Pilot Report: Dassault Falcon 8X

Largest cabin, longest range, most-capable Falcon trijet yet

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The Falcon 8X now is more than halfway through its flight test campaign, putting it squarely on track for certification in mid-2016. Recently, we flew the first flight test aircraft to evaluate the progress of the program, to gauge how well Dassault is meeting the trijet's stated weight, performance and cabin comfort goals and to sample its handling qualities. Thus far, the results look promising, as one might expect from a low-risk iterative design that's closely based on the well-proven Falcon 7X.

The Falcon 8X represents something of a paradigm shift for Dassault. This is the first time in the company's history that it has stretched one of its existing Falcon Jets to create a derivative model rather than embark on a clean-sheet design. Two 21-in. barrel plugs, one ahead and one aft of the wing root, were added to the 7X fuselage. The modification makes room for two additional windows on each side of the fuselage and adds about 3.5 ft. to cabin length. The stretch also makes room for a longer belly fairing with a more conformal tank that increases fuel capacity by about 2,500 lb. Internal modifications to the wing tanks add another 460 lb., increasing total fuel capacity by 2,960 lb. compared to that in the Falcon 7X.

Dassault claims the extra fuel capacity boosts the 8X's range by 500 nm. At a maximum of 6,450 nm, the actual range improvement over that of the Falcon 7X with eight passengers aboard is closer to 770 nm, according to BCA's May 2105 Purchase Planning Handbook. The range increase enables the aircraft to fly between new city pairs, such as Boston and Beijing, Singapore and Stansted, and Blackpool and Buenos Aires.

The increased range, however, assumes the 8X will have a 500-lb. lower basic operating weight than the 7X because of structural changes to the wing and lighter weight acoustical insulation.

The range increase results from a combination of several small improvements. The junction of the leading edge slats with the upper surface of the wing has been fine-tuned. New winglets reduce both induced drag and shock-wave drag, even though they're shorter than the winglets on the 7X. The engines were modified to improve specific fuel consumption by 1.5%. And relaxed static stability will reduce horizontal stabilizer trim drag.

Dozens of other refinements add operational flexibility, cabin comfort and situational awareness. Delve into the details to discover why this Falcon trijet is the most-capable business aircraft yet developed by Dassault.

As with all previous Falcon Jets, most of the 8X's primary airframe is a conventional semi-monocoque, high-strength aluminum alloy structure using stressed skins, with hoop frames and longerons in the fuselage and spars and ribs in the wings. Composites mainly are used in secondary structures, including the nose radome, fuselage fairings, winglets, vertical stabilizer and carbon/titanium horizontal stabilizer, among other components.

Using Dassault Systemes' CATIA and other design tools, Dassault engineers shaved off nearly 600 lb. from the 7X's internal wing structure. As noted, further modifications increased each wing's internal fuel capacity by 230 lb. The wing assembly now is more flexible. As wing area remains unchanged at 761 sq. ft. and the 8X has a 3,000-lb. higher MTOW, the result should be an even smoother ride in turbulence than offered by the 7X. Notably, Dassault is conducting a full range of demonstrated dive speed tests to assure the 8X retains the 7X's 370 KIAS Vmo and Mach 0.90 Mmo redline speeds.

The 7X/8X airfoil has 34 deg. of inboard section sweep and 30 deg. of outboard section sweep, a 9.72:1 aspect ratio and a pronounced reflex s-curve on the bottom surface near the trailing edge. The most-efficient cruise speed is Mach 0.80. BCA estimates that pushing up cruise speed to Mach 0.85 should reduce range by about 830 nm, based upon extrapolating Falcon 7X cruise performance data. However, Dassault officials declined to provide cruise performance numbers until flight tests are complete. That's also why we're omitting a specifications box with this report.

The 3.5-ft. fuselage stretch enables the 8X to have 16 windows on each side of the cabin. The stretch also increases cabin volume by 143 cu. ft. Dassault engineers have created a more effective, yet lighter weight acoustical insulation package for the 8X, one that concentrates noise absorbing materials at specific locations where the sound levels are the greatest. The result is a 2 to 3 dB reduction in cabin sound with a 25% reduction in acoustical insulation weight.

Short, medium and long galley/crew compartment configurations are available. Each comes with a standard, forward, right-side crew lavatory. A chemical toilet is standard and a vacuum toilet is optional. Dassault believes that most operators will select the 3.5-ft. longer forward galley/crew compartment. It features a 78-in. left-hand crew berth and 93-in.-long galley, affording the most crew rest space and the largest food, beverage and tableware storage for flights that can last up to 14 hr. duration.

The main cabins typically are configured with a four-chair club section up front, a four-chair conference grouping with adjacent credenza in mid-cabin and a pullout sofa sleeper plus single-chair executive workstation in the aft cabin. Many operators, though, are expected to order a second, pullout divan in place of the executive workstation as it provides an additional lay-flat berth for overnight missions.

Assuming customers order the 93-in. galley and the 78-in.
crew berth, the main cabin will have the same dimension
as the Falcon 7X. Credit: Dassault Falcon Jet

At the rear of the main cabin, there is a lavatory with vacuum toilet. Forward and aft lavatories have independent water and waste systems, a design feature that adds redundancy, according to Dassault.

A 140-cu.-ft. aft baggage compartment is accessible by means of a secondary pressure door in the rear of the passenger lavatory. Access to the aft bay is forbidden above FL 400 to comply with engine rotor burst certification requirements.

Similar to the Falcon 7X, the 8X has a 10.1-psi pressurization system that provides a 6,000-ft. cabin at FL 510. At typical cruise flight levels, cabin altitude is at or below 4,500 ft. At FL 410, cabin altitude is 3,900 ft.

Falcon 7X systems are carried over to the Falcon 8X with minor changes. There is plenty of redundancy to assure critical systems remain operational in the event of multiple failures.

The electrical system, for instance, has three engine-driven and one APU-driven, brushless DC generators plus a ram air turbine that automatically deploys if those four power sources are unavailable in flight. Permanent magnet alternators on engines 1 and 2 provide emergency power for the flight control system if no other generators are available. Each engine also has a separate PMA to provide power for its FADEC.

Forward section of the cabin has four-seat club grouping with 20-in. wide chairs. A new acoustical insulation package is expected to lower cabin sound levels by 2 to 3 db while reducing completion weight by up to 500 lb. Credit: Dassault Falcon Jet

The 3,000-psi hydraulic system has triple redundancy. There are five engine-driven pumps and one electrically driven aux pump. The 10.1-psi differential pressurization system has a single air-cycle machine pack backed up by an emergency heat exchanger system. The cabin has separate forward and aft temperature controls. Part of the cabin air is recirculated to reduce engine bleed air loads, thereby improving engine efficiency.

The basic triple-source fuel system is carried over from the Falcon 7X. However, the three systems do not have identical fuel capacities. To equalize fuel levels in all three systems, Dassault added an automatic balance function that transfers fuel from high to low tanks at the touch of a button on the overhead panel. In addition, the pressure refueling system has been modified to allow faster replenishment of the tanks.

Dassault carried over the 7X's digital flight control system (fly-by-wire) to the 8X, featuring three dual-channel main flight control computers backed up by three single-channel secondary flight control computers. The basic control law is modified C star, blending g and pitch rate commands, with flight path stability and extensive flight envelope protections. The more-flexible wing structure, though, required roll command software revisions to shape and smooth roll response. In addition, tighter close loop pitch response algorithms were added to the software in order to smooth and shape pitch response on takeoff rotation, resulting in less chance of inadvertent over-rotation at aft c.g.

In spite of the Falcon 8X's relaxed static stability, pilots and passengers won't sense the change as the fly-by-wire control system will dampen out any latent pitch oscillations as long as the aircraft remains within its c.g. envelope.

The Falcon 8X will be a full MSG-3 maintenance friendly aircraft with 800-hr./12-month basic inspection intervals. FlightSafety International has been tapped to be the primary training services provider. The first simulator will be operational at FlightSafety's Teterboro, New Jersey, training facility in 2016 and the second will come on line at the company's Le Bourget center in 2017.

Garbed in a tan Nomex flight suit and military boots at Istres-Le Tubé Air Base, the main facility used by Dassault for flight test, we belted into the left seat of Falcon 8X No. 1. We were accompanied by Eric Gerard, chief test pilot for the program, in the right seat and Frederic Lascourreges, Dassault Aviation's chief test pilot, on the jump seat as safety pilot. As the 8X was only halfway through its flight test program, this would be a qualitative, rather than quantitative, evaluation of the aircraft. Our objectives were to evaluate general flying qualities, the aircraft's fly-by-wire envelope protections, engine-out takeoff characteristics and aerodynamic handling characteristics in the direct law mode when the aircraft would be stripped of almost all of its sophisticated digital flight control capabilities.

Loaded with ballast tanks containing 2,200 lb. of water, air data sensor nose boom, test equipment and data recorders, the aircraft's BOW was 39,000 lb., or about 2,900 lb. more weight than for a production aircraft, according to Dassault projections. Because of the nose test boom, the aircraft had no radar and the new Elbit HUD/EVS system was not installed.

With 10,000 lb. of fuel, our ramp weight was 49,000 lb., about 67% of a fully loaded production aircraft. We ran through the prestart checks, including checking oxygen, fire detection and emergency lights, along with windshield heat, RAT and environmental control systems, plus CVR, ice detection, TCAS and built-in-test systems. We started the APU, waited 2 min. for warm-up and then tapped off bleed air to the pack to cool the cabin. Girard programmed takeoff, climb and cruise flight phases into the FMS using a sequence of flight management windows and point-and-click entries.

The FMS automatically computed V1 at 101 KIAS, Vr at 107 KIAS, V2 at 114 KIAS and best one-engine-inoperative climb speed at 169 KIAS, using SF2 (slats/flaps 20 deg.) at 49,000 lb. Computed takeoff distance on the nearly sea-level runway at 20C was about 3,250 ft.

Starting the engines is easy, usually in a 2-3-1 sequence. We moved the center engine fuel switch to run and twisted the start knob to start. Fuel, ignition, starter motor and bleed air systems automatically responded, including diverting APU bleed air from the pack to the engine starter motor. The FADEC handled all aspects of start, including guarding against start malfunctions. After all three engines were running, we shut down the APU, checked flight control freedom and initiated a first-flight-of-the-day FBW flight control system functional check. This takes a full minute to complete, during which various flight control surfaces move up and down, left and right, extend and retract in response to computer commands. The aircraft must remain parked while the test is underway.

We armed the nosewheel steering, set SF2 and taxied to Runway 33 for departure. At the aircraft's comparatively light weight, it took little more than idle thrust to start rolling. Nosewheel steering is controlled by the rudder pedals. The Falcon 7X and 8X are the first Falcons that don't have steering tillers.

Initially, our taxi technique caused some directional twitching and brake jerking. But after a few moments, we adjusted to the feel of the steering and brake systems, substantially improving smoothness and precision. We checked operation of the single thrust reverser on the center engine.

Once cleared for takeoff, we armed the autothrottles and pushed up the levers to the forward stops. Dassault designed the autothrottle system so that it doesn't engage until the aircraft climbs 400 ft. above the runway. That way, the pilots retain full control over thrust commands when the aircraft is close to the runway surface.

The Falcon 8X now is midway through its development and flight test campaign, S.N. 1, the aircraft we flew for this report, is chock-full of orange flight test equipment. It's being used for flight and c.g. envelope expansion along with performance tests. Credit: Dassault Falcon Jet

At Vr, the rotation symbol on the PFD moved upward from its 14-deg. nose-down parking position on screen. We pulled back on the sidestick to pitch up until the rotation symbol was on the horizon, resulting in about 14-deg. nose-up pitch attitude. The rotation symbol disappears 3 sec. after liftoff.

About that time, the flight director cue appeared on the PFD. It doesn't provide nose attitude guidance. Instead, it provides flight path guidance. Thus, we adjusted nose attitude to match the flight path symbol on the PFD with the flight director command. With a positive rate of climb, we retracted the landing gear. By 400 ft., the aircraft had accelerated to V2 + 30 kt., triggering a "clean the wing" call for slats and flaps retraction, plus calls for flight guidance system climb mode and the after-takeoff checklist.

Following ATC instructions, we leveled off at 2,500 ft. and proceeded northbound for 8 mi. to stay well below jetliner traffic arriving at Marseille Provence Airport. We then climbed to FL 150 for a series of handling checks at 250 KIAS.

As with the Falcon 7X, the sidestick controller in the 8X has a nice balance between moderate fore-aft pressure for pitch commands and softer left-right force for roll inputs. The result is low hand effort, but there is enough spring resistance and damping to prevent over-control.

We sampled flight envelope protections, including the typical round of positive and negative g limiting, angle of attack (AOA) protection and overspeed protection. The FBW system automatically adjusts elevator and horizontal stabilizer positions to provide envelope protection, overriding as necessary the pilot's sidestick inputs to prevent exceeding the certified flight envelope.

As with previous Falcon Jets equipped with EASy avionics suites, if the autopilot is engaged, the system will automatically engage the autothrottles and adjust thrust as needed to prevent exceeding high- or low-speed flight envelope limits. When the aircraft returns to the normal flight envelope, the Falcon 8X's EASy III system automatically resumes normal autothrottle functionality.

The Falcon 8X, in keeping with all previous Falcons, exhibited unsurpassed low-speed handling qualities. When approaching stalling AOA, in any configuration, the mid-section and outboard slats extend and the inboard slats retract. As the aircraft nibbled at CL max, with the sidestick all the way aft, the 8X remained fully controllable as we maneuvered through several gentle turns and banks.

At a weight of about 48,000 lb., we respectively attained minimum airspeeds in the clean configuration, at SF2 (slats + flaps 20 deg.) and at SF3 (slats + flaps 40 deg.) of 120 KIAS, 98 KIAS and 92 KIAS. The aircraft epitomized the renowned Dassault design principal of providing fat, soft edges to the flight envelope. It never lost its composure while being abused to the limit. No other business aircraft offers more docile low-speed handling characteristics, in BCA's opinion.

As soon as we reduced nose attitude and increased thrust, recovery from each of the Vmin maneuvers was nearly instantaneous. As the aircraft's AOA was reduced and speed increased, the slats returned to their normal positions for each selected slat + flap configuration.

We retracted gear and flaps and then stabilized the aircraft wings level at 250 KIAS. Then we switched off the primary flight control computers so that we could evaluate the aircraft in direct law mode. The aircraft proved to be as easy to fly in direct law as the Falcon 7X. The aircraft has quite sufficient natural aerodynamic stability to make it easy to handle in direct law mode. Stab trim is a manual function and the rate of change is nearly perfect — quick enough to relieve sidestick control pressure, and slow enough to prevent over-control. Rocker switches on the center console activate the dual stab trim motors. Yaw damping is retained in the direct law mode.

During the direct law demonstration, we configured the aircraft for landing, slowed to Vref and descended on a 3-deg. glidepath to 14,500 ft. Reaching that point, we executed a simulated go-around, reconfigured to SF2, retracted the landing gear with a positive rate of climb and leveled off at 15,000 ft.

Thrust, configuration and speed changes produced mild pitching moments that easily were controllable with sidestick inputs and use of the manual pitch trim system. Girard noted that the FBW system provides some pitch damping in direct law mode.

Dassault long has been renowned for its craftsmanship and attention to detail. The technician is touching up paint with a fine brush on this fully extended trailing edge flap. Credit: Dassault Falcon Jet

We transitioned back to normal law mode, engaged the autothrottles and stabilized the aircraft at 250 KIAS. Girard then shut down the No. 3 engine to demonstrate that the autothrottles remain fully functional with the remaining two engines in operation. Afterward, we disengaged the autothrottles so that we could maintain the No. 3 throttle at the idle position and restarted it.

With all three engines back on the line, we climbed to FL 400 to assess handling qualities. Qualitatively, the aircraft appeared to be quite stable with good Mach buffet boundaries at light gross weights. However, as wing area remains unchanged from the Falcon 7X, the 8X's 3,000-lb. greater weight will slightly reduce Mach buffet boundaries.

Then we executed a simulated emergency descent by reducing thrust to idle, initially pitching over to 20-deg. nose down, extending the spoilers all the way out to AB2 and pushing speed up to Mmo/Vmo limits.

There was noticeable, moderate airframe rumble with the spoilers extended to AB2, but descent rate was impressive. Passing through FL 160 we partially retracted the spoilers to assure that we didn't overshoot the bottom altitude. We leveled off at FL 150 in 1 min., 15 sec. and also noted that extending the spoilers midway to the AB1 position results in a moderate increase in drag but virtually no buffet.

Returning to Istres for pattern work, we arrived at a landing weight of 44,000 lb. Based on using SF3 (slats + flaps 40 deg.), Capt. Lascourreges computed Vref at 110 KIAS.

Aft lavatory features a vacuum waste system. Access to the aft 140 cu. ft. baggage compartment is through a secondary pressure door in the rear of the lavatory.

Using the autothrottles to manage engine thrust, we aligned with Runway 33, captured the glidepath using the VASI and flew a normal landing approach. Though landing weight was 22 tons, the aircraft displayed the handling ease, agility and responsiveness of a far smaller aircraft. The Falcon 10's genes can be found in the Falcon 8X's DNA.

At 50 ft., the autothrottles automatically reduced thrust to idle and we followed the talking radio altimeter's cues to touchdown. The aircraft's long-travel, trailing link main landing gear and slow approach speeds all but guarantee a soft touchdown.

We used plenty of reverse thrust from the single thrust reverser on the No. 2 engine to slow the aircraft, using very light wheel braking action to prevent residual heat buildup.

About 60% of customers are expected to order the longest forward crew compartment, on the includes a 93-in. galley.

Our second takeoff would be a simulated one-engine-inoperative maneuver. Based upon a departure weight of 44,000 lb. and using SF2 (slats + flaps 20 deg.), takeoff speeds were 94 KIAS for V1, 102 KIAS for Vr and 110 KIAS for V2.

Five knots below Vr, Girard pulled back the No. 3 throttle to idle and, soon after, called "Rotate." As we rotated, it took less than 70-lb. force on the left rudder pedal to maintain the aircraft in balanced flight. The FBW system's yaw damping function made rudder and aileron control inputs to provide limited yaw and full roll stabilization. There was no doubt that we'd lost thrust on the right engine because of the associated yawing moment. But directional control was easy, especially as there was virtually no proverse roll due to asymmetric lift in the sideslip. Indeed, the aircraft was so easy to control that we saw little need to trim out rudder pedal pressures to maintain balanced flight.

The 78-in. left side crew berth converts into a roomy divan, when not needed for sleeping.

Climbing to pattern altitude at Istres, we headed downwind and Girard gave me control of the No. 3 engine thrust lever. We set up for a normal landing, but Girard had me align the aircraft with a parallel taxiway, just east of Runway 33. We acknowledged that the maneuver was inconsistent with standard stabilized approach criteria, but the goal was to demonstrate the aircraft's agility.

As we descended to 500 ft. above touchdown elevation, about 1.25 nm from the runway threshold, Girard instructed me to break off the approach to the taxiway and realign the aircraft with Runway 33. It was quite easy to sidestep to the runway centerline, as the approach speed was comparatively low and the aircraft was so agile. We realigned with Runway 33 within 0.5 nm and landed the aircraft smoothly and uneventfully.

Conclusions? The Falcon 8X is just as nice to fly as the Falcon 7X. Its EASy III avionics suite provides new functions and features that assure it will be one of the safest and most capable ultra-long-range business aircraft when it enters service in the second half of 2016.

Svelte Weight Allowances

The Falcon 8X's advertised 6,450-nm NBAA IFR range with eight passengers clearly puts it in BCA's ultra-long-range class, joining an elite group of business aircraft that includes the Bombardier Global 6000 and Gulfstream G550, among other purpose-built business jets.

But in order to achieve that range figure, operators will need to watch weight as carefully as an haute couture model on a Paris runway. Dassault's quoted 36,100-lb. BOW does not include satcom, broadband Internet connectivity, Elbit HUD and EVS, power cabin window shades, galley refrigerator, electrically powered cabin chairs or aft cabin privacy bulkhead, among other popular options. An aft cabin shower also will be offered, but as yet there is no weight estimated for it. In addition, BOW is based upon having three pilots aboard. There is no weight allowance for a flight attendant.

Add in the extras plus a fourth crewmember, and BOW could increase by 400 lb. to 500 lb. or more. Dassault officials, though, counter that it's unlikely that more than six 200-lb. passengers will be aboard any purpose-built business aircraft having a 14+ hr. endurance as that is the maximum number of full lay-flat berths provided in three cabin sections.

Several Dassault Falcon 7X operators told BCA, during our 2011 Operators Survey interviews, that they wanted more range, a usable crew rest bunk, more galley space for stores and a larger work area for a flight attendant. The Falcon 8X delivers the goods with some important qualifiers. Assuming operators practice strict weight discipline, this trijet Falcon flagship promises to be a strong competitor in the ultra-long-range class.