Business & commercial Aviation
PILOT REPORT

Status Report: Cessna's New Citation V

B/CA met with the engineering and flight test managers for an update on the certification program for this longer, faster Citation.

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One of the more interesting growth stories in corporate aviation has been that of Cessna's Citation line. If you recall the first Citation mockup at the 1969 NBAA meeting, you'll probably also remember that, conceptually, the airplane seemed to be little more than a 421 Golden Eagle with jet engines. Yet, it captured the imagination of convention attendees and ultimately sired the most popular line of business jets in the world.

The Citation was smaller than the other jets, it flew slower and liked lower altitudes. In the early days of the Citation, Cessna salesmen actually argued that the airplane was really a turboprop with a very large number of very short propeller blades. (In those days, after all, few of us understood the virtues of relatively high-bypass fans.) Much to our delight, though, this new machine was the nicest handling airplane of its size. . .period.

The Citation 500 grew into the Citation I, then the Citation II and finally the S/II. Each step provided a little more speed, a little more lifting power and a little more room. Bird-strike-from-the-rear jokes notwithstanding the Citation line became the accepted standard for safe, reliable entry-level jet operations.

Still, the Citation story is far from over: Cessna management believes that there is room for at least one more growth version of the basic Citation. Enter the Citation V.

Before we go any further, a note on the V designation is in order. The roman numeral in the name "Citation V" is based on the fact that the airplane will be equipped with the -5 version of the Pratt & Whitney JT15D powerplant. Or perhaps more importantly, on the fact that Cessna marketers wanted to emphasize the significant differences between the new aircraft and earlier Citation models.

The Citation I, II and III designations had been taken. The Citation IV is believed to be an experimental prop-fan. (It's convenient to describe certain aspects of the Citation V as improvements over or changes to the Citation S/II. Such references here, however, are not to suggest that the former is intended to replace the latter, although our guess is that it just might happen.)

To learn first-hand of the Citation V development status, B/CA was briefed by flight test program managers in early spring, just as the prototype reached 137 hours (113 flight) and the preproduction airplane logged its 30th hour. The Cessna briefing team included Milt Sills, director of engineering, Ellis Brady, manager/engineering flight operations, Roy Phillips, senior project engineer/Model 560, and Paul Kalberer, manager/technical engineering.

The prototype airplane, which has been a Citation I, II and S/II at various times in its life, first flew as a CITATION -V in mid-August 1987 and is the CITATION -V that appeared at last fall's NBAA meeting in New Orleans. (Actually, during the fall test period, the prototype was a Citation in that it had a 20-inch cabin plug and the "IV and-one-half" JT15D-5 engines, but it

lacked the larger horizontal tail that will be a significant part of the production CITATION -V configuration.)

Notwithstanding the marketing interests satisfied by having the prototype's first incarnation as a CITATION -V at the NBAA visit, the machine accomplished much more than the brief exposure to prospective customers. Early flight tests in the temporary configuration let engineers look at numerous aspects including water ingestion, basic handling qualities and low-speed performance. That aircraft also generated a fair amount of information on environmental system performance at FL 450.

At the end of November, the prototype had been returned to Cessna's developmental flight-test hangar where the engines were removed for modification by Pratt & Whitney Canada at its Quebec facility. At the same time, the empennage was removed for modification at Wichita. The airplane was then back in the air on January 25 with a new horizontal tail, reworked engines and a significant amount of flight test gear.

After its January rebirth, the prototype was tested for stall-speed determination and evaluation of primary stall characteristics. Engineers continued to use that prototype for high-altitude work including pressurization-system adjustment. It was also being flown for additional handling and speed/power experimentation.

While all that prep work was going on in the fall, the preproduction airplane, the first machine built from scratch as a CITATION -V, was nearing completion on new tooling. Complete with the 20-inch stretch (as opposed to a plug), new engines and a new horizontal tail, this airplane entered the test flight program on January 29, just four days after the prototype resumed flying.

That preproduction airplane, which ultimately will go to a customer, is making a more gentle contribution. At this writing, the aircraft was being used as a test bed for final environmental-system work and anti-/deice certification.

FLIGHT TEST UPDATE

At the time of our briefing, the entire altitude envelope had been developed-that is, from sea level to FL 450. (The CITATION -V will be certificated to 45,000 feet compared to 43,000 feet for the II and S/II.) The speed envelope had not been expanded at this writing. In fact, at press time, Cessna technicians were installing shakers in the wing and horizontal tail. But, enough work was done to make the determination to retain the S/II's rudder/aileron interconnect.

Shakers are used to run frequency sweeps from zero to 50 Hz or so during speed runs in order to define the aircraft's flutter boundaries. Earlier, the test airplanes had been flown to 270 knots below 10,000 feet and to 215 knots above 10,000.

Speed targets are set for a VMO of 290 knots and an MMO of 0.75, which compare with the S/II's 275 knots and 0.72 Mach, respectively. The engineers say that they may back off the 290-knot VMO if flutter problems develop, but a decision such as that would come late in the test program. Interestingly, the leading edge of the speed envelope of the Navy's T-47 (JT15D-5-powered, modified S/II) leans back from 355 knots at sea level to 275 knots at FL 200. The front edge of the CITATION -V envelope is planned to be vertical at 290 knots from sea level to Mach transition altitude.

Static testing, which is limited to the new tail structures discussed later, was about 70 percent complete at this writing and was expected to be finished sometime in May.

A definite improvement is the CITATION -V wing, which is an S/II wing with slight modifications to the leading edge to accommodate new anti-deice systems-hot air inboard and pneumatic boots outboard. (The S/II, you'll remember, has a TKS leading-edge anti-ice system, which has enjoyed less than enthusiastic popularity among Citation operators.)

The wing designers have also added a few extra stringers and ribs internally to handle the CITATION -V's gross takeoff weight of 15,900 pounds, an 800-pound increase over the S/II. Drop tests on the landing gear are complete at the new design weights. The only changes involved redeveloping the main gear metering system.

An 11,200-pound zero fuel weight is standard. Cessna Jet marketers want to offer an optional increased ZFW, perhaps 400 pounds heavier, however. This paperwork option would increase payload but reduce VMO as much as 15 knots. No firm decision has been made, although optional ZFWs are available on most other Citations. The certification team also expects to go for optional single-pilot certification and anticipates no problem getting it.

If you haven't been keeping up with the somewhat complicated business of single-pilot certification, here's how it goes now. Cessna has single-pilot certification for most Citation I and II models. Originally, single-pilot operations were restricted to weights below 12,500 pounds regardless of the design max gross takeoff weight of the identical two-pilot version. Ultimately, Cessna convinced the FAA that weight had nothing to do with the safety of single-pilot operations, and coincidentally, there are no differences in the safety statistics of single-pilot versus two-pilot operations.

Now, under an FAA exemption, the Citation I, S/II and the Navy's T47 can be flown single-pilot at the identical weights that are permitted for two-pilot operations so long as the pilot passes a single-pilot check ride

with the FAA. CITATION -V engineers believe a similar exemption will be in order for the new airplane.

The team expects all test work to be completed and final FAA certification to come sometime between mid-November and year's end. So far, all is on schedule, and the "surprises" that arise in all flight test programs have been minor. We'll discuss some of those surprises as we look at configuration and systems.

CONCEPT AND STRUCTURE

The "why" of the CITATION -V is pretty straightforward. Basically, Citation marketers were looking for an airplane with a more roomy or spacious feel to the cabin and a cruising speed about 25 knots faster than the popular S/II. At the same time they wanted to backtrack a bit to the super-short-field capabilities of the earlier (and much lighter) Citations

Getting the more spacious cabin was easy: The constant cross-section cabin would be stretched 20 inches between the wing leading edge and the cabin door, which provides room for completely private bathroom facilities and easier access to galley stores.

Getting the additional 25 knots and improved short-field capability would require more power, thus the installation of the -5 powerplant, the latest version of the JT15D that has powered Citations I and II from the beginning.

While those changes are easy to describe, they are a lot more complicated in execution. Therefore, some interesting good-news bad-news engineering tradeoffs must be worked out. For example, a more powerful engine burns more fuel if run at its max cruise settings (bad news). Of course, an attendant improvement of power-to-weight ratio allows the airplane to get to efficient, higher altitudes quicker (good news). In the end, the CITATION -V should have range performance similar to the Citation S/II.

Another engineering challenge arises out of the weight of the new engines in that the JT15D-5 installation is about 118 pounds heavier than the -4 installation, and the additional weight tends to move the c.g. aft (bad news). True, the 20-inch stretch forward of the wing leading edge tends to provide some compensation for the increased engine weight, but not enough to meet FAA stability criteria with the desired c.g. range.

Likewise, the Navy T-47, which is a Citation S/II fuselage with a chopped, strapped wing, the -5 engines and a slightly modified S/II horizontal tail, has a limited c.g. envelope because of the weight of the engines. But that condition doesn't bother the Navy because the airplane is flown in a highly controlled operational environment. Similar restrictions would be impractical in a commercial/corporate airplane, however. So, for the CITATION -V, Cessna designers decided to increase the span (read as power) of the horizontal tail.

Serendipity came into play at this point (really good news). So long as the designers had to increase tail power to keep c.g under control, they decided to step up tail power enough to lighten rotational forces that had increased significantly as the Citation I grew into the Citation S/II. Both challenges (c.g. and rotational forces) were met by adding a 15-inch, constant-section, inboard panel to either side of the horizontal tail, thus increasing tail span by 30 inches.

Another element of the tail-end serendipity was that the requirement to change the shape of the tail gave Citation engineers an opportunity to "start out with a new piece of paper" when designing it. Actually, they started with a new piece of software- a state-of-the-art computer-aided design and manufacturing (CAD/ CAM) system, with which the engineers were able to realize "tremendous savings" in design and retooling time.

The internal structure of the CAD/ CAM horizontal tail is "totally different" from earlier Citation tails. Basically, the design has gone from four spars to three; weight, parts count and fabrication time all are reduced.

A final note on structure: While a plug is visible in the accompanying photos, production aircraft will not have a plug. Instead, tooling has been changed to make the aircraft 20 inches longer with continuous internal structure, which keeps the parts count down and strength up.

ENGINES

The P&WC JT15D-5A is a 3,200-pounds-thermodynamic-thrust growth version of the JT15D. It'll be flat rated to 2,900 pounds-thrust in the CITATION -V installation for optimal hot-day performance.

Citation engineers were frank in pointing out that they've "had a little trouble getting the engine lined up with what P&WC was saying." There were several elements to the airframe engineers' mild initial disenchantment, including the fact that the Navy -5 engines with their electronic fuel controllers seemed more subject to surging than was experienced in earlier JT15Ds.

Additionally, Cessna Jet wanted to be able to dispatch the CITATION -V with an electronic fuel controller switched to the manual mode. The FAA frowned on that idea. The solution to both problems was to get rid of the electronic fuel controllers in favor of mechanical ones.

We mentioned earlier that the engines on the prototype were sent back to Canada while the airplane was down for its new tail feathers. P&WC changed the fuel controllers and made some minor rear-end modifications to the engines in hopes that they'd meet full spec during the rest of the flight test program. Initial reports are positive.

Airframe designers were able to retain for the CITATION -V the basic nacelle profile and pylon structure

used on the S/II. The CITATION -V's Rohr thrust reversers are similar to the S/II's with the exception of a bit of reinforcement to handle the additional thrust loads. (Thrust reversers are standard equipment.) The aft fairings also have been adjusted to handle slight differences in thrust velocity.

SYSTEMS

The new aircraft's systems are substantially the same as installed in the S/II except for the anti-/deice system. Engine bleed air is used for anti-ice protection on the engine inlets, inboard wing cuff leading edge and the windshields. The outboard wing and horizontal tail are protected by pneumatic boots.

Pressurization system outflow valves were recalibrated to provide an 8,000-foot cabin at FL 450. The 9.0 pressurization differential will maintain a sea-level cabin to 23,586 feet.

One of the secondary design goals was to enhance the ability of the crew to get the airplane down from altitude, which has been accomplished by adding a backup, fixed door seal. (The S/II has a single inflatable door seal.) The backup door seal and an increase in gear extend speed to VMO will enable a Citation V to get down from FL 450 in about two minutes and 45 seconds. A similar descent in the S/II takes about four minutes and 30 seconds (This advantage is simply a product improvement. In over four million operational hours, no Citation passenger or crewmember has ever been injured from high-altitude decompression .)

Perhaps the most interesting system changes are those involving the avionics. Standard equipment on the pilot's side includes a two-tube Honeywell/Sperry electronic flight instrument system. EFIS for the copilot's side is optional. The familiar SPZ-500 flight director/ autopilot is also standard, as is the Global-Wulfsberg GNS-X "regional" navigation management system, which has the power of a heavy-iron system compacted into a unit for medium jets (see B/CA, October 1987, page 49).

All in all, the CITATION -V is beginning to emerge as a highly competitive airplane. Preliminary flight tests prove that the numbers and handling are as good as hoped for, if not better. Its B/CA fully equipped price of $3.84 million will help that competitiveness against other medium and small jets and even against some of the larger turboprops.

We'll be watching developments closely, and of course, we'll keep you posted. **B/CA**