Business & commercial Aviation
PILOT REPORT

First Look: The Newest Gulfstream

The G-V promises to be the fastest, longest range business aircraft ever built by Gulfstream Aerospace.

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When William C. Lowe, president and chief executive officer of Gulfstream Aerospace, introduced the Gulfstream V to the press September 6 at the Farnborough Air Show, he correctly anticipated a profusion of skeptical looks among those in attendance. After all, isn't this the same company that promised us Gulfjets, SSBJs and aft-fan noise suppressors?

But, in a one-on-one conversation with B/CA, Lowe convinced us that the G-V is for real. "Our fits and starts are over," he explained. "We're not announcing a market study; we're saying that deliveries will begin in October 1996."

Forstmann-Little, majority owners of Gulfstream Aerospace, gave the G-V program the green light in 1991 and, according to Lowe, it's fully funded through scheduled certification in October 1996. Gulfstream spent $11 million on product development in 1991 and will spend $40 million in 1992.

The Gulfstream V won't replace the Gulfstream IV, as has been the case with previous models. Both aircraft will be manufactured in parallel, according to Lowe. The G-V (green) will be priced at $29.5 million in 1993 dollars.

Charles N. Coppi, Gulfstream's senior vice president of engineering and technology, claims the G-V will have a maximum range of more than 6,000 nm with NBAA IFR reserves.

That's New York-to-Tokyo, London-to-Singapore or Honolulu-to-Paris against 85 percent probability headwinds. The only civil airplanes which we know to have longer legs weigh at least 90 tons empty, and they need nearly two miles of concrete to take off.

In contrast, Coppi says the Gulfstream V will take off in 5,400 feet with full fuel and passengers, climb directly to 43,000 feet, cruise at 0.80 Mach for 6,300 miles and land with NBAA IFR fuel reserves, assuming standard day conditions. On an ISA+10°C day, the initial cruise altitude will be 41,000 feet.

On trips up to 5,500 miles, such as Hong Kong-to-Zurich, Coppi alleges the G-V will cruise at 0.85 Mach. A 4,000 mile sprint, which is about the distance from Cleveland-to-Munich, could be flown at 0.88 Mach. On a 3,500 mile trip, similar to a trip from White Plains-to-Geneva, the G-V will be able to climb directly to FL 470 and cruise at 505 knots, according to engineering estimates.

Why build an airplane with so much range and speed? Lowe explained, "More and more companies are diversifying their business into Europe, the United States and Asia. The G-V will enable them to fly across the Pacific as easily as the G-III and G-IV cross the Atlantic."

Coppi amplified Lowe's remarks. "We held customer meetings at Atlanta, New York, Chicago and Long Beach and pitched a 5,000-mile-range aircraft that would have been powered by Rolls-Royce Tay engines,

but operators told us they wanted more range." So, Gulfstream then proposed a 5,600-mile airplane powered by growth-version, Tay 650X engines.

Customers responded much more favorably. At Farnborough, Gulfstream announced the G-V will be powered by BMW/Rolls-Royce BR710 turbofans which will boost the range more than 12 percent, or 700 miles, compared to any of the proposed Tay-powered versions.

From a distance, the computer-generated sketches of the G-V make it appear to be a slightly stretched G-IV. Despite the G-V's new engines, this first impression leads cynics to question Coppi's lofty performance predictions. If one takes a closer look at some of the design details, however, the numbers become more believable.

COMPUTER-DESIGNED WING

The Gulfstream V will have an entirely new, three-dimensional computer-designed wing, benefiting from both CATIA and Silicon Graphics software. The shape is entirely original and not a derivative of another design, although it will incorporate a two-spar structure similar to the G-IV.

Coppi commented, "We've developed quite a computer-aided design capability, and we've incorporated the latest data about subsonic and transonic drag rise." The planform looks quite conventional; but it has a 16 percent higher aspect ratio than the G-IV and its span is 14 feet longer. Its 6.9 aspect ratio is modest compared to other contemporary wing designs.

Straight leading and trailing edges plus the well-known winglets used on the Gulfstream III and IV are features of the new wing. The airfoil sweep at quarter chord is 27 degrees, virtually identical to that of the G-IV.

The G-V's 1,135 square foot wing area is almost 20 percent larger than the G-IV's, giving the considerably heavier new aircraft a slightly lower wing loading. The wing's stiffness will be nearly the same as that of the G-IV, so the new aircraft should have similar ride characteristics in rough air.

Additional span permitted the trailing edge fowler flaps to be lengthened, increasing their effectiveness and lowering V-speeds compared to the G-IV. Coppi explained that longer flaps and slightly lower wing loading eliminates the need to fit the new wing with leading edge devices. However, vortex generators and other boundary layer control devices have not been ruled out.

Coppi said the new wing's "peaky design" profile, quite different from the airfoil of the G-IV, minimizes shock wave strength in the supercritical speed range. The G-V's inboard wing cross section is, most assuredly, a departure from time-honored, high speed, laminar flow wing shapes. It has a generous leading edge radius, a relatively flat upper wing surface for a large portion of the chord and a slow taper to the trailing edge. The result? An inboard wing cross section less aft-loaded with respect to generating lift compared to classic supercritical wing designs.

There's less twist from root to tip than the G-IV's wing. The outboard section has a more highly cambered, classic profile. The G-IV's winglets are retained, almost without modification.

Aerodynamics 101 taught us that wing designs with similar appearance suffer a brick wall drag rise at high speed. But Coppi said the first round of wind tunnel tests in early August validated the computer's performance predictions for this new wing's high speed efficiency. Apparently, the computer's aerodynamic fine tuning of the wing shape is much more subtle and effective than meets the eye.

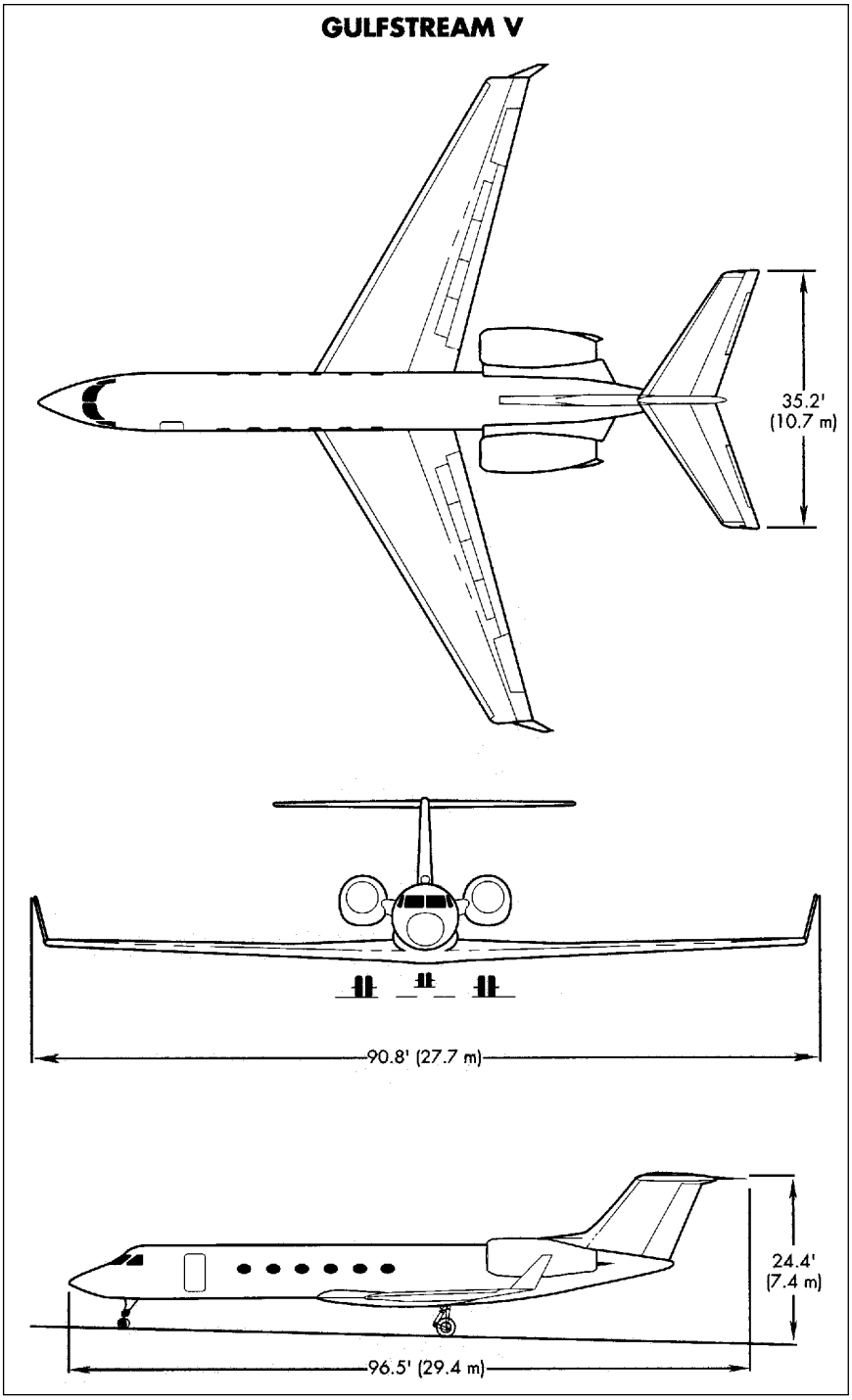
The new wing also gets a boost in coefficient of lift because the engines will be moved aft a little less than five feet—the distance between the G-IV's forward and aft engine mounts. A new aft mounting point will be designed and the old forward mount will be eliminated. Pushing the engine nacelles back reduces the flow interference between the nacelles and wing, thereby reducing drag and improving wing efficiency.

Moving the engines aft also causes the c.g. to shift back, but that's not as much of a problem as it appears. The longer, higher aspect ratio swept wing of the G-V has a more rearward center of pressure compared to the G-IV's wing, so it helps to offset the change in c.g. The result is a relatively small shift in c.g. relative to the mean aerodynamic chord of the new wing.

The inboard section of the G-V's wing produces more lift compared to that of the G-IV. According to Gulfstream, that's one reason the G-V should be 25 percent more efficient than the G-IV when the yardstick is the classic Breguet Range Parameter comparing the product of cruise Mach and lift-over-drag coefficient to specific fuel consumption.

The wing's relatively thick chord section and overall size provide enough volume for 38,000 pounds of fuel—about 8,000 pounds more than a G-IV's capacity. Coppi said Gulfstream is "philosophically opposed" to storing fuel in the fuselage.

For the first time, Gulfstream will build the wing for the G-V in-house rather than subcontracting the work as it did for its previous Gulfstream models. Because the firm builds the BAe Jetstream 41 wing at its Oklahoma City plant, it has ample experience manufacturing such structures.



PRELIMINARY SPECIFICATIONS GULFSTREAM V

Empty weight (lb/kg)	37,700/17,100
Typical BOW (lb/kg)	45,500/20,638
MZFW (lb/kg)	52,000/23,587
Max landing (lb/kg)	70,000/31,751
MTOW (lb/kg)	85,100/38,601
Max ramp (lb/kg)	85,500/38,782
Max fuel (lb/kg)	38,000/17,237

STRETCHED FUSELAGE, MORE SPACE

The Gulfstream V will be seven feet longer than the G-IV. There's a five foot stretch just ahead of the cabin door at fuselage station 193, and another two foot stretch over the wing at station 452.5. Both the G-IV and the G-V have six windows per side, suggesting that the passengers will have about the same room in either airplane. That's essentially true. The forward stretch is primarily intended for pilots, who will need a crew rest area for flights possibly lasting more than 14 hours.

Gulfstream's drawings of the interior show one reclining sleeper seat on the right side of the crew cabin and a lavatory on the left. It's reasonable to assume, though, that many operators will provide a crew rest area for two off-duty crewmembers, complete with mini-lav. The avionics, power distribution panel and other systems now spread out from the cockpit bulkhead aft several feet on the cabin's right side will be repackaged to take up less space and will be stacked vertically in front against the bulkhead.

The circuit breakers will be located on the bulkheads behind the pilots and on trimmed-down "water fall" panels outboard of the crew seats. The comm, nav and pulse radios in the nose will be moved inside the cabin next to the other avionics and electrical systems on the bulkhead. Repackaging and relocating the avionics and electrical components will increase the unobstructed cabin length by 92 inches.

The cockpit partition will be moved back to provide a welcome one foot increase in seat track adjustment. Even so, the crew rest area will me sure seven feet from end to end, which makes room for six feet plus crew bunks.

The over wing stretch is behind the cabin windows. Eight inches of the aft stretch moves the tail back, and the rest increases interior room, although not by much. A foot of the extra room goes into the rear baggage

compartment, increasing its volume to 224 cubic feet. There will be a new secondary pressure bulkhead separating the aft lavatory from the baggage compartment to comply with engine rotor burst certification requirements. The Gulfstream V will be certificated for flight up to 51,000 feet—6,000 feet higher than any previous Gulfstream aircraft

We asked Coppi why Gulfstream didn't elect to use an area rule design for the aft section of the fuselage near the engine nacelles and empennage. In reply, he noted the aircraft is large enough and those components are spaced sufficiently far apart to eliminate the need for a radical redesign of the tail. He explained that the engine pylons were reshaped to reduce drag.

The aft fuselage section will be beefed up for two reasons. First, the engines will be mounted farther aft, increasing the loads on the structure. Second, the G-V will have a larger, heavier horizontal tail and elevator, requiring a correspondingly stronger and heavier vertical tail.

BMW/ROLLS-ROYCE BR710 ENGINES

Gulfstream has a high level of confidence in the Rolls-Royce engines that have powered four models of Gulfstreams during the last three-plus decades. Why, then, would Gulfstream choose an entirely new engine company to supply engines for the G-V? The history of each company making up BMW/Rolls-Royce GmbH may be one reason.

Bayerische Motoren Werken AG and Rolls-Royce almost simultaneously, though completely separately, developed the world's first production jet engines in the mid-1940s.

In mid-1990, the two firms an-nounced they were forming an independent company to develop a new line of fuel-efficient, low emission turbofan powerplants in the 10,000- to 22,000-plus pounds class.

A look at the new engine's specifications indicated it could transform the G-V from a direct competitor of Canadair's 5,650-mile range Global Express into the heavy-iron class leader in range and speed. So, Gulfstream decided to become the launch customer for BMW/Rolls-Royce's new BR700 series turbofan engine.

Physically, the Tay and the BR710 are so similar that it's difficult to tell them apart. On an airplane the size of the G-V, the weight difference is almost insignificant. The BR710 nacelles are about 10 inches shorter and four inches larger in diameter than the Tay 611-8 nacelles on the Gulfstream IV. Thus, there's a negligible increase in form drag.

While the BR710 has a slight advantage at sea level and high altitude thrust, the increased weight of the G-V over the G-IV will give the new airplane a lower thrust-to-weight ratio. Coppi observed that the new engine is not only slightly lighter in weight, but it also runs cooler than the Tay because of improved internal aerodynamics.

The BR710 will maintain its takeoff thrust rating to ISA+20°C. Gulfstream claims that there will be no restriction on maximum takeoff weight up to 5,000 feet in ISA+20°C.

However, along with the new wing, the BR710's seven- to 10-percent lower specific fuel consumption is another major reason the G-V is 25 percent more efficient than the G-IV, using the Breguet Range Parameter measure.

The engine features a wide chord fan, high pressure ratio, low emissions combustor and a Full Authority Digital Engine Control. According to Gulfstream, the engine will have an initial TBO of 7,000 hours.

BALANCING SPEED, PRODUCTIVITY AND COMFORT

"I don't think the [business aircraft] industry has paid enough attention to the productivity of the customer in flight," said Lowe, explaining Gulfstream's "Office in the Sky" being developed in cooperation with IBM and Honeywell. "These people are working 80-hour weeks, and they can barely get the job done."

As a customer's option, Gulfstream will fit the aircraft with multiple work stations equipped with flat panel monitors and keyboards. These will all be linked together on a local area network and tied to ground stations via unique satellite communications datalink channels.

Lowe foresees the need to include voice, data and fax communications capabilities to enable the business aircraft to become an extension of an office rather than isolation from one.

How important is the "Office in the Sky?" Consider

ENGINE COMPARISON

	Gulfstream IV	Gulfstream V
Engine	Rolls-Royce Tay 611-8	BMW/Rolls-Royce BR710-44
Dry weight (lb)	3,135	3,016
Fan diameter (in.)	44	44
Flange-to-flange length (in.)	94.7	88.4
Sea level static uninstalled thrust	13,850	14,750
Sea level static uninstalled SFC	0.44	0.40
Installed max cruise thrust @41,000 ft, 0.80 Mach, ISA	2,391	2,480
Installed max cruise SFC @41,000 ft, 0.80 Mach, ISA	0.73	0.676

that a G-V might depart Osaka at 1800 hours local on a Wednesday, bound for Boston, where it's 0400. The aircraft wouldn't arrive until well after closing time for most businesses on the U.S. East Coast. The entire business day could be lost if the aircraft weren't equipped with a complete range of office equipment tied into communications satellites.

Gulfstream also is focusing on passenger comfort. The G-V's improved speed and range are in part made possible by its lean fuselage cross section—smaller than most other large business aircraft. Although the G-V will share the same fuselage cross section with previous models, Gulfstream redesigned the interior and relocated the passenger service units to add seven inches of width at the shoulder level and one inch of headroom. Slimmer side wall panels will open up four inches more width at the seat level. At the same time, the acoustical insulation will be upgraded to lower ambient noise levels.

The wider and taller cabin interior will close much of the cross section gap between the G-V and its competitors, but the Canadair Challenger will still remain the class leader in cabin cross section.

The G-V's exceptionally long endurance made Gulfstream look at some of the hotel amenities associated with long distance travel. Look at the artist's renderings of the aft lav, and you'll find a shower tucked into the left side of the enclosure. That thoughtful touch will go a long way to eliminate the crumpled, well-beyond-five-o'clock-shadow discomfort associated with transoceanic trips.

RETAINING PROVEN TECHNOLOGY

Don't expect to find the latest generation of ultra-compact, integrated avionics and virgin systems on the Gulfstream V. Why? The Gulfstream IV leapt so far beyond contemporary technology upon its certification in April 1987, that customers encountered a steep learning curve regarding maintenance and reliability woes. Operators told Gulfstream they didn't want to repeat the ordeal.

Additionally, an all new integrated avionics system would have required a complete autopilot re-certification which might have slowed aircraft development.

After the four focus group meetings, a Gulfstream official confided, "We came away battered, but rewarded for the experience. There is no question that the G-V is a better airplane as a result of those meetings." Coppi countered that there's been a 65 percent improvement in avionics reliability since 1989 and the firm has a huge investment in avionics development.

The new airplane's updated Honeywell SPZ-8000 avionics suite will virtually match the capabilities of the latest Primus 2000 package. Triple hybrid Laseref III inertial reference units with two-channel GPS sensors will replace Laseref II boxes, saving about half in weight, volume and power consumption while adding capability.

> The G-IV systems proven to be reliable will be retained on the G-V.

The G-V will have new Flight Management Systems half the size of the G-IV's FMS boxes, and they will have more processing power, five times the memory and 60 percent more database storage. The dual FMS boxes will be supplemented by a Lasertrak IRS navigation system that can be used as a third long range nav. The FMS boxes will be located in a triple-wide center console. TCAS will be standard, and the empennage will be fitted with a radome for an optional satcom antenna.

The G-IV systems proven to be reliable will be retained on the G-V. Three systems will be modified:

- Nose wheel steering will be modified to prevent the hydraulic fluid from getting cold-soaked.
- Brake-by-wire is out; a proven hydraulic brake system with analog anti-skid will be used in its place.
- Trouble-prone Bendix variable speed/constant frequency electrical generators will be replaced with Sundstrand integrated drive generators which have earned high marks in airline service aboard the Fokker 100.

Generally, the Gulfstream V will use airline-proven systems wherever possible. If advanced technology was the central design theme of the G-IV, then exemplary reliability is the engineering focus of the Gulfstream V. The engineers in Savannah want to make extended overwater operations the Gulfstream V's strong suit.

APPLES-TO-APPLES COMPARISON

Gulfstream hopes to attain a common type rating for both the G-IV and G-V aircraft because of their similarities. But, on comparable length missions, the performance differences between the G-IV and the G-V will be quite pronounced.

Gulfstream originally hoped the G-V would achieve fuel consumption numbers equal to the G-IV for trips of the same distance. Now, because of the new wing and engines, they believe the G-V will burn 10 percent less block fuel—that's regardless of stage length.

According to Gulfstream projections, the G-V's estimated balanced field length numbers are even more impressive. On a 4,000-mile trip, a G-IV with eight passengers on board needs about 5,000 feet of runway at

SL ISA. Under the same conditions and payload, the G-V will need only 3,500 feet—even though it has roughly a six percent disadvantage in thrust-to-weight ratio. B/CA estimates the G-V's shorter BFL numbers may be associated with V-speeds as much as 20 knots lower than the G-IV's. Even when it's loaded to MGTOW, the G-V should require slightly less runway than the G-IV, a direct result of its more efficient wing and wider span flaps. Gulfstream also claims the G-V will be able to depart at maximum takeoff weight up to 5,000 feet at ISA+20°C.

Without looking at the aircraft's gross weight, the more sprightly airport performance of the G-V might make it appear to be a lighter, more nimble aircraft than the G-IV. From the pilot's seat, the feel of the G-V could reinforce that illusion of reduced bulk.

The G-V, similar to the G-IV, will be fitted with hydraulically boosted elevators and ailerons with manual reversion. Gulfstream's test pilots, however, wanted the G-V to have lighter pitch and roll forces than the G-IV. Partly to accomplish that goal, the elevators will be 28 percent larger than the G-IV, and they will have a higher aspect ratio. The longer wing span moves the ailerons outboard, increasing the moment arm and, thus, the roll authority. Those changes should reduce the G-V's yoke control forces.

The first of three production configuration flight test aircraft is scheduled to begin flying in September 1995. The BR710 engine is scheduled for certification in August 1996.

Whenever possible, low risk technology is being used to prevent possible delays in the certification schedule. There won't be any significant change in the proportional use of metal and composites, compared to the G-IV.

These plans should prevent having to play catch up with new materials technology and sophisticated systems after initial type certification in late 1996.

If the Gulfstream V can live up to the engineering projections, it will be far and away the class leader in performance and speed. **B/CA**