PILOT REPORT

FALCON 8X

Dassault's largest and longest-range business jet

by Matt Thurber

The Falcon 8X is not only Dassault's largest business jet; it also propels the OEM into the popular ultra-long-range arena, the segment that has experienced the most activity in the past few years. The 8X isn't just a 7X with fuselage plugs, and it isn't replacing the 7X; the newest Falcon stands on its own as the flagship of the French manufacturer's fleet.

The 8X received EASA and FAA certification in June, and in September the first aircraft was delivered, to Greek operator Amjet. Production is ramping up, and while Dassault doesn't disclose exact delivery schedules, in mid-December there were 11 Falcon 8Xs assembled and 14 in the completion stage, according to sales engineer Frédéric Recher. "We will deliver in 12 countries in the next few months," he said.

Besides boosting range at Mach 0.80 to 6,450 nm from 5,950 nm, the 8X fuselage is 3.7 feet longer than the 7X's, accomplished via two fuselage plugs. The 8X is 3,000 pounds heavier, with a maximum ramp weight of 73,200 pounds, and all of the extra plus another 200 pounds goes to fuel, with maximum fuel now 35,140 pounds, up from the 7X's 31,940 pounds.

Although the 8X's three Pratt & Whitney Canada PW307D engines, which each deliver 6,722 pounds of thrust, are about 5 percent more powerful than the 7X's 6,402-pound-thrust PW307As, the direct operating costs for both jets are the same, according to Recher. The 307D is more efficient, with specific fuel consumption lower by 2 percent. Further contributing to the 8X's efficiency, Dassault engineers were able to carve 600 pounds out of the wing. "It's the same wing as the 7X's," he said. "We know the wing perfectly, and we saw it could be optimized internally without changing anything."

Other changes are more subtle, such as new winglets that add a tiny bit of span, reinforced landing gear for the higher mtow and some changes to the avionics. The 8X has the Honeywell Primus Epic-based EASy III flight deck, complete with a new Honeywell RDR-4000-based digital radar and Dassault's optional FalconEye head-up display (HUD) and enhanced vision system, the first certified application of combined vision, where synthetic vision and enhanced vision imagery is shown simultaneously on the HUD.

The 8X's cabin is now the longest in the Falcon line, 42.6 feet long and providing 1,695 cu ft of volume. Like the 7X, the cabin altitude in the 8X is maintained at 1,000 feet to FL270, then holds 3,900 feet at FL410 and 6,000 feet at the FL510 maximum altitude. Interior noise has been cut substantially below that of the 7X, down 2 to 3 dB SIL.

With full fuel, the 8X can fly at Mach 0.80 up to 6,450 nm from a sea-level runway with a balanced field length of less than 6,000 feet, carrying eight

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PHOTOS: DASSAULT AVIATION

The extra length of the 8X's fuselage allowed designers to outfit three zones and include a shower in the lavatory. All completions are done in Little Rock, Ark.

Sidestick-operated fly-by-wire flight controls make for a clean, uncluttered flight deck. The 8X's EASy III avionics system, based on Honeywell's Primus Epic suite, features synthetic vision and 3-D digital radar. The FalconEye HUD and combined vision system is optional.

passengers and three crew.

Before climbing into the 8X cockpit, Dassault test pilot Hervé Laverne took me for an introductory flight in FlightSafety's 8X simulator at the FlightSafety Paris Le Bourget learning center. The simulator is an excellent representation of the 8X and highly accurate in all respects, including the difficult-to-replicate nosewheel steering and taxiing regime.

We spent some time letting me get used to the handling of the 8X's fly-by-wire flight controls, which are flight-path stable, meaning that the jet will remain on the same flight path or trajectory until the pilot moves them for a different flight path. Non-FBW airplanes are speed-stable and tend to remain at the trimmed speed when nothing is done to the controls. By comparison, Gulfstream's G650 and in-development G500 and G600 are also speed-stable FBW designs. The Embraer Legacy 450 and 500 FBW systems are flight-path stable, with the addition of a trimmable speed-stable regime during landing. Airbus designs are also flight-path stable. (I have flown the Legacy 450 and 500 as well as the G500 lab simulator, but as yet not the Airbus.)

For most pilots, what they'll notice right away in a flight-path stable FBW jet is that there is no pitch trim. The 7X and 8X (I'll refer to the 8X henceforth as both FBW systems are identical) move the trimmable horizontal stabilizer for pitch trim, but the pilot doesn't feel this happening as it's completely automatic and part of the FBW system.

The primary pilot control in the 8X, as in most other FBW airplanes, is a sidestick. Exceptions include the yoke-fitted G650 and all FBW Boeings. Unlike the active control sidesticks in the G500 and G600, which move together like traditional yokes and also like the G650 and Boeing yokes, the Falcon sidesticks move only at the pilot's command. For this type of sidestick (also found in the Legacy 450 and 500 and Airbuses), pilots need to know when the other pilot is trying also to move the stick simultaneously. In the 8X, this is done with a vibration in the stick and an aural warning ("dual input"). When both pilots move their sticks simultaneously, the command is algebraically summed.

There is a priority button on each stick, with which one pilot can deactivate the other stick by holding the button. The priority remains activated by pressing the button for more than 30 seconds, then the button can be released. The other pilot can reactivate his stick at any time by pressing his priority button.

From a complexity standpoint, FBW might seem to present some challenges; after all, the system must supply not only the desired trajectory, handling characteristics, envelope protections and other features but also reliability that meets the same certification safety requirements applied to a mechanical flight control system. Dassault has been designing FBW flight controls for decades, and the 8X's system is the latest generation.

For the pilot of the 8X, there is very little that must be known about the system except for how it degrades when a problem arises and what backup systems serve its electrical needs. In actuality, there is little that the pilot can do other than be prepared if the FBW moves from normal law to alternate law or direct law, which can happen when there is a flight control computer, sensor or actuator problem.

In direct mode—which is not accessible in normal flying conditions; that is, there is no switch in the cockpit that allows changing to direct mode—the pilot needs to be careful not to exceed normal envelope restrictions, the same way as when flying a traditional airplane. Some of the flight envelope protections available with FBW disappear in alternate law and all of the protections are unavailable in direct law.

In short, the FBW system is supported by three main flight control computers (FCCs) and three secondaries (backups), which calculate how to move the flight control surfaces in response to information provided by five flight data concentrators. Four actuator control and monitoring units select which of the FCCs will provide the calculation, then transmit that command to the actuators and measure the amount of the actuation. Four maintenance and avionics

FalconEye

Dassault's new FalconEye combined vision system (CVS) will be certified soon on the 8X and is already approved on the 2000S/LXS. CVS plays on the 8X's single head-up display (HUD) on the pilot's side, although Dassault will certify a dual-HUD setup for the 8X in 2018. The HUD and FalconEye camera are optional on the 8X, and so far 90 percent of 8X buyers have opted for the HUD, although not all have selected the FalconEye camera. The system uses an Elbit HUD and camera system, and the HUD uses LCD technology, which is lighter and smaller than the CRT-based HUDs on older Falcons. The FalconEye camera sensors are partially recessed into the upper nose cone for better aerodynamics than the earlier sensor.

CVS blends synthetic vision, thermal (infrared) and low-light camera imagery into a single depiction of the outside world on the HUD. HUD resolution is 1280 pixels horizontal and 1024 vertical, the same as a high-definition display, with a larger field of view of 40 degrees horizontal by 30 degrees vertical.

The camera sensor scans 35 degrees horizontal by 36 vertical, with slightly lower resolution. The sensor is uncooled, so there is no delay during initialization as there is with cooled sensors. Six different multispectral sensors make up the camera package, four for daytime, one nighttime and one thermal (infrared). The system fuses the images from all of the sensors to present the best image to the pilot, and one of the sensors can see LED lights, which are found at a growing number of airports.

An interesting characteristic of FalconEye is that the camera image is not superimposed on top of the synthetic vision (SVS) image on the HUD. The HUD view is divided into two parts; the upper is SVS and lower is the camera image. A switch on the sidestick allows the pilot to move the limit line between SVS and camera image to show more or less of each. The way this works is that the pilot typically wants to see the camera image, especially thermal, of the runway and surrounding terrain, and thus will move the sidestick switch until this shows on the lower part of the HUD. The upper part of the HUD will be set to SVS, which gives the pilot a good look at terrain farther away in case of a missed approach or go-around. Even if the pilot pulls the SVS image down toward the runway, the runway area is always available as a clear zone to be shown using only camera imagery, so the limit line bends around the runway in this case.

Future capabilities for FalconEye include operational credit to descend to 100 feet using the HUD during IFR approaches, and this is expected after the 8X FalconEye certification. ■

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With AIN writer Matt Thurber in the left seat of the 8X, Dassault test pilot Hervé Laverne (left) flew right seat while senior chief test pilot Philippe Deleume (right) provided an extra set of eyes from the big Falcon's jump seat.

interface computers are responsible for data exchange with avionics. The backup to the backup is provided by an analog computer, which gives the pilots direct control of the horizontal stabilizer and spoilers (backup mode). In this case, pilots control pitch using trim switches designed only for this purpose and spoilers via the rudders. The analog backup is considered temporary while all the other computers reset themselves and restore some or all FBW functionality. Most flight controls are electrically controlled and hydraulically actuated, except the horizontal stabilizer, which is electrical only. The 8X has three hydraulic systems.

Electrical power is essential for FBW, and in the 8X each of its three engines has a generator and a dedicated permanent-magnet

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Falcon 8X Specifications and Performance	
Price (typically completed and equipped)	$57.5 million
Engines (3)	Pratt & Whitney Canada PW307D, 6,720 lbs each
Avionics	Falcon EASy III (Honeywell Primus Epic)
Passengers (typical)	3 crew + 14 pax
Range (w/NBAA reserves, 200-nm alternate)	6,450 nm at Mach 0.80
High-speed cruise	Mach 0.90
Long-range cruise speed	Mach 0.80
Fuel capacity	34,900 lbs
Max payload w/full fuel	1,959 lbs
Maximum altitude	51,000 ft
Cabin altitude at ceiling	6,000 ft
Max takeoff weight	73,000 lbs
Balanced field length at mtow (sea level, standard)	5,880 ft
Landing distance	2,150 ft
Length	80.2 ft
Wingspan	86.2 ft
Height	26.1 ft
Cabin	
Volume	1,695 cu ft
Width	6.27 ft
Height	6.17 ft
Length (seating area)	42.6 ft
Baggage capacity	140 cu ft
FAA certification (basis, date)	FAR Part 25, 6/27/16
Number delivered	3 (12/01/16)

alternator. If all of those fail (or all three engines fail), a ram-air turbine powers the flight control system. There is a Honeywell 36-150 APU, but this is for ground use only.

For the most part, these issues are not top of mind when flying the 8X, unless an emergency develops. What I found more compelling and relatable was how the airplane handles and what happens when I experienced the 8X's stability-augmentation and envelope-protection features.

The FlightSafety simulator gave me a foretaste of the real thing, and Laverne used our time in the sim to introduce me to some of the 8X's flying characteristics, chief among them the flight-path stable trait. This means that wherever I pointed the airplane in certain attitudes, the FCS would maintain that flight path. If I want a 20-degree bank to the left, I deflect the stick left until reaching the desired bank, set the nose level, and the FCS automatically maintains that path. The same is true of pitch: set the path and release the stick.

The indicator for the flight path is the flight path symbol (FPS), which gives a direct indication of the flight path or trajectory on the attitude display indicator (ADI) on the primary and secondary flight displays. Dassault explains that flying with the FPS is much simpler than using the pitch angle as on traditional ADIs, because pitch angle doesn't always correspond to the flight-path angle. During a stall, for example, the pitch angle could be well above the horizon, yet the airplane's trajectory is descending. The FPS eliminates the need for the pilot to interpret the trajectory by assessing the pitch angle, airspeed, vertical speed and altitude.

When banking, the FBW controls automatically compensate for loss of lift so there is no need to pull back on the stick to keep the FPS level on the horizon. However, at steeper bank angles it's necessary to pull the stick aft to compensate for loss of lift. At bank angles of up to 35 degrees, letting go of the stick maintains the trajectory, but beyond 35 degrees the FBW automatically drives the angle back to 35 degrees. It is necessary to move the stick beyond the soft limit to bank steeper than 35 degrees, so the pilot feels some pressure on the stick. Pitch has a similar soft limit in the down direction as well as hard limits that protect the airplane from excessive up or down pitch inputs.

In the simulator, I tested the low- and high-speed protections. I pulled the stick back to maximum pitch, and the FBW system maintained a margin above stall, even as I banked left and right. If the pilot pushes the nose down as far as the stick will move, the FBW pulls the nose up to keep from overspeeding. With the autopilot on, autothrottles will switch on and pull the power back to help slow the 8X, but if the autopilot is off, then autothrottles don't assist and only the pitch change prevents the overspeed.

I flew the sim back to Le Bourget for a raw data ILS to Runway 27, then a go-around followed by another ILS approach and landing. We then took off from Runway 7, and Laverne pulled the number-one (left) engine to idle after V1. I had to step on the right rudder to avoid drifting off the runway heading—although the FBW does compensate somewhat for the inop engine—as we climbed to 2,000 feet and entered a left downwind while Laverne ran the engine-out checklist. We flew the ILS then landed.

The 8X Aloft

When I climbed aboard the 8X the next day at the Istres-Le Tubé Air Base military flight test facility where Dassault's flight-test operations are located, I felt immediately comfortable in the cockpit. We were flying Serial Number 1, the first 8X to fly (with Laverne at the controls). This 8X is still equipped with full flight-test instrumentation and no cabin furnishings. Senior chief test pilot Philippe Deleume flew jumpseat. We were fairly light, with about 12,000 pounds of fuel on board and a 51,000-pound takeoff weight, well below the 73,000-pound mtow. The sidesticks leave space for a stowable work table in front of each pilot. And the rudder pedals are adjustable using a switch on each pilot's side ledge.

I taxied from the Dassault ramp to Runway 33 and quickly became comfortable with the nosewheel steering. The 8X's nosewheel steering, operated entirely with the rudder pedals, is surprisingly steady, not at all too

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More Space for Cabin Interior Designers

The extra 2.6 feet in length in the 8X cabin (compared to the 7X) offered new options for interior designers, and buyers can choose various ways to outfit the entryway to accommodate operational needs. The short entryway plan adds the extra fuselage length to the passenger cabin, while the mid entryway plan shares the added length between the cabin and the forward section near the main entry door. The large entryway floorplan uses the extra length to accommodate a crew rest area, for operations that plan on fully using the 8X's long-range capability or for commercial operators where a crew rest facility is mandatory. Mid- and short-entryway floorplans are for operators that will fly shorter routes regularly.

The passenger cabin space excluding the added space for the larger entryway is exactly the same as the 7X provides. The forward area accommodates a 93-inch galley, and two windows add extra light. The crew rest section opposite the galley is convertible to a crew seat qualified for takeoff and landing.

The choice of the entryway size doesn't affect the layout of the cabin, just the space between each zone. The added length offers more outfitting flexibility, according to sales engineer Frédéric Recher. "You can have a cozy corner in the back with a huge screen and two long divans."

While the 7X can have a shower in the back of the cabin, that limits the cabin to two lounge areas. The added length of the 8X allows for installation of a shower while retaining three lounge areas and the crew rest area opposite the galley. "It's a huge lavatory because of the extra room," he said. The shower stores enough water for up to 30 minutes of use.

Another factor was the new length of the long entryway, which could look like a narrow corridor without the two additional windows on each side. "We said we need extra light," explained Rémi Bachelet, director of aircraft specifications and design. "Thanks to the extra space, we were able to open up this area and bring in more light."

More than 80 percent of 8X buyers are opting for the standard dual three-place divans in the aft zone, but this area can also be customized with cabinets, he said. "We remain quite flexible on this airplane."

The 8X's cabin management system is the Falcon Cabin HD+, which is based on the Rockwell Collins Venue system. Features include up to 32-inch bulkhead monitors, dual Blu-ray players, Airshow moving-map, plug-in monitors and iPad connections at each seat for video/audio on-demand and cabin control, and movie streaming via the Rockwell Collins Skybox.

Falcon 8X buyers can visit Dassault's Le Bourget showroom and spend the day with manager of interior design Caroline Larmaraud and her team to select interior materials and the paint scheme. A mockup cabin section is used to demonstrate galley layouts and seats. Each customer gets an opportunity to evaluate one seat built to their specifications; once satisfied, the rest of the seats can be completed.

All 8X completions are being done at Dassault's facility in Little Rock, Ark. ■

sensitive and carefully graduated according to speed. I found it less prone to the jerkiness that I suffer from in jets with tiller steering.

We set the slats/flaps to SF2, and I pushed the power levers to the stops. It didn't feel at all strange to be manipulating three levers, and other than three sets of engine gauges and the more crowded throttle quadrant, three engines doesn't seem too much different from two.

The weather was clear but the wind was blowing at 30 knots gusting to 42. The three PW307Ds quickly accelerated the 8X to rotation speed, and I pulled the sidestick back smoothly, rotating the FPS into the flight director cue. There is a rotation indicator on the PFD, but both pilots said it isn't really necessary to use that unless making a high-performance takeoff.

Pulling the power levers back to the climb detent, we climbed to FL350 at 260 kias while I replicated some of the moves from the simulator, feeling the FBW controls in turns and varying pitch attitudes. I find getting used to the flight-path stable FBW system easy, after flying the sim and other FBW jets. It doesn't take long to get comfortable flying with tiny nudges of the stick to put the attitude right where I want it. And it's pleasant not to have to be constantly manipulating the controls, to the point where it's not even tempting to turn on the autopilot.

Once at altitude, I did some more turns, some with steep banks, and we tested the FBW's low-speed and high-speed envelope protections. Laverne had me start with shallow turns, where the bank angle stays as selected (below 35 degrees), then increasingly steep. My 60-degree steep turns weren't so pretty; balancing the

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Falcon Sphere II EFB

Dassault selected a new Esterline CMC electronic flight bag for the Falcon Sphere II EFB installation on the Falcon 8X. The Microsoft Windows-based touchscreen EFB mounts on brackets on the upper left and right sides of the cockpit, and it is connected to ship power and the aircraft's databus, but it can be removed for off-aircraft use. Falcon Sphere II is an option on the 8X.

The EFB comes with apps for flight manuals, weight-and-balance, cruise and takeoff and landing performance, charts and weather. An EFB manager function allows a central administrator to manage all EFBs for a flight department and issue notifications to all EFB users.

Pilots will soon be able to run mission planning on an iPad then synchronize with the in-aircraft EFBs, saving the trouble of removing the EFBs for off-airplane use. Another useful feature in development is a maintenance dispatch app. The pilot simply types in the type of fault, and the app steps through the MEL process, which will be much simpler than looking up the information in the MEL manual.

Documents in the EFB are linked, so if a pilot is looking up an emergency procedure, any supplementary information is just a hotlink away. ■

Manuals

Flying many different airplanes gives me an opportunity to sample a variety of flight manuals, and the 8X's manuals are among the best I've seen.

All OEMs are required to provide documentation, but Dassault goes further to help pilots, especially those new to the brand. My favorite of the bunch are the Crew Operational Documentation for Dassault EASy (Codde) documents, such as Codde 1, Airplane Description, Codde 2, Operations Manual, and Codde 3, QRHs. Unlike many OEM manuals, the Codde documents don't always assume that the pilot comes to the 8X with an understanding of some important fundamentals.

For example, Codde 1 starts with an excellent explanation of the flight path symbol (FPS), how and why it is used and how pilots can use it to fly smoothly, accurately and safely. Codde 1 delves into all the aircraft systems, starting with a discussion of design principles and how the system works with detailed diagrams and descriptions of system controls. The document's avionics sections are well laid out and delve into deep and useful detail on operation of the Honeywell-based EASy III flight deck, especially the I-Nav flight planning functions, which are extensive. The explanation of how the fly-by-wire flight controls work is also well done.

For more detail on certain aspects of avionics operation such as lateral and vertical flight planning and other FMS operations, weather radar, datalink and satcom functions, the EASy III tips and tricks manual is a handy guide. ■

need to pull the stick back at the higher bank angles and pushing against the stick's gentle force as it tried to return to 35 degrees was challenging. But putting the FPS right on the ADI's horizon line made maintaining altitude simple. From there, I banked even steeper, to 90 degrees, watching the FBW drop the nose to keep within the safe flight envelope.

Descending to 15,000 feet, we accelerated to the Mach 0.90 VMO then slightly above that to test the overspeed protection feature. With autopilot off (and thus no autothrottle), the FBW system automatically pulled the nose up as we reached Mach 0.91and slowed the 8X to below redline.

I flew some more steep banks, then Laverne had me slow the 8X with gear and flaps/slats fully extended. I then pulled the sidestick all the way back, feeling the 2-g limit that the FBW enforces in that configuration (it's 2.5 g clean). Then with the stick full aft and at idle power, the 8X slowed to its maximum margin over stall speed—we were flying at VMIN well under 100 kias—and stayed comfortably there, even though I banked from side to side. The 8X was flying perfectly smoothly, with no hint of lack of control; I could make it do exactly what I wanted, and it would never stall. After switching on the autopilot, the FBW automatically engaged the autothrottles and powered the 8X out of the VMIN condition.

Returning to Istres-Le Tubé, I flew a steep approach at minus 6 degrees in landing configuration with airbrakes extended. These operate smoothly with no rumbling and, thanks to FBW, no limits on how fast they can be activated.

As we neared the runway about 200 feet above the landing zone, Laverne pulled the left engine to idle and I flew an engine-out go-around, first pushing the takeoff/go-around button then advancing the other two engines' power levers to maximum. Laverne selected slats/flaps SF2, retracted the landing gear then selected SF1 until we climbed to a safe altitude. The 8X still felt like it was flying on three engines, and I needed just a light touch on the right rudder to keep flying straight.

While flying away from the airport, we received an actual Tcas resolution advisory, and I had to shove the nose down quickly to follow the guidance on the ADI, the first time I had ever done so in a real situation. The 8X reacted quickly to my command, and the FBW protected any imaginary occupants in the cabin from being thrown around.

I flew a relatively large traffic pattern to accommodate some local fuel tankers, then flew another ILS approach on raw data for a full-stop landing. The gusty wind blew straight down the runway and still at up to 42 knots, but I was easily able to fly the 8X straight down the glideslope. The 8X stayed solidly right where I wanted, and keeping it on speed—VREF was about 115 kias plus about five knots for the gusts—required just occasional light touches on the sidestick. Descending below 50 feet, I flared high and had to add a little power, but the Pratts responded promptly and the resulting touchdown was satisfyingly smooth with little need for reverse thrust thanks to the powerful brakes.

Dassault's Falcon 8X is impressively easy to fly, and the well designed EASy III flight deck should present a low learning curve for pilots new to Falcons. ❏