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Class Warfare: Falcon 2000S

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Entry-level Falcon Jet takes on all comers in super-midsize segment.

CHARLES EDELSTENNE, CHAIRMAN AND CEO OF DASSAULT AVIATION, UNVEILED THE FALCON 2000S on the eve of EBACE 2011. In doing so, he dispelled any misconceptions about how and when the French firm would field a super-midsize business jet. Plainly put, it won't. Not now. Not anytime soon.

Instead, Dassault created a new and more affordable version of the large-cabin Falcon 2000 family that's intended to upstage smaller super-midsize aircraft by offering considerably more cabin volume, better runway performance and more tanks-full payload than the competition. The Falcon 2000S started flight tests in February 2011 and is slated to enter service in 2013, leaving little time for manufacturers of super-midsize aircraft to prepare a defense for Dassault's blitz assault in this segment.

Most importantly, the Falcon 2000S is priced at $25 million for the first 20 deliveries, a scant 1% above the Bombardier Challenger 300, currently the best-selling business aircraft in the SMS class. There is a $1 million spread between the Falcon 2000S and the Gulfstream G250. It's $2 million higher than a Hawker 4000. With so little price differential, Edelstenne is betting that many potential SMS buyers will pay the premium to step up into a large-cabin aircraft, especially if it is a Falcon Jet.

The 2000S concept was developed in early 2009 by John Rosanvallon, president of Dassault Falcon Jet, and Olivier Villa, Dassault Aviation's senior vice president of civil aircraft.

"Our idea was to re-create the 1994 Falcon 2000 Classic, updated with all possible improvements. That aircraft didn't have the best runway performance, so we fitted this aircraft with winglets and full-span slats. We also wanted to have very different cabin accommodations, a BMW Design layout Falcon 7X," Villa said. The Falcon 2000S also will get an auto-braking system to reduce landing distances up to 300 ft., reduced NOx emissions combustors for its two upgraded 7,000-lb.-thrust Pratt & Whitney Canada 308C engines and Dassault's second-generation EASy II cockpit. The entire package is defined by Dassault Modification M5001.

Villa said that the biggest obstacle was achieving the $25 million price. "That's so simple an idea, so straightforward. The key was how to do it. That's the challenge we gave to our industrial group."

The production staff focused on three main areas to control costs. First, Dassault squeezed vendors for lower parts costs. Next, Dassault refined its planning and lean manufacturing processes. And finally, it limited to three the choices of cabin interiors for the Falcon 2000S, which helps speed completions.

Performance will be the Falcon 2000S's strong suit. It will be able to fly six passengers 3,350 nm while cruising at Mach 0.80. Approximate fuel burn on that mission will be 12,775 lb., yielding nearly the same nautical mile per pound fuel economy as much smaller super-midsize aircraft. But with 10 passenger chairs the Falcon 2000S will have markedly better seat-mile fuel efficiency than current SMS aircraft with fewer seats.

Dassault's last attempt at an entry-level business aircraft was the 2007 Falcon 2000DX. It had 20% less range than the 2000LX, but it was priced only $2.2 million lower. Buyers rejected that value equation. Only four Falcon 2000DX aircraft were delivered before the model was discontinued in 2009.

The company learned from that misstep and took a much different approach in creating the 2000S. While the S and DX share the same fuel capacity, there are many differences between the two aircraft. The S has more range, shorter runway requirements and better fuel efficiency. It also has a more comfortable cabin, lower operating costs and reduced exhaust emissions. Most importantly, it's $5 million less expensive than the DX in current year dollars. This creates a $7 million spread between the S and the $32 million, 4,000-nm range Falcon 2000LX, but without compromising the quality long identified with the marque.

Proven Structure, Systems Improvements

All Falcons have been built mainly with high-strength aluminum alloys since the mid-1960s. The Falcon 2000S uses the same time-proven, damage-tolerant, aluminum monocoque construction. Titanium and steel also are used in the primary airframe structure. The horizontal stabilizer and APU firebox are constructed from carbon-fiber-reinforced plastic. Fiberglass and Kevlar are used for secondary structures, such as the radome and certain aerodynamic fairings. The aircraft has a 20,000-cycle/30,000-hr. basic design life.

The fuselage has a nose section housing avionics and radar, a center pressurized section and aft section containing systems components, the engine carry-through structure and APU, among other components. The pressurized section is circular for structural efficiency under pressurization loads. The seven cockpit windows are glass laminate with a left-side, opening weather window. Stretched acrylic is used for the 18 cabin windows.

The aluminum wing is a classic ladder structure of milled spars and ribs sandwiched between upper and lower machined skins. Robots do most of the assembly, and with great precision. The Aviation Partners Inc. (API) winglets reduce induced drag both by increasing span and, therefore, wing aspect ratio from 7.62:1 to 9.34:1 and by redirecting most of the tip vortices as thrust vectors.

When examining Falcon Jet performance, one should distinguish between indicated Mach number(MI) and true Mach number, which determines true airspeed (TAS) at a specific outside air temperature. Dassault publishes both MI and TAS in its performance manuals. A comparison of the two values reveals a 0.005 to 0.015 difference between indicated and true Mach numbers depending upon indicated speed. That's why MI 0.80 cruise, when corrected, is equivalent to 0.79 true Mach, and results in a 453 KTAS cruise speed at ISA temperature in the stratosphere.

The Falcon 2000S features Dassault's first-generation super-critical airfoil, which was created for the Falcon 50 in the mid-1970s. Having an inboard quarter-chord sweep of 29 deg. and outboard sweep of 24.5 deg., the wing, Dassault says, is now optimized for MI 0.80 cruise because of the winglets. In reality, though, parasitic drag decreases long-range cruise speed to MI 0.77-0.79 depending upon altitude, as illustrated by the accompanying Specific Range chart for a 33,000-lb. mid-cruise-weight aircraft.

The Falcon 2000S retains the 28-VDC electrical architecture of the Falcon Jet family with both main and essential buses. Left- and right-sides of the system normally are split for fault isolation and manually switched together when needed. Power is supplied by two engine-driven brushless generators, two lead-acid batteries and an APU, rated for both ground and flight operations up to 35,000 ft. External power can be supplied by a ground power unit.

Total fuel capacity is 14,600 lb., or 2,060 lb. less than on the Falcon 2000LX. Fuel is contained in left- and right-wing, fore and aft center wing, and fore and aft fuselage tanks.

The left- and right-side 3,000-psi hydraulic systems, each having two pumps and using MIL-H-5606 red fluid, power the flight control actuators, leading-edge slats, trailing edge flaps and wheel brakes, along with the nosewheel steering, landing gear and gear doors, plus airbrakes and thrust reversers. One of the pumps in the right-side system is electrically powered and can provide power to essential hydraulic equipment if all three engine-driven pumps are inoperative.

An auto-brake system will be standard. This will reduce landing distances by as much as 150 ft. when landing on runways that use standard approach gradients. The aircraft also will be certified for 5.5-deg. steep approaches, such as those at London City Airport. Auto-braking will shave as much as 300 ft. off landing distances at such airports.

The primary flight controls are fully hydraulically powered in all three axes. There is an indicated speed-proportionate

artificial control feel (Arthur Q) system for roll. Position of the horizontal stab varies the amount of control feel force in pitch. The rudder has a simple spring box for artificial feel.

The control surfaces have no trim tabs. Electro servos also reposition the neutral points of the aileron and rudder artificial control feel units to provide trim in those axes.

Dual electric trim motors reposition the movable horizontal stabilizer for pitch trim. There is an automatic Mach trim that increases speed stability between Mach 0.77 and Mach 0.87. The stab range of motion has been recalibrated from +2 deg./-10 deg. to +1 deg./-11 deg. to provide increased nose-up pitch control authority to counter the effect of the winglets and new high-lift system.

The slats and three-position flaps work together as high-lift devices. On Falcon Jets, the slats provide most of the slow-speed lift augmentation. The S is equipped with the Falcon 900LX's full-span slats and other aspects of its high-lift system.

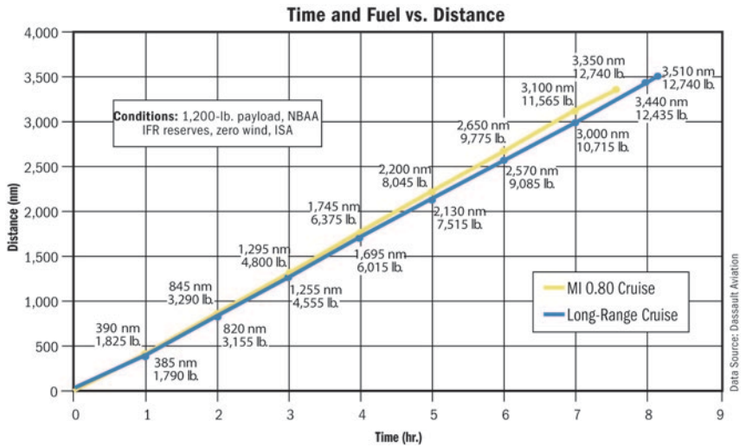
The API winglets also enable the S to climb higher and cruise 30-kt. faster than the DX. The winglets, the new high-lift system and more standard equipment all add empty weight to the airframe, but the aircraft still has a 1,850-lb. payload with full fuel tanks.

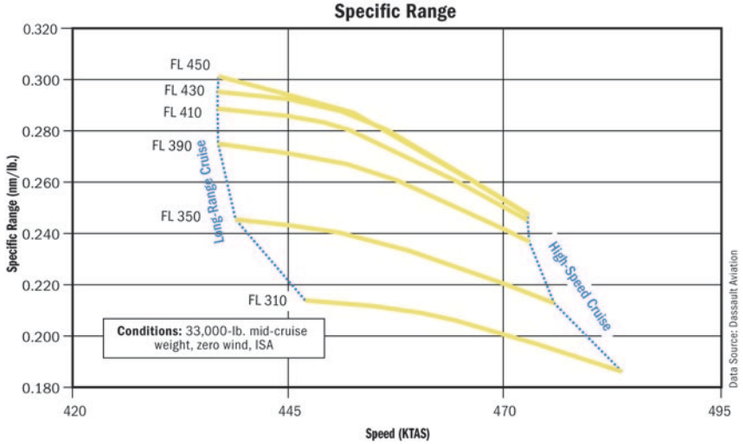
The standard interior has 10 passenger chairs, thus operators will have to leave one passenger on the tarmac with full tanks. With all 10 seats occupied, the aircraft still can fly 3,260 nm and land with 200-nm NBAA IFR reserves, as illustrated by the accompanying Range/Payload Profile chart.

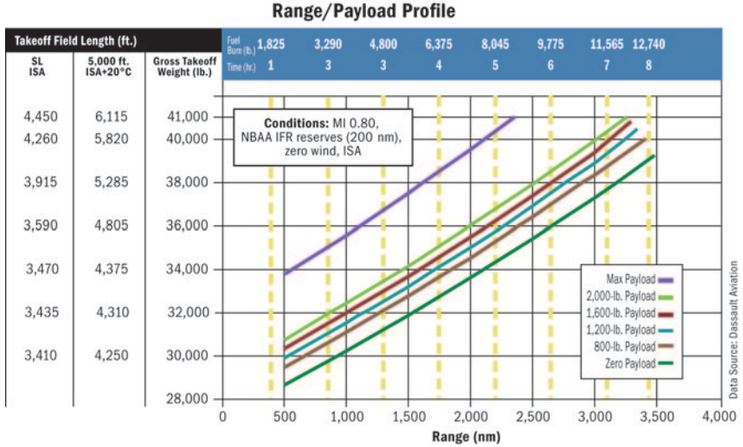
Dassault's engineers are running a complete runway performance recertification program for the S, potentially reducing V speeds by as much as 10 kt. and shrinking runway distances by as much as 850 ft. compared to the DX, assuming standard day conditions. The new high-lift system and winglets are so effective at reducing V speeds that rudder authority had to be increased by 10% to keep minimum control speeds below stall speeds.

The slats extend before the flaps and retract after the flaps. The outboard slats also extend automatically below 265 KIAS at high angles of attack to enhance handling characteristics at stall. With the slats extended, aerodynamic stall behavior and recovery characteristics are the best of any aircraft in the business fleet, in our opinion. We reached that conclusion after fully stalling all members of the Falcon

Dassault Falcon 2000S







NOTE: *Do not use these data for flight planning purposes because they do not take into account ATC delays and less than optimum routings and altitudes, along with other factors that can alter actual aircraft performance.*

These graphs are designed to illustrate the performance of the Dassault Falcon 2000S under a variety of range, payload, speed and density altitude conditions. Bill Miller, Dassault Falcon Jet's chief sales engineer, provided the data for the Range/Payload Profile. Data for the Specific Range chart were extracted from the Dassault Falcon 2000LX Performance Manual, adjusted for the projected basic operating weight and fuel capacity of the Falcon 2000S.

Time and Fuel Versus Distance — Time and Fuel Versus Distance — This graph shows the relationship between distance flown, block time and fuel consumption for a typically equipped aircraft having a 24,750-lb. BOW and carrying six passengers. The fuel and distance points were individually computed by Dassault Falcon Jet for each hourly mission. Normal cruise speed is 0.80 indicated Mach (MI 0.80), equivalent to 0.789 true Mach when corrected for instrument error. Long-range cruise speed varies depending upon cruise altitude and actual aircraft weight. It averages 0.738 true Mach for the longest missions. The Falcon 2000S should be able to fly 160 nm farther at long-range cruise than 0.80 indicated Mach. Dassault believes that most operators will cruise the aircraft at MI 0.80 or higher on all but the longest range missions.

Specific Range (Mid Range Weight, ISA) — Specific Range (Mid-Range Weight, ISA) — This graph shows the relationship between cruise speed and fuel consumption for the Falcon 2000S at representative cruise altitudes for a 33,000-lb., mid-weight aircraft, based upon data published in Dassault's Falcon 2000LX Performance Manual DGT 115001. The data indicate that FL 450 is the optimum for fuel efficiency at 0.80 indicated Mach number at this weight. We had no opportunity to verify these data during our brief intro flight. Fitted with Aviation Partners Inc. winglets, the Falcon 2000S should provide up to 5% better fuel efficiency at 0.80 indicated Mach number (0.789 true Mach) than the Falcon 2000DX and at least 7% better fuel efficiency at long-range cruise.

Range/Payload Profile — The purpose of this graph is to provide simulations of various trips under a variety of payload and two airport density altitude conditions, with the goal of flying the longest distance at MI 0.80 (0.789 true Mach) cruise. Each of the six payload/range lines simply was plotted from beginning and ending data points provided by Miller. The dashed hourly cruise lines were computed individually for each hourly mission and they assume a six-passenger (1,200 lb.) payload. The takeoff field lengths assume either a slats/7-deg. flaps (SF1) or slats/20-deg. flaps (SF2) configuration, depending upon density altitude. When departing our 5,000-ft. elevation, ISA+20C airport, the maximum allowable takeoff weight permitted by the one-engine-inoperative climb requirements is 41,000 lb., the maximum takeoff weight. Thus, range with four passengers actually is greater than when departing a sea-level airport because the aircraft has a 5,000-ft. head start on the climb to initial cruise altitude.

The pressurized section of the Falcon 2000S is circular for structural efficiency under pressurization loads.

50/900/2000 family that share this wing airfoil and high-lift design.

Bleed air, supplied by the engines or APU, is used for main-engine start, air-conditioning and pressurization, and ice and rain protection, plus pressurization of the hydraulic, fuel and potable water systems. A ground pneumatic cart can be used in lieu of the APU for main engine start. A single air-cycle machine provides refrigeration. Pressurization control is automatic and the 9.0-psi differential provides an 8,000-ft. cabin at FL 470, the aircraft's maximum cruising altitude.

Passenger Accommodations

The Falcon 2000S has a 1,024-cu.-ft. cabin that is about 22% larger than that of the average SMS aircraft. Being longer, wider and higher than most SMS cabins, it will accommodate its 10 passengers in two seating sections. There is a four-seat club section in the forward section and six seats in the aft section, including two facing chairs on the right side and a four-seat conference grouping on the left.

There is a 5.6-ft.-high by 2.6-ft.-wide airstair main door, equipped with a right-side telescoping handrail, tread lights and electrically powered door closer. The seventh window on the right side of the cabin is contained in a 1.7- by 3.0-ft. Type III over-wing emergency exit. The aft internal baggage compartment has a lavatory access door and a 2.6- by 2.5-ft. external airstair door.

The forward vestibule, ahead of the main seating area, has a 15-in.-long galley annex and a 46-in.-long main galley on the right side. The galley has a tap and sink, coffeemaker and generous storage compartments. There is a 30-in.-long combination closet and entertainment cabinet on the left side, aft of the entry door.

Standard equipment will include a second-generation Rockwell Collins cabin management system, a media center with a 19-in. HD color monitor on the forward cabin bulkhead, two plug-in individual seat monitors with eight stations, an Aircell Axxess II Iridium satcom phone and eight 115-VAC/60-Hz or 230-VAC/50-Hz power outlets. A special application program will be offered for Apple iPod Touch or iPhone PDAs, enabling them to control cabin temperature, interior lights, video playback and optional electric window shades.

In the forward club section, left- and right-side electrically powered chairs will be optional for the second row. Internet connectivity will be available by means of an optional Aircell air-to-ground high-speed data link or medium-speed MCS 7120 Inmarsat system.

While the interior configuration will be standardized for the first 20 production units, three different color and material schemes will be offered. The Sedona option has light desert hues, the Havana option has tobacco and tan colors and the Alpine option has snow white that contrasts with dark earth and rock.

The Sedona interior choice was installed in Falcon 2000LX s.n. 228 at the EBACE static display to provide visitors with an idea of how a completed Falcon 2000S will appear. While the interior is attractive, functional and spacious, the matte-finish faux wood laminates on the cabinets appear to fall short of the quality buyers expect in a $25 million business

There is a four-seat club section in the forward section and six seats in the aft section.

aircraft. Villa said that interior was not the final version and that it will be improved before the Falcon 2000S enters service. "We and the operators will be proud of the interior," he claimed.

Aft of the main seating section, there is a full-width lavatory with tap and sink, an externally serviced toilet and additional storage compartments. The lav has a rear door that provides inflight access to the 131-cu.-ft., 1,600-lb. capacity baggage compartment. The compartment is larger than that of most SMS aircraft, but the Gulfstream G250 offers 17% more volume.

The external door to the Falcon 2000S's baggage compartment eliminates the need for a ladder or lift and speeds luggage loading and unloading.

Initial Flying Impressions

During a May visit to France's Istres Air Base, we climbed into the left seat of s.n. 701, the first production Falcon 2000S, accompanied by Jean-Louis Dumas, Falcon 2000S lead test pilot, who took the right seat, with chief pilot Philippe Deleume on the jump seat, for the 38th flight of the aircraft. Our goal was to sample the aircraft's low-speed handling characteristics and airport performance capabilities.

Most Falcon 2000S takeoffs will be performed using the SF1 configuration, which extends the slats fully and flaps to 7 deg. This creates more lift than the SF1 configuration aboard the Falcon 2000LX, which extends the outboard slats and flaps to 10 deg. The full-span slats increase stalling angle of attack by as much as 4 deg., thus V speeds will be decreased by as much as 10 kt. This means that SF2, which extends the flaps to 20 deg., only will be needed when takeoff field length is critical. The tradeoff will be decreased one-engine-inoperative climb performance at SF2 versus SF1 because of increased drag.

For our demo flight, the test aircraft was loaded to 37,300 lb., or slightly more than 90% of its 41,200-lb. max ramp weight. Serial number 701 had a full suite of orange test equipment, including ballast tanks, resulting in a pronounced forward c.g. Based on a takeoff weight of 37,000 lb., Istres' 82-ft. field elevation, an OAT of 26C, 1023-hPa QNH and using the SF1 configuration, our computed takeoff speeds were 110 KIAS for V_1, 115 KIAS for rotation and 122 KIAS for the V_2 one-engine-inoperative takeoff safety speed. Slat and flap retraction speed was bugged at 147 KIAS. Takeoff distances still are being calculated, but we estimate FAR Part 25 takeoff field length that day would have been about 4,000 ft.

The aircraft's Honeywell EASy II flight deck will have a basic runway performance calculator that will compute V speeds and runway distances. Dassault also is developing a Falcon Perf application for EFBs and laptops that will be capable of producing a full airport analysis, including SIDs, STARs and obstacle clearance gradient requirements.

Dumas fired up the APU and prepped the aircraft for flight while we conducted a walk-around inspection with Deleume. Once in the cockpit, we ran through a simple series of checks and started the engines. We adjusted the position of the cockpit video-cams for the flight test engineers on the ground at Istres, reminding us that our every move would be seen on their monitors in the flight test control room. Flight test telemetry would record hundreds of parameters during the mission.

With a little nudge on the throttles, the aircraft rolled out of the chocks. In moments, the aircraft reinforced our old impressions regarding the Falcon's smooth, chatter-free carbon brakes and responsive tiller-controlled, nosewheel steering. There is no steering available through the rudder pedals.

Lining up on Runway 33, we pushed the power levers to the forward stops. At 80 KIAS, we released the tiller and took the control yoke. After rotation, Dassault's flight test center recorded an all-engine takeoff distance of 3,435 ft., resulting in a takeoff field length of 3,950 ft. The precision control exercised by Dumas and his flight test pilots undoubtedly will reduce certified runway distances as performance testing progresses during the development program.

Seconds after liftoff, the Falcon 2000S reminded us that Dassault designs some of the nicest handling aircraft in production. Pitch transients caused by gear, slat and flap configuration changes were minimal; the aircraft has excellent speed stability. The pitch trim rate was well-matched to trim forces and pitch control force varied nicely with speed change as we accelerated to 260 KIAS. Roll control force was equally proportionate and natural feeling because of the Arthur Q unit that varies artificial feel in relation to the dynamic pressure (Q) of the indicated airspeed.

Roll control force was light and responsive, but the aircraft was very stable in roll. Overall, the Falcon 2000S feels as though it were a much smaller and lighter-weight aircraft fitted with well-harmonized manual flight controls. Think Beech Bonanza or Baron.

Leveling at FL 150, we slowed the aircraft and performed basic stability and control checks with gear up and SF1; gear up and SF2, which extends slats and flaps 20 deg.; and gear down with SF3, which extends slats and flaps to the landing configuration. At SF1, we slowed to V_2+10 or 132 KIAS. When we side-slipped the aircraft and then released the rudder pedal, the aircraft was very stable in roll and very well damped in yaw. Admittedly, these checks were performed at low altitude and at a low indicated Mach number, thus they were only partially indicative of the aircraft's stability at high altitude during high-speed cruise.

We performed the same maneuvers at SF2 at 126 KIAS or V_2+10 for the aircraft weight and configuration. Roll characteristics and yaw damping was just as impressive. Lowering the landing gear and selecting SF3, the landing configuration, we slowed to 122 KIAS, computed V_{REF} at a weight of 36,500 lb. At that weight, configuration and speed, we could roll into 40-45-deg. bank turns and still have stall margin. Wings level, we slowed until we reached aural stall warning at 16 deg. angle of attack.

We wanted to slow the aircraft until it completely stalled, but Deleume cautioned that such maneuvers would require an extensive post-flight inspection of the empennage and trim actuator, tasks that might delay the flight test schedule. However, based on our previous flight

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The Falcon 2000S Honeywell EASy II flight deck will have a basic runway performance calculator that will compute V speeds and runway distances.

experiences in Falcon Jets, we're confident that the Falcon 2000S will live up to Dassault's unsurpassed standards for handling qualities.

At stall warning, we recovered by adding full thrust, relaxing control wheel back-pressure and selecting SF2. As we recovered from the maneuver, we retracted gear and flaps and headed back to Istres for pattern work.

There, the Falcon 2000S proved to be just as easy to handle as other members of the Falcon 2000 family. But its approach speeds were slower. VREF was 122 KIAS at a weight of 36,500 lb. We flew one low approach, one touch-and-go and one full-stop landing. Then Istres Tower encountered radio problems, so we taxied back to the Dassault ramp after 50 min.

Our brief first flight in the aircraft left us eager to put the Falcon 2000S through the full gamut of our flight evaluation checks. Based upon our initial impressions, this aircraft promises to live up to the family heritage.

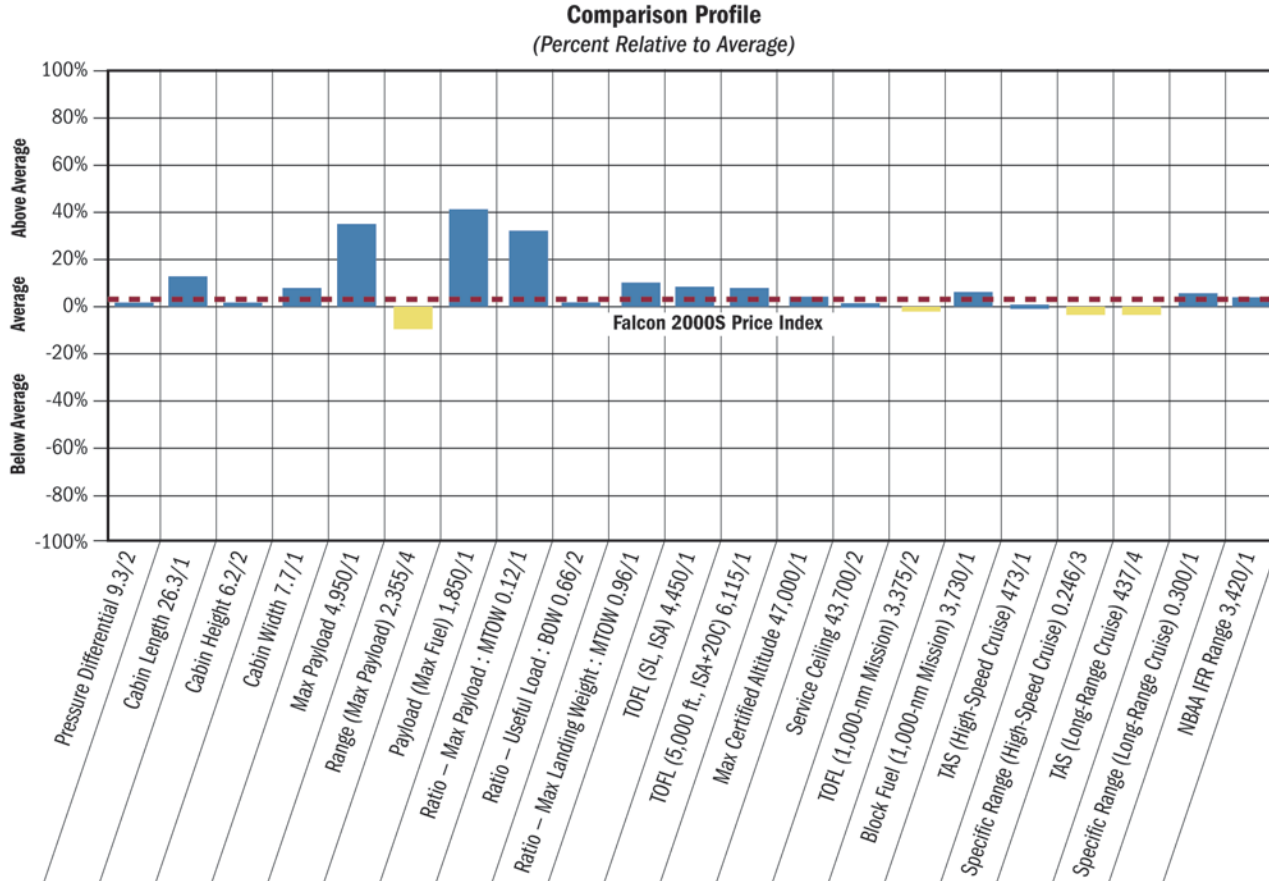
Price and Value

The accompanying Comparison Profile illustrates that the Falcon 2000S will be a formidable competitor in the super-midsize class because of its selling price. The right side of the chart highlights the aircraft's fuel efficiency. It indicates that the large-cabin Falcon 2000S will burn about the same fuel as a super-midsize aircraft. Direct operating costs should be on a par with the three main SMS competitors.

The aircraft also has many assets that are not shown by the bar graph, including overall cabin volume and baggage capacity, and floor width. It offers large-cabin head and shoulder room for seated passengers. It's the only aircraft in its price range to offer a four-seat conference grouping with two additional facing chairs on the opposite side of the cabin.

Orders for large-cabin aircraft are returning and Dassault has caught the growing wave with its Falcon 2000 and 7X families of large-cabin aircraft. The Falcon 900LX also remains a stalwart in the large-cabin class. The Falcon 2000S now gives the firm a way to field a large-cabin aircraft in the super-midsize class, offering more cabin comfort, better field performance and higher tanks-full payload.

It's a lot of airplane for the money, and the company's biggest challenge will be holding to the $25 million price. If it succeeds, the Falcon 2000S will likely attract potential SMS buyers, but if the price balloons after the first 20 units are sold, then the big Falcon 2000S will likely exit the SMS competition. BCA



Designers attempt to give exceptional capabilities in all areas, including price, but the laws of physics, thermodynamics and aerodynamics do not allow one aircraft to do all missions with equal efficiency. Tradeoffs are a reality of aircraft design.

In order to obtain a feeling for the strengths and compromises of a particular aircraft, we compare the subject aircraft's specifications and performance attributes to the composite characteristics of other aircraft in its class. We average parameters of interest for the aircraft that are most likely to be considered as competitive with the subject of our report, and then we compute the percentage differences between the parameters of the subject aircraft and the composite numbers for the competitive group as a whole. Those differences are presented in bar graph form along with the absolute value of the specific parameter for the subject aircraft and its ranking relative to others in the composite group.

For the Falcon 2000S Comparison Profile, we compared the aircraft to a composite group of four aircraft including it, the Hawker Beechcraft Hawker 4000, Gulfstream G250 and Bombardier Challenger 300. Please note that the Comparison Profile is meant to compare the relative strengths and compromises of the subject aircraft to a composite average, rather than being a means of comparing specific aircraft models to each other.