

Piloting: Cockpit Comforts

New thinking, technologies and engineering are making ultra-long-range business jet cockpits more efficient, safer and comfortable

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The biggest challenge for any business aircraft manufacturer is determining how much space, comfort and amenities to dedicate to the crew and the passengers. For ultra-long-range business jets, these factors are magnified by the amount of time these aircraft spend aloft. Passengers' needs can be met with comfortable, flexible seating and tables, good lighting and well-equipped galleys, as well as a fully functioning airborne office, fast inflight connectivity, entertainment systems and cabin controls. But the restraints of cockpit space — and until recently, technology — have limited what can be done to make the flight deck more comfortable. But that's changing for the better.

New thinking and technology have combined to alter the flight deck from a functional, utilitarian space to one that offers a harmonious design aesthetic while actually enhancing information acquisition, attentiveness and control. The industry is moving toward more technologically advanced solutions such as digitally interconnected active control sidesticks and touch-screen avionics utilizing resistive input developed in real-world conditions to provide crews accuracy in turbulent flight, and is significantly recalibrating traditional cockpit seat designs for extended trips.



Credit: Gulfstream

The evolved cockpit is the result of the advancement of human factors as a formal discipline in aviation engineering. As defined by professional ergonomist Jeff Koonce, human factors is "The study of the human's capabilities, limitations and behaviors and the integration of that knowledge into the systems we design for them with the goals of enhancing safety, performance and the general well-being of the operators of the system."

Aircraft designers call upon human factors guidelines to ensure functional accommodation of pilots. Medical and anthropometric research has led to today's fully adjustable seats, for example, with vertical and horizontal positioning, as well as fully contoured pan and back cushions and a full range of articulations, including thigh angle, horizontal and vertical lumbar, headrest rotation, recline angle, articulating headrests and armrest positioning.

In addition to seating, the aircraft manufacturers are considering other components in the cockpit landscape: sidesticks, foldout workstations, the design and location of switches, functional grouping of systems controls, handholds, grips, force transducers, reading and area illumination, rest areas, lavatories and showers, and personal storage areas.

Meanwhile, the emergence of crew rest areas in ultra-long-range aircraft is a result of Advisory Circular 117-1, Flightcrew Member Rest Facilities, guidance that incorporates the latest fatigue science to set different requirements for pilot flight time, duty period and rest based on the time of day pilots begin their first flight, the number of scheduled flight segments and the number of time zones they cross.

Eliminating traditional flight control columns also has freed space for foldout workstations and more room for adjustable crew seats. Because of this, cockpits with sidesticks are roomier than ever. Ample additional storage space in the flight deck is available for each pilot in side consoles, overhead, and in dedicated crew rest and wardrobe spaces located behind the flight deck.

Take a Seat

When selecting flight deck seats for extended-range business jets, designers consider the length of time pilots will be spending in the flight deck. This confined environment subjects pilots' spines to continued vibration and compression as well as restricted movement. Back pain is considered an occupational hazard among pilots, according to aeromedical physicians. Similar problems in the trucking industry were addressed long ago with the introduction of ergonomically designed pneumatic seating.

Studies have shown that it is possible to design ergonomically correct cockpit seating that eliminates or at least reduces pilot spine fatigue and injury. And this can be accomplished despite the recently updated FAR Part 25 and EASA certification rules requiring seats to sustain forces of a minimum of 16 Gs of acceleration; in addition, cockpit and passenger seat fabrics are required to pass stringent fire retarding standards and testing insofar as the seat foam is concerned.



Credit: Airbus

Aircraft manufacturers also must consider the functionality of the seats for different activities beyond routine piloting operations. For long flights the seating must allow for relaxing or dining. And since pilots come in a wide range of sizes, the seats must accommodate people in the fifth percentile as well as those in the 95th percentile.

Ipeco, Stelia, United Technologies and Zodiac are among the leading cockpit seat makers today. Ipeco cockpit seats can be found in two dozen business and commercial aircraft types, including Alenia (ATR 42/72), Boeing (nine models), Cessna (Citation Mustang), Gulfstream (GIII, GIV, GV and G650), Hawker Beechcraft (800 and 4000), HondaJet, Pilatus (PC-12), and Tupolev (TU214). Stelia provides the cockpit seats for all of the Airbus A320 line, including the Airbus Corporate Jet. United Technology seats are in the cockpits of all Cessna Citations except the Mustang, as well as the Embraer Phenom 100 and 300 and Legacy 450 and 500, and Dassault Falcon Jets. The Embraer Lineage 600, 650 and 1000 and some Falcon Jet models have Zodiac cockpit seats.

Inceptors

Another significant development in cockpit ergonomics is the incorporation of inceptors — sidestick controls — in civilian aircraft (they've been used in military cockpits for years). Removing the control yokes allows for larger flight displays and moving pilot seats closer to the instrument panel, thus easing the use of touch screens. The change also provides space for an electronic flight bag (EFB) or a meal tray.

The biggest drawback of earlier, so-called passive sidesticks used in some civil aircraft was the lack of control feedback from the aircraft or the other pilot. But the transfer of “active inceptor” technology to the commercial sector from the military is helping to overcome that objection. Active sidesticks provide tactile and visual feedback in response to pilot and autopilot commands.



Recalibrating traditional cockpit designs for extended trips relies on the latest advances in the ergonomics of crew seating, flight control technology, and other features designed to keep pilots comfortable, efficient, alert and healthy as they cross oceans and continents. Credit: Bombardier

Gulfstream is the first civil manufacturer to adopt active sidesticks, for its new G500 and G600 business jets, and in 2010 selected BAE Systems to supply technology. Commercial inceptors are dual-duplex, using dissimilar processors so there are no common failure modes between channels. Sidestick force and position-sensing is quadruplex redundant to meet certification requirements.

The sidesticks are, obviously, digitally connected to the aircraft’s flight control systems, with dedicated links to the autopilot, pilot and copilot controls for enhanced situational awareness. The design reflects the idea of the cockpit as a cognitive system. Sidestick characteristics for breakout forces, force displacement gradients, stick-shaker and soft stops in each axis are programmable and can be tailored by the aircraft manufacturer.

Bombardier selected sidestick controls for its CSeries airliner and is incorporating fly-by-wire (FBW) and sidestick controls in its new Global 7000 and 8000 business jets. Dassault,

Embraer, Bell, Sikorsky, Comac, Irkut and Sukhoi are also adoptees of the BAE Systems inceptors, and competitors are expected to soon follow suit.

Touch Screens and CCDs

Touch-screen avionics controllers reduce the number of switches on the flight deck and can act as a radio, display flight plans, perform systems checks and more, and allow pilots to directly access controls. Tablet-based interfaces logically structure input options to match only the tasks appropriate to the phase of flight. The controller panels are equipped with ergonomic frames to stabilize the pilot's hand while using the touch screens.

Meanwhile, computer control devices (CCD) provide a means for pilots to indirectly access controls on electronic displays. Typical CCDs in the flight deck include trackballs, touch pads and joysticks.

A key benefit of CCDs is their convenience; they are typically located on or close to the pilots' natural hand position, and are often accompanied by a hand stabilizer or armrest. This arrangement allows for convenient pilot inputs, particularly since hand and arm motion is minimized.



Credit: Bombardier

As with all instrumentation, CCD inputs can be erroneous, especially when the aircraft is subjected to vibration or turbulence. And these errors are more likely to go unnoticed by the other pilot because they are typically accomplished with small finger motions on the CCD.

In addition, the FAA has encouraged avionics makers to address the problem of simultaneous “dueling cursors” during product development.

Comparisons

General comparisons of the ergonomics-driven features developed by the makers of extra-long-range business jets from Bombardier, Dassault and Gulfstream illustrate the range and similarities of approaches. The much larger Airbus Corporate Jet and Boeing BBJ offer similar amenities for their cockpit crews as well.

Bombardier



Crew seating research and engineering has led to cockpit seats providing improved vertical and horizontal positioning, as well as fully contoured, “breathable” pan and back cushions, and articulating thigh, lumbar, headrest and armrest positioning options to accommodate people from the fifth to the 95th percentile. Credit: Airbus

In the Global 7000 and 8000, for example, the Bombardier Vision flight deck, launched on the flagship Global 6000 in early 2012 (and also available on the company’s Learjet and Challenger aircraft), features synthetic vision system (SVS) imagery on head-up displays (HUDs), and larger display screens, providing pilots with greater situational awareness.

The Global 7000 cockpit offers a new sidestick armrest support that reduces wrist and arm fatigue and provides a better level of control for pilots. There's also a highly portable EFB available to help pilots plan missions outside the aircraft.



Credit: Bombardier

Bombardier's Global business jets offer a side-mounted jump seat outside the cockpit. This can be used by anyone facing sideways or can track and pivot into a forward- or aft-facing position, if desired. When not in use, the seat stows neatly out of the way, leaving ample room in the flight deck for ease of movement. However, citing "competitive and confidential reasons," Bombardier declined to share additional information about its cockpit seats.

Still, a convenient grab bar above those seats on Global aircraft eases movement in and out of the cockpit. And there's storage on the flight deck of both Global and Challenger aircraft for each pilot in the side consoles. The manufacturer also redesigned the cockpit reading lights and improved integrated map lights and side console lighting. Globals follow the dark cockpit philosophy — controls are only lit when they require the attention of the pilots.

Moreover, the Global 7000 features a 195-cu.-ft. crew rest area with two large windows, berthable seating and a forward lavatory nearby. Additional overhead compartments can be configured to provide extra storage space.

And Bombardier offers a bunk variant on Global 7000 aircraft that can accommodate an additional pair of pilots to meet the requirements of the longer missions that this aircraft is capable of achieving.

Dassault

Like Bombardier and Gulfstream, French business jet maker Dassault Falcon Jet says it has made significant changes to cockpit crew amenities as a result of extensive feedback from pilots and other crewmembers.

Its two ultra-long-range aircraft, the Falcon 7X and 8X, also feature an FBW flight control system with sidestick controllers, providing the pilots with a considerable amount of additional leg movement since they are not straddling a control column. In addition, the aircraft feature pullout tray tables, offering a generous surface area for meals, beverages and documents. EFBs are available for both sides of the cockpit for viewing Jeppesen charts and other flight data. Falcon Sphere is a Dassault-designed EFB software suite that aggregates operational applications to support pilots on the ground and in flight. It includes Falcon flight manuals, flight documentation by aircraft serial number, access to operator-specific documentation (MELs, etc.), charts and weather apps, and more.

The cockpit seat pan cushioning has been increased by half an inch, with larger bolsters and a new material for the cushion. The designers have removed the front slit in the seat pan and used a mechanical means of fixing the cushion to prevent any local high pressure that could cause discomfort.

To further increase comfort, Dassault has added a pneumatic lumbar support and improved the foam material used on the backrest. The shape of the headrest has been improved and made adjustable. The armrests are longer and have two new positions with 7 deg. of lateral adjustment, and +/-15 degrees of vertical adjustment. The thigh rest is now controlled by a pneumatic actuator. Also, some minor changes have been made to the seat restraint system to make it more comfortable for crews.

The 7X and 8X cockpits can be configured during operation to accommodate additional recline for both front seats. The standard third flight deck seat can swivel 180 deg. and features a pop-out leg rest.

The long-legged Falcons feature a crew rest area measuring 78 in. by 30 in. When not in use, the space can be converted into a closet and storage area. A convertible crew closet is also standard on both aircraft. A crew closet and a fold-down hanger bar are standard.

Gulfstream



Advanced flight controls and instrumentation, such as active control sidesticks, touch screen controls, and computer control devices provide a means for pilots to indirectly access controls on electronic displays while freeing up cockpit space for other uses. Credit: Gulfstream

Meanwhile, the Gulfstream G500 and G600 feature the Symmetry Flight Deck, ushering in the company's latest thinking in cockpit design, integration, functionality, ergonomics and aesthetics. The new design leverages active control sidesticks and touch-screen technology and will accept continual upgrades.

Meanwhile, Gulfstream-designed CCDs, standard on its long-range models, feature ergonomically angled handholds and thumb-operated force transducers that allow pilots to control the cursors on screen. And the touch-screen controller panels are equipped with ergonomic frames to stabilize the pilot's hand while inputting commands.

The G500 and G600 cockpits also feature a new headrest with a more functional hand grab that helps pilots get in and out of the seat easier. The cockpit seat positions can be adjusted forward, aft and vertically, the backrest can recline and there is adjustable thigh support on the base cushion. Additionally, the new seats provide a full seat pan, instead of a split one, since they have replaced the control yokes with active control sidesticks.

Fixed cockpit footrests are provided on the lower area of the left-hand and right-hand instrument panels for the pilot and copilot. There is also storage space in the cockpit for small items.



Adding crew rest areas, lavatories and showers, wardrobe and personal storage spaces are in part a response to FAA and EASA guidance on crew member rest facilities that incorporate the latest fatigue science to set different requirements for pilot flight time, duty period and rest. Credit: JK

All lighting in the Gulfstream G600's crew rest area is LED and features dimming controls. Also, the controls prevent someone outside of the rest area from accidentally turning on lights or entertainment within the space and awakening someone at rest there.

The rest area meets the FAA's requirement that the sleeping surface measure 70 in. by 30 in. and individual sleeping space volume is 35 cu. ft. A dedicated area for crew to change clothes and separate crew lavatory is available on all long-range models. The aircraft also provide computer and Wi-Fi access, charging ports for personal devices, and a monitor with headphone jack for crewmember entertainment. The rest areas on the G550 and G650/G650ER feature a window.

Sweet Spot

The science and art of keeping flight crews alert, informed, comfortable and in control has become ever more important as aircraft range — and thus mission length — has increased significantly in recent years. Manufacturers are focusing on the care and needs of the people up front more than ever. And by the end of a long mission, business aircraft crews will appreciate these thoughtful combinations of cockpit functionality, ergonomics and aesthetics that have been applied to their workspace.