Flight test

The feel of a fighter
7X lives up to its heritage
Fast and easy

Dassault’s Falcon 7X was designed digitally in a virtual environment, but what is the real thing like? Flight International took the controls of the business jet to find out.

PETER COLLINS / BORDEAUX
If you wanted to buy a new business jet that could fly from London to, say, Singapore non-stop at Mach 0.80, until recently your decision would have been between the Bombardier Global Express XRS and the Gulfstream G550. Now there is a third choice – the Dassault Falcon 7X.

But you will have to wait for delivery. By 27 April, the day on which the 7X received joint European and US certification, the company had booked more than 165 firm orders for the aircraft and the waiting time, for an order placed today, is four years. Dassault’s aim is to capture 40% or more of the long-range business jet market.

The 7X is an all-new design, and the development and certification flight-test programme took 22 months from mid-2005, involving 590 flights totalling 1,600h. European Aviation Safety Agency and US Federal Aviation Administration certification pilots joined Dassault test pilots on more than 25% of all flights.

Production rate at Merignac is set to be three aircraft a month initially, but that is expected to increase. Falcon 7X cabin completion will be performed at Dassault’s Little Rock, Arkansas plant and pilot training centres with Level D simulators have been established by CAE at Morristown, New Jersey and Burgess Hill, Sussex in the UK. Dassault expects 50% of sales will go to the USA and 50% to the rest of the world, with Russia emerging as a major market.

An opportunity to evaluate the 7X came with a flight at the controls of aircraft number 3 as it was ferried from the Dassault test centre at Istres to Bordeaux Merignac for the joint EASA/FAA certification ceremony. A visit to Dassault’s design centre at Saint Cloud in Paris provided background on the programme.

The 7X was launched at the Paris air show in 2001. Key design drivers were long range, around 11,100km (6,000nm) with NBAA IFR reserves, a high level of passenger comfort, low direct operating costs and high dispatch availability. The complete manufacturing process was to be controlled by the Catia three-dimensional design environment developed by sister company Dassault Systemes.

For the two years after launch, Dassault gathered together its seven airframe partners and 15 system partners from Europe, Canada and the USA in Paris to refine and define the physical design using Catia workstations. The partners then returned home in 2003 to design and manufacture their respective parts, but remained linked to the product-definition database and kept in lockstep with each other via a Catia virtual-reality centre at St Cloud.

Dassault says the 7X is the first transport-category aircraft to be completely designed in virtual reality. Catia reduces waste and improves manufacturing accuracies, the company says. There is no engineering mock-up and no prototype or pre-production models. Three of the four aircraft in the certification programme are already sold to customers. On the day of certification the complete 7X manufacturing process was regarded as “mature” by Dassault and the company is close to its commercial break-even point based on orders.

Not only does Catia act as the standardised design environment throughout the manufacturing process, it is also used in other ways: to design the assembly tooling ergonomically; to optimise component accessibility by modelling maintainers’ bodies and actions; and to produce virtual-reality depictions of cabin interior options. All maintenance documentation is to be electronic, web- or DVD-based and Catia controlled and standardised.

Dassault currently builds the Falcon 2000DX, 2000EX, 900DX and 900EX. All production Falcons feature the same EASy...
Cover story

integrated flightdeck as the 7X. Dassault’s own design, the EASy cockpit is based on Honeywell’s Primus Epic integrated avionics. Controlling the flightdeck functionality, rather than using an off-the-shelf solution, has allowed Dassault to offer a common cockpit across the Falcon range, and any pilot moving up to the 7X will be familiar with the avionics and require only differences training to gain a type rating. The EASy flightdeck was first certificated in 2003, but remains a significant advance in man-machine interface over the cockpit layout in most other modern aircraft.

Clean-sheet approach

In designing a long-range aircraft to compete with Bombardier and Gulfstream, Dassault could have taken the simpler and cheaper option of stretching the 900EX and adding more fuel. But it opted instead for a clean-sheet approach with several major differences and improvements. First is a new transonic wing design allowing a maximum operating Mach number of M0.9, but a reference speed ($V_{REF}$) at landing of around 105kt (195km/h) at lower fuel weights. It is also the first Dassault wing to feature winglets, which were added during development to extend range.

Secondly, the 7X is the first fly-by-wire business jet, with a triplex digital flight control system. The architecture and control laws build on Dassault’s experience developing fly-by-wire systems for its Mirage 2000 and Rafale fighters. The EASy cockpit is now married to a sidestick controller and a head-up display allowing manual Category IIIA ILS landings as well as a forward galley and forward (crew) and rear (passenger) toilets.

The lengthened cabin (11.5m/37.8ft) retains the generous cross-section dimensions of other Falcons (height 1.88m and width 2.34m), but pressurisation is electronically controlled to prevent pressure “bumps”; altitude is maintained at 6,000ft (1,830m) at a cruise altitude of 51,000ft; temperature is held to within 1°C (33.8°F) from floor to ceiling and from front to rear; and internal sound levels are reduced to around 52dB. The number and size of cabin windows have been increased to provide 40% more natural light and the cabin now features a large baggage compartment as well as a forward galley and forward (crew) and rear (passenger) toilets.

The final difference is the improvement in availability, reliability and maintainability through increased redundancy in the system architecture, integrated “on-condition” dispatch and maintenance intervals longer by 30-50% over those for the 900EX (a C check is required only every eight years or 4,000 flight cycles).

Both the Bombardier and Gulfstream aircraft are much heavier than the 7X – the G550 at 41,280kg (91,000lb) maximum take-off weight and the XRS at 44,450kg – and both use two Rolls-Royce BR710 engines derated to around 15,000lb thrust (67kN). Weighing in at 31,300kg, the 7X has three Pratt & Whitney Canada PW307A engines, each developing 6,400lb of thrust (19,200lb total), with the centre engine featuring a thrust reverser.

Aircraft loads

Maximum fuel load is 14,280kg, giving a range of 11,000km at M0.8 with NBAA IFR reserves. Its rivals can go further at M0.8 – Gulfstream quotes 12,490km for the G550 – but require around 18,600kg (G550) to 20,400kg (XRS) of fuel to do it. Typical basic operating weight is 15,510kg, which means the useful payload of the 7X, with full fuel, is around 1,360km and therefore 450kg more than for its bigger rivals.

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Pilot Collins found the EASy cockpit lives up to its name

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eight passengers and full fuel is 1,680m, and the landing distance (unfactored) with NBAA reserves is an eye-wateringly short 670m. The 7X features a new trailing-arm main landing gear, carbon brakes and automatic lift dump, and the aircraft will be certificated shortly for steep approaches into London City airport.

Extended-range operation over water for business jets (equivalent to ETOPS for airliners) is still a complex subject given the regulations under which the aircraft operates: private, charter, commercial, EASA or individual national ones. In the absence of harmonised rules, Dassault is content that a three-engine solution suits its design purposes in terms of performance, redundancy, noise footprint and fuel efficiency.

Dassault also says its centre-engine exhaust reduces overall drag while the three-engine configuration reduces the need for a large flight-capable auxiliary power unit so the APU fitted is small and for ground use and engine starting only. The 7X also features an emergency ram air turbine. Additional enhancements for extended-range operations will be the integration of automatic dependent surveillance – broadcast and controller/pilot data link communications.

Safety pilot for my the flight was Yves “Bill” Kerhervé, Dassault chief test pilot. He would take the right-hand seat and I would fly the complete sortie from the left-hand seat, apart from the flypast at Bordeaux.

We were assisted by Dominic Chenevier, the 7X project test pilot, in the jump seat. I had never flown any Falcon model or operated the EASy cockpit before. My own type rating in the Global Express would give me a means of comparison.

**Cockpit impressions**

My first impression on entering the cockpit was that it was simply the cleanest, neatest, most uncluttered flightdeck I have seen on any large business jet or small airliner. The four large (4in/355mm diagonal) flat-panel displays, arranged in a “T”, truly give a new meaning to the term glass cockpit. The sidestick controller and lack of steering tiller (all steering at any speed is via the nosewheel and the rudder pedals), heightened the feeling of available space and of being in an advanced flightdeck with outstanding attention to the man-machine interface.

Seat height and rudder pedals have electrical adjustment, so it was delightfully simple and accurate to get to the design eye-point position for the HUD without the gymnastics that accompany other more mechanical seats. The sidestick fell naturally to my left hand and, with the adjustable forearm support, the position felt little different to holding the left-hand side of a conventional yoke. The top of the sidestick moves about 7cm in all directions with similar force gradients up to about 3kg at full deflection. The new four-panel front windscreens gave an excellent field of view and the narrow windscreens pillars meant virtually no obstruction.

With the APU running Kerhervé and Chenevier demonstrated programming the flightplan and performance data via the EASy interface. All input is through either one of two integrated trackballs and menu panels on the centre console. The design uses a “Windows”-type philosophy and a “point-and-click” cursor that can move across any of the four screens. The left trackball cursor is a vertical cross and the right a diagonal cross and the marker “blooms” when it is moved so it is easily seen and “dragged” on the screen.

There are no “hidden pages”, no writing in the “scratch pad”, no inputting data in one area and searching to confirm it has been accepted somewhere else, and no having to change to another navigation display mode to see it. The EASy is wonderfully intuitive and since all information and data input are “on screen”, both pilots will know what the other is doing or can monitor cross-cockpit.

The resolution of the displays is the best I have seen and there were other outstanding features like the overlay of the flightplan route on a real moving map showing terrain, rivers and coastlines, and the vertical profile on the lower part of the screen showing the actual terrain profile below the flightpath in side view. Up to four aircraft system synoptic pages can be shown on the centre screens at the same time without losing other critical information. Up to two electronic Jeppesen charts can also be shown and Dassault can supplement this with two additional side displays for electronic flight bag use as a customer option. The EASy flightdeck lives up to its name and is a substantial improvement on conventional glass cockpits.
Starting the engines involved simply putting the small individual run switch forward and turning a single rotary start knob behind the throttles. Each PW307A was fully stable within 25s, with an idle fuel flow around 135kg/h. Checklists were electronic and on a central EASy screen and Dassault plans to make them interactive and linked to the checklist action being completed. My only comment on the post-start sequence is the automatic computer check of the flight-control surfaces was a little too “firm” for a business jet. Kerhervé says Dassault is working to “soften” the control stop as the surfaces reach their full displacements during this ground check.

**Accurate steering**

Our all-up weight at start was 26,760kg. Once moving, taxi speed could be maintained with idle thrust. The lack of a familiar steering tiller initially felt slightly disconcerting, but I quickly adapted my technique to using the rudder pedals (with the computer controlling turn angle dependent on forward speed). I found the steering to be accurate and it allowed the aircraft to be turned tightly at low speed. The brakes were powerful, progressive and without snatch and this combination of power, steering and braking gave the 7X the nimble feel of a much smaller aircraft when manoeuvring on an apron.

Take-off at Istres was with an outside air temperature of 20°C, and barometric altitude setting of 1020. Rotation speed was 129kt indicated using slat/flap position 2. With the configuration set as designated, the digital flight control system automatically set the pitch trim. Power was slammed from idle, with full-authority digital engine control ensuring no limits were exceeded. It took about 4s to “bite”, but afterwards acceleration was brisk.

I was using the head-down primary flight display (PFD) for the take-off, which has a flight director (FD) based on flight path vector (FPV) rather than attitude/ pitch angle. At rotation speed I pulled the sidestick fully back to the rear stop and the fly-by-wire system gave me the precise rotate rate as I aimed for 15° nose-up pitch. Given that FPV will always lag pitch on take-off, I would have preferred the PFD to have shown me a clearer pitch-up “target” to aim for until the FPV/FD had settled. Kerhervé says this is being considered.

As gear and flaps were retracted after take-off, the beauty of digital flight controls immediately hit home; no need for trimming in any axis, ever, for any speed change or deployment of flap, gear or air-brake; highly accurate control when making small flightpath changes around neutral; consistent, repeatable pitch/roll rates at all speeds; and a rapid response to sidestick input that was instantly damped when the sidestick was released. With FPV zero demand, the aircraft could be left at any bank or climb/dive angle (up to around 25°) and the set FPV would be maintained without use of the autopilot. The sidestick had perfect centring, no freepage and the force/displacement gradients versus generated pitch/roll rates seemed beautifully harmonised. Roll control was immediate and powerful (maximum 40°/s), with no “notch” as the roll rate started to build up and no adverse yaw.

**Fighter heritage**

The 7X flew like a fighter and its Mirage/Rafale heritage was evident. With the combination of digital fly-by-wire and sidestick control, it was simply the easiest and most rewarding large aircraft I have flown. Why can’t all aircraft be designed this way?

Accelerating from around 200kt at full power, at 8,000ft, airspeed increased at about 4kt/s and that rate did not slow even as we passed V\_MO at 370kt and the warning horn sounded. The 7X is indeed a fast ship. Conversely the aircraft cannot be stalled. Decelerating with slat/flap 2, engines in idle, the PFD speed tape showed amber at 118kt and red at 108kt. In manual flight, with full back stick, the flightpath could be held level until the start of the amber
speed band where the flight-control system gently lowered the aircraft’s nose to prevent it entering the red and a continual “increase speed” digital voice warning began. Distinct natural airframe buffet also indicated the approach to stall. In autoflight, for the same manoeuvre, the autthrottle would engage.

Kerhervé demonstrated the warning buzzer in the sidesticks that activates if both pilots move their controls in opposition, which is accompanied by a “dual input” digital voice warning. Autopilot and autothrottle modes, flight mode panel and EASy inputs, and flight with the HUD were all evaluated and showed the aircraft to be intuitive to manage. I never once felt “out of the loop” even though we were often in a busy ATC environment.

**Manual landing**

After the low-level flypast at Bordeaux, Kerhervé gave me back the aircraft for a manual landing from a right-hand turning visual approach, autothrottle engaged and using the HUD for flightpath control. Gear (200kt limit) and slat/flap 1, 2 and 3 (limits 200/190/180kt respectively), were taken in stages aiming for a VREF of 123kt. The aircraft was a delight to fly and easy to position around finals, with no complex approach modes. With the FPV in the HUD placed manually on the touchdown point of Bordeaux Merignac’s runway 23 there was literally nothing else to do apart from click off the autothrottle around 100ft.

The landing roll showed the brakes in combination with automatic lift-dump to be extremely effective and the centre thrust reverser to be quick to deploy, giving a ground roll of 915m without any heavy braking effort. On shutdown we had been airborne for 1h 30min, all at medium level and had used 2,100kg of fuel.

The 7X is stunning to fly and manage. Not only does it set the new benchmark in long-range, high-speed business jets, it offers such significant improvements in key areas that it looks likely to redefine how an aircraft of this capability is designed, manufactured, maintained and supported. And a clean-sheet approach in which high technology is married with an advanced man-machine interface also produces a superb cabin environment for the passengers.

Add to this a cruise fuel consumption Dassault claims reduces direct operating cost by 20-30% compared with the competition, similar savings in direct maintenance costs, field and flight performance that equals or exceeds its rivals, and a lower quoted price in standard eight-pas-
senger configuration of $41 million and becomes clear that, with the 7X, Dassault has thrown down the gauntlet to the other manufacturers.

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*Eight passengers and three crew **Eight passengers and four crew.
SUDDENLY THE SKY IS MADE OF SILK.

Nothing can make the air perfectly smooth — but nothing can touch the incredible Falcon 7X for smooth flying. Fly-by-wire technology gives it the reflexes of a fighter, the agility of a bird. And its all-muscle-no-fat design will whisk you over 5,950 miles with the efficiency of a smaller plane — in a cabin of silken quiet — within a whisper of the speed of sound. Technology not just on the leading edge, but leading the edge.

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