B/CA Analysis: Cessna Citation S/II

They look similar and they feel the same to pilot and passenger, but there is an impressive difference between the new Citation S/II and its predecessor.

By John W. Olcott and Richard N. Aarons

That the airframe manufacturers have been going through adverse times is news only to aliens from outerspace. While increased activity among FBOs and flight departments signifies that business aviation is rebounding smartly from the deep recession, the recovery has yet to have a significant effect on sales of new aircraft, partly because many used aircraft are available with performance that matches that of the new but higher-priced factory offerings.

Adversity, however, has a way of forcing change and often prompts improvement. The need for models that offer more than their predecessors is clear, and manufacturers are spending large quantities of time, effort and dollars to develop aircraft with more performance and lower operating costs. Some of those efforts are resulting in radically new aircraft that feature composites and unusual configurations. Others are employing advanced engineering techniques to significantly refine existing designs.

Cessna's Citation S/II falls into the latter category. Using computer-aided design of the wing and detailed analysis of the airflow around the wing root, engine nacelle and pylon, Cessna's engineers were able to provide the S/II with improved aerodynamics and lower drag.

The airfoil of the S/II has been shaped to provide less drag rise than the Citation II's at cruise Mach number. By incorporating slightly more thickness toward the trailing edge, the S/II's airfoil is more aft loaded than its predecessor's. Thus it exhibits the favorable drag characteristics of supercritical airfoils. Since the new aircraft also has an extended chord and significant taper at the wing root, due to the addition of a pronounced break in the wing's planform where the wing joins the fuselage, the fineness ratio (percent slimness) of the wing at its root is greater than the II's. Consequently, the S/II wing experiences the onset of its drag rise between 0.59 and 0.64 Mach, which is about 0.04 Mach higher than its predecessor and is impressive for an unswept wing.

The S/II's wing does not have pneumatic boots on the outboard portion of the wings and a bleed-air-heated cuff inboard as does the Citation II. Instead, the aircraft is fitted with a TKS system for the dispersal of anti-icing fluid, similar to what the British Aerospace 125 has used since that aircraft's inception. The S/II carries 63 pounds of TKS fluid, which is sufficient for six hours of continuous use if applied only to the inboard sections that previously were heated by bleed air. Since Cessna had not completed its icing certification at press time, the details of how the TKS system would work on the S/II were not available. No delays with icing certification are anticipated.

In addition to being an effective anti-icing system, TKS on the S/II results in a smooth leading edge and might help the wing remain cleaner since TKS is known for its ability to disperse squashed bugs from surfaces.

In an attempt to prevent the airflow from separating and producing pronounced drag as it flows through the channel formed by the wing root, the fuselage and the nacelle, Cessna engineers also extended the wing-root fairing aft of the wing and designed a thinner engine pylon. Furthermore, the S/II's pylon has a longer, more aerodynamically efficient "duck tail." (Cessna engineers recognized the presence of separated channel-flow on the Citation I and attempted to correct the situation on the Citation II by lowering the wing on the fuselage, but they were not successful in eliminating the condition.)

FROM THE DECEMBER 1984 BUSINESS & COMMERCIAL AVIATION.

A skillful observer of Citations will note that the S/II does not employ small fences on the upper inboard sides of the ailerons as does the Citation II. These devices are used to aid dihedral effect: the tendency for a wing to roll when the aircraft is yawed. Applying right rudder should cause the left wing to rise. By placing small fences on the upper inboard portions of the aileron, they interact with the crossflow caused by the yaw and the aileron is forced down, thereby helping the aircraft roll in the desired direction.

Cessna engineers tried to achieve the desired dihedral effect using the fence technique but opted instead for a spring interconnect between the rudder and aileron. While the handling-qualities purist doesn't like spring interconnects, the S/II flies nicely despite the rudder/aileron spring.

While the Citation S/II does not have aileron fences, and therefore does not suffer the drag of such devices, it does have a row of vortex generators at approximately the mid-chord position ahead of the ailerons. The VGs improve aileron effectiveness at the high end of the S/II's velocity/g-loading performance-envelope.

As a result of the aircraft's aerodynamic improvements, the Citation S/II offers less drag than the Citation II. But Cessna was not content with just relying on their cleanup program, particularly when Pratt & Whitney offers an improved version of its JT15D-4, known as the "B" model.

Like the -4, the JT15D-4B develops 2,506 pounds of thrust and has a time between overhaul of 3,000 hours. But it is certified for higher N1 speeds above FL 300. This change in fan speed enables the JT15D-4B to provide higher thrust in the thin air of higher altitudes. All other aspects of the powerplant are identical to the Citation II's -4s.

As a result of its lower drag and higher power at altitude, the Citation S/II offers a normal cruise speed of 397 knots on 1,090 pph at FL 370 in ISA conditions; at FL 410 it has a long-range cruise speed of 357 knots while consuming 820 pph. The respective figures for the Citation II are: high-speed cruise of 374 knots on 1,081 pph at FL 350, and long-range cruise of 327 knots on 690 pph at FL 430. About 80 percent of the S/II's speed advantage is attributed to aerodynamics; the remaining 20 percent results from the higher N1 limits of the -4B powerplant, according to Cessna engineers.

More Than More Speed

The higher speeds of the Citation are impressive by themselves. For example, the S/II provides a specific range at normal cruise of 0.364 nm per pound, which is about five percent better than the Citation II's corresponding value of 0.346 nm per pound. But the S/II achieves its speed and specific-range advantage while lifting a higher gross weight than its predecessor. Thus its improvement in maximum productivity is greater than the increase in either speed or specific range.

The Citation S/II is certificated for a ramp weight of 14,900 pounds, 1,400 pounds more than the II, and it has a max takeoff weight of 14,700 pounds. Thus, the S/II achieves its greater speed while carrying more, thereby emphasizing the benefits of Cessna's aerodynamic and powerplant changes. Furthermore, the S/II can achieve an initial cruise altitude of FL 410 after a takeoff at max gross.

Mainly because the S/II's flaps extend inboard until they nearly reach the fuselage rather than ending about a foot outboard as in the Citation II, the new aircraft has a stalling speed that is one knot slower than its predecessor's, despite the S/II's higher gross weight.

Part of the weight advantage of the S/II is consumed in the new aircraft's heavier B/CA-equipped basic operating weight — 8,756 pounds, compared with the II's BOW of 8,035 — but the new Citation has a useful load that exceeds the II's by a respectable 679 pounds. An operator may choose to use that greater useful load for carrying passengers, or he can take advantage of the S/II's 5,777-pound-capacity fuel tanks, which hold 805 pounds more than its predecessor.

Classic Citation

The S/II incorporates all the qualities that made the Citation II a popular aircraft. It offers room for seven to eight passengers and has a fully enclosed lavatory, and its flight deck has space for a full complement of avionics. Interior appointments for the S/II that B/CA flew were attractive and well-built.

The S/II also enjoys typical Citation quietness. Cruising with normal power at FL 370, we observed an average noise reading of 80 dBA in the cabin and 84.5 dBA in the cockpit.

The relative position of the Citation S/II with respect to a hypothetical aircraft that possesses the average characteristics of all business jets within the S/II's class is illustrated by the B/CA Comparison Profile. Clearly, the new Citation presents a competitive picture that is enhanced by the aircraft's speed and useful load, which were areas where the Citation II fell farther below the average than does the Citation S/II.

The S/II possesses the good airport performance and fuel specifics that are Citation trademarks, and its healthy fuel capacity gives the aircraft a highly competitive tanks-full range.

B/CA's evaluation of the Citation S/II's performance occurred during a trip from Atlanta's Fulton County Airport to Cessna's delivery center in Toledo, Ohio.

For our flight, which carried a useful load of 4,511 pounds, we had a takeoff weight of 13,200 pounds, which equated to 85, 92 and 97 knots V1, VR andV2 respectively. Balanced field length was conservatively calculated to be 3,350 feet.

Once we were released from the confines of Atlanta Departure Control and the congestion of the Atlanta area, we climbed to FL 310 and observed a true airspeed of 399 knots on 1,235 pph, which is two knots and about 85 pph better than what Cessna states is possible in temperatures averaging about ISA+3. We then climbed to FL 370 and observed a TAS of 388 knots with a fuel flow of 1,020 pph, which equates to a specific range 0.018 nm per pound better than book but about six knots and 68 pph under handbook figures. Possibly our power setting was slightly low. On average, however, the S/II lived up to its advertised billing in terms of speed and specific range for our weight, temperature and altitude.

As we approached the Toledo area and descended, we applied the spoilers to observe their effectiveness and vibration. While spoiler deployment causes a slight rumble, the disturbance is minimal and should not be a distraction to passengers. With the spoilers deployed, the aircraft can descend at a rate that easily exceeds the limits of the vertical speed indicator, and actuation of the devices causes almost no effect on handling qualities.

Below FL 180 we canceled our airways clearance and did some air work, including stalls. The S/II responded in typical Citation fashion: The aircraft has to be one of the gentlest jets flying. Its handling qualities are very well-behaved. The pitch dynamics are nicely damped, and lateral/directional characteristics are equally pleasant. During stalls, the aircraft gave ample warning of its condition, and the stall break was not severe, although we did observe a tendency to roll slightly to the left as the nose pitched down at the stall.

The S/II's speed stability on the approach was very good, with the aircraft responding nicely to power changes and easily trimmed for a stabilized flight path. The fact that Cessna increased the strength of the elevator down spring and added slightly to the bob weight (to account for a small change in pitch stability due to the wing redesign) in the pitch system was apparent as we commenced the flare. More force was needed to effect the roundout, but otherwise the aircraft behaved pleasantly-like a Citation.

The Citation S/II is an example of how technology can subtly improve a good product and make it more attractive. No doubt exists that the S/II is a more capable aircraft than its predecessor, and that's good news for both the operator and the manufacturer. B/CA

FROM THE DECEMBER 1984 BUSINESS & COMMERCIAL AVIATION.