

AVIATION WEEK'S

SPOTLIGHT

A SPECIAL REPORT FROM THE PUBLISHER OF THE WEEKLY OF BUSINESS AVIATION AND AVIATION WEEK

2003 Collier Trophy Winner

Gulfstream's G550

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for Foggy
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May 2004

AVIATION WEEK'S
SPOTLIGHT

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ON THE COVER:

The Gulfstream G550/Gulfstream

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A SPECIAL REPORT FROM THE PUBLISHER OF THE WEEKLY OF BUSINESS AVIATION AND AVIATION WEEK

May 19, 2004

The history of flight is a history of achievement. Decade after decade, airplanes have become safer, faster and able to fly longer distances at increasing altitudes.

Aviation also has become remarkably more reliable as demand for improved safety spurred a cornucopia of technological advances. Air-ground communications, navigational aids, improved engines and materials, weather radar and air traffic control systems have eliminated much of the chance from flying. Modern aircraft are equipped with Traffic Alert Collision Avoidance Systems to warn of other aircraft and Enhanced Ground Proximity Warning Systems to alert pilots when they are getting too close to the terrain.

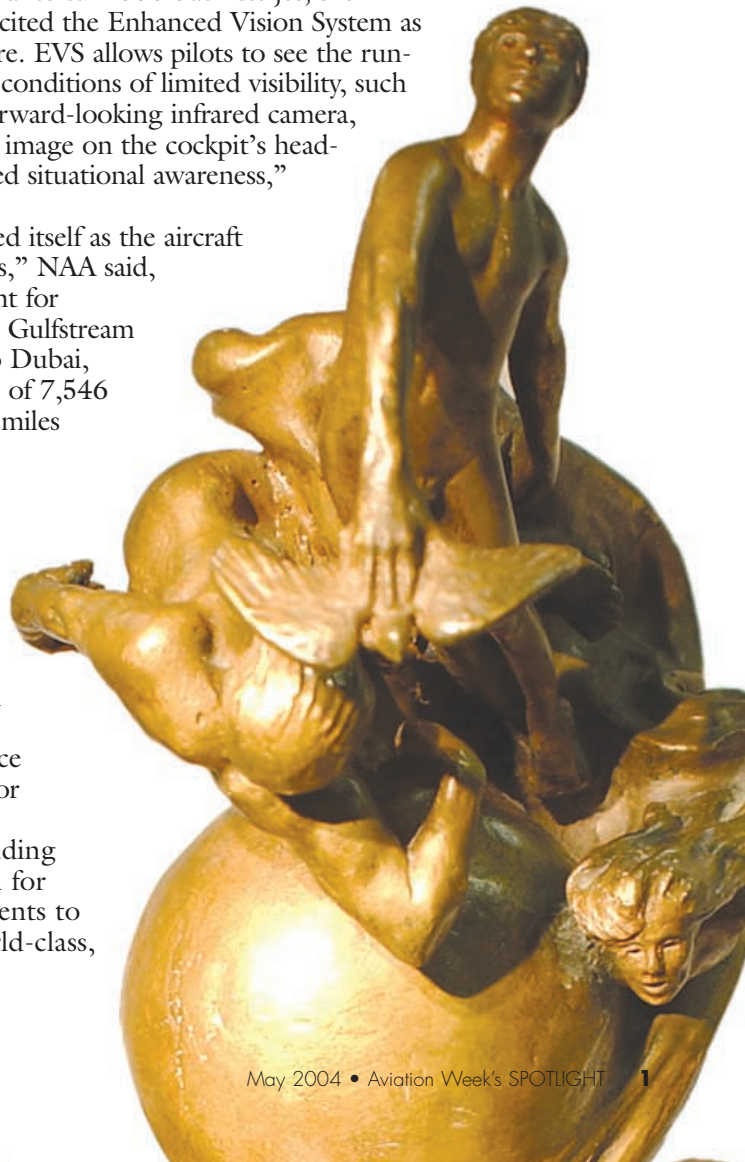
Despite those innovations, until recently business and corporate pilots still faced one unyielding obstacle, the inability to clearly see the runway and airport environment at night and during low-visibility conditions. Improved aircraft systems and navigational aids have made all-weather operations a reality for decades, but the inability to see through the murk has maintained an element of uncertainty and risk.

Now even this barrier is yielding to technology. In awarding the 2003 Collier Trophy to the team that developed the Gulfstream 550 business jet, the National Aeronautic Association cited the Enhanced Vision System as "the G550's greatest safety feature. EVS allows pilots to see the runway and the surrounding area in conditions of limited visibility, such as at night or in fog." Using a forward-looking infrared camera, the system "projects a real-world image on the cockpit's head-up display to give pilots unparalleled situational awareness," NAA said.

The G550 also has "established itself as the aircraft that can fly the farthest in its class," NAA said, noting a December 6 record flight for Distance Without Landing, from Gulfstream headquarters in Savannah, Ga. to Dubai, United Arab Emirates, a distance of 7,546 miles at an average speed of 549 miles per hour.

NAA anointed the G550 as "the greatest achievement in aeronautics in the United States with respect to improving the performance, efficiency or safety of air or space vehicles," and saluted Gulfstream Aerospace Corp. and its principal partners on the G550 program, Honeywell, Kollsman, Rolls-Royce and Vought Aircraft Industries, for their success.

We join with NAA in applauding the members of the G550 team for successfully combining their talents to develop and manufacture a world-class, prize-winning aircraft.







PICTURE PERFECT

Gulfstream's G550 technology investments pay off with a safety-advancing, all-seeing cockpit, greater range and *another* Collier trophy

BY JAMES OTT



Photo: Stork Fokker



Preston (Pres) Henne



Bryan Moss

“We knew there were significant technology steps coming in the avionics area. In 1998-1999, we combined that with customer desires for more performance and for more in the cabin and that led really to the concept of the G550.”

How do you make improvements to a Collier-award winning aircraft design for the most expensive and useful playthings on the planet?

At Gulfstream Aerospace Corp. of Savannah, Ga., a wholly owned subsidiary of General Dynamics and manufacturer of the G series corporate aircraft, the scenario runs something like this:

- Engineers look for new technology and consider how it may serve the user.
- Owners are consulted to determine their needs and desires.
- Partners are assembled to broaden expertise in key technology areas.
- A tuned-in, top-notch design team lets the creativity flow.
- Engineers try something new and test exhaustively.

Then they relax to awe the aerospace audience with their new aircraft and start breaking records.

The G550 followed that course and won the 2003 Collier trophy for, as the trophy criteria state: “The greatest achievement in aeronautics in the United States with respect to improving the performance, efficiency or safety of air or space vehicles.”

And to think that the ultra-long-range G550 began its pre-life as a glint in an engineer’s eye.

“We started in the mid-1990s just after the Gulfstream GV had crystallized. We were in the certification activity, and we asked, ‘what would be the next step?’” said Preston (Pres) Henne, senior vice president, engineering, programs and test. “And the answer started with the cockpit. We knew there were significant technology steps coming in the avionics area. In 1998-1999, we combined that with customer desires for more performance and for more in the cabin and that led really to the concept of the G550.”

The Enhanced Vision System (EVS) outfitted with Honeywell’s Primus Epic avionics became the heart of the G550. Now the system is available as a retrofit on six other G series aircraft. Developed in cooperation with Kollsman Inc., the EVS incorporates a new-design, forward-looking infrared (FLIR) camera. An infrared real-world image is projected on the pilot’s Honeywell Head-Up Display (HUD). Even in conditions of limited visibility, it is possible to identify areas surrounding the airplane. The pilot can see runway markings, taxiways and nearby roads. A cryogenically cooled detector points out runway lights during approach.

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for the Gulfstream G550*



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Pilots use Gulfstream's cursor control device in a Windows-style environment.

What basic philosophy drives this engineering achievement?

"Clearly for years, safety has been the primary factor. Performance and reliability follow very quickly," said Bryan Moss, Gulfstream's president who was vice chairman in 1995, when the GV won the Collier. "Interest in the EVS predates my arrival. It was a safety-driven initiative because people believe that a system like this could be a significant contributor. That Gulfstream stuck with it through thick and thin and invested heavily to bring this system to market speaks well of our commitment to safety."

Gulfstream engineers are among the first to appreciate new technology, but it must pass another test. What does it really offer the customer?

Henne observed, "One important thing is to combine the technology with value for the customer. We look at a particular technology and say, 'Does it increase functionality, reduce weight or improve reliability in the classical sense?' So we are not sticking a gee-whiz kind of thing on the airplane that doesn't really offer anything to the customer."

Gulfstream remains close to its customers with its Customer Advisory Board, the CAB as it's known, and its four committees, comprising G100-G200 operators, flight operations, maintenance and service operations, and product and reliability

In the late 1990s, as the conceptual design of the aircraft then known as the GV-SP, was emerging, the Gulfstream team started discussions with potential partners and suppliers. Gulfstream has had alliances with long-time partners, such as the engine manufacturer Rolls-Royce, while other alliances are comparatively new.

To become a partner, much "depends on the supplier and the situa-



EVS team at Kollsman produced the 'unfair advantage' for the G550./Kollsman

SEEING IS BELIEVING

When the Gulfstream Aerospace design team approached the people at Kollsman, Inc., for an Enhanced Vision System (EVS), they were looking for what was whimsically referred to as an "unfair advantage" in the hotly contested business jet market.

The design requirement called for an EVS system that would penetrate fog from the point of a pilot's instrument approach decision height. The pilot was to be provided with normal visual cues so he could "see" through the fog and continue the descent.

The Kollsman EVS team, based at Merrimack, N.H., comprised engineers Ernest Grimberg, Matty Katz, Steve Antal, Steve Hoffman and EVS development veterans Glenn Connor and Gary Ball. They tapped into two advances in infrared (IR) technology — the improvement in image processing and new detector technology that offered the ability to see airport lights in fog — to carry the new EVS IR design into a working, practical solution.

A joint team from Gulfstream and Kollsman tested a prototype system in 1998 and 1999. Gulfstream test pilot Gary Freeman, test engineer Bill Osborne and EVS pilot Glenn Connor of Kollsman worked with the team to complete more than 500 dense fog approaches.

The Kollsman EVS consists of three main components: an infrared window mounted to the aircraft's radome, an EVS sensor mounted in the radome area, and an EVS processor mounted in the electronics bay. On Sept. 29, 2000, a flight test demonstration validated the results with Gulfstream pilot Ron Newton at the GV's controls. He was flying blind; the cockpit of the GV had been covered over.

Newton's Sept. 29 flight was completed 71 years after then U.S. Army Lieutenant Jimmy Doolittle made the first takeoff and landing circuit, using the Sperry gyrocompass, artificial horizon, and the Kollsman precision altimeter, without looking outside the cockpit.

Development of all-weather landing systems had been underway since 1926 with the establishment of the Daniel Guggenheim Fund for the Promotion of Aeronautics. Doolittle, who held a doctorate in engineering from the Massachusetts Institute of Technology, worked with eminent engineers Elmer Sperry, Jr., the inventor of the directional gyrocompass and the artificial horizon, and Paul Kollsman, who had developed the precision altimeter.

Basic concepts developed by this team more than seven decades ago remain the staple of the standard cockpit configurations today.

The Enhanced Vision System concept began to form in 1979. A program called the "Magic Window" was developed for Fred Smith, founder and chairman of FedEx. He had proposed a system so that pilots could "see" through fog on a head-up display (HUD) with the aid of infrared and radar. But no program was developed for successful commercial application.

Kollsman's EVS provides a real-time image of the external scene even through darkness and low-visibility conditions. The FAA certificated the system in 2001 after extensive testing by FAA pilots. The system brings a new level of safety, enabling safer approaches, reduced missed approaches and improved situation awareness. It also is a significant aid in the campaign to prevent runway incursions.

The EVS system is available for seven Gulfstream aircraft, including the G550.



Mike Mena

tion,” said Henne. “Let’s take the case of the engine. That in reality has been in the past a competitive situation, but Rolls has prevailed. With the cockpit, it is probably less competitive, but who’s to say in the future? In any supplier situation, there’s nothing that guarantees an incumbent position on a new Gulfstream.”

With Mike Mena as program manager for the GV-SP, the Gulfstream team began talks in late 1998 with officials at Honeywell International, who later signed a letter of intent to participate. By mid-1999, a memorandum of understanding locked in the partnership. At the Savannah, Ga., headquarters, the proposed new aircraft program was regarded as underway, at least from an internal standpoint. In 2000, the other primary partners, Kollsman, Inc., Rolls-Royce, Stork Fokker and Vought, came on board and were joined later by other suppliers.

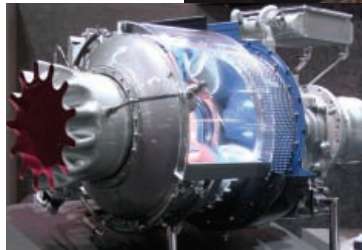
As anticipated, the PlaneView™ cockpit, based on Honeywell’s Primus Epic integrated avionics system, launched Gulfstream into a new era. Pilots point-and-click on electronic displays and no longer use dials, knobs and switches. Liquid crystal displays are large flat panels that provide all the information a pilot needs.

During the creativity stage, engineers encountered typical obstacles, but the integrated modular avionics system presented a new kind of challenge. In Gulfstream’s previous experience, the effect of changes to a stand-alone avionics instrument, such as an auto pilot, would be held to that instrument. With the G550 avionics suite, Gulfstream was playing in a new game. Mena recalled the challenges:

continued on page 11



G550’s PlaneView™ cockpit, based on Honeywell’s Primus Epic integrated avionics system, offers all the information a pilot needs. Other Honeywell projects, from the left, are the RE-220 APU, the thrust recovery outflow valve, and the air conditioning pack./Honeywell



G550 BRINGS A NEW ERA IN AVIONICS

Certification of the G550’s integrated cockpit completed a huge avionics design effort and launched a new era in which pilots use electronic displays and cursor control devices in place of dials, knobs and switches.

The PlaneView™ cockpit for the G550, based on Honeywell International’s Primus Epic integrated avionics system, drives four 10-by-13-in. liquid crystal displays in a point-and-click, Windows-like environment. Primus Epic’s architecture offers far more integration, more functions and more intuitive human-machine interface than any previous system. The payoff comes with improved “situational awareness,” a big safety benefit.

Large landscape flat panels are able to present moveable navigation maps and information on weather, terrain, traffic and real-time video in addition to the required horizon displays and aircraft operational information.

The compact, integrated design of the Primus Epic system saves space and more than 200 lbs. of weight. This weight-saving factor helped Gulfstream provide more passenger room and payload in the G550.

Honeywell products on the G550 also include:

- RE220 auxiliary power unit, the turbine engine that provides pressurized air and electrical power for starting the main engines and running aircraft accessories.
- Environmental control system.
- Cabin pressurization control system with new thrust recovery outflow valve, which controls cabin pressurization. By directing this air into the free air stream, the system boosts takeoff performance, speed, fuel efficiency and range.
- Lighting products, such as Honeywell’s new Astreon systems, based on long-lasting, light-emitting diodes. These can help improve dispatch reliability and reduce maintenance cost.

THE G550: FROM CONCEPT TO REALITY

1995

Gulfstream engineers begin thinking about the follow-on to the GV.

1998

Customer desires for improved performance expand the concept of the GV-SP as the aircraft was then known

1999

Honeywell signs memorandum of understanding as a partner

2000

Vought, Rolls-Royce, Stork Fokker and Kollsman sign on as partners, followed by other suppliers

Critical Design Review is completed

New G Series aircraft officially announced

GULFSTREAM G550 SPECIFICATIONS

Performance

Long-Range Cruise Speed (8 passengers, 4 crew, NBAA IFR reserves) 6,750 nm at Mach 0.80

High-Speed Cruise

5,000 nm at Mach 0.87

Takeoff Distance

(Maximum Takeoff Weight) 5,910 ft.

Landing Distance

2,770 ft.

Maximum Cruise Altitude

51,000 ft.

2001

GV is modified with PlaneView™ cockpit, uprated engines and new wings.

First flight on Aug. 8, a month earlier than scheduled.

Enhanced Vision System is certificated by the FAA

Fluid Visualization Test validates data from wind tunnel experiments

2002

EVS installed on Air Force C-37A
May 15

First production aircraft rolls out, June 19

First flight, July 18, 2002

2003

FAA type certification and production certificate,
Aug. 14

Entry into service, Sept. 29

G550 sets four new city-to-city speed records during around-the-world trip, Sept. 28-Oct. 3

G550 breaks record in its class Dec. 6 for Distance Without Landing, flying 7,546 mi., at an average speed of 549 mph.

2004

JAA/EASA certification,
Mar. 9

Collier trophy presentation,
May 19

Weights

Maximum Takeoff Weight
91,000 lbs.

Basic Operating Weight

(including 3 crew)
48,300 lbs.

Maximum Payload

6,200 lbs.

Interior

Cabin Height
6 ft., 2 in.

Cabin Width
7 ft., 4 in.

Cabin Volume
1,669 cu. ft.

Baggage Compartment Volume

226 cu. ft.

Exterior

Length
96 ft., 5 in.

Height
25 ft., 10 in.

Wingspan
93 ft., 6 in.

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"It became clear as we started to test the system that there were surprises happening. With the new integrated nature of the modular avionics, if you changed one area in one system, it could conceivably have an effect on the display and vice versa. It was because the system was so integrated. It took a lot of testing, both on our bench here at Savannah and a lot of flight testing to work the system through and make sure it was developed as thoroughly as it could be."

Compared with the GV, the G550 is more software-driven by an order of magnitude, Henne calculates.

"Major advances in avionics come once in every 20 years, and this cockpit is out in front," said David Hughes, senior editor of *Aviation Week & Space Technology*, who accompanied Gulfstream test pilots on one of the distance record-breaking transatlantic flights. He evaluated the Honeywell Primus Epic avionics in an article, June 2, 2003. "We have a Windows computer-style environment with the ability for pilots to customize the displays to show the data they want, when they want it, in the format they want it," he said. "It tells the pilot where he is and where he is heading. It's clearly a pioneering effort."

The G550's Enhanced Vision System completes the package, the "icing on the cake," says Hughes. He foresees a major safety advancement from the EVS system that will flow quickly to other parts of business aviation and to the airlines that adopt it.

Gulfstream conducted the critical design review in the middle of the year 2000. In October, the company officially launched the G550, still known as the GV-SP. A mock program began the following February. The proposed new cockpit was installed in a GV. To simulate the G550, the aircraft also received uprated Rolls-Royce BR710 engines, modifications to the fuselage for improved drag reduction and advanced wings from Vought. The trailing edge contour of the flap was modified to increase aerodynamic performance and range.



Increased-thrust Rolls-Royce BR710 has powered the G550 to a new Distance Without Landing record./Rolls-Royce

TWEAKING THE BR710

The partnership between Gulfstream Aerospace Corp. and Rolls-Royce traces back some 45 years. Starting with the Dart turboprop engine in the G 1, Rolls-Royce engines have powered all of the G Series aircraft up to and including the latest, the Collier award-winning G550.

To boost performance of the G550, Rolls-Royce engineers increased the thrust of the BR710, the engine for the Gulfstream V and G500, by 4.3% to 15,384 lbs. "This was clearly the most obvious and measurable change," said Alan Stiley, the manufacturer's vice president of marketing and product strategy for the Corporate and Regional Aircraft Division. "It allows improved performance, not that it was shabby," and a benefit is an improved rate of climb.

The engineers also took some weight out of the G550 engine and reduced fuel burn. These advancements enabled Gulfstream to achieve a series of record-breaking flights, including the record in its class for Distance Without Landing. That was on Dec. 6 when a BR710-powered G550 flew from Savannah, Ga., to Dubai, United Arab Emirates, a distance of 7,546 mi., at an average speed of 549 mi./hr.

Rolls-Royce's corporate and regional aircraft unit manages the manufacturing, supply and support for engines powering business jet and regional aircraft up to 20,000 lbs. of thrust. The company offers aircraft owners an engine maintenance program, CorporateCare, that involves maintaining the engines.

Stiley calls the program, "power by the hour — and a bit more. It's sort of a risk-reduction, peace-of-mind program that enhances the value of the product. A second user will know that the engine has been maintained and [is] up-to-date."



VOUGHT'S CONTRIBUTION TO G550 PERFORMANCE

Redesign and production of the complete integrated wing assembly for the G550 comprised a two-year effort at Vought Aircraft Industries of Dallas, Texas. The work paid off in a valuable contribution by Vought to the G550's improved aerodynamic performance and range.

The redesign was accomplished through a CATIA-driven process that involved Vought's Integrated Product and Process Management team. Members included representatives of the airframe manufacturer Gulfstream Aerospace Corp. and Vought suppliers.

The total wing assembly comprises the flaps, ailerons and leading and trailing edges.

Working with Vought, ShinMaywa Industries of Kobe, Japan, changed the trailing edge contour of the flap to increase aerodynamic performance and range. As a result, the inflight center of pressure shifted aft and inboard on the wing and increased loads. Approximately 40% of the flap structure required changes or strengthening. Vought completed structural design changes to handle the resulting increased loads and performed certification static testing of the new flap at Dallas.

To support FAA certification, 15 stress and fatigue/damage tolerance reports were updated or revised.

The manufacturer used custom-built tooling and advanced manufacturing technology to produce the wing. The upper wing skin was formed by a technique called "age-creep forming." The upper wing skin is a solid sheet of machined aluminum. Use of automatic riveting machines to attach stringers to the wing skins improved the quality of the product and saved both time and costs.

Dave Bauer served as G550 wing program manager throughout the development effort.



Above: The Vought team assembles at Dallas./Vought

Inset: The wing was Vought's main contribution to the G550./Stork Fokker

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Pres. Kennedy with Scott Crossfield, Major Robert White (USAF), test pilots of the X-15



Pres. Eisenhower with the Atlas ICBM team

This year, the Gulfstream G550 joins the long line of advancements that have earned this prestigious award.

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The first flight of the mock aircraft went smoothly. It took place on Aug. 8, 2001, at least a month earlier than the original schedule. Three months later, the aircraft underwent a fluid visualization test. In that test, dye was released during flight and it dried on the fuselage. On the ground, engineers were able to trace the dye and track air flow over the fuselage. They made some minor changes as a result, but the tests for the most part validated earlier tests, including wind tunnel experiments.

“Nothing made us go back to the drawing board,” Mena said.

The partners’ computers were linked in a CATIA system. Gulfstream served as the integrator for changes to a three-dimensional mockup. Key structural changes involved Vought, which produced a more advanced wing.

Henne said, “We changed the camber of the wing with the trailing edge contour mod, which puts a blunt trailing edge on the inboard part of the wing. The vortex generator pattern was actually run up on the winglet, and we got benefit out of that. We did a lot in terms of sealing control surfaces, changing the auxiliary power unit exhaust shields and a lot of smaller things that all added up to a significant reduction in the drag on the airplane.”

Another Honeywell contribution was the new thrust recovery outflow valve in the cabin pressurization control system. The TROV, as it is known, recovers wasted energy by reusing air released from the cabin outflow valve. By directing air into the free air stream, the system boosts takeoff performance, speed, fuel efficiency and range.

Gulfstream designers take pride in the look of their product. “It’s a remarkably smooth airplane,” said Henne. “There are no external flap hinge bearings, and the bottom of the wing is completely smooth. We have a fundamentally different design in the flap system. It’s a pretty slick airplane.”

While the mockup aircraft was still undergoing tests, the first production G550 was rolled out June 19, 2002. The G550 has seven Gulfstream signature round windows on each side, just like the earlier G500. Because of the reduced avionics volume, cabin room was increased by 58 cubic feet. With the redesign, baggage capacity was boosted



Stork Fokker brought its long and varied manufacturing experience to bear on the Collier-winning G550./Stork Fokker

TAIL SECTION BY STORK FOKKER

A full partner with Gulfstream on the GV, Stork Fokker AESP B.V. of Papendrecht, Hoogeveen, Schiphol, The Netherlands, designed and developed the complete tail section for the G550 and is producing both the tail and the thermoplastic floor boards.

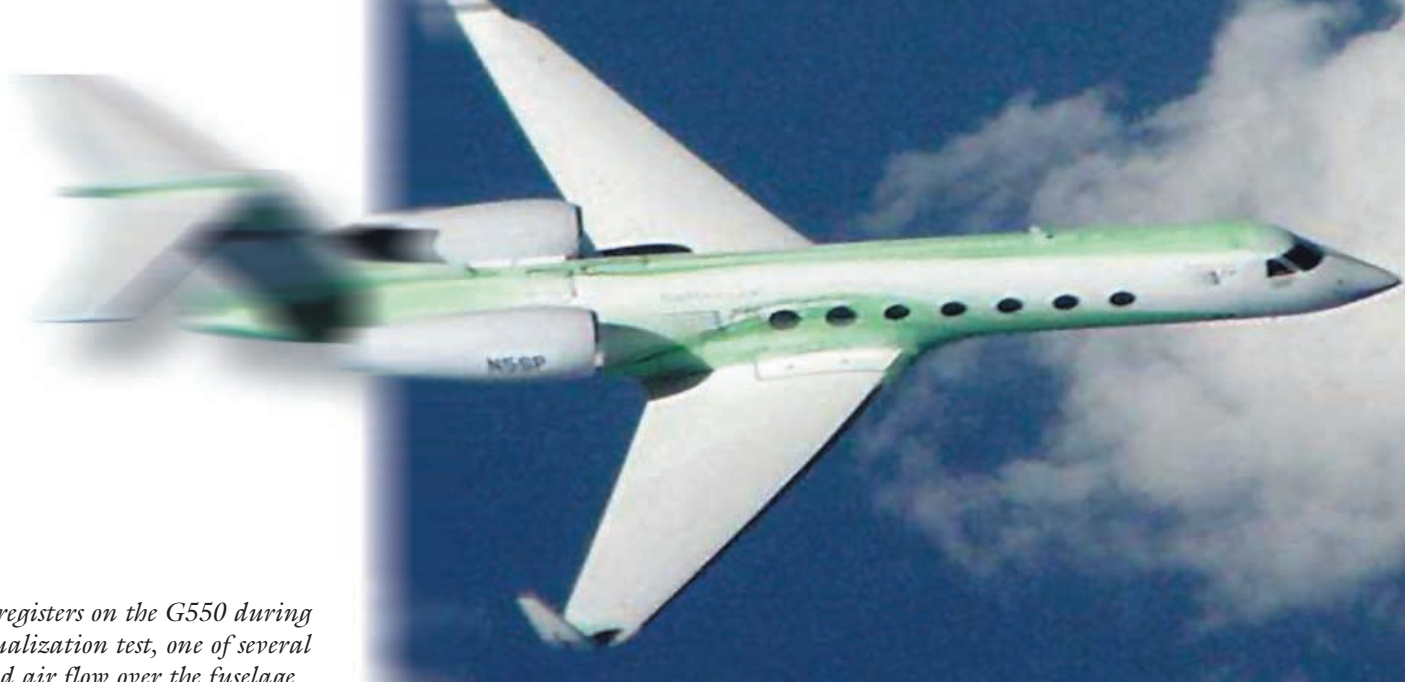
In 1998, Stork Fokker redesigned the common composite rudder for the GIV and GV aircraft and now manufactures the rudder. It also produces the GIV main landing gear doors.

Under the Gulfstream GV Sea Watch program, Stork is modifying aircraft for the Japanese Coast Guard.

The descendant of the former Fokker aircraft manufacturing company, Stork leans on its experience as a manufacturer of complete aircraft, bringing that knowledge and skill in focus to key areas, such as materials and development, design and production. Its core competencies include integrated technical and logistics support for aircraft, especially Fokker planes, as well as automated design and production of electrical wiring systems.

Key technologies under roof are metal bonding, thermoplastic composites technology, high-speed machining and 3D design, and the application of glass fiber-reinforced aluminum. The latter, known by the registered trademark Glare, is a cross between metal and composites. A resin epoxy bonds sheets of aluminum with layers of glass fiber. The material has demonstrated improved fatigue resistance and impact tolerance. It is also a weight-saving procedure. The material has been selected for parts of the Airbus A380 fuselage.

Stork provides technical and logistics support for the Lockheed Martin F-16, for all Fokker aircraft and the Boeing 737. It handles projects, conducts system engineering and supply of components, under contract to international aerospace and defense companies and to the Netherlands Ministry of Defense.



Green dye registers on the G550 during a fluid visualization test, one of several that tracked air flow over the fuselage.

by about 25%. The first flight of the production aircraft on July 18 took slightly longer than five hours. The unusual length of this flight provided sufficient time to complete the entire flight test card. The FAA issued the type certificate a little over a month later on Aug. 14, and on the same date issued a production certificate for the aircraft. This was the first time in Gulfstream history that an aircraft received both certifications on the same day.

Ahead of schedule by a few days, the G550 entered service Sept. 29. Less than a month out of the assembly line, the G550 flew around the world between Sept. 28 and Oct. 3, a 20,120-nautical mile journey, and set four new city-to-city records. The average speed was 486 knots. (559 mph) or 0.847 Mach.

Crew for the first three legs included Gulfstream's chief demonstration pilot, Capt. Bill Watters, Al Moros, senior engineering test pilot, and Ray Wellington, demonstration pilot, from Savannah to Ankara, Ankara to Langkawi, and Brunei to Seoul. [A leg was flown between Langkawi and Brunei for a customer demonstration.] The last leg, from Seoul to Orlando, was flown by Roc Miles, director of demonstration and corporate flight operations, Tom Horne, senior experimental test pilot and G550 project pilot, and Tony Briotta, demonstration pilot.

By March 11, the G550 had established 11 city-pair speed records. It was also breaking distance records at the same time. The G550 had increased range to

6,750 nm, 250 nm longer than the range of other recent aircraft in its class, more evidence that Gulfstream had produced a performance winner. Furthermore, the EVS and the avionics suite had ushered Gulfstream into a new era. The improvement in "situational awareness" arising from the EVS capability addressed issues raised by the U.S. government's Safer Skies initiative. Henne said Gulfstream executives thought it over and decided that the G550 met the Collier criteria.

"The Collier," Henne said, "is the equivalent of every single academy award lumped into one. It's the equivalent of winning the awards for best actress, best script, best special effects."

Bryan Moss had shared in the excitement of the 1995 GV Collier win when he was vice chairman. As president, he takes special pride in the Collier win for the G550. He was aboard the aircraft for nine of the 11 speed and distance records. "I had another kind of feel for it," he said.

Winning the Collier trophy for 2003, the 100th anniversary of powered flight, brought additional satisfaction to all associated with the G550. Moss said, "We recognize the hard work and dedication of all the people here at Gulfstream and equally of all those who work for our partners and suppliers."

James Ott is a contributing editor to Aviation Week & Space Technology. In 2002, the Royal Aeronautical Society named him Aerospace Journalist of the Year.

Gee, 550, take a bow.



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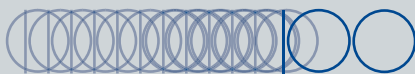
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