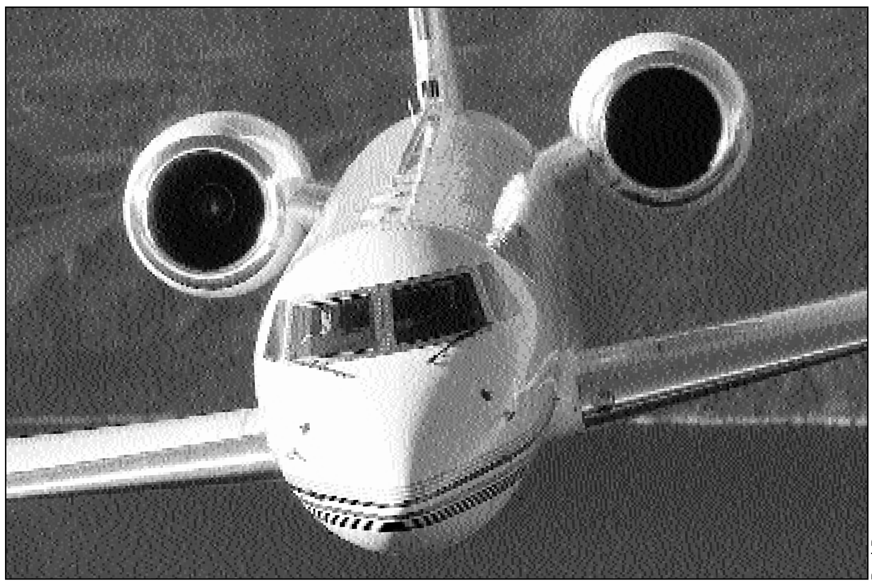
Gulfstream V

The first of the ultra-long-range business jets now delivers on promised performance; fewer growing pains than with the G-IV.

By Fred George


Paul Bowen

When Gulfstream Aerospace announced the performance goals for the G-V in 1992, the firm's competitors scoffed and industry critics chortled. It would never be able to fly eight passengers from New York to Tokyo, the naysayers concluded after detailed examination of the G-V's fuselage, wing and engines.

More anti-aircraft ammo became available to skeptics when Gulfstream subsequently announced two increases in weight. On top of that, the first green production aircraft delivered in late 1996 and early 1997 weighed in heavier than spec in part because the BMW/Rolls-Royce BR710-48 engines weighed more than forecast. The extra weight in the tail required adding as much as 600 pounds of forward ballast to some aircraft during the completion process.

The nose ballast, in many cases, cut into the advertised 1,600-pound payload with full fuel. The tanks-full payload of some aircraft was reduced to four or five passengers. For example, serial number 544, the aircraft we flew for this report, had a 48,537-pound BOW, effectively reducing the tanks-full payload to five-plus passengers. Conversely, its range with eight passengers was 6,395 miles because of the 537-pound reduction in allowable fuel load.

In addition, some early aircraft had irregular wing contours, a few wings needed internal reinforcements to prevent cracks, and all of them needed to go on a low-fat drag diet.

Undeterred, Gulfstream engineers gritted their teeth and went back to work. They put the airframe on a diet, decreased variability in the wing contours, strengthened the internal structure and took five steps to cut the fat out of the drag curves. BMW/Rolls-Royce also starting taking weight off the BR710 engines.

Fierce competition from Bombardier, plus pressure from Boeing and Airbus, is driving Gulfstream to make refinements, improvements and upgrades to the G-V, such as reducing weight and broadening the c.g. envelope at a much faster rate than it did with the G-IV. As a result, the firm's newest large-cabin business aircraft is maturing at a more rapid rate than any previous model. Gulfstream has firm orders for more than 120 G-V aircraft and, as of the end of 1998, there are 31 aircraft in service.

The folks at Gulfstream are the ones smiling now. The final results have been tabulated. The G-V is making its weight and performance numbers. The average green weight of current production G-V aircraft is 39,449 pounds, which is 51 pounds below the spec weight. The lean, green weight, along with drag reductions that boost range by 150 miles, enables a G-V, fitted with a 6,700-pound spec interior, to fly eight passengers 6,520 miles and land with NBAA IFR reserves.

Just as importantly to customers, in late 1998, Gulfstream and Honeywell developed an upgrade for the stall warning/stall barrier, stick shaker/pusher system that allows a two-percent increase in the aft c.g. limit. Moving the aft c.g. limit from 43 percent MAC to 45 percent MAC allows customers to remove much, if not all, of the forward ballast from completed airplanes, most of which tend to be tail heavy. That cuts BOW by as much as 600 pounds.

This allows customers to configure the aircraft with aft galleys and aft lavs, plus it allows them to add most popular avionics, equipment and cabin furnishing options without having to add forward ballast. This helps to keep the BOWs of completed aircraft closer to the 48,000-pound limit needed to provide a 1,600-pound (eight passenger) payload with full tanks.

In the case of the aircraft we flew for this report, the expanded c.g. envelope will allow 400 to 600 pounds of ballast to be removed. The actual amount of ballast retained will depend on how much baggage weight capacity and allowance for future equipment the operator needs. If the operator decides to remove all the ballast, then this aircraft's eight passenger range will be increased to more than 6,520 miles.

Structure and Systems

The G-V's fuselage cross section and basic construction is unchanged from the G-IVSP, but it has been recertificated to allow an increase in pressurization to 10.2 psi to provide a 6,000-foot cabin at FL 510. A computerized pressurization controller, linked to the air data computers and FMS, automatically adjusts the cabin altitude for departure and destination airport elevations and it maintains optimum pressurization at cruise altitude.

The 36-inch-wide by 62-inch-tall, front airstair door is actuated by the auxiliary hydraulic system. Similar to the G-IVSP, the G-V's two 19-inch-high by 26-inch-wide windows over each wing function as Type IV emergency exits. The 39.5-by-35.9-inch baggage compartment door also can be used as an emergency exit.

The wing's planform and loading per square foot is similar to that of the G-IVSP, but the airfoil incorporates some super-critical design elements, such as larger leading edge radius and a flatter upper surface, that spread the lift pressure distribution over a longer chord section. Gulfstream elected not to use a pure super-critical airfoil because it was too thin at the trailing edge to house flap actuation hardware internally.

The aft loading of a true super-critical airfoil also increased trim drag and created undesirable aileron hinge moments, according to the firm's aerodynamicists. The G-V, though, can cruise at 0.80 to 0.85 Mach with less transonic drag rise than the G-IVSP and its blended radius winglets reduce induced drag. When flying the same length trips in the G-V, operators report considerably lower fuel consumption than in the G-IVSP.

The G-V's wing also has better low-speed lift characteristics than the G-IVSP's. The longer span, trailing edge flaps give the wing more lift and less drag at high lift coefficients, endowing the G-V with lower V-speeds.

Recent enhancements to the air data computer and stall warning system have eliminated the artificial 125-knot VREF speed that was imposed on early aircraft. With the enhancements, VREF landing speeds now are as low as 110 knots, limited more by VMCA rather than wing performance. (See avionics sidebar.)

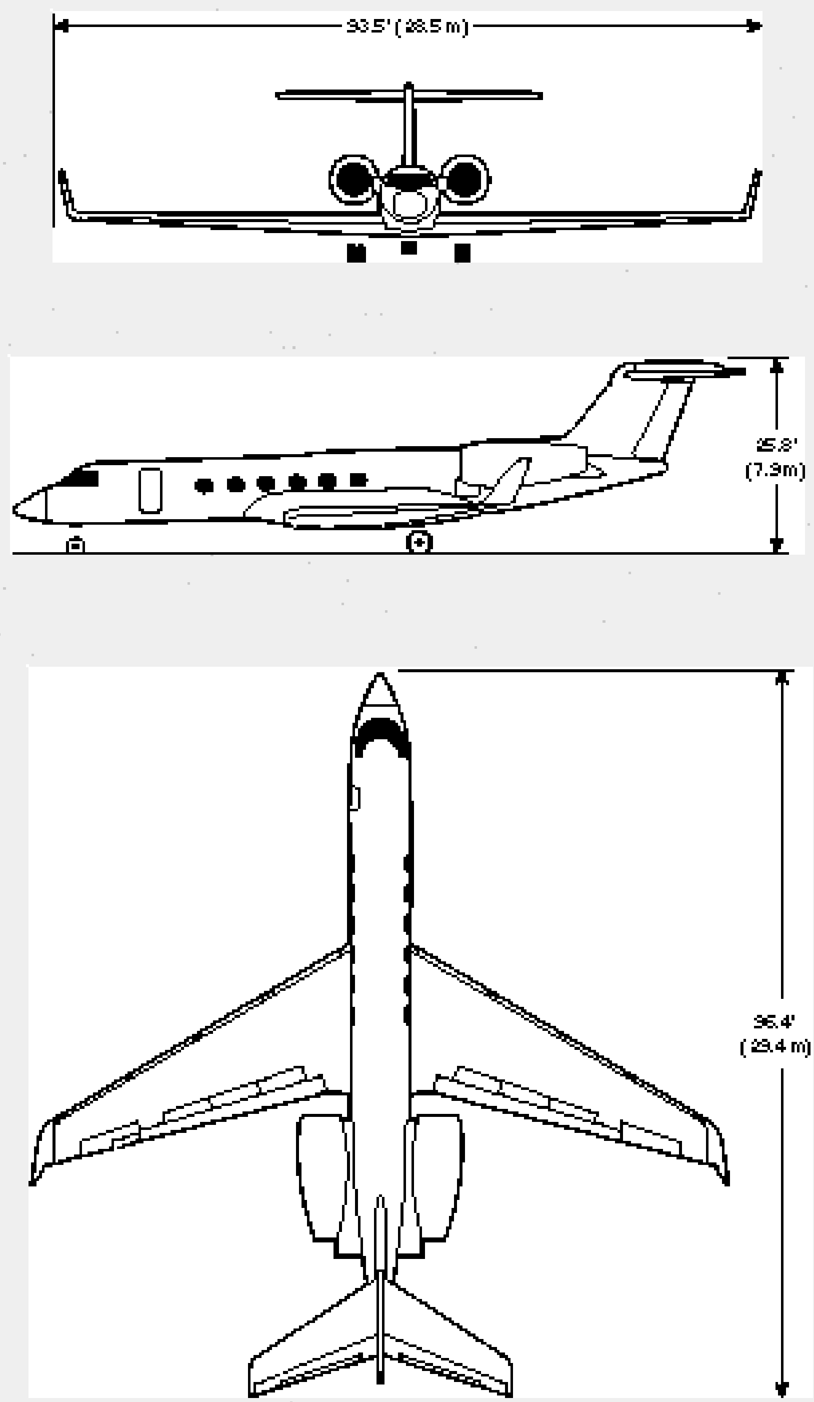
Early aircraft had higher than expected drag, which threatened the 6,500-nm range performance.

Gulfstream made five minor design changes to solve the problem:

(1) The fuselage cowl over the windshield was recontoured to reduce the velocity spike.

(2) The engine pylons were lengthened to ease the sharp drop in overall airframe cross section aft of the nacelles.

Gulfstream V



The G-V has dual bulb navigation lights on the wingtips and tail for dispatch reliability.

(3) Aerodynamic fairings were added to the TCAS antennas.

(4) Bulb seals were put on the rudder.

(5) The windshield wipers were removed and replaced with a rain removal blower system.

Engineers also fitted the wing and tailplane with wave generators instead of vortex generators. The wave generators energize the boundary layer, thereby delaying transonic flow separation, but do so with less drag penalty than vortex generators. The airframe drag reduction, coupled with one percent better-than-forecast engine SFC, now ensure that the G-V can make its advertised range.

The G-V's systems basically are carried over from the G-IVSP, with the goal of providing high reliability.

All fuel is carried in integral wet wing tanks that had a 41,026-pound usable fuel capacity when the G-V was type certificated in 1996. A fuel pump inlet in each tank was relocated to increase the usable fuel capacity to 41,300 pounds in aircraft serial numbers 549 and subsequent, plus earlier models that have been modified.

Electrical gremlins have affected the fuel quantity management system of some aircraft. Most of the problems have been solved with computer hardware, software and airframe wiring upgrades, along with detailed troubleshooting instructions added to the maintenance manual.

Similar to the G-IVSP, main and alternate DC-powered fuel boost pumps in each tank supply fuel to the engines. A heated fuel return system was added to the G-V to prevent the fuel from becoming cold-soaked and potentially gelling during extended high-altitude cruise.

Electrical power is supplied by four, three-phase, 400-Hz, AC electrical generators, including one 40-kVa main generator on each engine, plus a 40-kVa auxiliary unit on the APU and a 10-kVa emergency hydraulic motor generator. The G-V has airline-proven Sundstrand constant speed, integrated drive generators, rather than the wild frequency generators and solid-state power converters used on the G-IVSP.

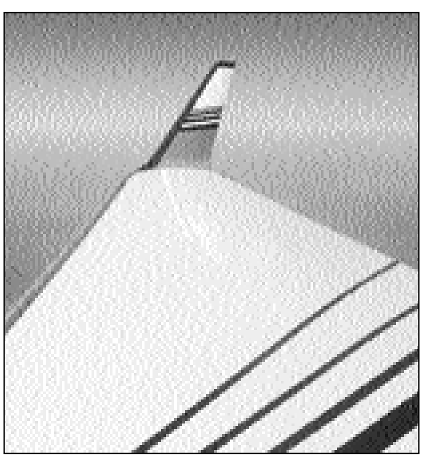
AC power is used by high current draw electrical equipment, such as the windshield heat, APU oil heat, landing lights and aileron/elevator trim servo heat and windshield rain removal blower. Most other electrical equipment uses DC power supplied by five transformer-rectifier units located in the vestibule area. Two 53-AH, Nickel cadmium batteries supply DC power for starting the APU, for the electrically driven aux hydraulic pump and for essential DC equipment in an emergency.

The G-V has dual bulb navigation lights on the wingtips and tail for dispatch reliability. There are 600,000 candle power landing lights in the wing leading edges near the roots and triple taxi lights on the nose gear. Various other safety and convenience lights are mounted on the exterior, in the baggage compartment and in the aft equipment bay.

Bleed air is used for engine starting, air conditioning and pressurization, wing leading edge and engine cowl anti-ice. Engine bleed air, supplied from the fifth and eighth compressor stages, flows through pre-coolers in the engine pylons to the bleed air distribution system. Two air cycle machines in the aft equipment bay cool and dehumidify the cabin air. Three-zone temperature control is provided for the cockpit, forward and aft sections of the cabin.

If the cabin air at altitude is too dry for your passengers, you can order the newly certificated, optional AirData/LeBozec humidification system that injects water into the ECS flow to boost the relative humidity to 18 to 22 percent. The 10-gallon capacity of the system is good for 12.5 hours of flight.

An AlliedSignal RE-220 [GV] APU, rated for starting up to 39,000 feet and operation up to 45,000 feet, supplies bleed air for engine starting and ground air conditioning. Ground service equipment also can be used to supply bleed air and electrical power for air conditioning, avionics and engine start.



All fuel is carried in integral wet wing tanks.

Time to load G-V's 41,300 lb of fuel: 20 minutes.

The airstair door is 36 inches wide by 62 inches tall.

As of February, Gulfstream had delivered 61 G-Vs, and 31 were in service as of December 1998.

The APU's 40-kVa AC generator also provides ground electrical power and backup power supply in flight, if needed. Cold-soaked APU starting at altitude is assisted by engine bleed air fed to the APU inlet and an electric APU oil heater.

In contrast to earlier Gulfstreams that had one hydraulic pump on each engine, the G-V has two Vickers pumps, with the goal of increasing reliability. In airline use, Vickers pumps last more than 38,000 hours. Unfortunately, that hasn't been the case on the G-V. Pumps have failed at an alarming rate, causing contamination of the entire left- or right-side system and often failure of the second on-side pump.

Three iterations of Vickers pumps, a filter design modification and a change in flight test procedures haven't completely cured the problem. However, Gulfstream and Vickers are confident that a final fix will be ready by mid-year.

The four engine-driven pumps, supplemented by an electrically powered aux hydraulic pump (ground use only) and a right-to-left power transfer unit, supply the left- and right-side, two-channel hydraulic system. The left side powers the flight controls, landing gear/wheel brake/nose wheel steering utility systems, hydraulically powered emergency AC generator and left thrust reverser. The right side also powers the flight controls, plus the right thrust reverser and an emergency, right-to-left power transfer unit.

The G-V's hydraulically boosted flight controls have a higher boost ratio than the G-IVSP's, resulting in lower control pressures. The G-V, as a result, has more of the light control feel of a G-II rather than the heavier feel of a G-III or G-IV.

The primary flight controls, powered by the left- and right-side hydraulic systems, have a mechanical backup. The G-V has an electronic flap/stab interconnect, in place of the G-IV's mechanical link, to compensate for pitch trim changes caused by flap configuration changes. Three-panel, composite construction, electrically controlled and hydraulically actuated spoilers on each wing provide roll augmentation, speed brake and ground spoiler functions.

The G-V has dual wheels at each landing gear. Long travel, trailing link main landing gear make for soft landings. Hydromechanical, anti-skid wheel brakes, with carbon/carbon heat packs, are more reliable and cost less to maintain than the first-generation, brake-by-wire system used on early G-IVs. Seven degrees of nosewheel steering are available through the rudder pedals. A steer-by-wire tiller on the left-side panel provides an additional 80 degrees of steering authority.

Cabin Amenities

Operators typically configure the G-V's cabin in three lounge areas. The forward section, for example, can be configured as a convertible crew rest, three-place divan or executive work area. Some operators have expressed an interest in adding a seventh window on the forward right side for extra natural light in the forward-most cabin section. Gulfstream's Aircraft Service Change (ASC) 77 accommodates that request.

The middle section typically is configured with facing pairs of individual chairs and/or three-place divans. The aft section can be fitted with two pairs of seats facing a conference table, plus a credenza

BMW/Rolls-Royce Engines

The G-V's BMW/Rolls-Royce BR710-48 engines are a conservative design featuring a modest 4:1 bypass ratio, a ten-stage high-pressure, axial flow compressor with a moderate 14:1 compression ratio and a low emission, annular combustor. Two high-pressure turbine stages furnish the power for the high-pressure compressor and two more low-pressure stages power the wide-chord fan that provides most of the thrust. A deep-fluted hot/cold mixer nozzle boosts high-altitude thrust and reduces exhaust noise. A dual-channel FADEC controls all engine functions, including thrust reverse. An update to the FADEC software provides fully automatic functioning of the heated fuel return system, eliminating the need for pilot control.

Midway through the development program, a streamlined fairing was added to the inside of the bypass duct to help boost fuel efficiency. The fairing fasteners, however, frequently become loose in everyday operation, prompting Gulfstream to issue a service bulletin that requires torque checks at 50-hour intervals. Increasing the torque values may extend the maintenance intervals to 100 hours. BMW/Rolls-Royce anticipates that a final fix will be developed by mid-year.

The engine's rotating components have proven very reliable during the early stages of the G-V program, but that's not true for some of the accessories. The AlliedSignal starter turbine developed cracks due to a resonant, harmonic vibration and has since been redesigned to eliminate the problem. The aluminum shear pin on the starter shaft proved too weak. It has been replaced with a steel pin.

The Hurel-Dubois thrust reversers were designed with three locks to provide 10-9 critical level protection. The tertiary locks are prone to galling during manual operation, resulting in a minor redesign to enhance durability.

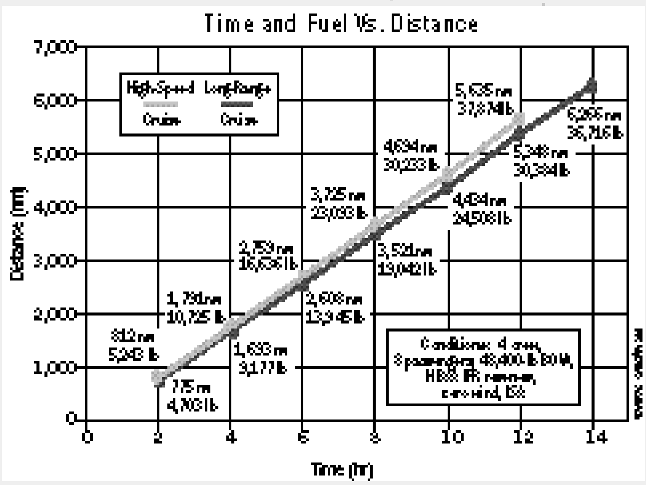
Gulfstream V

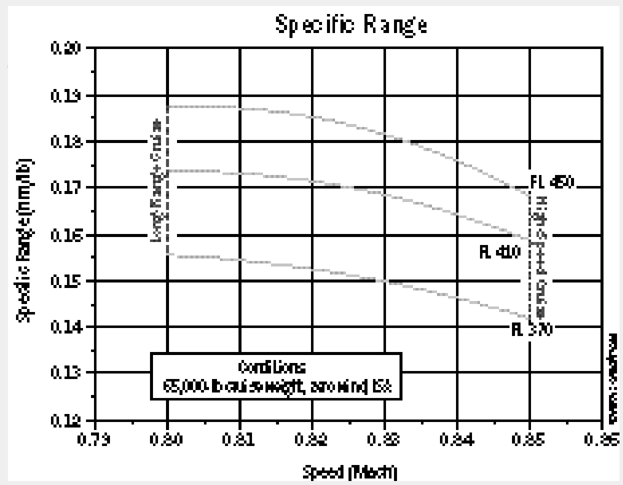
These three graphs are designed to be used together to provide a broad view of Gulfstream V performance. Do not use these data for flight planning. For a complete operational performance analysis, use the Approved Airplane Flight Manual and appropriate mission planning data published by Gulfstream Aerospace.

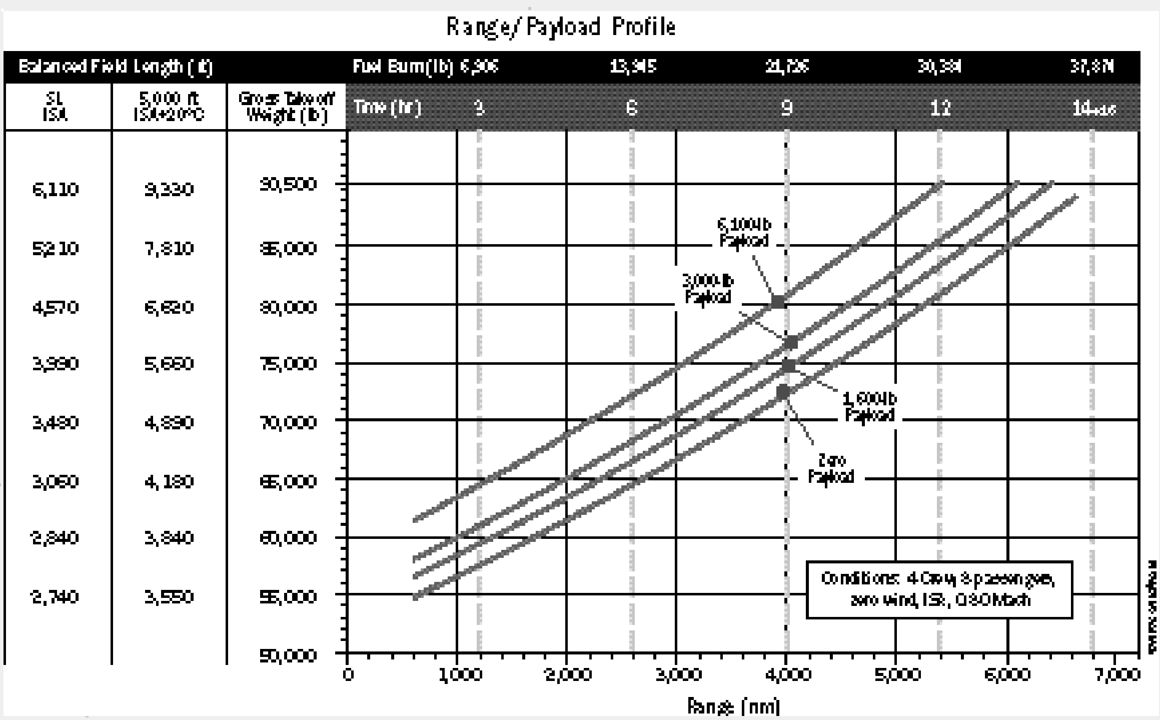
Time and Fuel Vs. Distance — This graph shows the performance of the G-V at long-range and high-speed cruise. The numbers at the hour lines indicate the miles flown and the fuel burned for each of the two cruise profiles. Each of the hour points is based on appropriate mission data supplied by Gulfstream Aerospace. While flying the G-V for this report, we found Gulfstream's data to be very accurate.

Specific Range — The specific range of the G-V, the ratio of nautical miles flown to pound of fuel burned (nm/lb), is a measure of fuel efficiency. Each curve on this graph is mathematically derived from three data points supplied by Gulfstream; thus it is an approximation of the actual change in SFC from long-range to high-speed cruise at the speeds and altitudes depicted on the chart. A close examination of the G-V 0.80 Mach cruise performance charts indicates that at 65,000 pounds, the optimum cruise altitude actually is FL 470. But cruising at FL 450 only increases fuel burn by one percent.

Range/Payload Profile — The purpose of this graph is to provide rough simulations of trips under a variety of payload and airport density altitude conditions, with the goal of flying the longest distance at high-speed cruise. The payload lines, solely intended for gross simulation purposes, are valid only for the midpoint and endpoint marks. The time and fuel burn dashed lines are based on 0.80 Mach cruise with eight passengers with NBAA IFR fuel reserves as shown on the Time and Fuel Vs. Distance graph. Notably, the runway distances for the G-V are based on flaps 20 degree takeoffs from both the sea-level standard and hot-and-high airports. The flap configuration does not have to be reduced to comply with one-engine-inoperative, second-segment climb requirements when departing from hot-and-high airports depicted on this chart. For most hot-and-high departures, runway performance will be more limiting than FAR Part 25 minimum climb gradient performance.







A G-V typically is configured with facing pairs of individual chairs and/or three-place divans. The aft section can be fitted with two pairs of seats facing a conference table, plus a credenza on the opposite side of the cabin. At least half of the G-V operators are installing the galley in the rear of the aircraft.

on the opposite side of the cabin. Divans and pairs of seats typically have adjacent telephone handsets in the side walls that are linked to the optional six channel Honeywell-Marconi satcom and L-band air-to-ground radiotelephones.

At least half of the G-V operators are opting to install the galley in the rear of the aircraft, just ahead of the full-width lavatory. Galleys typically are fitted with convection and microwave ovens, ice chests, food, beverage and eating ware storage, plus a basin with hot and cold running water.

Aft of the lavatory, the 226-cubic-foot baggage compartment is accessible through a door in a secondary pressure bulkhead. Above 40,000 feet, the door may be opened for five-minute periods for passenger access to the baggage compartment. While the baggage compartment floor has a 2,500-pound weight limit, the actual baggage weight generally is determined by the aft limit of the c.g. envelope.

Many G-V aircraft, such as the one we flew for this report, have coat closets in the forward section of the cabin, along with small storage compartments below passenger seats. Office supplies and equipment, such as stationery and a fax machine, are housed in the credenza.

Notably, the 6,700-pound outfitting weight Gulfstream allows for the G-V provides customers with virtually the same furnishing weight per square foot of cabin floor area as the G-IVSP's 5,700-pound outfitting allowance.

G-V customers, though, are bulking up their aircraft with a lot more options than G-IVSP operators. They're adding vacuum lavatories (225 pounds), six-channel satcom (100 pounds), head-up displays (55 pounds), multi-screen cabin entertainment systems (minimum 20 pounds, plus display screens) and cabin humidification systems (140 pounds). The result is that average completions weigh in at 7,100 to 7,200 pounds, thus reducing the design payload of 1,600 pounds with full fuel. This doesn't seem to concern customers. Early data indicate that their stage lengths average two hours, seven minutes.

Most G-V cabin configurations aren't well suited for eight passengers who want to sleep during 12- to 14-hour flights. There aren't full berths for all eight passengers. In most G-V aircraft we've seen, five or six occupants can sleep on three-place divans or facing pairs of seats folded flat into berths. Other folks, such as a third pilot and flight attendant, semi-reclined on individual passenger chairs.

Flying Impressions

Serial number 544, fitted with a fully operational HUD, Puritan Bennett external camera system, satcom and other popular options, had a BOW of 48,537 pounds on the day I strapped into its left seat. Randy Gaston, one of Gulfstream's senior test pilots, took the right seat and John Maxfield, representing the aircraft's owner, served as the safety pilot.

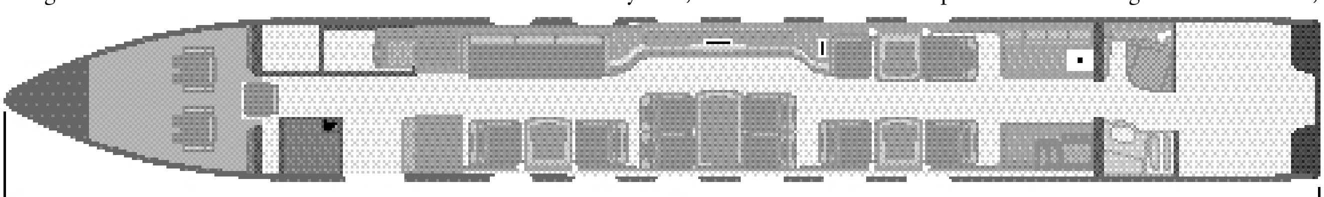
Our initial plan was to climb directly to FL 510 to check climb performance, cruise fuel flow at 0.80 Mach and handling characteristics. Then, we planned to descend to 15,000 feet for airwork and a stall series.

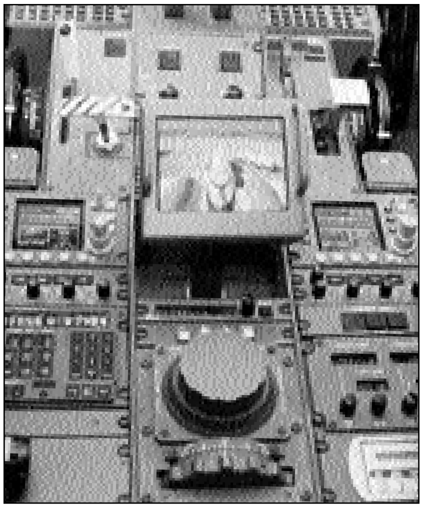
So much for good intentions. A large-scale NATO exercise in progress in the warning areas, off Georgia's east coast, would all but scrub our game plan.

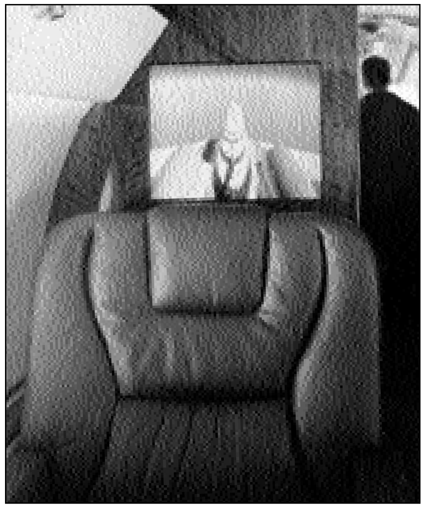
The APU already was running when Gaston and I stepped on board the aircraft. Gaston guided me through the pre-start checks. Loaded with 8,000 pounds of fuel, the ramp weight was 56,707 pounds, 62 percent of max ramp weight, which provided the wing loading of a Citation and the thrust-to-weight ratio of a Learjet 23. The Honeywell SPZ-8500 system computed V_1 at 110 KIAS, V_R at 117 KIAS and V_2 at 122 KIAS for the flaps 20 degree takeoff. The performance computer also set the takeoff bugs to 1.53 on the EPR gauges.

The takeoff field length was 2,685 feet on the cool 13°C day at Savannah International Airport, elevation 20 feet.

Gaston guided me through the rest of the prestart checks. Engine start was slow,







The optional Puritan Bennett video-cam system allows crew and passengers a better view of what is going on outside of the aircraft

consistent with the mass of the rotating components and design of the FADECs. The left and right turbine gas temperatures peaked at 429°C and 460°C, well below the 700°C redline for starting.

When I released the brakes, I didn't have to touch the power levers to start the aircraft moving. There was plenty of residual thrust. The brakes were very touchy, not unlike the original BBW brakes of the G-IV. Gaston explained that this aircraft's brakes needed to be bled to eliminate residual air in the lines.

All but the shallowest turns required use of the tiller, but the rudder pedals alone enable you to correct for small deviations from a straight line.

The operating manual allows the pilot to use one or both thrust reversers to control taxi speed, thereby eliminating the need to ride the brakes, potentially causing heat buildup and premature wear. Brake temperature is a consideration when computing accelerate/stop distances for a 90,500-pound MTOW. The SPZ-8500 performance computer is linked to a brake temperature sensor, enabling it to adjust accelerate/stop performance predictions for that factor.

Prior to takeoff, I flipped down the HUD and used it for most of the rest of the demonstration flight profile.

When cleared for takeoff on Runway 9, I advanced the power levers to 1.05 EPR, allowing the engines to stabilize. I engaged the auto-throttles, causing servos in the quadrant to advance the power levers to the 1.53 EPR takeoff setting. Engine spool up was leisurely, but once the power was set, acceleration was brisk.

At VR, I rotated to 17 degrees commanded by the HUD symbology. Gaston called out V2, positive rate and I called for gear up, flaps up. The aircraft already had accelerated through the 140 KIAS minimum flap retraction speed when the flaps started to retract. The initial fuel flow was 5,800 pph per side.

Passing through 400 feet agl, the SPZ-8500 performance computer function automatically reduced thrust to maintain 200 KIAS in the Class D airspace. When we climbed above 3,000 feet agl, the performance computer advanced the auto-throttles to 1.44 EPR to accelerate to 250 knots. The fuel flow was 4,100 pph per side.

An FMS command speed bug on the HUD's round airspeed indicator display, plus an acceleration marker and a speed deviation bar, keep the pilot fully informed about auto-throttle functionality.

Three minutes after takeoff, we passed through 10,000 feet msl with a fuel flow of 2,800 pph per side and accelerated to 300 KIAS, the recommended climb schedule airspeed. Optimum range, though, is obtained if the crew uses a 260 KIAS/0.75 IMN climb schedule, according to the operating manual.

ATC directed us to level off at 15,000 feet for traffic, thus preventing us from recording continuous time, distance and fuel to climb numbers. When cleared to continue the climb, we continued it at 300 KIAS until transitioning to a 0.75 IMN climb in the low thirties.

Climbing through FL 490, the performance computer commanded a series of increasing climb speeds, reaching 0.80 IMN as we approached FL 510 at 45 minutes after takeoff. In ISA-7°C conditions, our cruise speed was 452 KTAS while burning 980 pph per side, yielding a specific range of 0.2306 nm/lb. When adjusted for aircraft weight and OAT, that was spot on the specific range cruise performance predicted by Gulfstream.

Climbing to FL 510 isn't just for boardroom bragging rights. At weights of 55,000 pounds or below, that's the G-V's optimum cruise altitude in ISA conditions, according to the performance charts. In truth, though, climbing from FL 490 to FL 510 only nets a 13-mile range gain.

After the cruise performance check, I rolled into an increasingly steep turn to check high-speed buffet boundary characteristics. Admittedly, at 53,500 pounds the aircraft was comparatively light, but I was able to increase the sustained bank angle to 43 degrees, corresponding to a 1.5-g load factor, before encountering light buffet.

Descending to 7,500 feet for airwork, we noted that fully extending the speed brakes produces moderate buffet, a modest nose-down pitching moment and a very slight increase in airspeed. Extending the landing gear produces an almost indiscernible pitch change. The electronic flap/stab trim interconnect all but eliminates pitch changes with flap configuration changes.

At light weights, the G-V has impressively slow stall speeds. At 52,300 pounds, the clean stall was preceded by very light airframe buffet prior to the stall-warning stick shaker activating at 107 KIAS. The actual stall, defined by activation of the stick pusher, occurred at the book-predicted stall speed of 98 KIAS.

The dirty stall was not preceded by airframe buffet. At a weight of 53,200 pounds, the stick warning shaker activated at 94 KIAS and the stick pusher fired at 86 KIAS, again right on book predictions.

In everyday flying, it's difficult to enter a stall inadvertently. The auto-throttle system offers low-speed and high-speed envelope protection. Newly activated low speed limit symbology on the HUD and PFD, along with airspeed trend vectors, tell the pilot when the aircraft is approaching the stall-warning stick-shaker angle of attack. A red low-speed awareness bar appears on the airspeed scale when approaching stall-warning stick-shaker angle of attack. In addition, it's comfortable to fly a lightly loaded G-V around the pattern at straight-wing Citation speeds.

If the pilot promptly initiates stall recovery when the stick shaker activates, there is very little, if any, altitude loss. Delaying recovery until stick pusher, though, results in 200 to 500 feet of altitude loss during the recovery.

Returning to Savannah for pattern work, the performance computer automatically set the VREF speed bug to 111 KIAS for the flaps 39 degrees landing at

51,100 pounds. The FAR Part 91 landing distance was 2,206 feet.

If you're using the FMS for lateral and vertical navigation for a published instrument approach, it will automatically select the appropriate speeds for the downwind or initial leg, base or intermediate leg, and final leg of the approach. The SPZ-8500 will do just about everything needed to fly the approach other than extending the gear and flaps, turning on the passenger safety lights and calling the tower over the marker.

I manually flew the approaches, using the HUD, but not the auto-throttles, to gain more familiarity with the G-V's handling characteristics. The high lift characteristics of the wide-span flaps and relatively low wing loading result in very low thrust settings on final. The HUD's speed deviation bar and speed trend vector symbols made it easy to hold speed within three knots of the target.

It's advisable not to pad your approach speeds in the G-V unless you're compensating for wind gusts. The generous lift characteristics will cause the aircraft to float. At 50 feet agl, I closed the throttles and flared the aircraft into a flat attitude, following the HUD flare command symbol. The long-travel, trailing-link landing gear provided a featherbed touchdown.

I deployed the thrust reversers, but kept the thrust at idle. Using light to moderate brake effort, the aircraft slowed to takeoff speed by midfield.

Our bug speeds for the second takeoff at 51,000 pounds were 105 KIAS for V_1, 117 KIAS for rotation and 122 KIAS for V_2 for the flaps 20-degree takeoff, according to the computer. The takeoff field length was 2,590 feet.

But this time, Gaston retarded the right throttle to idle shortly after V_1 to simulate an engine failure. Engine deceleration was gradual and the yaw rate increase was slow. Moderate rudder pedal pressure countered the yaw and the lightly loaded G-V climbed out at V_2 at 1,500 to 2,000 fpm.

With gear retracted and flaps at 20 degrees, I simulated a one-engine-inoperative VFR return to the airport. I flew the downwind leg at 135 KIAS, which provided plenty of stall margin and enabled me to stay close to the airport.

One-half mile from touchdown, we extended the flaps to 39 degrees, slowed to a 110-KIAS V_{REF} landing approach speed and landed uneventfully.

The total fuel burn for the one hour, 58 minute flight was 4,800 pounds.

Our conclusion? For routine transcontinental and transatlantic flights, G-V

G-V Avionics

The G-V's SPZ-8500 digital avionics system combines elements of Honeywell's Primus 2000 hub-and-spoke architecture and the SPZ-8000 local area network layout. The most visible components of the system are the six, eight-by-eight-inch DU880 CRTs in the instrument panel.

Two integrated avionics computers (IACs), forming the hubs of the hub-and-spoke system, contain FMS cards, performance and auto-throttle computers, thereby eliminating the need for a half dozen stand-alone boxes.

Most of the Honeywell components are linked by means of the ASCB local area network. Other avionics equipment connects to the IACs by means of ARINC 429 interfaces.

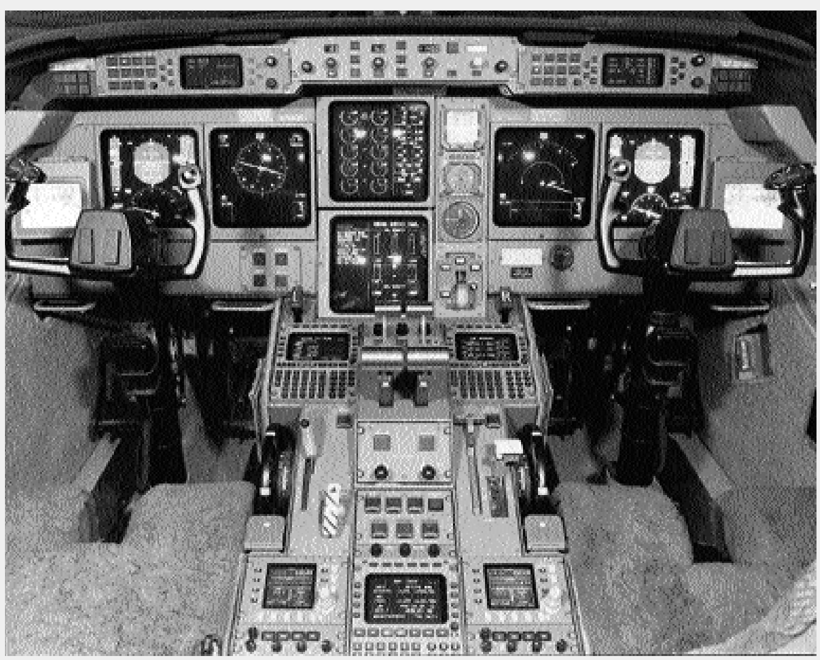
Standard equipment includes triple Honeywell air data computers, Laseref III IRUs and EFIS symbol generators, three Orbit audio control panels, dual Honeywell data acquisition units, fault warning computers, GPS receivers and radio altimeters, plus a single Primus 880 weather radar. Dual Collins radio frequency management units, VHF com radios, nav receivers, DME transceivers, ADF receivers, Mode S diversity transponders and HF radios also are in the standard package. AlliedSignal Enhanced GPWS (newly certificated on the G-V) and TCAS systems, along with B & D flight data and cockpit voice recorders, round out the package.

Options include a third Honeywell FMS or IAC, six-channel Honeywell / Marconi satcom, Honeywell / Marconi HUD, an air-to-ground radiotelephone, MLS, a lightning sensor system and, within 18 months, a FLIR-based enhanced vision system, if Gulfstream development plans proceed on schedule. (See EVS sidebar.)

Recent improvements include ASC 35, which makes available CAT II approach certification. The HUD now is CAT II certificated. The Collins VHF comm transceivers now offer 8.33 kHz channel spacing for European operations. RVSM certification is expected by the end of the year, which possibly is a moot point considering the G-V's mid- to high-forties cruising altitudes.

ASC 73 modifies the stall warning system to use pitch attitude inputs, in addition to angle of attack and angle of attack rate, for more precise operation. The upgrade eliminates the need for the artificial 125-KIAS minimum approach speed and extends the c.g. envelope to 45 percent MAC.

Other modifications include incorporation of a visual stall limit indicator on the HUD and PFD, integration of brake temperature sensing with the performance computers, more powerful Pentium processors on the FMS cards, plus an FMS database update crossload capability.



operators will be comfortable operating out of 5,000-foot runways, at modest airport density altitudes. Plan on 460-knot cruise speeds and initial cruise altitudes in the middle to high forties with total fuel burns of 2,400 to 3,000 pph.

If you push up the thrust levers, you can cruise at 0.85 Mach (488 KTAS) for 5,700 miles, but you'll need more runway and full fuel. On 6,000- to 6,500-nm missions, you'll want 6,500 to 7,000 feet of runway at low airport density altitudes. You'll need more than 9,000 feet of runway for B/CA's 5,000-foot elevation, ISA+20°C, hot-and-high takeoff profile, but there is no weight-altitude-temperature reduction in the 90,500-pound maximum takeoff weight.

Price Vs. Value

Forty million dollars is a considerable investment in a business jet.

The G-V, the dream of Charles N. Coppi, Gulfstream's recently retired senior vice president of engineering and technology, fulfills the promise of delivering greater flexibility than the G-IV/IVSP, lower fuel burns and half-again as much range with eight passengers.

We've omitted the Comparison Profile from this report because the G-V has reached more mature production, completion, weight and performance numbers than others in the ultra-long-range business aircraft class. As a result, the Comparison Profile would not be based on a level playing field.

However, the accompanying Time and Fuel Vs. Distance, Specific Range and Range/Payload Profile charts indicate that the G-V will deliver on its promised eight-passenger, 6,500-nm range performance — with three qualifiers. Operators must trim their appetites for completions to 6,700 pounds, including optional avionics and airborne office equipment. That shouldn't be too much of a challenge, if operators incorporate the expanded c.g. envelope service change that allows most, if not all, of the forward ballast to be removed from tail-heavy aircraft.

The G-V has taken the lead in the ultra-long-range class by being first in service and capturing the lion's share of early sales. Gulfstream's newest large-cabin business aircraft will face increasing stiff competition from Bombardier, along with Boeing and Airbus. However, the G-V's rapid maturation indicates that Gulfstream won't give up market share without a tough fight. With a track record of dominating the large-cabin business aircraft market for four decades, Gulfstream is off and running with a strong head start. **BCA**

HUD/EVS

Imagine you're flying a Gulfstream V on an ILS approach into Westchester County Airport, currently a Type I ILS facility. The tower reports the weather as ceiling partially obscured, RVR 700. In most aircraft, that would be an automatic prescription for a divert to an alternate with better weather or one with a Type II or Type III ILS approach system. But who wants to commute back to the office from Kennedy, La Guardia or Newark?

However, if you're flying a Gulfstream V equipped with a HUD and a Kollsman/Opgal Enhanced Vision System (EVS), you would be able to fly the ILS approach at Westchester County down to CAT I minimums and then take over visually with the approach and runway lights, plus pavement and stripes in full view on the HUD.

There's plenty of energy coming from the lights and pavement, but your unaided eye can't see it because it's in a spectrum scattered by water vapor. However, a dual, narrow-band Forward Looking Infra-Red (FLIR) sensor, tuned to detect 1.2- to 2.2-micron light waves that make up 70 percent of the energy emitted by incandescent bulbs and the three- to five-micron light radiated by pavement, can see through fog well beyond the limits of your eyes. This technology makes it possible to "see" FLIR images of lights and pavements projected on a HUD at CAT I minimums even though visibilities are as low as 700 RVR.

Does Gulfstream's goal of CAT III operations at Type I ILS facilities seem like pie in the sky? It seemed so to me until I had the chance to fly Maryland Advanced Develop Labs' Cessna 402 that was fitted with a proof-of-concept EVS system. The weather was clear the night I flew the aircraft, but flying two approaches down to 50 feet agl using the HUD and a vision restricting device convinced me of the system's potential.

Seven miles from the airport, I peered outside to locate Savannah International amidst a sea of sodium vapor city street lights and mercury vapor lights at shopping centers. Without sequencing strobes, the airport approach and runway lights virtually drowned in the non-aviation lights in the foreground.

Inside, looking at the HUD, I saw an entirely different picture. The FLIR sensor filtered out all the city and commercial gas vapor lights and portrayed the approach and runway lights as though they were the only light sources on the ground for miles.

At localizer capture, the runway lead-in light image on the HUD confirmed that the ILS avionics were working properly. After intercepting the glideslope, I flew down the approach path, cross-checking guidance accuracy with the image of the approach lights in the background. Nearing the middle marker, the Runway 27 localizer signal started its well-known dance that local pilots have learned not to chase. I ignored the wavering and flew inbound using the approach light image on the HUD.

Nearing CAT I decision height, the runway lights, numbers and stripes came into clear view. With the vision-restricting device in place, I continued the approach down to 50 feet agl and tracked down the runway center line almost as though I were flying in daylight conditions.

A second approach produced the same results.

Gulfstream officials say they plan to have the FLIR-based HUD/EVS certificated for installation in the G-V by year-end. Company insiders, though, say that mid-2000 is a more realistic time frame, assuming that every step in the development program goes according to plan.

Gulfstream has not yet priced the EVS system, but it can't be inexpensive. The FLIR sensor uses a liquid nitrogen refrigerator to increase its heat-seeking sensitivity and software development costs have been considerable.