful work, and then got on to the flight deck for the return journey home.

The crew were ready to go and all passengers in their seats, along with the cabin crew who always do a fantastic job on these charters. Nos. 2 and 4 engines were started, followed by 1 and 3 with the ground power disconnected, and all doors checked shut; then the Danish engineer waved us off.

The take-off was amazing. As we roared up the fjord all went well, and as we flew down the west side of Greenland we could accelerate almost straight away towards Mach 1 and ultimately Mach 2. The journey home was extremely smooth and high. The passengers had had a super time, having had on their last day a barbecue by a lake with an orchestra playing nearby.

We arrived home late at night local time, as the time difference between the two countries is 5 hours. I seem to remember getting into Heathrow around 10.30 pm. What a day. It was incredible – across the Atlantic twice in one day. This can only be done on Concorde – but no longer for civil passengers, I'm afraid. The trip to Greenland was done again by another engineer later the same year, but it remains a lasting and distinctive memory of my 37 years on this remarkable aircraft.

New territory Concorde G-BOAA with passengers at Kangerlussuaq airport, Greenland, on the inaugural Concorde visit, June 1996. This photograph was taken by one of the passengers on the trip. *Photo: Christian Fuhrhop / http://www.grimble.de/Snapshots/addons/greenland.html*

CONCORDE WATCH

Concorde G-AXDN

British pre-production aircraft

Location: Imperial War Museum, Duxford, UK
Reporter: Katie John **Date:** 12 August 2017

On 12 August 2017, three Concorde preservation groups came together at Duxford, to view the work that has been done on Concorde G-AXDN in the last couple of years and to share news and information on their own projects.

Exterior view
An exterior shot of G-AXDN. The black wing markings were used to help pinpoint areas of ice build-up.
Photo: Graham Cahill

The hosts for the day were the British Airliner Collection/Duxford Aviation Society, who have responsibility for Concorde and the other airliners at Duxford. The team comprised Steve Jeal, Vice-Chairman of DAS; Chrissie Eaves-Walton, DAS Director of Marketing and Communication; and David Norman, DAS Commercial and Marketing Manager. Graham Cahill, John Dunlevy, and Peter Ugle of Heritage Concorde, who have been carrying out the work on G-AXDN, were to show us round the aircraft.

Inter-group co-operation

The largest group of visitors was "Foxie's Filton Flyers", the team of former volunteers who ran the "Concorde at Filton" display featuring Concorde G-BOAF. This group of passionate and knowledgeable volunteers, including people who helped to build and operate the Concorde fleet, were extremely keen to share information with the Heritage Concorde team, who also include former BA Concorde engineers (Peter and John). Also in attendance was James Cullingham, from the team at Brooklands who maintain Concorde G-BBDG, and Fred Finn, holder of the Guinness World Record as Concorde's most frequent passenger, who is keen to use his influence and connections to raise public awareness of the Concorde museums.

Graham Cahill, head of Heritage Concorde, opened the proceedings. His introduction was followed by a talk from David Norman, who outlined the history of G-AXDN from the day of her arrival at Duxford on 20 August 1977 – almost 40 years ago to the day.

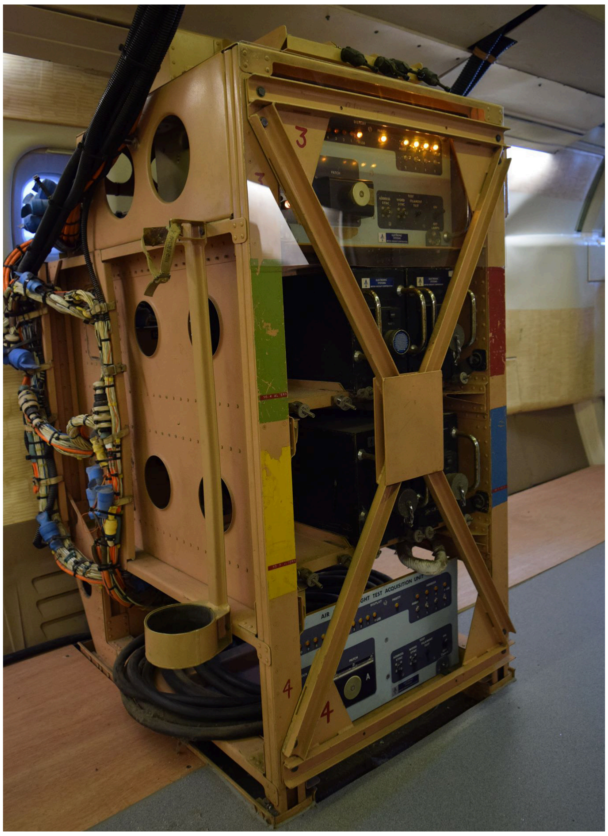
Paul Evans, head of the Filton group, thanked Graham and our DAS hosts for organising the day. Graham made the point that teamwork is vital: the various Concorde preservation projects are continually improving as more information is shared between the groups.

Recent restoration work

We were then taken to look round Concorde G-AXDN. After the extensive work done to restore the aircraft and return some systems partially to life (see previous issues of Mach 2), the latest jobs have been done to showcase how the aircraft would have looked while in use for test flights.

The forward cabin has been cleared so that the flight test instruments and the escape hatch are shown to their best effect. Lights are active on the flight test panels, and sections of wiring are displayed behind Perspex. DAS have created replicas of the flight test cabinets in the aft cabin, and of the panels on the flight test observer's station. DAS have also created a replica of the hyposcope (the instrument used to view the underside of the aircraft

Restored to action
Left: the original red "evacuate aircraft" light. Right: the monitors that were originally used to view ice build-up during flight, now set up to show a film about this work.
Photos: Graham Cahill



Zonal units
Above: replicas of the zonal units (test data units) have been constructed by the Duxford Aviation Society.
Photo: Graham Cahill

Digital control test units
Left: rack containing the intake computers and data acquisition units, first used to test the digital control of the intakes on Concorde. The black boxes at the centre are the intake control computers. The top and bottom units are intake test acquisition units, which acquired test data from the intake systems and computers and sent the information to zonal units in the cabin.
Photo: Graham Cahill

directly while in flight) and of the "ice desk", originally used to monitor ice build-up on the aircraft during flight; the latter includes TV screens (replicas of the original CCTV) that show a brief film about this work.

The rear cabin has been fitted with 10 basic seats, which would originally have been used by the flight test crew.

We were allowed access to all areas of the aircraft, and DAS and Heritage Concorde allowed their visitors to inspect G-AXDN in minute detail; at one point, James Cullingham disappeared through a hole in the cabin floor so he could explore the baggage hold!

Fuel panel
The dials for the fuel panel, in the underside of the aircraft. Duxford had never opened the panel until Heritage Concorde requested this, and the group has now restored and relit the dials.
Photo: Graham Cahill

I was highly impressed by the attention to detail about this unique period in Concorde's history. As one example, Graham showed us a solid steel bar that had been made especially for the ferry flight, to operate the air intakes instead of the actuators normally used during flights.

We also viewed some of the exterior touches that have brought G-AXDN to life, including the lights inside the rear of the engine bays, and – most exciting – a replica of the sound of Concorde's Olympus engines starting. (Listening to this recording, we could almost smell the jet fuel!)

Even the smallest touches were fascinating. There is a cut-away model Concorde displayed underneath AXDN; Paul Evans noted that this model showed the toilet fittings that had been designed for the "Project Rocket" refurbishments of the in-service Concordes in the early 2000s.

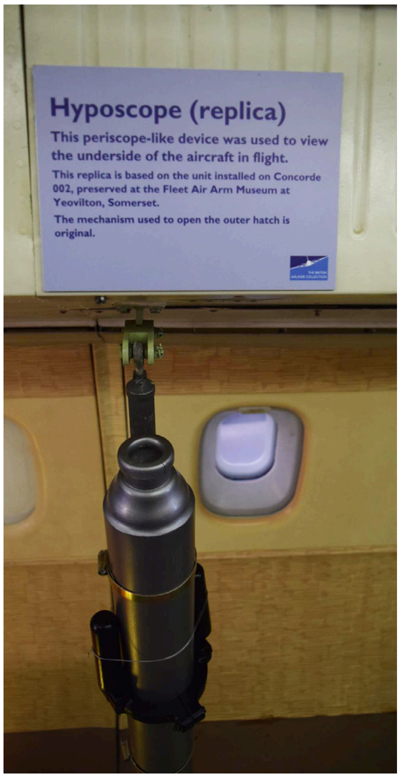
As a bonus, DAS showed us around the York, Hermes, and Comet – other airliners on display in the AirSpace hangar.

Lunch allowed people to relax and share their stories about Concorde, from Doug Newton's accounts of working on test flights in the early days, to James and Graham comparing detailed notes on how to re-activate various Concorde systems for the current museum exhibits. During the afternoon, we were treated to tours of other airliners in the DAS collection, including the VC-10, BAC 1-11, and Britannia.

Nose and visor move

The day ended with a demonstration of G-AXDN's nose and visor moving and lights in action, with commentary by David Norman of DAS. The aircraft gleamed as though she had only just arrived. The droop snoot and lights worked flawlessly. Past and present came together to bring history alive for future generations.

For further information, visit the following websites:
http://www.heritageconcorde.com
http://das.org.uk



Hyposcope
A replica of the hyposcope, an instrument used to view the aircraft exterior directly during flight.
Photo: Graham Cahill

Nose and visor in action
The team at DAS lower G-AXDN's nose and visor in one of Duxford's monthly displays for visitors.
Photo: Graham Cahill

Concorde G-BOAF

British production aircraft

Location: Aerospace Bristol, Filton, UK
Reporter: Nigel Ferris **Date:** 24 September 2017

Nigel Ferris reports on the condition of Alpha Fox and the other exhibits at Aerospace Bristol, as the museum nears its opening day.

The 16S hangar (the World War 1 hangar containing items from BAC, including missiles and satellites) has been restored very well inside, with good brickwork and roof trusses. However, most of the display items are still in plastic wrapping, and the lecterns and construction work around the displays are unfinished. There is a small gift shop on the way in, as well as a café (which we thought would benefit from having some of the BAC's unique photo archive displayed on the walls). We were told that 3 weeks' time was the possible opening date.

Alpha Fox has had some cleaning on the underside; the smell of polish was obvious, and the aircraft was clearly shinier underneath. Standing on the balcony looking down the length of the aircraft, the polished areas could be seen reaching to halfway across the top of the fuselage. Video projections were shown on the starboard side of the fuselage, which had had a polish to make the projections stand out.

We had a speech from Iain Gray, who lauded the efforts by volunteers, and spoke at length about the challenges they had faced over the years of getting the new museum up and running. There is a lot that they can be proud of. He said he thought that the museum would become one of the UK's top visitor attractions.

The work that had been done on the aircraft was less than expected, but efforts had been made so all the members could be the first to see the 16S display.

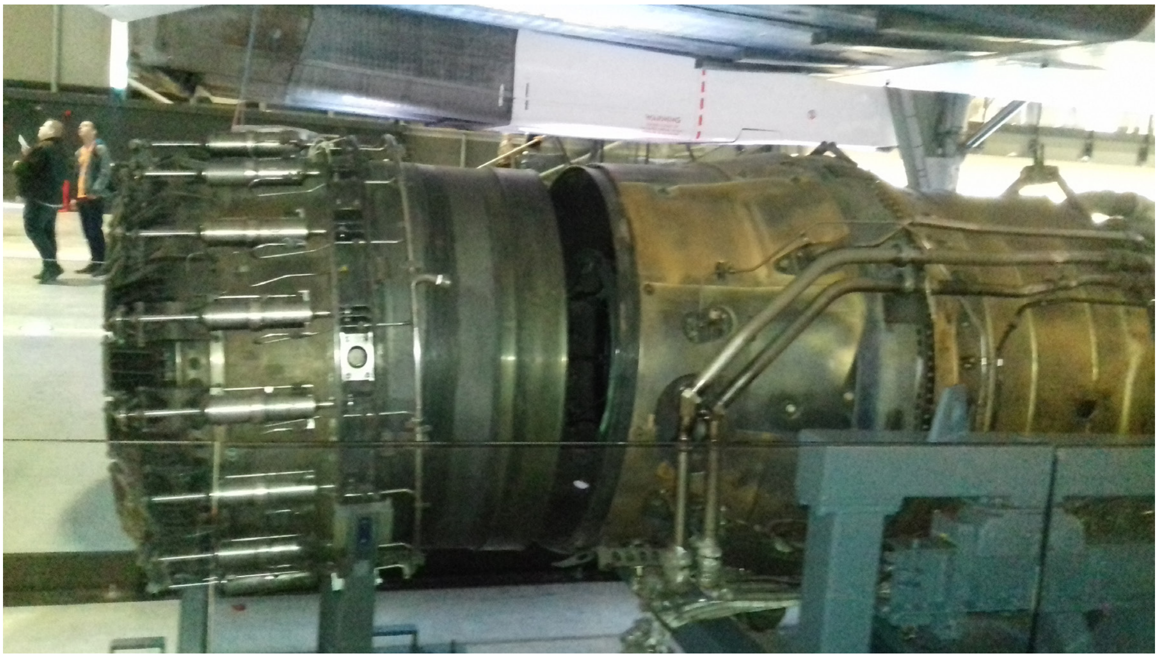
Features of the new Concorde exhibition are shown below and on the following page.

For further information on Aerospace Bristol and confirmation of the opening day, please see the museum website: http://aerospacebristol.org

Multi-faceted display
Concorde's history is presented as a film projected on to the side of the aircraft. Inset: the wing and fuselage, viewed from the balcony walkway.
Photos: Nigel Ferris

Flight deck
The flight deck was accessible to visitors. Former volunteers have noted, however, that the flight engineer's hat – inserted into the side panel during Alpha Fox's last flight – has been removed.
Photo: Nigel Ferris

Olympus engine
One of Concorde's Olympus engines is on display beneath the aircraft. The system of pneumatic rams for operating the primary nozzles has been placed at the rear of the engine.
Photo: Nigel Ferris



Clarification

In the previous issue of Mach 2 (August 2017), in the report on the visit to F-BVFC at Toulouse, our friends at Cap Avenir Concorde wish to make clear that it was Jean-Michel Rougier who worked on Concorde maintenance for 27 years, not Hubert Protin.