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Technology:

## Garmin's New G5000 Integrated Flight Deck



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# The Ten by Cessna

Second-generation Citation 750 cruises faster, higher and farther with more cabin space and payload.

By Fred George

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Cessna announced its new top-line flagship, the Citation Ten, at the 2010 NBAA Convention, providing potential customers with an introduction to the firm's second-generation midsize speedster that will be delivered in 2013. The Ten will offer quicker climb times, higher cruise altitudes and higher cruise speeds, along with 6% to 7% more range, compared to the current Citation X.

The Citation Ten also will incorporate a 15-in. fuselage stretch, just behind the entry door, and a redesigned interior that will offer more legroom and greater passenger comfort. An empty Citation Ten will be heavier than the current aircraft, but it's also getting a 500-lb boost in MTOW, thereby enabling it to carry one more person with full tanks. The allowable MTOW, though, will be subject to airport density altitude limitations.

"Our goal is to provide as good or better runway performance for the Ten, which will have increased payload with max fuel," explained program manager Kevin Steinert. The Ten, albeit longer and heavier than the current Citation X, will have almost the same airport performance because it has a 4% boost in takeoff thrust boost and winglets that reduce induced drag in all flight regimes.

While other midsize aircraft offer a larger cabin cross section and more volume, the strong suit of the Citation Ten continues to be class-leading cruise performance, even more so than with the current Citation X.

"The Ten originally started life as a different platform. But we've been thinking about variations [of the Citation X] since last summer," explained Steinert. The Ten will not have the wider fuselage wanted by some customers. (See "Passenger Accommodations" below.) Cessna killed development of the larger cross section Citation Columbus in 2009 when the business aircraft market all

but imploded, but the program could be revived if industry conditions improve in the future.

Upgraded engines and winglets also will enable the Citation Ten to fly 190 nm farther at its Mach 0.82 long-range cruise speed. Compared to the current Citation X, the range increase extends block times by about 24 min. With 3,242 nm of range, the Ten will be able to fly seven passengers from Shannon to White Plains, Gander to Seattle or Detroit to Anchorage against 85-kt. average headwinds. With one refueling stop, operators will be able to fly between most city pairs in North America and Europe.

Cruise speeds approaching 500 kt. are this aircraft's strong suit, at least if maximum range is not a concern. It will be able to fly from New York to Shannon at Mach 0.85 to 0.86 high-speed cruise. With a 25-kt. headwind on the return leg, the Ten must slow to Mach 0.82 to make the trip nonstop. Stronger headwinds over the North Atlantic will require an en route refueling stop on westbound trips. Even

Artists renderings courtesy of Cessna Aircraft

with a refueling stop, passengers traveling eastbound between most city pairs in the United States and Europe will be aboard the aircraft for no more than 5 or 6 hr. on the longest legs. Westbound, the aircraft will be able to fly Le Bourget-Gander-Dallas at high-speed cruise against 80-kt. headwinds. Some westbound transatlantic trips, though, will require two fuel stops, depending on city pair distances, winds and weather at the refueling stop.

However, Cessna officials believe that most operators are likely to take advantage of the extra cruise speed to zip between more pairs of North American cities. At high-speed cruise, the new model will be able to fly from Boston to Seattle, Miami to Santa Barbara, Calif., or New York to Vancouver against 100-kt. headwinds. With light winds, most transcontinental U.S. missions can be flown in 4.5 hr. or less. Cessna performance engineers also claim that the new model will burn slightly less fuel on such trips.

### Airframe and Systems Changes

Except for the 15-in. fuselage plug behind the cabin door and wingtip modifications, Citation Ten's monocoque aluminum airframe remains virtually unchanged. Cessna engineers believe the existing airframe, landing gear and rolling stock will handle the higher ramp, MTOW and zero fuel weights, without modifications. The ventral fairing is being lengthened and reshaped, resulting in virtually no change in cruise drag from the current aircraft.

As such, the Ten is a low-risk derivative, so the firm doesn't plan to build a full-scale ground test article. However, the wing structure has been ground tested to evaluate loads and stresses imposed by the winglets and the Garmin G5000 system, complete with autothrottles, will be wrung out in an iron bird mock-up.

First flight of the engineering prototype is on track for December 2011, with a production conforming airplane to enter the flight-test program soon thereafter. FAA certification is planned for the first half of 2013 with customer deliveries in the second half of the year.

Outside of the engine upgrade, adding winglets to the Ten is the other main change. They reduce drag by about 3% to 6% in high-altitude cruise, according to Bob Kiser, president of Wichita-based Winglet Technology, the firm that partnered with Cessna to develop the modification. Kiser also noted that the winglets considerably reduce induced drag during takeoff and landing, having a favorable impact on V speeds, runway



Techno-futuristic interior mock-up eschew British midsize traditions in favor of chris dark and light contrasts, metal and composite surfaces, and multi-color accent lights.

distances and OEI climb performance.

The Citation Ten should be just 2-kt. faster at FL 350 than the current Model 750, even though it has 7% more cruise thrust, according to Cessna's projections. The razor-thin 527 KTAS versus 525 KTAS margin suggests that the new model will have greater form drag at high indicated airspeeds than the current aircraft.

But cruising at Mach 0.91-plus is not the new aircraft's forte. The prime benefit of the winglets and uprated engines will be the ability to climb 2,000 ft. higher and cruise faster than the current aircraft. Assuming standard-day conditions, the current Citation X can climb directly to FL 430 in 28 min. and then cruise at Mach 0.83 or 475 KTAS. The Ten, in contrast,

will be able to climb directly to FL 450 in 23 min. and cruise at a somewhat higher speed.

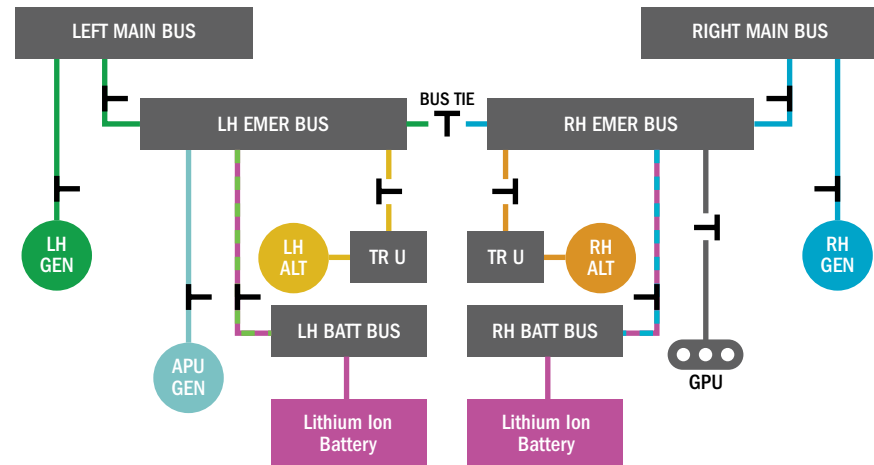
The Ten consistently will be able to climb 2,000-ft. higher than the Citation X under the same conditions and cruise faster at the higher altitudes. This will result in both better fuel efficiency and faster block times.

Full-authority autothrottles, a first for Cessna, will be a welcome improvement aboard the Ten. Autothrottles will reduce pilot workload, especially during approach and landing. The Citation X has rather sensitive thrust response to throttle movement at low power settings. Combined with its comparatively low drag, that can make precision airspeed control somewhat of a challenge.

### Cessna Citation Ten Specifications (preliminary)

Price	\$45,000,000	Max Takeoff	36,600/16,602
Seating	2+9/11	Max Landing	32,000/14,515
<b>Characteristics</b>			
Wing Loading	NA	Zero Fuel	24,978/11,330c
Power Loading	2.60	BOW	22,461/10,188
Noise (EPNdB)	NA	Max Payload	2,517/1,142
<b>Dimensions (ft./m)</b>			
<b>External</b>			
Length	73.6/22.4	Useful Load	14,439/6,549
Height	19.3/5.9	Executive Payload	1,600/726
Span	69.2/21.1	Max Fuel	12,931/5,865
<b>Internal</b>			
Length	25.1/7.7	Payload w/Max Fuel	1,508/684
Height	5.7/1.7	Fuel w/Max Payload	11,922/5,408
Width (maximum)	5.5/1.7	Fuel w/Executive Payload	2,802/1,271
Width (floor)	3.9/1.2	<b>Limits</b>	
<b>Power</b>			
Engine	2 RR AE3007C2	M <sub>MO</sub>	0.920
Output (lb ea.)	7,034	V <sub>MO</sub>	350
Flat Rating	ISA+15°C	PSI	9.3
TBO	4,500* hr.	<b>Climb</b>	
<b>Weights (lb/kg)</b>			
Max Ramp	36,900/16,738	Time to FL 370	14 min.
<b>Ceilings (ft./m)</b>			
Certificated	51,000/15,545	<b>Certification</b>	
All-Engine Service	45,000/13,716	FAR Part 25, 2013	
Engine-Out Service	NA/NA	*Engine flight-hour inspection interval	
Sea Level Cabin	24,000/7,315		

### Citation Ten Electrical System



Autothrottles, integrated with the G5000 avionics package, will handle the airspeed control function during these critical two phases of flight, among others.

The upgrade to the DC electrical system is the Ten's biggest airframe system change. As shown by the accompanying diagram, the emergency buses now have quad-redundant power supplies. Following the design example of the CJ4, Cessna's engineers decided to use the left and right engine-driven alternators for something other than just supplying AC power to the windshield heaters. Aboard the Ten, the left and right alternators also supply power to their respective transformer-rectifier units (TRUs) that convert 115 VAC to 28 VDC. This provides third and fourth DC power sources for the essential buses. For pilots, this means the complete avionics package will be available after the loss of up to three essential bus power sources.

Similar to the CJ4, the Citation Ten will have lithium-ion batteries. The pair will replace the 44-amp nicads in the current airplane. Lithium-ion batteries will be lighter in weight, have higher power output than the nicads and require less maintenance. Notably, aircraft-grade lithium-ion batteries have much lower power density than ones used in cell phones and laptops, so they're fire resistant, even when exposed to high temperatures.

Gutting the center pedestal of the Primus 2000's FMS CDUs, radio management units and HF radio controls and replacing them with twin G5000 touch-screen controllers will enable Cessna to slim down the width of the console. This will make it easier to enter and exit the crew seats. In keeping with legacy Citation design protocol, there will be no cockpit overhead control panel

— only work lights, air outlets and satcom handset.

Cessna is updating the IRS from Laseref IV to Laseref VI, the latest version of Honeywell's top-line product. Laseref VI is an all-digital system that has automatic mode control and an alignment-in-motion feature. The upgrade should eliminate the need to keep the aircraft parked for 6 min. for IRS alignment. Laseref VI, in combination with the G5000 avionics, will reduce risk in meeting RNP 0.3 requirements and provide a growth path to RNP 0.1.

Other systems remain virtually unchanged. The three-tank fuel system has the same 12,931-lb capacity; the two main power sources for the split bus electrical distribution system are left and right, engine-driven, 40-amp, brushless DC generators; there is a dual-channel, 3,000-psi hydraulic system that powers the landing gear, nosewheel steering, spoiler, wheel brake, thrust reverser and flight control actuators, except for the electrically powered trailing edge flaps; dual ACM packs supply heated or refrigerated air for the 9.3-psi cabin pressurization system; and bleed air is used for anti-ice protection on the wing and horizontal tail leading edges.

#### Cabin Environment

The techno-futuristic design theme of the Citation Ten cabin mock-up shown at NBAA is in sharp contrast to Cessna's current Citation interiors that embrace many legacy British midsize aircraft traditions.

Gone are the soft lighting and smooth curves, high-gloss wood veneers and faux granite counters, jacquard and damask wall coverings. In place, Citation Ten passengers will find mostly metal and

composite surfaces, with plenty of sharp angles and creased edges, along with strong dark and light contrasts. Color is conspicuously absent. The mock-up's cabinets still have wood veneers, but they're finished in matte black. Metal fixtures have brushed stainless surfaces. Polished jet black and dove gray plastic panels replace many of the wood surfaces on the cabin sidewalls and worktables.

Overhead wash lights beam directly through diffusion panels, not unlike the lighting used in some spacecraft. The side rails, worktable pockets and aisles have multi-color mood lighting that offsets its stark black-and-white motif, giving the cabin a techno club ambiance that's anything but traditional.

The 15-in. fuselage plug, just aft of the entry door, enabled the designers to add 5 in. of extra legroom for each passenger, an improvement long sought by customers. The plug also increases the space between the two club sections so that all eight chairs can be fully reclined. In addition, there are larger cabinets between the back-to-back chairs, providing room to store laptops and other carry-on gear.

Each passenger chair has been redesigned to better fit human contours. The seat and back cushions were inspired by Cessna's preliminary design work on the 4,000-nm-range Citation Columbus. The new seats are wider, but they don't crowd the cabin any more than the current chairs because the armrests now extend only over the seat cushions when folded down. They fully retract behind the seat backs when folded up, thereby increasing usable width in the center aisle between opposite side chairs.

Cessna also is adding adjustable lumbar supports for the chair backs. Pockets in the backs of the chairs provide storage for magazines and small personal items, not unlike airliner seats.

The wider chairs, though, still intrude into access along the center aisle when the passengers track them inboard for more elbow room. The cabin will be 25-ft. long, but it's still 5.7-ft. high and 5.5-ft. wide, making it the smallest cross section in the midsize class.

The side rail ledges, outboard of the folding worktables, have been completely redesigned with rail-fenced shelves that can hold PDAs, cell phones, glassware and personal items. Each end of the shelf has two powered USB ports for recharging and data connections, plus a headphone jack. Standard AC power outlets for laptops and other office equipment will be mounted low in the sidewalls. Overhead,



Longer cabin makes room for larger work tables and more legroom. Each seat has a built-in touch screen.

there are individual LED reading lamps for each passenger and presumably air outlets.

Increasing the legroom between facing chairs enables Cessna engineers to fit the Ten with larger worktables than in the current aircraft.

Ahead of the entry door, there is a generously sized utility closet that houses entertainment system components and provides hanging storage for clothes. The G5000 avionics suite hosts electronic charts, thus freeing up a considerable amount of space in the compartment for passenger use.

On the right side, there is a galley with increased storage space, both above and below the counter, for beverages, food and tableware. It appears that the galley now spans across the right front window



New seats have retractable arm rests. Multi-color accent lights provide contrast to dark and light motif.



Rail-fenced shelves, outboard of the work tables, are brightly illuminated. End caps have USB, audio and aux data ports.

At the back of the cabin, there is a full-width lavatory with an externally serviced toilet. Some Citation X operators have remarked that its 5-gal. tank is a little short on capacity for long missions. Cessna looked at replacing the current system with a vacuum lav, but the current production components are too bulky for this class of aircraft.

The lavatory has an adjoining aft storage closet. There is a separate 72-cu.-ft., pressurized baggage compartment in the tail cone that only is externally accessible.

Cessna is partnering with Dallas-based Heads-Up Technologies to develop an integrated cabin management system that links passenger communications, entertainment and electrical systems by means of a fiber optic network. Using fiber optics should both reduce weight and provide band width margins for future applications. Cabin WiFi will be an option, but Cessna has not announced a supplier for air-to-ground connectivity. Cessna is developing its own moving map and flight progress information system that will link with the aircraft's avionics suite.

#### The Ten Versus Competitors

The Citation Ten, the second iteration of the original aircraft, is an example of Cessna's commitment to improve its 14-year-old flagship. More than 300 units have been delivered and the Ten should help extend the Model 750 production run.

The Citation Ten's strong suit continues to be the ability to turn fuel into speed, when needed. It can fly a 1,000-nm trip in less time than any business aircraft in current production, according to *BCA's 2010 Purchase Planning Handbook*. It's the only business aircraft priced under \$45 million that routinely can cruise at over 500 kt., topping out at 527 KTAS or Mach 0.914 at FL 350. Fuel burn



The Ten is the first announced launch customer for Garmin's G5000.

with the throttles full forward, though, will approach 3,000 pph under those conditions, approaching the nautical miles per pound thirst of a heavy-iron jet.

The 15 min. to 20 min. or so that you can save on a 1,000-nm trip will cost you almost 50% more fuel than some slower flying midsize jets. On a 5-hr. mission flown at high-speed cruise, you'll burn about 9,000 lb of fuel, less than a 2% savings compared with the current aircraft.

Most operators, however, are likely to balance the need for speed and efficiency as they do in the current Citation X. Assuming mid-range weights, the new model will be 4 kt. to 19 kt. faster when cruising between FL 430 and FL 490. It also will squeeze out slightly better fuel efficiency at those speeds and altitudes.

At high-speed cruise, the Ten will be able to fly seven passengers more than 3,100 nm on the same amount of fuel that the current aircraft uses to fly six passengers slightly less than 2,900 nm. Notably, the Citation Ten will not cruise at Mach 0.92 any more than the original model could. But, it will fly faster, higher and more efficiently than its predecessor, which already is the fastest civil airplane in production. The Gulfstream G650 will claim that title in 2012, but it's three times the price.

The Garmin G5000 brings much needed improvements in cockpit capabilities, ones that will enable the Ten to operate efficiently in the FAA's NextGen and Europe's SESAR air traffic management systems. The Citation X was one of the last midsize aircraft to have early 1990s' vintage avionics and CRT displays, thus the G5000 represents a two-decade leap forward in technology aboard the Ten.

Historically, the Citation X never has sold in large numbers. Slightly more than 300 units have been delivered since 1996. Only 36 have been delivered in the last three years. That tapered off to a half dozen in 2009.

The last upgrade to the Model 750 was in 2002 and that version is getting old. Thus, the 2013 Citation X is a much needed, and perhaps overdue, improvement to Cessna's niche speedster model. The Ten measures up to what upgrades operators want in Cessna's current flagship. But the big issue is customers' needs for a larger cabin in a long-range aircraft. Until Textron and Cessna resurrect the wider-body Columbus, or a larger, long-range variant, that need remains unfulfilled and

Cessna risks losing orders to super midsize aircraft built by Bombardier, Hawker Beechcraft and Gulfstream.

The Model 750, though, always has been a special performance demonstrator, intended to show off Cessna's engineering prowess rather than appealing to the mass market.

The Ten again raises the bar, as did the Citation X in 1996 and 2002. With the latest version, Cessna is betting that there's a strong core of customers who

still swagger more about speed than size.

The C2 variant of the Rolls-Royce AE3007 is moderate 4.7:1 bypass ratio turbofan that is rated at 7,034 lb thrust for takeoff to ISA+15°C. A 0.5-in. larger fan with two fewer and mildly swept, wide-chord blades makes possible a 4% boost in takeoff rated thrust, along with 9% more climb thrust and a 7% increase in cruise thrust compared to the C1 engine.

The core of the engine remains virtually unchanged with a 14-stage axial flow compressor, annular combustor and two high-pressure turbine stages. Internal temperature limits will remain unchanged from the C1 variant, but the C2 will have improved cooling in the turbine section. The new high-flow fan is powered by a three-stage, low-pressure turbine, and the engine will provide 1.4% lower specific fuel consumption than the C1.

According to Rolls-Royce, the C2's larger, higher thrust fan will turn at slightly slower speeds than the C1's fan, suggesting that low-pressure turbine section will have to be modified to extract more work. But the C2 only produces about 75% as much thrust as the A2 variant used by Embraer on some of its regional jets, so it's relatively unstressed. This should help it preserve its reputation as one of the most reliable turbofans used aboard general aviation aircraft and hold down maintenance costs.

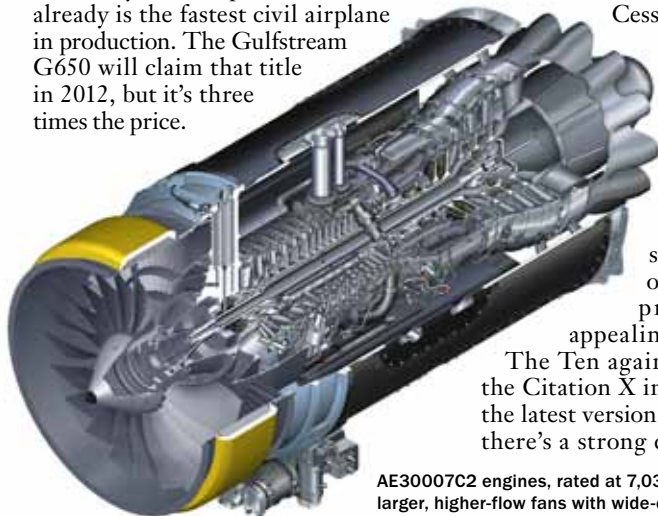
Certification of the C2 is scheduled for 2013.

### Launch Customer for Garmin G5000 Avionics

The Citation Ten's Garmin G5000 cockpit will be far different than the Honeywell Primus 2000 system installed in current production aircraft. Three, 14-in., landscape configuration, flat-panel displays will replace the five CRTs of the current system, providing considerably more display area. The quad-redundant power sources for the emergency buses will enable Cessna to eliminate three of the four standby instruments mounted in the instrument panel.

The suite includes left and right outboard, plus two console-mounted, touch-screen controllers with high-resolution, 5.7-in. color LCD screens. The controllers are used for radio tuning, flight planning, and certain temperature and pressurization control functions, along with cockpit lighting and audio panel controls. **BCA**

*(For complete details on the new Garmin G5000 see Fred George's article beginning on page 45.)*



AE3007C2 engines, rated at 7,034 lb thrust for takeoff, have larger, higher-flow fans with wide-chord, swept leading edge blades.