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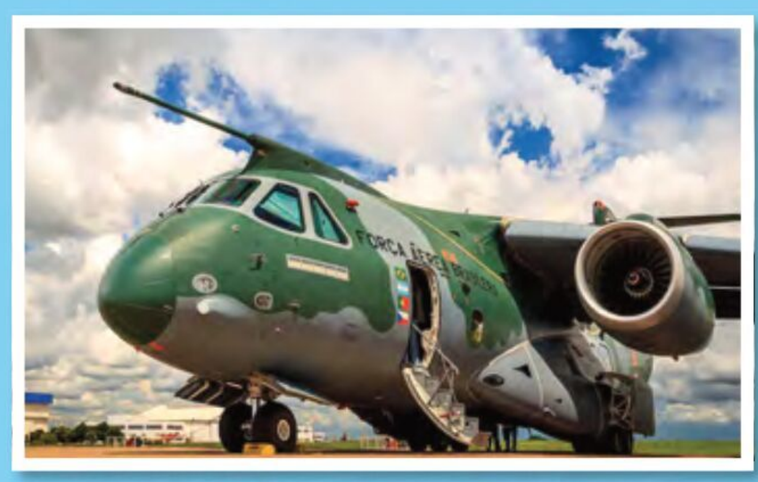


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Embraer: Brazil's Aerospace Company

Now in its sixth decade of operation, Brazilian aerospace company Embraer has come along way since it designed its first aircraft in the late 1960s – the EMB 110 Bandeirante.

To the air traveller, Embraer is perhaps best known for its E-Jet family of airliners which serve national and continental routes around the world.

But the Brazilian company does not just build commercial passenger aircraft for airline customers, they are also key players in the agricultural, executive, military, and future urban mobility market sectors.

Embraer's portfolio of aircraft ranges from the diminutive Impanema crop duster to the C-390 Millennium multi-role transport aircraft.

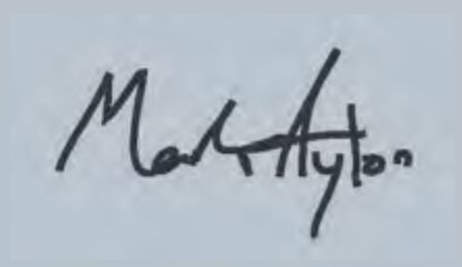
After success with the Bandeirante, Embraer went on to develop regional passenger aircraft like the turboprop Brasilia and jet-powered ERJ, licensed-built MB.326 and AMX military jets, the original EMB 312 Tucano turboprop trainer.

Today, in addition to the C-390, Embraer's Defense and Security unit build the EMB 314 Super Tucano and the ERJ 145-based R-99 airborne early warning and control aircraft. Embraer Defense and Security is also involved in the production and flight test of the Brazilian F-39E Gripen.

Based in Melbourne, Florida, Embraer Executive Jets builds the Praetor and Phenom series.
The Phenom 300 series' popularity was confirmed last year when it was the world's best-selling light jet for the tenth consecutive year and the most delivered twinjet of 2021.

And what next for Embraer? Its research and development unit are busy developing a family of low- or zero-emission concept regional aircraft with the intent to power the types with either all-electric, hydrogen or hybrid sources.

Embraer: Brazil's Aerospace Company provides historical and current insight of the range of aircraft produced by this forward-looking business. ●



EMBRAER S.A.



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Sao Paulo to the World

Mark Ayton charts the history of Embraer S.A., Brazil's aerospace powerhouse now operating from production facilities in multiple countries.

In 1950, the Brazilian government inaugurated the Instituto Tecnológico de Aeronáutica (Technological Institute of Aeronautics or ITA) to train aeronautical engineers.

Nine years later, student Ozires Silva graduated from the institute as an aeronautical engineer and went on to participate (and subsequently coordinate) in a study commissioned by the Ministry of Aeronautics through its then Aeronautical Technical Center (CTA) of the potential increase in the fleet of medium-sized Brazilian passenger aircraft. The minister in charge was Brigadier Eduardo Gomes, who signed the basic project approval document IPD-6504 which eventually became the Bandeirante. Three prototypes were built and designated EMB 100s.

Convinced of the market potential for regional aviation, a first flight in 1968, and a successful flight test programme with the prototype Bandeirante aircraft, the team set-up a serial production line for the type. After failed attempts to set-up production with private sector companies, the team, led by Ozires Silva, worked with the Brazilian government to form a joint company, with initial capital provided by the state.

On August 19, 1969, Embraer was formalised by legal decree. Activities began on January 2, 1970, at Avenida Brigadeiro Faria Lima, 2170 in São José dos Campos, the site still used today.

To make the Bandeirante a viable aircraft for the market, Embraer introduced several modifications and gave the model the EMB 110 designation, a type that gained market prominence throughout the 1970s led by the Brazilian Air Force which ordered six to meet some of its transport needs. This aircraft was certified in 1973.

More Types

Simultaneously, Embraer developed and produced the Ipanema agricultural aircraft and license-built the Aermacchi



BELOW • ***A Brazilian Air Force C-95C Bandeirante.*** EMBRAER S.A.

MB.326, designated the AT-26 Xavante for the Brazilian Air Force.

The Bandeirante was followed by the EMB 120 Brasília, which was certified in 1985. The EMB 120 Brasília was a high performance commercial aircraft of pressurised turboprop design that integrated the most advanced technologies available. The Brasilia seated up to 30 passengers and was designed to serve longer routes with higher passenger loads in the then growing regional aircraft market. Over 350 EMB 120s were operated by 26 airlines in 14 countries.

Starting in 1979, Embraer developed the EMB 312 Tucano, a low-wing, tandem-seat turboprop trainer aircraft that combined equivalent performance to a jet trainer with lower operating costs. The prototype made its maiden flight in 1980, and the first initial production T-27 aircraft were delivered to the Brazilian Air Force in 1983.

During the 1980s, Embraer formed partnerships with Italian companies, Aeritália (today Alenia) and Macchi (today Aermacchi) to develop the AMX fighter-bomber for the Brazilian Air Force.

Embraer developed the ERJ regional jet with a family of three models, which seat up to 37, 44 and 50 passengers, respectively. The first model, the ERJ 145, was certified in 1996.

Embraer expanded its jet product line with the development of the Embraer E-jet family with capacity to seat between 70 and 118 passengers. The Embraer 170 and Embraer 190 were designed to serve the market's trend toward larger, higher volume and longer-range jets.

The first member of the family, the Embraer 170, was certified in February 2004, and its derivatives, the Embraer 175, and the Embraer 190, were certified in December 2004 and August 2005, respectively. Certification of the Embraer 195 was granted in June 2006.

In June 2013, Embraer launched a family of second generation of E-Jets, the E175-E2, E190-E2 and E195-E2. The E190-E2 and the E195-E2 entered service in April of 2018 and September of 2019, respectively.

Embraer Services and Support

On December 20, 2016, Embraer announced the creation of Embraer Services and Support, a business unit focused on services and customer support, combining capabilities that were previously allocated to each business area. Embraer Services and Support is responsible for support of current and new products and services, as well managing the associated processes and resources. The strategic objective is to enable Embraer to gain greater operational efficiency and recurring revenues.

During 2019, Embraer and Israeli company ELTA Systems formalised a strategic cooperation agreement to develop and sell a comprehensive airborne early warning, or AEW, aircraft based on the Praetor 600 super-mid-size executive jet. This missionized aircraft is designed to provide extended coverage and situational picture for air surveillance, air defence, and homeland security missions enabling monitoring of aerial activity outside ground-based radar detection coverage.

In December 2019, Embraer and the Brazilian Air Force signed a Memorandum of Understanding formalising the intent to develop a small aircraft for cargo, personnel, and troop transportation.

Embraer's investment in innovative technologies, such as automated design tools, has increased its operational efficiency by reducing engineering

BELOW • ***Embraer's E190-E2 in the company's corporate colour scheme.***
EMBRAER S.A.







ABOVE • ***The C-390 Millennium is a multi-role transport aircraft seen air dropping parachute bundles during a test flight.*** EMBRAER S.A.

LEFT • ***Brazilian Air Force C-95 Bandeirante 2132 on take-off in the early days of the programme.*** EMBRAER S.A.

and production costs, and customers' maintenance costs.

With respect to its range of commercial and business aircraft, Embraer has developed strategic relationships with key risk-sharing partners who develop and manufacture systems and components of the aircraft with their own funds, thereby reducing Embraer's development costs.

Embraer's partners also fund a proportion of Embraer's research and development cost with direct cash contributions or materials.

The strategic relationships enable Embraer to also improve its operating efficiency, enhance the quality of its products and reduce the number of suppliers, thereby providing flexibility in its production process, which in turn enables the company to respond to market demand.

Embraer Defence

Historically, development expenditure for defence aircraft has been funded in large part by customers, mainly governments. An example is the EMB 312 Tucano part-funded by the Brazilian Air Force. Those customers have had an important role in Embraer's engineering and industrial development.

In addition, the company uses proven civil aircraft types as baseline aircraft for certain defence products such as the Brazilian Air Force R-99 AEW&C which is based on the ERJ 145 regional jet.

Today, Embraer's defence portfolio comprises two main products, the EMB 314 Super Tucano and the EMB 390 C-390 Millennium. The Super Tucano, equipped with a high precision weapons delivery system is the only combat proven light attack aircraft currently in production. The C-390 Millennium is a medium-size, twin jet transport aircraft capable of cargo, troop, aerial refuelling, and firefighting roles.

Commercial Aviation

To gain insight into Embraer's commercial aircraft division, the author spoke with Rodrigo Silva E Souza, vice president marketing Embraer Commercial Aviation about current operations.

Discussing lasting effects of the COVID-19 pandemic, Souza explained that Embraer is reviewing its supply chain strategy and bringing its operations closer to Sao Paulo so greater control can be maintained.

BELOW • ***A sign at an entrance to the São José dos Campos site reminded visitors that the Bandeirante was made at the site. It reads 'The Bandeirante is made here'.*** EMBRAER S.A.





He said: “We are also encouraging working from home and allowing people to move from the big cities to regional smaller cities and therefore fragment the market. And we are assisting airlines to rethink their fleet strategy to opt for smaller gauge aircraft to deal with lower levels of passenger demand, a more fragmented market, strengthened domestic air travel markets as opposed to international air travel markets caused by the reallocation of the supply chain.”

In terms of product design Souza outlined Embraer’s use of virtual tools to accelerate the development of an aircraft especially multi-disciplinary optimisation which involves running thousands of different iterations of design concepts. “These are narrowed down to just a few to make sure we have the most optimised aircraft based on parameters for wing design, structure, loading, and performance as examples, until we reach the final design concept.”

In production since 2002, Embraer set stringent parts reliability criteria for its original E-Jets and required suppliers to test their parts to ensure requirements’ compliance.

On the E2, Embraer went one step further as Souza explained: “Requirements were more stringent, parts had to be tested until failure with full failure mode disclosure. In some cases, Embraer asked the supplier to reinforce a particular part to counter the mode of failure. This is an effective means of ensuring the highest reliability aircraft in the market. Our own testing is conducted in house using item boards, test rigs, and engineering simulators.”

Assembly of both E1 and E2 aircraft is conducted on the same line at São José dos Campos which has capacity to produce 150 E-Jet aircraft per year. Embraer delivered 48 commercial aircraft and 93 executive jets during 2021. The 48 commercial aircraft comprised 27 E175s, two E190-E2s and 19 E195-E2s. Embraer began 2022 with a firm order backlog across all business units valued at US$17m, the highest since Q2 2018.

The backlog includes commercial aircraft firm orders from Nigerian carrier Overland Airways for three E175s, American Airlines for three E175s, and from Azorra for 20 E2 family aircraft, all of which were placed in Q4 2021.

ABOVE • ***The super-mid-size Praetor 600 executive jet oozes elegance.*** EMBRAER S.A.

BELOW • ***The Brazilian Air Force operates more than 60 A-29 Super Tucano light attack aircraft. Embraer has built over 250 A-29s for 15 different air arms around the world.*** EMBRAER S.A.



Current Operations

As of today, engineers make up approximately 20% of Embraer’s workforce. Due to the high level of knowledge and skill of their employees, and continuous training and incentive programmes, Embraer can efficiently pursue new programmes and provide its customers with technical expertise and guidance.

Embraer has grown from a government-controlled company, established to develop and produce aircraft for the Brazilian Air Force, into a publicly held company (privatised in 1994) that produces aircraft for commercial and executive aviation and for defence and security purposes and related services.

Based on the number of aircraft delivered, Embraer is the leading manufacturer of jets with up to 150 seats. Around 180 airlines from over 90 countries fly Embraer commercial aircraft on five continents. Embraer’s customers include some of the largest and most significant network, regional, and low-cost carriers in the world.

Currently there are over 2,300 Embraer commercial aircraft, over 1,600 executive jets, and more than 620 defence aircraft, in operation. ●

Bandeirante: Embraer's First

The Bandeirante turboprop aircraft, as João Paulo Moralez relates, helped establish Embraer, which is now the third largest aircraft manufacturer in the world.

In the 1960s, Brazil's major airlines were gradually replacing their piston-engined aircraft with more comfortable, faster, and internally quieter pressurised jet aircraft. The Sud Aviation SE 210 Caravelle, Douglas DC-8 and Boeing 707, among others, became the bywords of progress, technology, and modernity, but the operation of these jets was complex.

They required longer, paved runways and aviation jet fuel, for example. In addition, their cost of operation was much higher compared to piston aircraft. Notably, the cities that did not have the required infrastructure or the volume of passengers to make the jet economically viable were gradually abandoned. In the 1950s around 350 out of more than 5,500 Brazilian centres of population had regular air connections. A few years later that number had been reduced to 250 and by 1975 to about 90.

The same development could be observed in the United States; large hubs and urban centres created a heavy demand for passenger jet flights, while smaller cities began to suffer from a scarcity of air connections.

In addition to the lack of an aircraft that could serve the smaller routes, in Brazil some commercial aviation accidents demonstrated the need for more modern and reliable models. The Força Aérea Brasileira (FAB/Brazilian Air Force), in turn, had another requirement: to replace the already obsolete and unreliable, twin radial-engine Beech 18.

ABOVE • ***The Cook Islands airline, Air Rarotonga was one of the last remaining civil Bandeirante operators. The type provided passenger service and charter flights to the smaller islands of the South Pacific nation.*** AIRTEAMIMAGES.COM/ROLF JONSEN

RIGHT • ***The historic first take-off of Embraer's first aircraft, the YC-95, on October 22, 1968. Note the three round windows and short fuselage of the prototype Bandeirante.*** KEY COLLECTION

Embraer's Beginning

São José dos Campos, then a small town about 62 miles from the state capital of São Paulo, was home to the Departamento de Aeronaves do Instituto de Pesquisa e Desenvolvimento (PAR/IPD or Aircraft Department of the Institute of Research and Development of the Aeronautics Technical Center), which today is the well-known Department of Science and Aerospace Technology (DCTA).

Aircraft

PAR/IPD had the primary mission of designing and producing aircraft that would meet the needs of Brazil. At the time, in the mid-1960s, the country was governed by the military and the Department of Civil Aviation (DAC) was subordinate to the air staff of the Brazilian Air Force.

Until then, the national aviation industry had made successive attempts to become established, but with very limited success. Many initiatives emerged, but few could sustain themselves over the years, mainly due to a lack of long-term orders, as the market was often restricted to purchases made by the air force. Thus, companies went through crises and then ceased operations.





By the time the first production C-95 rolled out in August 1972, the design had undergone considerable revision, with a stretched fuselage and a change to square windows. KEY COLLECTION

BELOW • ***C-95s and maritime patrol examples remain in service with the Brazilian Air Force in the light transport role and are sometimes used to drop supplies.*** JOÃO PAULO MORALEZ

But in 1965, things were different. Apparently, there was a desire to do something with government support to meet the need for civil and military aviation. It would be a dual solution.

To design a twin-engine aircraft to satisfy the requirements of the air force and smaller city airports. However, to get the aircraft into serial production, it was necessary to add an individual with more experience to the team.

This person came from France in March, 1965. His name was Max Holste, an aircraft designer and builder who had left his country after selling his company to the government. He went to Morocco to try to establish an aviation industry there following an invitation from the King, but nothing came of the venture.

Late Night Meeting

One night around 9.00pm the phone rang at the house of then director of PAR/IPD, Ozires Silva. José Carlos de Barros Neiva, owner of the light aircraft manufacturer Neiva, was offering a meeting with Holste. The meeting had to take place at that moment, because the Frenchman was leaving the next morning. So around 11.00pm the meeting took place, with aircraft designer Joseph Kovács also in attendance. It was agreed that Holste, the father of the single-engine Broussard and twin-engine Broussard Major, would assist in the development of a twin-engine turboprop aircraft, capable of carrying nine to 12 passengers plus two pilots. Maximum take-off weight would be 9,920lb with a useable load of 1,984lb, 1,000nm range, a maximum speed of 280mph and 1,735ft landing distance. The proposed aircraft would have an unpressurised cabin, a



tricycle landing gear and be powered by two 550shp Pratt & Whitney PT6A-20 engines.

Named IPD-6504 (the fourth project of 1965), its development was approved on June 26 that year. More than 100 technicians began working on the drawings following Holste's instructions at the X-10 hangar of São José dos Campos airport.

Brazilian Guido Fontegalant Pessotti was one of them. Coming from the Technological Institute of Aeronautics, he became a project manager and later became Embraer's technical director.

Over a three-year and four-month period, 110,000 hours were spent preparing more than 12,000 manufacturing drawings. Another 22,000 hours were invested in structural calculations and 282,000 hours to build tooling, three flight prototypes, and one for structural testing. The aircraft was designated the YC-95.

Bandeirante Takes Flight

The name Bandeirante was chosen after the pioneers, departing from São Paulo state, who from the 16th century were responsible for the integration of the Brazilian territory.

On October 22, 1968, following taxi tests, YC-95 Bandeirante FAB 2130, in the colours of the Brazilian Air Force, made the type's maiden flight flown by test pilot Major José Mariotto Ferreira and flight test engineer Michel Cury.

While the Bandeirante aircraft was born from the efforts of the PAR/IPD teams, with the help of other FAB units and civil companies, a movement began to create a company that could launch series production. Through Decree Law No. 770 of August 19, 1969, the mixed-capital firm Embraer was created, where the air force kept the leadership and control of 51% and the remainder was private capital.

The first prototype had space for six passengers and two pilots, but changes were subsequently made and YC-95 FAB 2131, also sporting the colours of the Brazilian Air Force, could accommodate nine passengers (all three prototypes had a length of 41ft 10in). FAB 2131 flew for the first time on October 19, 1969, around the same time that Max Holste left Embraer and moved to Uruguay.

Featuring a longer fuselage with capacity to carry 12 people, the third prototype, PP-ZCN, flew for the first time on June 29, 1969. During its assembly, the Brazilian Commission for Space Activities consulted Embraer about the feasibility of acquiring the first prototype for use in the remote sensing mission. To house the sensors needed for this role, a hole was cut in the aircraft floor and other internal changes were made to accommodate cameras. The aircraft served in the remote sensing mission for almost a decade. In the early 1970s, Embraer designated the YC-95 as the EMB-100.

In May 1970, the Brazilian Air Force signed a purchase agreement for 56 C-95 Bandeirante aircraft configured to the VIP transportation role and four EC-95s for airport radar and sensor calibration. Before production started, Embraer made further improvements to the aircraft.



LEFT• ***In the early 1980s, Air UK flew six Bandeirantes, including EMB-110P2, G-BGYS, on commuter services.***
BOB O'BRIEN COLLECTION

BELOW • ***In the early 1980s, Air UK flew six Bandeirantes, including EMB-110P2, G-BGYS, on commuter services.***
BOB O'BRIEN COLLECTION



The windshield design, a trademark of Max Holste, was remodelled, the landing gear was now fully enclosed in the engine fairing, the fuselage was lengthened by a metre to accommodate 12 passengers and the round windows gave way to square ones. The engine adopted was the 680shp Pratt & Whitney PT6A-27. In this form, designated the EMB-110, Embraer projected a production rate of two aircraft per month.

In August 1972, the first production C-95, FAB 2132, left the assembly lines, and in December of that year, Embraer obtained certification from the Centro Técnico Aeroespacial (CTA).

One Aircraft, Multiple Missions

Transbrasil became the Bandeirante's first civil customer when it placed an order for six EMB-110Cs (C for commercial) in January 1973. Transbrasil's aircraft could carry 15 passengers, four of which were seated on a side sofa. All Bandeirantes were fitted with a toilet. VASP was the second civilian customer with ten aircraft, but the major boost to its commercial success came on November 11, 1975, when the Brazilian government created the Brazilian Integrated System of Regional Air Transportation. The country was divided into five regions, for which five newly created regional airlines received a concession to operate air services. The objective was to promote routes to locations that were economically deprived, but which needed air links. In addition to subsidies, the federal government opened a 95% financing line for the Bandeirante to encourage its sale to airlines.

There were several variants of the Bandeirante. The EMB-110E was dedicated to executive transport flights with up to eight seats including four armchairs and a sofa, a typewriter, executive desk, bar, and AM-FM radio. Similar was the EMB-110J, which had a steward's seat, five armchairs and the sofa for a total of eight passengers.

The EMB-110F had a floor reinforced with special fixing hooks for cargo, while the EMB-110K1 had a rear side door on the left side, 5ft 10in high and 4ft 3in wide that allowed the shipment of bulkier loads, in addition to the reinforced floor. The fuselage was lengthened again to 47ft 10in, this being standard for all subsequent versions except the EMB-111. There was also the EMB-110P, with a new row of seats added on the right side, increasing the capacity from 12 to 18 passengers and more luggage space.

Based on studies by American transportation company FedEx for the acquisition of a new aircraft undertaken, which evaluated the Bandeirante as a possible solution, Embraer developed three other variants: the EMB-110K1, EMB-110P1 and EMB-110P2.

The EMB-110K1 received a crew access door on the left side just behind the cockpit. Both the K and P1 variants had a more powerful engine, the 750shp PT6A-34. The EMB-110P1 could carry freight loads or up to 20 passengers and the passenger-only EMB-110P2 had up to 21 seats, a galley, and a cabin crew seat. Although the FedEx deal was not completed, both the P1 and P2 were eventually certified in the United States. They led to further sub-variants: the EMB-110P1A, which had a 10° dihedral in the horizontal stabilisers, improving aerodynamics; and the EMB-110P1 SAR, which could carry six stretchers and was able to drop parachutists to aid rescue.

The EMB-110B was modified for aerial photography with an aft fitting that allowed the installation of vertical cameras. The EMB-110 B1 could be converted into an eight-seat VIP transport aircraft with a galley.

Patrol Versions

Finally, the maritime patrol variant called the Bandeirante Patrulha, often shortened to Bandeirulha, was developed. Designated EMB-111, it had a length of 47ft 2in and received







THIS PAGE MIDDLE • ***Muk Air Taxi had a mixed fleet that included four EMB-110P2s. The Danish operator went out of business in 2001.*** KEY COLLECTION

BOTTOM LEFT • ***Former Dolphin Airlines EMB-110P1, N61DA, ended up with California's WestAir Commuter Airlines, flying as part of the United Express system.*** BOB O'BRIEN COLLECTION

BOTTOM RIGHT • ***Eagle Air operated 13 Bandeirantes under the Air New Zealand Link branding. From Wellington, where ZK-TRM was photographed, the 'Bandits' replaced F27 Friendships on service to regional destinations such as Nelson, Blenheim and Gisborne.*** BOB O'BRIEN COLLECTION



wingtip tanks of 84 US gal, plus four weapons pylons, an APS-128 Super Searcher radar, Litton LN-33 inertial navigation system, Bendix M4-D autopilot, APX-92 IFF plus a Thomson-CSF electronic countermeasure systems. It has a crew of seven, plus space for a reserve crew member. It could carry a high intensity aircraft searchlight rated at 50 million candelas and, for communication with ships, a 1,400-watt speaker system installed close to the door. It had a ten-hour endurance and the capability to launch smoke markers, dyes or radio transmitters for pinpointing targets or survivors. The maiden flight of the patrol version was on August 1, 1977.

The second generation of the Bandeirante patrol version appeared in 1986 featuring the Thomson-CSF DR 2000A Mk II/Dalia 1000A Mk II electronic warfare system, APS-65 autopilot, Omega Canadian Marconi CMA 771 Mk III navigation system and a forward-looking infrared imaging system.

Exports

The Bandeirante's first military export was to the Uruguayan Air Force, which bought four EMB-110 VIP versions and one for photogrammetry on August 7, 1975. The Chilean Air Force bought three EMB-110s and six EMB-111s, while the air force of Gabon purchased an EMB-110 and an EMB-111.

In 1977, the French company Air Littoral also opted for the EMB-110P2, which was exhibited that year at the Paris-Le Bourget Airshow. On December 21, 1977, the aircraft was certified by the French Direction Générale de L'Aviation Civile (DGAC). On August 15 the following year the UK Civil Aviation Authority gave approval and, three days later, it was certified by the US Federal Aviation Administration (FAA).

The Bandeirante, or Bandit as it was nicknamed, did achieve civilian export sales but often in small quantities. In the United States it was initially sold to Aero Commuter which bought three EMB-110P1s. With FAA approval and entry into the US market, the Bandeirante's sales began to grow worldwide. Another 12 operators placed orders with Embraer and more than 30 aircraft of the EMB-110P1 and EMB-110P2 versions were delivered.

By 1984, Bandeirante aircraft were operated in 26 countries but in late 1991 production was ended. In all, 498 aircraft of all variants were produced, and three prototypes. Of this total, 253 served the domestic market, 156 were supplied to the Brazilian Air Force and the remaining 245 were exported to other nations.

In 2008, after evaluating options to replace its C-95 Bandeirante fleet, the Brazilian Air Force opted to modernise its aircraft by extending the service life by 20,000 hours or 30 years. Fifty aircraft, 42 transports and eight P-95 maritime patrol variants, went through the modernisation process which included extensive structural overhaul. In terms of avionics, they received new weather radar, autopilot, a new hydraulic system, emergency batteries, a directional altitude reference system, ADF receivers, new VHF/HF radios, and a cockpit voice recorder and transponder. The cockpit was updated with four multifunctional colour LCD screens, all compatible with night vision goggles. The first upgraded example made its inaugural flight on December 8, 2011, and the last one was delivered in 2015.

The FAB's maritime patrol examples were upgraded with the Leonardo Seaspray 5000E radar and new navigation system. Among its operational modes, the sensor can perform air surveillance and terrain mapping, and the navigation system offers greater accuracy, which is crucial for an aircraft that flies over the sea without visual references.

Despite its age, the Bandeirante remains a useful asset, especially in situations that require short field operations and require little or no infrastructure. ●

ABOVE • ***In the mid-1980s, Aberdeen-based Air Ecosse had a fleet of eight Bandeirantes. Several of these, including G-DATA, transported packages on the Royal Mail Datapost contract.*** BOB O'BRIEN COLLECTION



ABOVE • ***Fitted with a Racal Super Searcher radar, the EMB-111A(EM) or P-95B is a patrol version called the 'Bandeirante Patrulha' or 'Bandeirulha' for short. FAB 7108 was named Socó.*** KEY COLLECTION

Xingu

Mark Ayton provides an overview of the Embraer EMB-121 Xingu twin turboprop.

Armée de l'Air Xingu 086/YI and Aéronavale example 87 during a check flight from Sao José dos Campos. ALL IMAGES EMBRAER S.A.



Embraer's EMB-121 Xingu was initially developed in the mid-1970s as a business aircraft, but it was mainly used for military missions.

The Model 121 takes its name from an indigenous Brazilian tribe and a river that has its source in Mato Grasso and flows through the Amazon.

The Xingu's design is based on the Embraer EMB-110 Bandeirante including the same wing and engine nacelle designs. However, major differences to the Bandeirante are the use of more powerful engines, a longer fuselage, the tail shape, greater fuel efficiency and the ability to land and take-off from short runways.

Configured with a T-shaped tail, the horizontal stabiliser is positioned at the top of the vertical stabiliser, thus generating a faster and smoother airflow over the elevators to ensure the propeller flow misses the horizontal stabiliser, which in turn reduces noise and vibration. It was designed for executive transport with a cruise altitude of 28,000ft thanks to its pressurised cabin, which houses up to eight passengers.



ABOVE • ***The analogue flight deck of an EMB-121A Xingu was deemed an advanced system in the late-1970s.***

BELOW LEFT • ***Embraer's EMB-121 Xingu prototype PP-ZCT on an early test flight.***

BELOW RIGHT • ***EMB-121 Xingu PP-MBR was the 49th aircraft built.***



The first Xingu prototype made its maiden flight on October 22, 1976, with the cabin unpressurised. By flying the prototype with its cabin unpressurised, Embraer was able to conduct sufficient test flights before the Xingu was deemed ready for its official presentation of the type on December 4. Then, in May 1977 the cabin was pressurised, and the Xingu became the first pressurised aircraft type designed and built in Brazil.

The Xingu's first customer was the Força Aérea Brasileira (Brazilian Air Force or FAB), which selected and ordered six examples of the twin-turboprop to operate with the Grupo de Transporte Especial (Special Transport Group or GTE), based at Brasilia.

The aircraft was certified in 1979.

In September 1981, a modified version, the EMB-121A1 Xingu II, was introduced with more powerful Pratt & Whitney Canada PT6A-42 engines, more seats and greater fuel capacity to increase range.

French Military Operations

When production ended in August 1987, Embraer had built 106 Xingu aircraft: 86 PT6A-28-powered EMB-121A models and 20 PT6A-135-powered EMB-121A1 models. Half of the production run were exported to foreign customers, including 43 for the French Ministère de la Défense: 25 for the Armée de l'Air and 18 for the Aéronavale, including two EMB-121A1 Xingu II aircraft distinguished by their four-bladed propellers. The Xingu II entered Aéronavale service in 1990 and retired in October 2006.

EMB-121 Xingu aircraft started arriving in France during March 1982 following contract signature



on January 16, 1981. The ferry flights from Embraer's Sao José dos Campos facility took 27 hours with stops at San Fernando Island, Las Palmas and Seville. During 1982, the Xingu underwent a collaborative operational test programme between the Aéronavale's CEPA at BAN Fréjus-Saint-Raphaël and the Armée de l'Air's Center d'Expérimentations Aériennes Militaires (Military Air Test Centre or CEAM) at BA118 Mont-de-Marsan.

The French Aéronavale continues to operate a few Xingu aircraft assigned to two squadrons based at BAN Lann-Bihoué near Lorient in western France. The aircraft are used for a variety of roles that include liaison, anti-drug trafficking, firing range monitoring, fishery protection, anti-human trafficking, maritime surveillance, maritime pollution monitoring, radar calibration, target towing, transport, and assisting civilian ships in distress.

The Xingu has consistently performed well on the mission taskings assigned by the French Naval Command. Its range and speed combined with its ability to carry five passengers and their luggage makes its highly suitable for the routes flown around the European theatre.

Since the type entered service with the French Armée de l'Air, it has served just one primary role as a multi-engine trainer aircraft. Xingu aircraft started to replace the then antiquated MD 312 Flamant in 1983.

Assigned to the École de L'Aviation de Transport 319 (Transport Aviation School or EAT 319) 'Capitaine Jean Dartigues' based at Base Aerienne 702 Avord, the school trains student pilots to fly transport aircraft using the Embraer EMB-121 Xingu.

The first Xingu touched down at BA702 Avord on March 29, 1983, and the first student pilots graduated from the Xingu course in 1984.

Since September 1997, EAT 319 has trained French Naval pilots after the disestablishment of the Aéronavale's own multi-engine specialisation school which trained pilots for twin-engine aircraft in service such as the Atlantic, Atlantique and the Nord 262. EAT 319 was officially named 'Capitaine Jean Dartigues' on February 2, 2001.

EAT 319 runs a 40-week course comprising eight weeks devoted to ground instruction covering the EMB 121 and simulators followed by 32 weeks devoted to pilot training. This second stage comprises 125 hours of flying and 78 hours in a simulator.



ABOVE • ***Members of the EMB-121 programme team pose for cameras by the first aircraft to roll-out from Embraer's facility at Sao José dos Campos in 1976.***

The Xingu is perhaps an unusual choice for a training aircraft since its compact configuration generates noticeable aerodynamic characteristics which can be challenging for a new student pilot to handle.

Upon graduation, Armée de l'Air pilots are posted direct to a transport squadron for type conversion and their MN counterparts are sent to the service's own training centre at Lann-Bihoué in Lorient to complete a naval-specific phase of training.

Since the first class of pilots graduated in 1984, the Xingu has flown more than 380,000 hours with EAT 319 which still has 30 aircraft assigned. During that time, the Xingu aircraft has been flown by more than 2,250 cadets from Belgium, Burkina Faso, Cameroon, France, Gabon, Luxembourg, and Madagascar.

In 2012, the Armée de l'Air launched an avionics modernisation programme to extend the operational service life of its Xingu aircraft through until 2025.

Undertaken by EADS Socata, the modernisation programme included installation of two 10in primary flight displays and two multi-function displays. The latter display all flight information required by the pilots

BELOW • ***EMB-121 Xingu prototype PP-ZXI in a test facility at Sao José dos Campos.***



EMB-121A1 Xingu Characteristics

Length	40ft 2in (12.24m)
Wingspan	46ft 1in (14.05m)
Height	15ft 11in (4.85m)
Wing area	296ft^2 (27.49m^2)
Aspect ratio	7.18
Empty weight	8,179lb (3,710kg)
Max take-off weight	12,500lb (5,670kg)
Fuel capacity	2,884lb (1,308kg)
Max speed	252kts (466km/h)
Cruise speed	205kts at 10,000ft (380km/h at 3,000m)
Range	660nm at 20,000ft (1,222km at 6,096m)
Service ceiling	28,000ft (8,534m)
Powerplant	Two Pratt & Whitney Canada PT6A-135 turboprop engines each rated at 750hp



ABOVE • ***EMB-121 Xingu prototype PP-ZXI out on the field at Sao José dos Campos.***

and provide improved situational awareness designed to reduce pilot workload. Other navigation and communication systems fitted, all supplied by Garmin are a SL30 comms system, a GNS430 nav system, and a GTX330 Mode-S transponder.

Embraer Defence & Security in cooperation with Daher-Socata of France, with Airbus Defence & Space as maintenance provider, continue to support the French military Xingu fleets - a service the company has provided for 38 years. ●

BELOW • ***Embraer assembly workers pose for the camera with the fuselage of the 100th EMB-121 Xingu.***



18+

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Against All Odds

Bernie Baldwin charts the ERJ145's fascinating history and examines how it revived the Brazilian manufacturer.

When the Embraer EMB-145 first took to the air in August 1995, the regional jet era entered a captivating new phase which completely changed the fortunes of the Brazilian firm and the wider industry. There would most likely be no E-Jets had it not been for the success of the family that later became known – and is hereon referred to – as the Embraer Regional Jet (ERJ).

Having worked its way up in commercial aircraft size from the 18-seat EMB-110 Bandeirante to the 30-seat EMB-120 Brasilia, in 1989 Embraer decided that its next move should be from turboprop to turbofan. The company had already seen Bombardier announce its plans to extend the airframe of the Challenger business jet to create a 50-seat aircraft, the Canadair Regional Jet (CRJ). Here was a market in which Embraer saw considerable opportunities.

The Brazilian company realised that it too could create a product by adapting an existing type. It opted for the same fuselage cross-section

ABOVE • ***Régional has operated 21 examples of the ERJ145 and two ERJ135s on behalf of Air France Hop. This example, F-HRGD (msn 145369), was briefly leased from Regourd Aviation.*** AIRTEAMIMAGES/MATTHIEU DOUHAIRE



as the Brasilia, with the tube being extended to be able to offer 50 seats in a three-abreast configuration. This decision also gave Embraer good reason to think that it could compete strongly with the CRJ. It was felt that because the ERJ was adapted from a commercial aircraft, built for many rotations, its structure was better optimised for the new role.

Several configurations were considered for the ERJ family, ranging from engines under the wings, on top of the wings or mounted on the rear fuselage. Eventually, having chosen the AE3007 engine from Indianapolis-based Allison Engines (subsequently bought by Rolls-Royce) to power the aircraft, the rear-fuselage mounting was deemed the optimum location.

Paris Debut

While the programme received its official launch at the 1989 Paris Air Show, things did not run smoothly, as evidenced by the fact that it took another six years for the first prototype to achieve its maiden flight. During the early 1990s, Embraer suffered severe monetary problems, many of which were caused by the cancellation of military contracts, but others stemmed from a global recession causing a significant downturn in commercial aircraft orders. Sales of the EMB-120 Brasilia were seriously affected.

Concurrently, a joint venture project with Argentina's Fábrica Militar de Aviones (now Fábrica Argentina de Aviones, FAA) for the CBA 123 Vector – a pusher-prop intended to replace the Bandeirante which incorporated many new technologies – drained significant amounts of cash, but never made it to full production. Two prototype aircraft were built, one of which featured in the flying display at the Farnborough Airshow in 1990. By the time the plug was pulled on the project, it had run up losses of around US$280m.

While the termination of the project was a major blow, not everything from the Vector development effort was lost. Many production techniques and the engineering knowhow developed for the CBA 123 went on to be used in the ERJ145 programme. To ensure that the ERJ could continue, some out-of-the-box thinking in the financing of the project was needed. An initiative was thus proposed for the programme's financing, particularly as the company was already considering a second, smaller family member in what later became the ERJ135.

The lack of its own resources and the impossibility of counting on investments from the Brazilian government (its main shareholder at that time) led Embraer to conceive and implement – under the leadership of the then programme director, Satoshi Yokota – an ingenious industrial architecture based on so-called risk-sharing partnerships. In this process, the companies that supplied aerospace segments and equipment in the programme paid for their investment in engineering and production, betting on the programme success. In return for taking the financial risk, each supplier would receive greater rewards from each sale.

ABOVE • ***The prototype ERJ145 in production at the manufacturer's São José dos Campos facility.***
KEY COLLECTION

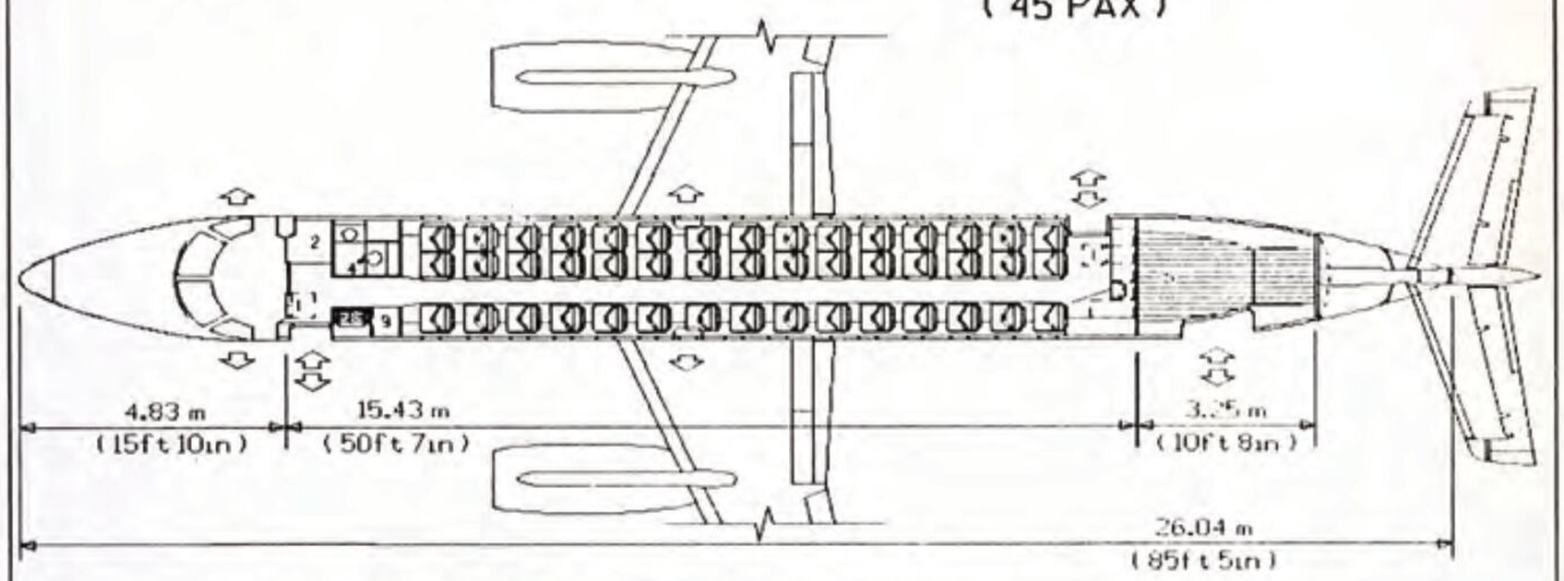
RIGHT • ***An early Embraer document showing the planned interior layout of the ERJ145. Note the engines are shown mounted under the wing.***
KEY COLLECTION

EMBRAER

EMB145

INTERIOR ARRANGEMENT

(45 PAX)



1 - STEWARDESS SEAT
2 - CARRY ON BAGGAGE - 0.9 m^3 (31.8 cu ft) / 160 kg (352 lb)
3 - GALLEY - 2.0 m^3 (71 cu ft) / CATERING - 251 kg (552 lb)
4 - TOILET
5 - BAGGAGE COMPARTMENT - 8.9 m^3 (315 cu ft) / 1000 kg (2202 lb)
6 - OVERHEAD BIN - 1.4 m^3 (49 cu ft) / 271 kg (600 lb)
7 - UNDERSEAT VOLUME - 2.0 m^3 (71 cu ft) / 405 kg (893 lb)
8 - AIRSTAIR STOWED
9 - ELECTRONIC RACK

Suppliers chosen were: Gamesa from Spain to manufacture the wings; Sonaca from Belgium, responsible for the two fuselage sections; ENAER from Chile to produce the tail; and C&D Aerospace from the United States in charge of the interior. This choice of contractors was based on careful evaluations that considered a variety of technical, commercial, and financial aspects.

In addition to sharing the risk and investing in the development of its own infrastructure for the manufacture of aircraft parts, the existence of suppliers in several countries was perceived as a strategy to reduce potential barriers related to the export of ERJ aircraft to each partner's country of origin. Among the other partners for the ERJ programme were Liebherr Group, Honeywell, Hamilton Standard and Goodrich (both now part of Collins Aerospace a Raytheon subsidiary) and Allison Engines (as noted, subsequently part of Rolls-Royce).

Farnborough Breakthrough

At the time of the first flight on August 11, 1995, the programme was already on the back foot. It did not have a vast number of orders and Bombardier's CRJ had been in service since November 1992. However, between the start of the flight test programme and the first delivery, a major change in the programme's fortune occurred. In September 1996, Embraer took a flight test aircraft to the Farnborough Airshow along with an order which caused a certain stir, initially among reporters who attended the press conference and then around the halls and hospitality chalets as the news spread across the site.

At that media briefing, Embraer and Continental Express, the regional airline subsidiary of Continental Airlines, announced an order for the airline to purchase 25 ERJ145s. Not such an unusual deal, one might think. But attached to those orders were options for a further 175 of the type. Reactions were mixed, somewhere between astonishment and bemusement.

At the time, David Siegel was the president and chief executive of Continental Express and he told those assembled that he was confident plans for all 200 aircraft would succeed. He picked up the story: "We were clear with the marketplace that we intended to take all 200. I waved my passport to the audience, showing off my five-year visa which I said I needed as I'd be going down to Brazil every month to take deliveries.

"During the negotiations, we showed our business plan for 200+ regional jets but explained that Continental's board needed flexibility with the financial markets not to look too aggressive and that Embraer had to trust in us and believe in us and agree to the highly unusual option structure. I even made a personal bet with Satoshi [Yokota] that if we took at least 100 aircraft that he'd have to quit smoking. We used to joke about that later."

As history records, every option in the deal was subsequently converted into a firm order and indeed all 200 ERJs were delivered to the airline. The first of those deliveries came on December 27, 1996 and made Continental Express the launch operator.

With that landmark deal, other orders followed. The United States proved to be fertile ground, strongly influenced by the fallout from the crash due to severe icing of an ATR 72-212 near Roselawn,





BELOW • ***Chautauqua Airlines, a Republic Airways Holdings subsidiary, and Delta Connection partner, was a major customer for the ERJ programme. It operated 105 examples of the type, equating to almost 10% of the entire production run.*** KEY COLLECTION

BOTTOM • ***Embraer ERJ135 and '145 demonstrators, PT-ZJA (msn 145001) and PT-ZJD (msn 145003), in formation during a photoshoot.*** KEY COLLECTION





ABOVE • ***Luxair used a dozen examples of the ERJ145 on inter-European links between 1998 and 2016.*** KEY COLLECTION

LEFT • ***This ERJ135, PT-SUC (msn 145431), was initially used by Embraer as a demonstrator. It was delivered to Irish regional carrier JetMagic in 2003, before working for Sweden's City Airline, BMI Regional, Flybmi. The 37-seater joined the Loganair fleet in March 2019 as G-SAJR.*** KEY COLLECTION

BELOW • ***Examples of the ERJ145 were produced by Harbin Aircraft Industries Group under licence between 2003 and 2016.*** VIA AUTHOR



Indiana, in October 1994. That incident created an anti-turboprop perception among the flying public for many years. Although regional jets were already making inroads in the United States, the market now succumbed to the 'RJ-mania' phenomenon.

Among the other US regional airlines to select the ERJ145 over the CRJ100/CRJ200 in the 1990s was American Eagle (in the days when it was what is now Envoy Air, rather than just the brand for all American Airlines' regional flying), Trans States Airlines and Chautauqua Airlines. So strong were the orders and deliveries after entry into service that, by 1997, the ERJ145 was responsible for around 60% of Embraer's total revenues. More importantly, just one year later, revenue from the programme helped the company to a profit. All in all, it seemed to be a good time to add another model.

Enter the ERJ135

The second family member, the ERJ135, was rolled out of the production line on May 12, 1998. With 37 seats, the aircraft competed with well-established turboprops such as the Saab 340, De Havilland Canada Dash 8-100, Dash 8-200, and Dornier 328 (though Dornier did later respond by making the Fairchild Dornier 328JET). It also gave the US regional airlines and their major partners another tool to strengthen hub-and-spoke operations, enabling the regionals to optimise capacity. Both models, of course, could also offer hub-bypass services where appropriate.

The ERJ135 made its first flight on July 4, 1998, and was certified by Brazil's CTA, the US Federal Aviation Administration and EASA's predecessor, the European Joint Aviation Authorities, in 1999. Entry into service was once again in the US market, this time with both Continental Express and American Eagle beginning operations later in July 1999.

With the plethora of regional jets entering the US market, scope clauses – the agreements between major airlines and their pilot unions which determine how many aircraft of a particular capacity a regional airline may operate for its major partner – were increasing in importance.

They were also becoming ever more restrictive, with limits on the number of 50-seaters which could be operated under capacity-purchase agreements.





















ABOVE • ***Embraer employees celebrated production milestones by posing with every hundredth aircraft.***
VIA AUTHOR

Manufacturers seeking to offer more aircraft into this lucrative market became creative with their models. Bombardier created the CRJ440, a version which would be certified for only 44 seats, although its structure was the same as the CRJ200. Embraer went a step further. In a September 1999 press conference at the European Regions Airline Association general assembly in Paris, the company launched the ERJ140 with then-CEO Maurício Botelho introducing the variant as the "scope buster". Unlike the CRJ440, the ERJ140 was structurally different from its fellow family members. With a change in fuselage, the ERJ140's overall length was 93ft 2in, sitting comfortably between the ERJ135's 86ft 3in and the ERJ145's 98ft 1in.

This relatively straightforward change in fuselage length meant the development time was shortened and the ERJ140 subsequently took to the air on June 27, 2000 – just over nine months after being announced. It entered revenue service in July 2001, this time with American Eagle.

By this time, ERJs could be found flying in many major air transport markets. While North America led the pack, South America saw carriers such as Brazil's own Rio Sul Serviços Aéreos Regionais operating the ERJ145. In Europe, British Regional Airlines (BRAL), France's Régional, Portugalia and renowned Swiss regional Crossair, all operated ERJ family aircraft.

Back in the United States, ExpressJet Airlines – which had been established in 1996 as the operating company for the ERJs, with Continental Express simply becoming the brand – extended its belief in the programme and asked Embraer if more range could be added to the ERJ145. Embraer responded with the ERJ145XR (extra-long range). Although the range with maximum passenger load was increased from 1,280nm for the ERJ145ER and to 1,675nm in the case of ERJ145LR, the largest buyer, Continental Express/ ExpressJet, wanted even greater range. This led to the development of the ERJ145XR, for which the carrier placed an initial firm order for 75 aircraft plus 100 purchase options in July 2000. To make it possible to reach the proposed 2,000nm for the ERJ145XR, Embraer not only increased fuel capacity again, but added winglets to the configuration and increased engine power at take-off and climb.

"The 145XR was the natural evolution for ExpressJet of the 145 family," recalled Siegel. "ExpressJet had excellent customer acceptance and financial results on the longer sectors and kept stretching the distance. Continental and Continental Express also had 59-seat scope clauses so a larger, longer-range 70+ seat regional jet was not an option. Accordingly, stretching the range was really the only alternative to access



additional market opportunities for Continental at the time."

The first prototype ERJ145XR took flight on June 29, 2001. The first delivery to ExpressJet came in October 2002, with the aircraft being put into service shortly after.

Eastern Expansion

While sales in the Asia-Pacific market had been a tougher task, a further milestone in 2002 greatly helped introduce the ERJ145 to the Chinese market. In early December that year, an agreement with China's Harbin Aircraft Industry Group and Hafei Aviation Industry Company (both part of China Aviation Industry Corp. II, AVIC II) was signed for an ERJ manufacturing facility in northern China. As part of this, a new joint venture organisation known as the Harbin Embraer Aircraft Industry Company (HEAI) was formed. Its first aircraft was rolled out in December 2006. China Southern Airlines, Wuhan Airlines and Sichuan Airlines all signed orders for the ERJ145.

According to Embraer, the establishment of the HEAI "was fundamental to solidify the co-operation between China and Brazil in high technology projects and to provide the backbone of the regional aviation system in China. The aircraft produced in Harbin have the same quality and standards of their siblings manufactured by Embraer in Brazil." When Embraer entered the co-operation, its own equity investment in the Joint Venture (JV) was US$25m. In total, the JV produced more than 40 ERJ145s plus six Legacy 650 jets (an executive version based on the ERJ135), before the partners confirmed the phase-out of the HEAI in 2016.

Over the ERJ family's lifetime, more than 100 commercial operators have flown at least one of the models. There have also been versions for other operations, too. Other variants include those built for military purposes such as airborne early warning, remote sensing, and maritime patrol. Fourteen military air arms from ten countries have used one or more of these special mission variants.

Since production of the family for airline use came to an end in 2020, there has been a buoyant market for used ERJs, which has led to them operating in even more countries around the world. But Embraer points to where movement in this secondary market is currently focused, saying that North America "remains as the centre of gravity."



ABOVE • ***BMI British Midland was one of two UK operators to acquire the type new from the manufacturer. Its aircraft were passed on to Flybmi when its parent company was acquired by International Consolidated Airlines Group and merged with British Airways in 2012.*** MARTIN NEEDHAM

RIGHT • ***Sichuan Airlines fielded a fleet of five Brazilian-built examples of the Rolls-Royce AE3007-powered jet. Other Chinese carriers, including Grand China Express, Tianjin Airlines and China Southern Airlines, all operated indigenously built examples.*** VIA AUTHOR

BELOW LEFT • ***Diexim Expresso used this former Air Caraïbes ERJ145, D2-FFW (msn 145360), on regional connections, as well as four Embraer EMB 120 Brasilias. The aircraft was last noted stored at Johannesburg/Lanseria.*** VIA AUTHOR

BELOW RIGHT • ***British Airways' regional subsidiaries operated 30 examples between June 1997 and the sale of BA Connect to Flybe in March 2007.*** RICHARD VANDERVOORD





ERJs have become an aircraft of choice for niche operators such as JSX (formerly JetSuiteX) and Contour Airlines which offer flights as public air charters.

As for used aircraft placements in other regions, in Europe, Scotland's Loganair has quietly grown to be a large ERJ operator. The airline took on some aircraft from bmi Regional, its former sister carrier in Airline Investments Limited (AIL), when the latter ceased trading. Those aircraft are now being put to greater use on routes previously flown by Flybe.

On Reflection

To conclude, it feels appropriate to return to David Siegel, the man who purchased more ERJs than anyone else, to assess the level of importance the type has in the annals of the US regional airline – the market where the three models had their biggest impact: "While the CRJ was the first mover, Embraer's superior product quality and cost was a true breakthrough in the regional industry," he declared.

"At the time, we called the 145 the 'Lite beer' of the industry – it tasted great and was less filling.

"Prior to the 145, the industry had a different economic paradigm – jets and regional jets enjoyed a 25%-plus revenue premium due to passenger preference for jets and the 'turboprop avoidance factor'. However, turboprops enjoyed superior [lower] unit costs that largely offset the revenue penalty. When the ERJ145 was launched, it was a true game-changer that delivered the revenue premium of a jet at turboprop costs – the best of both worlds. That new economic paradigm was a truly disruptive technology and changed the regional industry forever." ●





ABOVE LEFT • ***The Brazilian Federal Police Department operates a pair of ERJ145s. Embraer has stated that the jets are used for transporting officials and border control as well as combatting international drug trafficking and terrorism.*** AVSTOCK/RENATO FONSECA

ABOVE RIGHT • ***The air arms of Belgium, Brazil, Greece, India, and Mexico use the ERJ type in a variety of roles including airborne early warning, maritime patrol, and VIP transport.*** AIRTEAMIMAGES/JAVI SANCHEZ UTZET

RIGHT • ***Continental Express caused a stir with its order for 25 ERJ145s at the 1996 Farnborough Airshow. Options for a further 175 examples were included in the deal.*** KEY COLLECTION

BELOW RIGHT • ***The ERJ's enduring popularity is partly due to the lack of a successor. When in production, the type faced competition from the Bombardier CRJ100/CRJ200 and Fairchild Dornier 328JET, however the latter company collapsed in 2002, Bombardier exited the commercial aircraft market in early 2020 and Embraer has focused on larger aircraft, such as the E170, E190 and E195.*** AIRTEAMIMAGES/BRIAN SPURR





The type formed the basis of the Legacy 600 and 650 business jets, giving the manufacturer an opening into the executive market. AIRTEAMIMAGES/JAVI SANCHEZ UTZET/MATT7X





LEFT • ***More than 1,200 examples have been produced, including military variants.***
AIRTEAMIMAGES/JEHAN GHOUSE

BELOW • ***Loganair is Europe's largest operator of the 37-50-seat jet, fielding 17 examples.***
AIRTEAMIMAGES/ROLF JONSEN

BOTTOM • ***Six Continental Express ERJs on turnaround at Houston-George Bush Intercontinental Airport in January 2006.***
AIRTEAMIMAGES/NATHAN ZALCMAN





SIEGEL AND CONTINENTAL EXPRESS' ERJ SELECTION

When David Siegel, the Continental Express CEO, and his team were looking at 50-seater aircraft types, there were two regional jets eyed – the Embraer ERJ and Bombardier CRJ – plus the Saab 2000 'fast turboprop'. So how did the competition run for the carrier to conclude that the ERJ145 should be the choice?

"We did look at the Saab 2000 and the 328JET series [they also had a 50-seat version in planning]. However, we quickly narrowed it down to the ERJ and CRJ," he confirmed. "We spent almost a year doing technical and financial due diligence on both aircraft, especially on the Embraer. "We got a lot of support from our parent Continental Airlines – Gordon Bethune, Continental's CEO, who ran the 757 programme at Boeing, even did a tour of the factory production line in São José dos Campos and a review with the engineering team there. C D McLean, Continental's chief operating officer and himself a pilot, also travelled to Brazil to review operational details and take the 145 for a test flight, putting the aircraft through its paces."

Siegel gave an insight into the negotiations, including the carrier's grand long-term plans: "[In total] we spent a year negotiating the deal in parallel with our diligence process. Maurício Botelho and Frederico Curado [two former Embraer presidents and CEOs] were both very much involved, as was their head of engineering, Satoshi Yokota.

"The diligence process was really a two-way process. Continental was still early in its turnaround and Continental Express was also still in turnaround mode. We were each betting our companies on each other," Siegel observed. "Both Embraer and Continental Express were betting on each other to succeed. It was clear that we would both succeed, or both fail, but neither partner could survive if the other failed."

To underline what a success it turned out to be, Continental Express/ExpressJet Airlines ended up buying 30 ERJ135s, 140 ERJ140s, 245 ERJ145s and 105 ERJ145XRs.

Tucano: Embraer's Successful Trainer

Hercules de Araujo details the EMB-312 Tucano turboprop trainer, one of Embraer's best-selling military aircraft.



One of the most famous aircraft operated by the Força Aerea Brasileira (Brazilian Air Force or FAB) in recent decades was born to order. When the Cessna Aircraft Company announced, in late 1977, it intended to discontinue production of its model 318A twin-turbine jet trainer (designated the T-37 in US Air Force service and operated by Brazil, Chile and Colombia among others), the FAB carried out studies with a view to its replacement. The idea involved national production of a replacement.

Embraer applied to develop an aircraft that could replace the T-37 with a turboprop type. The Brazilian company had the know-how, specialised labour, and facilities to produce a military aircraft that would meet the proposed requirements.

The project was developed on paper, and on December 6, 1978, Embraer and the FAB signed a contract to produce a brand-new turboprop trainer aircraft. Using FAB nomenclature, the aircraft was designated the T-27.

Embraer developed the aircraft as model EMB-312 and began production work on the first four prototypes for flight test and evaluation. Specifications included:

- Advanced features, within an entirely new concept.
- Good performance with great fuel economy.
- Robust in design to meet training needs.
- Standardisation, to save on the stock of spare parts.
- Manoeuvrability, to provide student pilots with familiarity in preparation for fast jet operation.
- Effective weapons capability for use in tactical missions.
- Use of the latest safety standards for both student and instructor.
- Capability to operate from unprepared runways, which can dispense with line maintenance.
- Low acquisition and operating costs.

Design

On August 19, 1980, the project became a reality with the maiden flight of the first prototype from Embraer's airfield at São José dos Campos in São Paulo.

The second prototype made its maiden flight 116 days later, on December 13, 1980.

After their respective maiden flights, each prototype entered the flight test programme which involved checking for:

- stall characteristics
- static stability (longitudinal, lateral, and directional)
- dynamic stability
- operation of the oxygen, fuel, anemometric system, and powerplant
- take-off, landing, climb and cruise performance
- operation of the ADF, DME VOR/ILS and transponder systems
- night flying
- high-speed flying
- performing loops, spins, wing-over manoeuvres, stall turns, chandelles, and barrel roles

In an official flight test report, Luiz Fernando Cabral, Embraer's chief test pilot described the results as "highly satisfactory."

Brazil's minister of aeronautics, then director general of the CTA (and former commander of the Academia da Força Aérea or AFA), Brigadier Menezes, Colonel Donald Madona (commander of the US Air Force Test Pilot School) and Nick Warner of the UK's Civil Aviation Authority all expressed satisfaction with the behaviour and performance of the EMB-312 advanced turboprop trainer, following an extensive 190-hour flight test campaign.

LEFT • ***RAF Tucano T1 ZF446 assigned to No.1 Flying Training School was based at RAF Linton-on-Ouse, Yorkshire until the type's retirement in 2020.*** ROYAL AIR FORCE/ SGT RICK BREWELL

BELOW • ***Peruvian Air Force AT-27s are painted in a distinctive two-colour paint scheme.***



ABOVE • ***A factory model used for testing and demonstration flights.***

RIGHT • ***An EMB-312 Tucano in flight.***

With series-production underway, the first T-27 was delivered to the FAB and assigned to the AFA at Pirassununga-Campo Fontenelle and welcomed by the cadets. Prior to the aircraft's arrival, the AFA staged a contest to nominate names for the new aircraft.

Carlos Fernando de Souza Panissa, a fourth-year cadet won the contest with the name Tucano for which he was honoured. Tucano is native Brazilian for Toucan - the tropical bird known for its large, coloured bill and plumage.

The T-27 Tucano was equipped with communication and navigation instrumentation, IFR instruction capability, the ability to fly in formation, training, and tactical employment capabilities, ejection seats and a 1,000kg weapon payload.

In addition to automatic torque control, the T-27 has air conditioning, a much-needed capability for crew comfort.

Embedded Systems

As a new generation aircraft of the time, the Tucano was equipped with an enviable suite of automatic navigation and operating aids that included:







ABOVE LEFT • ***A T-27 Tucano assigned to the FAB's Smoke Squadron.***

ABOVE RIGHT • ***T-27s assigned to the AFA are painted in an orange and white colour scheme.***

RIGHT • ***The Tucano's PT-6A turboprop engine spins three Hartzell propellers.***



- stall warning
- load factor alarm
- landing gear position lights
- fire alarm
- canopy safety device (lock)
- safety of flap deflection asymmetry (back up protection system) to prevent accidental retraction of the landing gear
- involuntary activation of weapon prevention system
- emergency automatic payload jettison
- weapons cut-off switch
- emergency transmitter/locator
- emergency battery and redundant altitude indication systems

Trainer Comforts

The first production aircraft were delivered to the AFA at Pirassununga-Campo Fontenelle on September 29, 1983. Six aircraft intended for the former Smoke Squadron, now called the Esquadrão de Demonstração Aérea (Air Demonstration Squadron) and two for pilot training with the AFA.

With its spacious cabin and smooth controls, flying the T-27 with air conditioning is both stable and smooth for the student and instructor alike.

Stadium style seating provides both the student and instructor with all-round visibility. The higher aft seat allows the instructor full visibility and control within the associated specifications for lead-in pilot training to fast jets.

In that respect, the T-27 provides a reported 30% greater fuel efficiency compared to the legacy T-37 which yields a 20% reduction in flight hours during the basic flying training phase. Utilisation of the Tucano aircraft for flying training prepares a student for fast jet conversion after 250-hours of flight time.

Staggered Replacement

As new Tucanos left the assembly line, they were incorporated into the FAB fleet. Initially, 118 units were ordered to replace the T-37 which had been in operation between 1967 and 1981. But the Tucano was not just fielded as a replacement programme, as the FAB still used 65 T-37 jets and its 118-aircraft order almost doubled the fleet size.

The Tucano was intended to provide military flying schools with a more agile means of training new pilots. As T-27 Tucanos arrived at the AFA, AT-26 Xavante and the T-25 Universal trainers were transferred to other units.

The Tucano proved popular, and another 300 aircraft were sold to the French Armée de l'air, Egypt's Al Quwwat at Jawwiya il Misriya, and later licenced for production by Shorts in Belfast for an RAF order.

Development of the Embraer EMB-312 involved 250,000 hours of engineering, 113,000 hours devoted to prepararing the tooling and 50,000 hours to produce the first prototype, all inside of two years since the project was given the go-ahead by the Ministry of Aeronautics general staff. A favourable timeframe compared with other such programmes.

The sixth and final prototype, which incorporated all the improvements developed, was delivered to the Departamento de Ciência e Tecnologia Aeroespacial (Department of Science and Aerospace Technology or DCTA) for evaluation and certification to the Federal Aviation Administration's FAR Part 23 and the UK's BCAR standards.

Once the first requirements were met, Embraer began a programme of work to expand the roles to which the Tucano could be applied, not least for close air support and ground attack.

This made the T-27 a powerful weapon for counterinsurgency missions with the ability to carry a 1,000kg weapon payload. Four under wing hard points enable the carriage of 37mm or 70mm rocket launcher pods, pods housing 7.62mm or 12.7mm calibre machine guns, or 115kg or 225kg bombs.

An auxiliary fuel tank system can also be fitted to extend the aircraft's endurance to more than seven hours of flight time or a range of 3,800km.

In May 1983, Embraer embarked on a world tour with the Tucano. A demonstrator aircraft departed São José do Campos on a 57,000km route through Venezuela, Panama, Honduras, Haiti, Jamaica, Dominican Republic, and to the United States.

Departing Miami, Florida and passing through New York, the Tucano aircraft routed to Goose Bay, Canada, Greenland, Iceland (Reykjavik), Scotland (Prestwick), France (Paris), Greece (Corsica), Egypt (Cairo), Sudan (Khartoum) and Kenya.

Its return journey routed through Uganda, Tanzania, Zambia, Sudan, France, Sweden, Finland, Denmark, France and back across the north Atlantic to Canada and the United States back to São José do Campos in Brazil.

The world tour generated the award of two contracts for Embraer for the supply of Tucano aircraft to Egypt (120 for $181 million) and to the United States (eight for $10 million), and other letters of intent. The first ten Egyptian aircraft were supplied fully assembled and in flyable condition. The remaining 110 were assembled by the Arab Organization for Industrialization in Cairo. An option for another 60 aircraft was considered.



ABOVE • ***The Tucano's forward cockpit panel.***

RAF Tucanos

In the aftermath of the Tucano world tour through the Americas and Europe, Embraer began talks to sell the type to the UK government as a replacement for the RAF's fleet of BAC Jet Provost turbojet-powered trainer aircraft which was reaching the end of its service life and showing signs of fatigue following decades of service.

In August 1983, Shorts Brothers from Belfast started working on a collaborative agreement with Embraer to produce Tucano aircraft to meet the criteria outlined in the RAF's Air Staff Target 412 requirement for a new type of high-performance, turboprop-powered basic trainer valued at £200m.

The Shorts-Embraer agreement was signed on May 18, 1984, covering the manufacture of the Tucano in the United Kingdom to take advantage of British labour and the high technological index of the equipment manufactured there.

In March 1984, Michael Heseltine, the



then UK secretary of state for defence announced four types pre-selected for the requirement: the Embraer EMB-312, the Pilatus PC-9 (from Switzerland), the Turbo-Firecracker (from the UK) and the A-20 Wamira (Australia).

Two months later, the provisional agreement with Shorts was ratified, as were the agreements between the other competitor companies and their respective British partner companies.

A major mandatory requirement of the programme was for the chosen model to be produced totally or partially in UK territory. Pilatus partnered with British Aerospace; Firecracker with Hunting and Wamira with Westland.

On March 21, 1985, Heseltine declared the EMB-312 Tucano as the winner of the tender – Embraer's third international contract for the type.

The RAF committed to acquire a batch of 130 aircraft to be manufactured in Northern Ireland by Shorts. According to details in the announcement, the unit price was around US$1.05m.

A team of RAF technicians met with Embraer's board of directors at São José dos Campos for a first working meeting to define the negotiated parameters.

Unlike the other three competing types, the Tucano was already in full production. The RAF's decision to purchase the Tucano brought Embraer's total order tally to 500 aircraft and served as an underwriting to other nations which subsequently ordered the type.

A 35% advantage obtained by the UK government in the final price made the purchase of prefabricated kits more attractive. Under the terms of the tender, up to 50% of the components could be sourced from outside Great Britain. Embraer delivered the first kits to Short's Belfast facility for assembly in 1986.

Selection by the RAF had repercussions in Brazilian political circles. Brazil's interim vice president at the time, José Sarney, sent a note to the then minister of aeronautics expressing satisfaction: "Knowing that Brazilian planes will have serve the pilot training requirements of an air force whose technological level is internationally recognized, brought joy to the government, to industry, to the workers and all Brazilian people."

In the UK, the news resonated favourably with the electorate.

The Shorts Tucano T1 had several differences to the EMB-312.

- reinforced structure.
- dashboard layout like that of the Hawk advanced trainer.
- four-blade propeller, as opposed to three-blade.
- air brake and wingtip remodelling.
- Martin-Baker MB 8LC ejection seats.
- new oxygen system.
- new flight data recorder.
- new reinforced canopy.
- Garret TPE331-12B turboprop engine rated at 1,100shp.

ABOVE • ***Handover of EMB-312s to the EDA in 1982.***

BELOW • ***A Venezuelan Air Force Tucano.***



Project Developments

As a result of the worldwide success of the EMB-312 Tucano, Embraer and Grupo ABC signed a contract for production of the first Brazilian EMB-312 Tucano flight simulators. Valued at US$10m, the contract covered five units for Egypt's Al Quwwat at Jawwiya il Misriya.

Production of flight simulators was a long-time objective of Brazil's aeronautical industry. At the time, Embraer's then president, Ozires Silva, spoke of the mastery of advanced computing techniques used by ABC Sistemas in the manufacture of equipment and in the fact that the first units produced represented a substantial export. ●

ESQUADRÃO DE DEMONSTRAÇÃO AÉREA

The current FAB Air Demonstration Squadron was formerly called the Esquadrilha da Fumaça (the Smoke Squadron).

The team was originally formed in 1952 with six North American Texan T-6 aircraft, licence built in Brazil since World War Two.

After a few years of exceptional performances in exhibitions, the FAB opted to replace the T-6s with French Fouga Magister twin-engine jets. The French jets tenure in the team was short-lived though – the Smoke Squadron returned to the T-6s for more than a decade.

Until 1977, Fumaça performed 1,270 times throughout Brazil and abroad, before being deactivated on cost grounds. The T-6s burned high-octane gasoline and the Pratt & Whitney Wasp R-1340-AN-1 air-cooled radial engine, was costly to maintain. Consequently, the minister of aeronautics decided to temporarily suspend demonstrations, causing consternation in aeronautical circles.

In accordance with Decree 87739 dated October 21, 1982, after five years without flying, the Fumaça returned to Brazilian skies but under the new name of Esquadrão de Demonstração Aérea (EDA). Demonstrations began a few months later after the AFA had received new Tucano aircraft.

The EDA maintains a standard average age of 31 years among its members, who must have acquired 3,000 flight hours at the time they join the team. All team members are flight instructors who volunteer for the team out of dedication to aerobatics. They also spend three years with the squadron before continuing their career plan in operational FAB units.

The first members of the EDA flying T-27 Tucanos were: Aviator Captain Celso Luiz Cardoso Vilarinho (commentator), Aviator Captain Vânio de Figueiredo Crispim (left wing), Aviator Captain Juan Henrique Vergara Canto (right wing), Aviator Captain Antônio Bragança da Silva (solo) and Aviator Captain Ivan Nunes Siqueira Junior (solo).

The ground support and maintenance team are tasked with demonstrating the EDA's diligence, efficiency, and flight demonstrations at public displays. Before, during and after the demos, specialised technicians ensure the safety, availability, and serviceability of the aircraft. Experts in mechanics and engineering, the team pilots affectionately refer to them as 'the guardian angels'. All team members belong to the AFA's staff at Pirassununga, which as an organisation, provides supply and maintenance support.

In 2013, the EDA transitioned to the Embraer EMB-314 Super Tucano, which gave the team a new level of capability for demonstrations.







T-27 Tucano Characteristics

Length	32ft 4in (9.86m)
Wingspan	36ft 7in (11.14m)
Height	11ft 2in (3.4m)
Wing area	209ft² (19.4 m²)
Empty weight	3,990lb (1,810kg)
Max take-off weight	7,000lb (3,175kg)
Fuel capacity	153 Imp gallons (694 litres)
Powerplant	One Pratt & Whitney Canada PT6A-25C turboprop rated at 750shp
Propellers	Three-blade Hartzell
Max speed	247kts at 13,000ft
Cruise speed	238kts
Stall speed	67kts
Range	1,035nm (1,916km)
Service ceiling	28,710ft
g limits	+6/-3g
Wing loading	34lb/ft2 (164kg/m2)
Ferry tanks	Two 170 US gallon (660 litre) tanks



ABOVE LEFT • ***An Armée de l'air Tucano wearing Brazilian test registration PP-ZVD.***

ABOVE RIGHT • ***ABC Sistemas produced a Tucano simulator in collaboration with Embraer.***

LEFT • ***The EMB-312 final assembly line São José dos Campos in the late 1980s.***

RIGHT • ***Shorts' showcasing its range of weapons suitable for the Tucano at a Farnborough airshow.***

BELOW • ***The A-27 is a light attack version of the T-27 Tucano, this example with the Força Aerea Brasileira.***





The Super Tucano – Embraer's Lightweight Champion

Santiago Rivas and David Willis detail the development and operators of the Super Tucano, while Joe Copalman looks at the aircraft flown by the Colombian Air Force.

A pair of Chilean Air Force Embraer EMB-314 Super Tucanos flying in formation at the end of the day. Chile is one of 15 nations to fly the aircraft. CEES-JAN VAN DER ENDE



The EMB-314 Super Tucano is the most successful turboprop light attack aircraft in production today. Fifteen air arms have ordered more than 250 of them and it has been, and continues to be, used in combat in Latin America, Asia, and Africa.

The Super Tucano was developed from the EMB-312 Tucano, with a greater emphasis on air-to-ground and anti-helicopter roles, as well as for the interception of slow, fixed-wing aircraft. It also built on experience gained from the Short Tucano programme for the Royal Air Force (RAF), whose aircraft were powered by a more powerful engine than the Pratt & Whitney Canada PT6A-25C used by the original Tucano.

Although designed as a basic trainer, the Tucano built up an enviable reputation in combat operations, with for example, Colombia operating the aircraft against guerrillas in the country and for intercepting drug-smuggling aircraft in its airspace. This alerted Embraer to a new potential market for a refined version of the Tucano with greater power, more armament options and better equipment for combat missions.

From the late 1980s, Embraer began to study a ‘Super Tucano’ as the EMB-312F, with F standing for ‘future’. It incorporated some features of the Short-built aircraft, including the airbrake, while more powerful versions of the PT6A and the Garrett TPE331 engines were considered. Following the sale of Tucanos to the French Air Force as the EMB-312F (F for ‘France’), the project was retitled the EMB-312H Super Tucano.

A production Tucano airframe was modified with a 1.31m (4ft 31/2in) extension to the rear fuselage and an airbrake, while a 1,250shp (930kW) PT6A-67 engine was installed. The modified aircraft completed its first flight in the new configuration on September 9, 1991. A further pair of prototypes was built two years later, incorporating a new cockpit layout with a revised canopy and a 1,300shp (956kW) PT6A-68A turboprop.

Interest in the project was soon expressed by the Força Aérea Brasileira (FAB, Brazilian Air Force), which was seeking an aircraft to intercept illegal flights and for the light attack role in the Amazon under the proposed Sistema de Vigilância da Amazônia (SIVAM, Amazon Surveillance System) programme. The EMB-312H was also considered as a



LEFT • ***Air-to-air missiles have been cleared for use from the Super Tucano, although they are rarely carried in service. This aircraft is one of the two prototypes produced by Embraer.***

replacement for the EMB-326 Xavante trainers flown by Esquadrão 'Joker' (Joker Squadron), the 2°/5° Grupo de Aviação (GAv), from Natal Air Base.

A contract was signed on August 18, 1995, for 100 EMB-312Hs for the FAB, comprising 50 single-seat A-29As (with a fuel tank in the rear cockpit) and 50 two-seat A-29Bs. Several changes to the design were requested by the FAB, which were incorporated into the prototypes. They included adding an additional pair of underwing pylons (to five in total), and the ability to use smart weapons and two Mectron MAA-1 Piranha air-to-air missiles. The cockpit was revised, with Martin-Baker Mk 10LCX ejection seats; new avionics with dual liquid-crystal displays and a head-up display, all compatible with night-vision goggles, plus a helmet-mounted display; ultra- and very high frequency tactical radios; a hands-on-throttle-and-stick (HOTAS) flight control system; a GPS inertial navigation system, and dual-axis autopilot. The aircraft would also be able to carry a forward-looking infrared sensor and be protected by radar and missile warning systems.

Flight testing resulted in a further series of alterations during 1998. They included a redesigned wing, reinforced landing gear, further changes to the canopy, a greater weapons capacity and installation of a pair of 12.7mm (0.5in) machine guns, each with 200 rounds. More power was also required, leading to the installation of the PT6A-68/3 of 1,600shp (1,193kW), while the intake was redesigned to protect the engine from debris when operating from unprepared airstrips. The resulting aircraft was designated the EMB-314 Super Tucano (YA-29 by FAB), making its first flight on June 2, 1999.

An order for 76 aircraft, plus 23 more initially as options (later firmed up), was placed by the FAB on August 8, 2001. The 99 aircraft were delivered as 33 A-29As and 66 A-29Bs. The first was

BELOW • ***Several different powerplants were evaluated for the Super Tucano before the Pratt & Whitney Canada PT6A-68/3 was selected for production aircraft. The intake was also redesigned to reduce the possibility of damage during operations from rough airstrips.*** CEES-JAN VAN DER ENDE





handed over on December 18, 2003, and all 99 were with the FAB by June 2012.

As of early 2022, Brazil's Super Tucano are assigned to three operational squadrons (which use a mix of A-29As and Bs); 1°/3° GAv 'Escorpião' of Ala (Wing) 7 at Boa Vista; 2°/3° GAv 'Grifo' of Ala 6 at Porto Velho; and 3°/3° GAv 'Flecha' of Ala 5 at Campo Grande. They undertake light attack operations and intercept aircraft operating illegally in, or entering, Brazilian airspace, as well as surveillance missions. Two-seat A-29Bs are also used as trainers by 2°/5° GAv 'Joker' of Ala 10 at Natal. The final – and most famous – Brazilian operator is the Esquãdrao de Demonstração Aérea (EDA, Air Demonstration Squadron, also known as Esquadrilha da Fumaça or 'Smoke Squadron'), the FAB's display team. It received the first of eight Super Tucanos from October 1, 2012, to replace its T-27 Tucanos.

Brazilian Super Tucanos have been used on operations against illegal runways, destroying them with bombs, and to intercept unidentified aircraft crossing the country's borders, most of which are involved in the narcotics trade. In some cases, the A-29s have shot down the intruders, while in other engagements they were forced to land. The A-29s operates alongside Embraer R-99A airborne early warning aircraft in conjunction with ground-based radar stations, which are used to control operations over the Amazon. They are responsible for guiding the Super Tucanos towards any suspicious aircraft.

The main weapon used by Brazilian Super Tucanos during such interception operations are their internal guns. For air-to-ground missions the A-29 can also employ M117, Mk 81, 82 and 83 bombs, or pods for seven 70mm (2.7in) rockets, while for training sorties the SUU-20 with four 70mm rockets and six BDU-33 practice bombs can be carried. The FAB tested a GPS guidance kit developed by Britanite for the Mk 81, 82 and 83 bombs, as well as the Israeli-built Lizard laser-guided bomb, but neither were adopted for operational use by the air force. In 2013, Embraer submitted a proposal to integrate a P-Band (synthetic aperture radar) reconnaissance pod developed by Orbisat.

The Super Tucano can carry a wide variety of external stores; a total of 133 different external configurations had been qualified by mid-2011, with many more since. Some of the many other weapons that can be carried by the Super Tucano include the AIM-9 Sidewinder and Rafael Python 3/4 air-to-air missiles; AGM-65 Maverick air-to-surface missile; Israel Military Industries Delilah loitering munition; Paveway laser-guided bombs; GBU-38 and GBU-54 Joint Direct Attack Munitions; and GBU-39 Small Diameter Bombs.

ABOVE • ***The canopy of the Super Tucano underwent several changes during the development phase of the aircraft. The cockpit is compatible with night-vision googles, allowing the aircraft to operate both during the day and in the hours of darkness.*** SANTIAGO RIVAS

BELOW • ***Early Super Tucanos were delivered with a two-screen cockpit, but a third was later added. The aircraft is equipped with a HOTAS control stick and a head-up unit.***



Export Success

The Super Tucano has achieved considerable success in the export market, appealing to nations that do not need, or cannot afford, sophisticated, jet combat aircraft. It has entered service with air forces in Latin America, Africa, and Asia, as well as being selected for licence assembly in the United States by the Sierra Nevada Corporation (SNC) for the US Air Force and partner nations.

Initial interest came from nations in Latin America, with Colombia becoming the first overseas air force to receive Super Tucanos. An order for 25 was announced in December 2005, with the first five delivered one year later and the last entering service in August 2008. In service, the aircraft (FAC 3101 to 3125) were assigned to the Escuadrón de Combates (Combat Squadrons) 211, 312 and 611, although 211's aircraft were reassigned to the Grupo Aéreo de Casanare (Casanare Air Group) in October 2017. Colombia's Super Tucanos have seen extensive combat, fighting the Fuerzas Armadas Revolucionarias de Colombia (FARC, Revolutionary Armed Forces of Colombia) and other groups, as detailed below.

Although it was the second overseas customer to receive Super Tucanos, the Dominican Republic was actually the first to place an order for the aircraft, announcing a deal for 10 on August 20, 2001. The order was later abandoned, but the Super Tucano was again selected by Dominica in late 2008 and the first of eight was delivered on December 18, 2009. The last was handed over in October 2010. The aircraft (FAD 2900 to 2907) entered service with Escuadrón de Combate 'Dragones' (Combat Squadron 'Dragons') at San Isidro Air Base.

Chile received the first of 12 Super Tucanos in December 2009, having selected the type for the light attack and training roles to replace Cessna A-37B Dragonflies and some of the ENAER/CASA 101 fleet. The aircraft were the initial Super Tucanos with a full 'glass cockpit', featuring an additional screen over the two previously standard. Its aircraft were assigned to Grupo de Aviacion N°1 (1st Aviation Group) at Base Aérea 'Los Cóndores' in Iquique. Chile ordered a second batch of six in October 2017, which were delivered from March 2018, while a further four were delivered in late 2020 for a total of 22.

Ecuador signed for 24 Super Tucanos in 2008, although the commitment was later reduced by six. The initial pair arrived in the country on January 24, 2010, replacing A-37Bs of Ala de Combate 23 (Combat Air Wing 23) at Manta Air Base in the second quarter of 2011. The wing has two flying units, Escuadrón de Combates (Combat Squadrons) 2311 'Dragones' and 2313 'Halcones'. The aircraft (FAE 1010 to 1027) are equipped with a forward-looking infrared sensor, while they are armed with Lizard laser-guided bombs, 70mm rockets and free-fall weapons. Ecuador lost a Super Tucano (FAE 1016) on March 19, 2012, following engine failure during take-off.

Several other Latin American nations have expressed interest in the Super Tucano but did not take delivery. El Salvador wanted eight or 10 in late 2010, but no order was announced. From early 2011 Peru investigated acquiring 12 Super Tucanos, but instead selected the KT-1 the following year. In the second half of 2011 Guatemala sought finance for six aircraft, resulting in a deal being finalised in April 2013. Although the order was cancelled in November 2013, a requirement for two aircraft was revealed in early 2015, but again not fulfilled. The Super Tucano was selected by Paraguay in May 2012, but no order materialised. Honduras sought to acquire between eight and 12 in early 2012, reduced to five in mid-2014, with an order for two announced in October 2014. Bolivia also expressed an interest in the Super Tucano during November 2017.

Four countries in Africa have acquired Super Tucanos from Embraer. Burkina



ABOVE • ***The Super Tucano was designed to fulfil a Brazilian requirement for surveillance operations over the Amazon. Three Brazilian squadrons operate a mix of single-seat A-29As and (as seen here) two-seat A-29Bs in the role.***

BELOW LEFT • ***Two A-29B Super Tucanos of the Brazilian Air Force, wearing stickers marking the 100th anniversary of the first flight of Santos Dumont in 1906. Brazil was the first operator of the Super Tucano and continues to have the largest fleet.***

BELOW RIGHT• ***A pilot 'flying' a Super Tucano simulator. Embraer offers the Training and Operation Support System (TOSS) to Super Tucano customers, including ground-based training equipment.*** SANTIAGO RIVAS







ABOVE • ***Super Tucanos have been delivered in a variety of colour schemes, but the Ecuadorian Air Force is the only one so far to adopt a 'digital' camouflage for its aircraft.***

RIGHT • ***The view from the rear cockpit of a Chilean Super Tucano, with three aircraft in formation above.*** CEES-JAN VAN DER ENDE



Faso was the seventh nation to purchase the aircraft, receiving three (XT-MEA to XT-MEC) in September 2011, which were based at Bobo Dioulasso and operated by the Escadrille de Chasse (Fighter Squadron). They were used against militants in the joint French, Malian and Burkinabé *Operation Panga* in March and April 2017, and were also used in anger against militant bases near Pama and Gayeri on September 15, 2018.

The second African nation to fly the Super Tucano was Angola. Six (serial numbers R-701 to 706) were ordered in March 2012 and the first was handed over in Brazil on January 31, 2013. The aircraft were officially accepted into service on July 12. The Mauritanian Islamic Air Force officially received three aircraft on October 19, 2014, during a ceremony at São Paulo in Brazil. On June 17, 2015, Embraer announced the sale of six Super Tucanos to the Malian Air Force, but the deal was later reduced by two due to financial issues. All four were inducted into service at Air Base 101, adjacent to Bamako International Airport, in July 2018. One was lost in a fatal crash on April 7, 2020.

Two days after the Malian order was announced, it was reported that Ghana had ordered five Super Tucanos; at the time of writing delivery of the aircraft had not been reported. An earlier order by Senegal for three was also never finalised, with four KAI KT-1Ss being received instead. Brazil also offered to provide Mozambique with financial assistance to acquire three Super Tucanos in 2014, but the offer was rescinded two years later.

Indonesia was the first Asian country to buy the Super Tucano, ordering eight in November 2010. The first four were handed over in Brazil on August 6, 2012, and arrived in Indonesia on September 1, entering service with 21 Skwadron Udara at Abdul Saleh Air Base on East Java. The second batch of four was delivered in September 2014, by when a second order for an additional eight had been placed. These arrived in Indonesia in November 2015 and February 2016.

The Philippines selected the Super Tucano in June 2017 to replace Rockwell OV-10 Broncos, which were heavily involved in the fight against so-called Islamic State (IS) affiliated insurgents on the island of Mindanao. An order for six aircraft was signed later that year, with the first four arriving at Clark Air Base on September 19, 2020, and the last two by October 2. They were assigned to the 15th Strike Wing.



LEFT • ***An A-29B of the Dominican Air Force, wearing the bomb-carrying dragon badge of the Escuadrón de Combate 'Dragones'. Dominica was the first overseas customer to order the Super Tucano, but procurement was initially shelved until later being resurrected.***



LEFT • ***Chile's Super Tucanos are primarily used as trainers, although they are still capable of the light attack role.***

BELOW • ***Chile received 12 Super Tucanos from December 2009 – including this pair of aircraft – to replace Cessna A-37B Dragonflies and part of the ENAER/ CASA 101 fleet. They were augmented by a further six from 2018 and another four in 2020.*** CEES-JAN VAN DER ENDE



American Production

The most unusual purchaser of the Super Tucano was the American private security company Blackwater, which acquired one unarmed aircraft (N314TG) in February 2008 through its subsidiary EP Aviation of McLean, Virginia. It later passed to Tactical Air Support of Reno, Nevada. The aircraft was evaluated by the US Navy as '163056', with the US Mission Design Series designation A-29B (as per the Brazilian Air Force) officially being allocated to the aircraft in August 2008. It was later armed and equipped with a L-3 Wescam MX-15 electro-optical/infrared sensor and participated in the US Navy's Imminent Fury programme, which sought to acquire systems for 'anti-irregular warfare'. Phase two of Imminent Fury would have been a six-month deployment by four aircraft to Afghanistan, but it was superseded in late 2010 by Combat Dragon II supported by US Central Command. The second phase of Combat Dragon II aimed to test light turboprop attack aircraft in actual combat conditions but was cancelled before it could take place.

US Air Force interest in such aircraft crystalised as the Light Attack/Armed Reconnaissance (LAAR) programme launched in July 2009. Under LAAR



the US Air Force sought 100 aircraft to enter service from 2013, but the service's plans to acquire light turboprop strike and reconnaissance aircraft quickly became subject to competing requirements and controversy. LAAR was effectively subsumed into the Light Air Support (LAS) project, which sought 20 aircraft for supply to the Afghan Air Force, plus others for the US Air Force for training. The leading contenders for the requirement were the Super Tucano and the AT-6, an armed variant of the T-6 Texan II basic trainer developed by Hawker Beechcraft (later Textron).

ABOVE • ***Ecuador's Super Tucanos fly with two squadron from Manta Air Base. Its aircraft have carried the Star SAFIRE III and Brite STAR II electro-optical/infrared sensors.*** SANTIAGO RIVAS

BELOW • ***Six Super Tucanos were delivered to the National Air Force of Angola for border surveillance operations. This aircraft is one of the first three handed over on January 31, 2013.***

Embraer teamed with SNC for the competition to provide a US 'face', with any Super Tucanos ordered to be assembled at Jacksonville in Florida.

Two Super Tucanos were evaluated by the US Air Force at Kirtland AFB in New Mexico from January 25 to 28, 2011, under the Light Air Support System Demonstration. The programme became controversial in November 2011 when the AT-6B was excluded from the selection process, resulting in SNC being awarded a contract on December 22 for 20 A-29Bs for the Afghan Air Force. Work halted in January 2012 after Hawker Beechcraft went to the courts to overturn the deal, and the contract was cancelled on February 28. A new request for proposals was launched on May 4, with SNC again winning the contract on February 27, 2013. The first US Super Tucano (13-2001) assembled at Jacksonville was unveiled on September 25, 2014.

The 81st Fighter Squadron was reactivated under the 14th Flying Training Wing at Moody AFB in Georgia on January 15, 2015, tasked with training 30 Afghan pilots and 90 maintenance personnel on the aircraft. The first four Super Tucanos were delivered to Hamid Karzai International Airport in Afghanistan exactly one year later and the Afghan Air Force began flying combat missions with the aircraft on April 15, 2016. All 20 aircraft in the initial contract had been assembled by the end of July 2016, but an additional order for six was placed by October 2017. By then, 12 Super Tucanos had been delivered to Afghanistan, seven were at Moody AFB and one had been lost in March 2017 in a training accident.

The first of the additional six was delivered on April 24, 2018, and all had been built by September 2020. By then, 18 were in Afghanistan, although a second was written-off on July 9. Afghanistan was overrun by the Taliban in August 2021, following the withdrawal of NATO forces. It is understood that two aircraft then remained at Moody AFB, but the current status of the fleet in Afghanistan is unknown although most, if not all, are likely to be out of service.



In addition to supplying Super Tucanos to Afghanistan, US Air Force interest in light attack aircraft continued under the Capability Assessment of Non-Developmental Light Attack Platforms – unofficially known as OA-X. In late July and into August 2017 four light attack aircraft – including the Super Tucano and AT-6 – were evaluated at Holloman AFB in New Mexico during the Light Attack Experiment (LAE) but plans for a real-world combat demonstration (Combat Dragon III) in February 2018 were abandoned. A second phase of tests began in May 2018 however, but flying activity ended after a Super Tucano crashed over the White Sands Missile Range on June 22, 2018. Both the Super Tucano and AT-6 were declared to be Tier 1 candidates for the role, meeting the requirements of the envisaged mission.

On October 25, 2019, it was announced that two or three A-29Bs and AT-6Bs would be acquired to continue the LAE trials. By the time a contract for two Super Tucanos had been placed in early March 2020 (with a third soon added), interest in LAE had waned. The emphasis had moved on to the US Special Operation Command's (USSOCOM) requirement for an armed overwatch aircraft to provide special forces with close air support, precision strike and ISR capability. A total of 75 aircraft was sought. Prototype demonstration contracts were issued to five companies on May 14, 2021, but the Super Tucano was not one of them.

The second of the three A-29Bs for USSOCOM was delivered to SNC's modification facility on February 23, 2021, joining the first that was already there. All three will be operated by the 6th Special Operations Squadron at Duke Field in Florida to develop an instructor pilot programme for the Combat Aviation Advisory mission to train personnel from partner nations.

SNC has also built A-29Bs for delivery to other customers under the Foreign Military Sales programme. The first was the Lebanese Air Force, which ordered six aircraft on October 30, 2015, equipped with FLIR Systems' Brite Star DP electro-optical sensors, an AN/ALE-47 countermeasures dispenser and AN/AAR-60(V)2 missile launch detection systems, in a deal worth US$172.5m. Crew training began at Moody AFB on March 22, 2017, and the first two were delivered to Beirut that October. The final four were ferried to Hamat Air Base in Lebanon in late May 2018.

Nigeria's interest in the Super Tucano began in 2015, but a letter of offer and acceptance was only signed in early 2018. On November 28, 2018, a deal worth US$329m was announced, covering a dozen A-29Bs and support, with six of the aircraft to be equipped with FLIR Systems AN/AAQ-22F Brite Star electro-optical/infrared targeting systems. The aircraft were ordered to counter Boko Haram militants, as well as illicit trafficking within Nigeria and the Gulf of Guinea. The first Nigerian aircraft flew on April 17, 2020, and deliveries to Kainji air base, home of 407 Air Combat Training Group, began in July 2021. The aircraft was inducted into Nigerian service on August 31.



ABOVE • ***The Mauritanian Islamic Air Force was the third African adopter of the Super Tucano. It is understood that it has used them operationally.***

BELOW • ***One of the first batch of four Super Tucanos delivered to the Indonesian Air Force, at São Paulo prior to its ferry flight in late August 2012. Indonesia acquired 16 Super Tucanos, although delivery of the second order for eight was delayed when relations with Brazil became strained in 2015 after Indonesia executed a Brazilian drug smuggler.***

Colombian A-29s in Combat

Many countries have used Super Tucanos in combat. The aircraft had accumulated more than 33,000 combat flying hours by November 2015, according to Embraer, and this figure increased greatly as the Afghan fleet entered service and other air arms continued to use their aircraft in light strike and other roles. Colombia's fleet accounted for many of the combat hours flown by late 2015.

Following their combat debut against communist guerrillas on January 18, 2007, Fuerza Aérea Colombiana (FAC, Colombian Air Force) Super Tucanos played a crucial role in the fight against the FARC. In less than a decade, the aircraft helped turn the tide in the war against the narco-terrorists, as part of a new strategy aimed at taking down the organisation's leaders. They participated in all missions that ended with the death of FARC leaders.

Colombian Super Tucanos were assigned to two attack squadrons: the Escuadrón de Combates (Combat Squadrons) 211 'Griffos' at Apiay, Villavicencio, and the 312 'Dragons' at Barranquilla. Captain Miguel Sepulveda, a Colombian A-29 pilot, said: "The A-29





By 2015 Colombian A-29 units had gained more combat experience than any other Super Tucano operator, having participated in hundreds of attack missions. Among these, the attacks against the leadership of the FARC stand out. On March 1, 2008, the FAC conducted *Operation Fénix*, during which the terrorist group's camp near the border with Ecuador was attacked, killing FARC's second-in-command, Raúl Reyes, along with 16 others. In most cases the assaults consisted of an attack on the terrorist bases by the A-29s, followed by a ground assault by the Colombian army and national police. The operations were made possible due to intelligence provided by the United States, which managed to locate the precise whereabouts of the camps and confirm which commanders were present. The United States also played a role in helping to develop the capabilities of the Colombian Super Tucano pilots.

changed the course of the conflict because it introduced the element of surprise. We made the FARC withdraw from some areas of the country thanks to a combination of air and ground operations. We have also carried out missions in which we have managed to kill their leaders."

The weapons used by the aircraft included Mk 81 (500lb; 227kg) and Mk 82 (1,000lb; 454kg) GP bombs and 70mm (2.7in) rockets, as well as the internal 0.50-calibre machine guns. Although Colombian A-29s can carry Israeli-made Python 3 missiles, the air-to-air mission is not the A-29's primary mission priority, as other FAC aircraft are better equipped for it. According to Capt Sepulveda: "We are capable of air-to-air missions, but not in the most efficient way." At the end of 2010, the FAC carried out tests to provide the A-29 with a precision attack system, using IAI Griffin laser-guided bombs in conjunction with the Brite Star II electro-optical/infrared sensor. The munition was not adopted for use within the squadrons, however. Instead, the aircraft's Elbit mission avionics systems provided CCIP (constantly computed impact point) assistance that allowed precision bombing with unguided bombs. The forward-looking infrared sensor, together with night vision goggles, enabled the A-29s to carry out attacks at night. Colombia also investigated installing a sideways-looking airborne radar in the A-29 to reveal areas within the jungle used as refuges by the FARC.

ABOVE • ***The 81st Fighter Squadron of the US Air Force, based at Moody AFB in Georgia, trained all of the pilots for the Afghan Air Force's A-29B fleet. This aircraft is the third assembled by Sierra Nevada Corporation at Jacksonville, Florida.***
US AIR FORCE

RIGHT • ***Colombia acquired 25 Super Tucanos. These three are seen prior to delivery; PP-ZYE became FAC 3118 with the air force.***



Maple Flag

The adoption of new operations by the FAC was assisted by US Mobile Training Teams (MTT) manned by tactical experts. One of the MTTs, headed by US Air Force Captains Aaron 'Geezus' Cavazos and David 'Fife' Nagle, both A-10 Weapons Officers with the 355th Fighter Wing, worked with the FAC's A-29 force over a number of years.

Captain Cavazos outlined some of the history and mission of his MTT: "In 2011 the decision was made to send two experts in attack aviation to offer improvements in general tactics and develop instructional techniques. It wasn't so much about writing new tactics, techniques, or procedures, but more about pointing what was already there in the right direction and underlining some of the things that they have been doing in their internal conflicts. But it goes even further; we want them to think about external conflicts, so that if they were asked to be part of a coalition, they can start operating with an understanding of what the people they are going to work with are going to do. The long-term goal (within 15 years) was to have a much more prepared [US] ally in the Caribbean area, with a much more competent air force."

The FAC first deployed it's Super Tucanos overseas in 2013 for Maple Flag 46, held between May 27 and June 7 at CFB Cold Lake in Alberta, Canada. The MTT helped prepare the A-29s for the event. Major Roberto Patiño, an A-29 pilot who participated in the exercise, stated that in the year before it started, they "began to carry out different training missions in Colombia to verify the knowledge of procedures, tactics and necessary information about air threats, including aircraft, weapons systems, radars and surface-to-air threats."

A total of six FAC Super Tucanos took part in Maple Flag. The scenario for the exercise was a multinational coalition involved in a conventional conflict facing an enemy equipped with modern aircraft and ground-based air defences. In addition, Maple Flag presented the FAC with the opportunity to test its ability to deploy Super Tucanos 4,350 miles (7,000km) away from their home base and provide the logistical support needed to keep the detachment operational for two weeks. Support for the detachment was provided by a FAC Lockheed C-130H Hercules, which carried all the equipment and spare parts required by the turboprop. The C-130H also provided navigational guidance on the way to Canada, as the A-29 lacked the radar needed to avoid bad weather on the flight.

New Roles, New Tactics

The next major exercise for the FAC's Super Tucano was Angel Thunder 2014, a personnel recovery exercise held at Davis-Monthan AFB in Arizona between May 4 and 17. The FAC originally wanted to send three Rockwell OV-10 Bronco, the air force's combat search and rescue (CSAR) fixed-wing support aircraft, to the exercise. But two months before Angel Thunder began, the Colombian OV-10 fleet was grounded after cracks were discovered in the aircraft's fuselage.

Captain Cavazos said: "We had to make a critical decision... and we decided that we would carry out the MTT only with the A-29s. We specifically asked by name for the A-29 pilots we had worked with – or at least for most of them – on Maple Flag, who knew us beforehand and understand some of the concepts. In addition, that way we also knew who we were working with."

Experience from Maple Flag allowed the A-29 crews to squeeze nine months' worth of preparation into just two. The OV-10 crews also worked with the A-29 pilots to make sure they could pass the MTT Flight Proficiency Assessment – the final test for multinational exercises like Angel Thunder. The main objective of the A-29 contingent during Angel Thunder was to learn to escort rescue helicopters (RESCORT). "We wanted to keep them away from permissive or low-level anti-personnel recovery threats and force them to learn how to perform search and rescue missions in combat zones," said Captain Cavazos. "All they knew about CSAR included helicopters and special operations forces rescuing targets with little escort."



BELOW • ***US Air Force Captains Aaron Cavazos and David Nagle of the 355th Fighter Wing headed the Mobile Training Team that worked with the Colombian Air Force A-29B pilots.*** US AIR FORCE

To do this, the FAC used a single Bell 212 to put into practice lessons learned during the training for Angel Thunder. Captain Esteban Cabrejo, a Bell 212 pilot assigned to Escuadrón de Combate 411 'Rapaz' at Toleimaida air base, said: "Combined procedure training with A-29 pilots is not very common in Colombia. Helicopters are mostly used with other helicopters, so gunships are often used to escort rescue helicopters, without the intervention of any fixed-wing aircraft. Our training started with that kind of co-ordination, with the help of the A-10 pilots." A-29 pilot Captain Sepulveda stated that: "in Colombia we only carry out attack missions and now we are learning to escort rescue vehicles during search and rescue missions, which is important."

Angel Thunder also gave Colombian A-29 pilots the opportunity to work with Joint Terminal Attack Controllers (JTACs), Joint Forward Observers (JFOs), and Forward Air Controllers (Airborne) (FAC(A)s), something that the Colombian Air Force had not previously prioritised. Other US Air Force JTAC MTTs worked with Colombian Army JFOs to help improve interoperability with the aircraft. The need for such a capability was high, as Colombia intended to participate in coalition air operations with members of NATO. As the ability of the Colombian infantry to call in strikes by fixed-wing aircraft and helicopter gunships was still in its infancy, the decision was made to train its attack controllers to perform the functions of a JFO, rather than those of a JTAC. The differences, according to Captain Cavazos, are that: "there are a lot less minutiae, a lot less things to do. You don't have to give full reports of everything you do, you're only responsible for your assigned area. Really, it's just about communicating something like 'if I'm here, the bad guys are over there in this direction, move' and things like that."

Cavazos and Nagle put the A-29 pilots through a series of increasingly difficult Call-for Fire (CFF) scenarios in both Colombia and the United States. They began with threats within a permissive environment, with enough time to check on friendly positions and enemies before performing the CFF, then building up to troops in contact, with the JFO on the ground performing urgent and abbreviated CFFs – summed up as 'I'm here, the bad guys are here, HELP'.

During Angel Thunder, Colombian A-29 pilots worked with both JTACs and JFOs from the Marine Corps 2nd Air Naval Liaison Company (ANGLICO) and with A-10 FAC(A)s from the 354th Fighter Squadron 'Bulldogs'. The A-29s flew mainly in the Tombstone military operations area, in a scenario described by Captain Cavazos as "a war between East and West, in which the bad guys are winning and where things are only going to get more difficult." The A-29 crews practiced both RESCORT with the Bell 212 and responded to CFFs from the ANGLICO Marines, as well as the FAC(A)s in the A-10s. The exercises grew more complicated as the week went on, with 'downed' pilots, aborted helicopter missions and enemy ground fire from different locations introduced. They culminated in a scenario during which the A-29 pilots had to respond to multiple CFFs while protecting a helicopter during its entry, pick-up, and eventual exit, as well as defending survivors and para-rescuemen on the ground and ensuring that neither they nor other pilots in the squadron were shot down.

Summarising the lessons learned by the A-29 and Bell 212 crews during Angel Thunder, Cavazos reported that they had learned to work as a joint rescue force: "Of course there have been difficult and frustrating moments, but it has been really positive. They now have a concept that they can chisel and mould into their own. Now it's up to them to take it further, to start thinking tactically so they can improve on what we've taught them, get out there and practice, and adapt it to their environment." ●

EMB-314 (A-29) Super Tucano

Engine	One Pratt & Whitney Canada PT6A-68/3 turboprop, rated at 1,600shp (1,193kW) turning a five-blade Hartzell variable-pitch propeller
Length	37ft 4in (11.38m)
Wingspan	36ft 6.5in (11.14m)
Height	13ft 1/4in (3.97m)
Weight, empty	7,054lb (3,200kg)
Max take-off weight	11,904lb (5,400kg)
Max rate of climb	3,241ft/min (988m/min) at sea level
Max speed	301kts (557km/h) at FL200
Max cruising speed	286kts (530km/h) at FL200
Service ceiling	35,000ft (10,670m)
Max range	846nm (1,568km) at FL300, with max fuel, 30 min reserve
Max external load	3,417lb (1,55okg)



BELOW • ***A Colombian Super Tucano, armed with three Indumil IMC Xué 250lb (113kg) free-fall bombs, ready for a mission at Apiay Air Base. Colombia's aircraft have seen considerable combat use since they were delivered from late 2005.*** SANTIAGO RIVAS

The C-390 – New Millenni

Rodrigo Rodríguez Costa, Nigel Pittaway and David Willis review the development of the Embraer KC/C-390 and the air arms that have ordered it.



Jet-powered military transports are a relatively rare breed. The vast majority of air arms rely on turboprop aircraft for the bulk of their medium-lift capability and, until recently, options for anything else were severely limited. This changed following the launch of the Embraer KC-390, designed to meet Brazil's requirement for a new transport and about to enter service with two NATO air forces.

Embraer conducted a market assessment for a transport aircraft in the same class as the Lockheed C-130 Hercules during 2005. Design studies began the following year. While it was originally intended to create a new airlifter by mating a new fuselage to the wings and other systems of the Embraer 190 family, as work progressed attention turned to a design that owed little to the airliner. The C-390 was announced in April 2007, initially with a low set horizontal tailplane, which was soon replaced in the artist's impressions by a T-tailed aircraft. The designation was

ABOVE • ***The Embraer KC-390 is one of the few medium jet transports ever designed, and the only one to enter production in the west. It is also the largest military aircraft ever built in South America.***

Brazil's um

later changed to KC-390 to emphasise the aircraft's potential as a tanker, one of several different roles for which it was proposed that the aircraft would undertake. From the outset, Embraer designed the aircraft as a multi-mission platform, as in addition to air-to-air refuelling it was envisaged for aerial firefighting, search and rescue (SAR) and medevac, using equipment kits that it says can be installed in under three hours.

A development contract for the KC-390 was signed with the Força Aerea Brasilera (FAB, Brazilian Air Force) in April 2009. The deal covered the construction of two flying prototypes and single examples of the airframe for static and fatigue tests. As part of the contract, the two prototypes were to be refurbished and handed over to the FAB after development was

complete. Shortly afterwards strategic industrial partnerships were signed with Argentina, the Czech Republic, and Portugal for the manufacture of subassemblies and components.

A preliminary design review, in partnership with the FAB, was undertaken at Embraer's Eugênio de Melo engineering facility on the outskirts of São José dos Campos, which was concluded in September 2012. It was followed by the critical design review (CDR) in March 2013. The president and chief executive officer of Embraer Defense and Security at the time, Luiz Carlos Aguiar, told reporters: "The project has firmly and consistently moved forward, and now we have concluded the CDR we are ready to begin discussions with potential customers of the aircraft." At the Paris Airshow at Le Bourget in June 2013, Embraer announced it was partnering with Boeing to sell and market the KC-390, whereby the US giant would be responsible for sales, sustainment and training opportunities in the United States, the UK and select Middle East markets.

Embraer and the FAB subsequently signed the first acquisition contract, valued at BRL7.2bn (US$1.34bn) for 28 aircraft, at the manufacturer's Gavião Peixoto production facility and test airfield in São Paulo State on May 24, 2014. It coincided with the opening ceremony for a new final assembly hangar.

Inside the KC-390

Designed around a core military airlift requirement, the KC-390 is a high-wing, T-tailed aircraft with a rear cargo ramp and an uncluttered internal cargo bay. Constructed largely of traditional materials, it is in the same class of transport aircraft as the Lockheed Martin C-130J Super Hercules, currently in production in the United States.

Two IAE V2500-E5 turbofan engines, similar to those installed on some Airbus A320 family airliners, each rated at 31,330lb (139.4kN) thrust, power the KC-390 to a maximum cruise speed of 470kts (870km/h) or Mach 0.80 and a service ceiling of 36,000ft (10,972m). Embraer claims that by choosing turbofan engines instead of turboprops the KC-390 has greater efficiencies, due to a higher cruise speed and operating altitude.

The flight control system is fully fly-by-wire (FBW), with active sidestick controllers. Core avionics systems include the Rockwell Collins Pro Line Fusion flight deck, similar to that of the Boeing 787 airliner, and a Selex Gabbiano T-20 tactical radar. The flight deck is fully night-vision goggle compatible and the standard crew has two pilots and a loadmaster.



ABOVE • ***The first prototype had the flags of Brazil, Argentina, Portugal, and the Czech Republic painted in front of the crew door, the countries involved in the KC-390 production programme.***

An optional self-protection suite is available, including an Elbit radar warning receiver, laser warning receiver, missile approach warning system and directional infrared countermeasures in the tail cone, together with 14 chaff and flare dispensers and additional ballistic protection.

Embraer claims the aircraft can carry a maximum concentrated payload of 26,000kg (57,320lb), with a distributed payload of up to 23,000kg (50,700lb).

BELOW • ***The C-390 underwent several changes in its configuration before the design freeze. This illustration shows the original rear fuselage and tailplane configuration, similar to those of the Embraer 190.***

It states that the KC-390 is capable of hauling seven 463L pallets, including two on the ramp; or six pallets and 36 troops; or 80 troops (66 paratroopers).

Although the wing centre fuel tank reduces cargo bay height aft of the wing from 3.2m (10ft 6in) to 2.95m (9ft 8in) at the centre section, the rest of the cargo bay is unencumbered by the structure. It is 12.7m (47ft 8in) long – 18.5m (60ft 8in) including the ramp – and 3.45m (11ft 4in) wide. According to Embraer, loads include a Rheinmetall Boxer 8x8, GDLS Stryker (with armour), LAV (with turret) or one BMP-3 infantry combat vehicle. Alternatively, two 20ft (6.1m) ISO containers or one Sikorsky S-70 Black Hawk helicopter (disassembled for



transportation) can be carried. Electrical power and provision for oxygen is provided to support the medevac role, for which the FAB required a capacity of 74 stretchers and eight attendants.

With a 23,000kg (50,700lb) payload, brochure figures give a range of 1,520nm (2,815km) and an empty ferry range of 3,310nm (6,130km). Using Geneva in Switzerland as an example of a starting point, the KC-390 is capable of transporting 23,000kg (50,700lb) to anywhere in the UK or Ireland, or 14,000kg (26,455lb) to either Dakar in Senegal or Muscat in Oman.

ABOVE • ***Collins Aerospace Pro Line Fusion avionics, with five screens, form the core of the KC-390's cockpit avionics, while each pilot is provided with a head-up display.***

BELOW • ***The first prototype KC-390 made its maiden flight on February 3, 2015.***

To meet the FAB's requirement for a C-130 replacement, the KC-390 had to operate from a variety of locations, from unpaved austere airfields in the Amazon region to ice runways in Antarctica, as well as being capable of lifting 12,000kg (26,455lb) of cargo over 500nm (925km) from a 4,000ft (1,220m) long semi-prepared runway.

Optional roles include probe and drogue air refuelling of both fixed- and rotary-wing aircraft, using removable Cobham 912E wing-mounted aerial refuelling pods. Up to three optional fuel tanks can be installed in the cargo bay for the air-to-air refuelling role, controlled by an auxiliary crew station on the flight deck, which is not part of the aircraft's basic specification, but can be installed on the production line if requested by the customer.



The auxiliary crew station can also be used to display information from a Rafael Litening II electro-optical/infrared (EO/IR) pod mounted under the forward fuselage when the aircraft is used in the SAR configuration.

Production Team

Final assembly of the KC-390 is undertaken at Gavião Peixoto by Embraer. Embraer is also the design authority, responsible for development and certification, management, integration, structural and final assemblies, as well undertaking production in Brazil of the forward fuselage, rear fuselage (one structure), engine pylons, air-to-air refuelling pods, vertical stabiliser leading-edge, tail boom, wing tips, landing gear, and tubing and wiring.

In addition, strategic agreements signed with Argentina, the Czech Republic, and Portugal mean a significant percentage of each KC-390 is manufactured outside Brazil. At Évora in Portugal, Embraer Metálicas produces wing skins and vertical stabiliser boxes, while Embraer Compósitos supplies the horizontal stabiliser. OGMA-Industria Aeronautica de Portugal SA at Alverca (which is 65% owned by Embraer), together with engineering support from Empresa de Engenharia Aeronáutica (EEA), supplies centre fuselage panels, landing gear sponsons, main landing gear doors and elevators.

Fábrica Argentina de Aviones SA of Argentina manufactures the cargo door, tail cone, nose landing door, flap fairings, spoilers, and the forward bay racks to house electronics. In the Czech Republic, Aero Vodochody is responsible for the cargo ramp, a second rear fuselage structure, emergency doors/hatches, wing fixed leading-edges, and crew and jump doors.



ABOVE • ***Like nearly every military aircraft programme today, the KC-390 involves many different partner companies. This diagram shows the workshare for the programme, as well as the number of aircraft the countries intended to order.***

Roll Out

The first prototype, PT-ZNF (msn 390001), was rolled out at Gavião Peixoto on October 21, 2014, in the presence of the new president and chief executive officer of Embraer Defense & Security, Jackson Schneider; the Brazilian Minister of Defence, Celso Amorim, and the commander of the FAB, Lieutenant-Brigadier General Juniti Saito. At the event, Jackson Schneider said: "This significant milestone for the KC-390 programme demonstrates Embraer's ability to manage such a complex and high-technology project and to perform it to schedule. It paves the way for the beginning of the ground tests in preparation for the first flight."



BELOW • ***The first prototype landing at Gavião Peixoto, where the aircraft is assembled and the base for the flight test programme.***

On February 3, 2015, the prototype lifted from Gavião Peixoto's 5,000m (1,524ft) long runway on its maiden flight. The flight lasted 85 minutes and was performed by Embraer test pilots Mozart Louzada and Marcos Salgado de Oliveira Lima, with flight test engineers Raphael Lima and Roberto Becker onboard.

After the flight, Mozart Louzada said the aircraft performed in accordance with Embraer's computer modelling and testing – which included the use of a non-motion cockpit engineering simulator and iron bird test rig – validating the maturity of the ground test process. He said: "The aircraft behaved in a docile and predictable manner. The advanced fly-by-wire flight control system and avionics make flying easy and render a smooth and precise flight."

At the time of the maiden flight, Brazil was in the midst of a financial and political crisis, which impacted the KC-390 programme. The aircraft was grounded for many months after the first flight, which substantially delayed the test effort, as funding



dried up. However, in August 2015 the air force signed an agreement with Embraer covering a schedule of payments for the US$270m of debt accumulated by the KC-390 programme (US$1.8bn was allocated for research and development of the aircraft). With this in place, Embraer was able to commit itself to resuming testing of the aircraft and the second flight, after a nine-month hiatus, was completed on October 26, 2015. At the same time, the planned service entry with the FAB was pushed back from 2016 into 2018.

Flight Test Campaign

The initial phase of the flight test campaign undertaken by the first KC-390 sought to expand the aircraft's flight envelope to its maximum speed and altitude. Trials of the definitive fly-by-wire control system, with sidestick controllers linked and active, were conducted in October 2015.

ABOVE • ***The large windscreens provide an excellent view out, while also making the aircraft appear smaller than it actually is for the observer outside.***

The second flight test aircraft (PT-ZNJ, msn 390002) made its maiden flight at Gavião Peixoto on April 28, 2016. Such was the confidence in the FBW system that the second prototype flew for the first time in the normal mode, rather than the direct mode used by the initial aircraft. The second prototype was initially used for performance evaluation of the V2500-E5 engines, before moving on to role-specific testing. Both aircraft were configured with test instrumentation so that either could perform any flight test role, if required.

Two airframes were built in addition to the flying prototypes, exclusively for use in ground tests, with msn 390801 completed by November 2016. It was used for structural static tests, including wing loading trials. The fourth KC-390 airframe, msn 390802, was completed in 2017 and became the fatigue test airframe.

BELOW • ***The initial prototype was fitted with a trailing static pressure sensor at the top of the tail during early flights, to calibrate the aircraft's flight instruments.***

The flight campaign continued in 2016. Cross wind tests were conducted at Punta Arenas in Chile and Rio Gallegos in Argentina. The rear loading ramp and the opening of cargo doors in flight was tested in April 2016. Confidence in the maturity of the aircraft was such that Embraer flew the aircraft to the United Kingdom in July 2016 to attend the Farnborough International Air Show.

The first prototype departed Embraer's headquarters in São José dos Campos and routed via Recife, Sal in Cabo Verde Islands, and Alverca in Portugal, before arriving at Farnborough, where it was displayed on the ground. After the show, the aircraft was used for a limited demonstration tour that took it to Odolena Voda in the Czech Republic, Cairo in Egypt (for a technical stop) and Abu Dhabi. During the trip Embraer reported that the KC-390 displayed 100% availability over the 16 planned flights, operating in surface temperatures of up to 45°C (113°F). The return trip to Brazil included a technical stop in Malta. By the time it arrived home on July 28, the prototype had flown more than 16,300nm (30,200km) in 23 days and accumulated over 48 flight hours.

Certification trials loading the main types of vehicles to be carried by the KC-390 began in May 2017. Among the vehicles involved were the Chivunk, a Brazilian 4x4 fast attack vehicle; the Guarani armoured personnel carrier; M113 armoured vehicle, and AP-2A firefighter truck. On June 16, just a few days before the 2017 Paris air



show – at which the KC-390 appeared in the flying display – paratroopers and cargo were dropped from the rear ramp.

Tribulations

On October 17, 2017, the first prototype experienced a lucky escape during icing tests, while flying slowly at 20,000ft (6,096m). While attempting to return to cruise speed the aircraft entered an uncommanded, extremely rapid descent – reportedly up to 31,000ft/min (9,449m/min) – from which the pilots were only able to exit at 3,100ft (945m). The flight test programme was paused while the incident was investigated. Although Embraer has not commented on the cause of the incident, it was reported that test equipment came loose during the flight and slid aft, moving the centre of gravity to an almost unrecoverable position. Embraer stated that the aircraft was not structurally damaged, and it returned to flight after some external damage caused during the dive and recovery was repaired.

On May 5, 2018, the first prototype was involved in another serious 'incident'. The aircraft suffered a runway excursion accident during a ground test at Gavião Peixoto Airport, coming to rest around 260m (853ft) beyond the end of runway 20. The flight test crew escaped from the aircraft without any injuries. Embraer reported that the aircraft received extensive damage to each of the three sets of landing gear, as well as damage to the structure of the fuselage. It never flew again.

BELOW • ***Embraer designed the KC-390 for a variety of missions, including fire-fighting using roll-on roll-off systems.***

Certification

Initial operational capability (IOC) for the KC-390 was announced on December 20, 2017. For the KC-390, IOC meant that the aircraft had met standards set by both the FAB and the Agência Nacional de Aviação Civil (ANAC, the National Civil Aviation Agency), which had awarded it a





LEFT • ***An artist's impression of an electro-optical/infrared pod fitted to the pylon under the front fuselage.***

provisional type certificate. Full certification by the ANAC was achieved in late October 2018, and a ceremony was held to mark the occasion, attended by the Brazilian president, minister of defence and air force commander, in addition to Embraer executives.

The first production aircraft flew on October 9, 2018, joining the surviving prototype in the flight test campaign as a replacement for the lost prototype. During 2019 the KC-390 underwent certification tests for various missions, such as dropping cargo, operations from rough airstrips, and flight refuelling.

The KC-390 first carried refuelling pods in May 2016, when Cobham 912E units were installed on the first prototype. High- and low-speed drogues were flown to confirm that the hose was stable once deployed and trailing and rewinding tests undertaken. The 912E pod is a bespoke design for the KC-390, using the latest technology to meet the aircraft's high performance criteria, and compatible with a wide number of receivers at extended ranges. The FAB was the launch customer for the tanker capability for the aircraft.

Dry-contact air-to-air refuelling trials, with the KC-390 connecting to an Embraer-upgraded Northrop F-5M Tiger II, were originally conducted on February 19, 2017, near the Santa Cruz Air Base. By then, the aircraft had already demonstrated its ability to refuel low-speed aircraft, such as helicopters and transport aircraft, including other KC-390s. Final qualification for the KC-390 to refuel other KC-390s was announced on April 1, 2021, after a final series of flight tests that involved FAB pilots and engineers from Embraer's Gavião Peixoto site.

The test campaign for gravity airdrops and extraction of heavy loads using the aircraft's Container Delivery System (CDS) and Low Velocity Air Drop (LVAD), concluded in December 2019. The aircraft has an automated cargo handling and aerial delivery system in the cargo compartment, operated by a loadmaster. A system known as CCDP (Continuously Computed Drop Point) calculates the optimum airdrop release point for the pilots. Both systems were developed by Embraer.

The tests were conducted by Embraer in co-operation with the FAB and Brazilian Army, and testing took place at the US Army Yuma Proving Ground in Arizona. Notable achievements during the campaign were the airdrop of a single maximum platform with a weight of 19 metric tons (42,000lb), as well as the sequential aerial delivery of two platforms weighing 24 metric tons in total. During the 2019 airdrop campaign the KC-390 also demonstrated the delivery of several containers at once, with up to 24 dropped in one pass, and delivery of multiple Type V platforms using extraction parachutes. Altogether the KC-390 dropped 330 metric tons.

Additional achievements included the sequential aerial delivery by extraction of up to four platforms in one pass; airdrops using two 28ft (8.53m) extraction parachutes with the autopilot engaged; and demonstration of the accuracy of the CCDP for both gravity and extraction airdrops. The most demanding airdrop conditions were performed without pilot intervention (with the fly-by-wire sidesticks in a neutral position).

First Delivery

The KC-390 was designed with the requirements of the FAB in mind. It currently has the largest fleet on order and became the first air force to put the transport into service. The FAB signed a letter of intent for 28 aircraft in July 2010. A series production contract for all of the aircraft was agreed on May 20, 2014, of which six would be configured as tankers, while both prototypes would be refurbished and delivered to the air force. Handover of the first was expected in 2016, with an initial operating capability to be achieved with four or five aircraft in early 2017. The last would be delivered in 2026. This optimistic plan was later overtaken by events and subsequently revised.

The Primeiro Grupo de Transporte de Tropa (1º GTT, First Troop Transport Group) 'Esquadrão Zeus' was activated under Ala (Wing) 2 at Anápolis, Air Base in the mid-western state of

BELOW • ***Search and rescue is another of the roles that the KC-390 was designed to undertake, equipped with an EO/IR pod. The aircraft is able to deploy rescue personnel by parachute.***





Goiás, during 2018, in anticipation of becoming the first operational unit of the FAB to receive the aircraft. In April 2019, the chairman of the Co-ordinating Committee of the Combat Aircraft Program (COPAC), Air Brigadier Marcio Bruno Bonotto, spoke about the FAB's preparations to receive the KC-390. "We are finishing initial preparations for Ala 2 to receive the aircraft, with commissions analysing the receipt of the first aircraft and finalising maintenance and pilot training sessions. The certification test campaign continues until 2020 to release the aircraft's capabilities and meet the needs of the FAB." Crew training by the FAB on the KC-390 started in June 2019.

Embraer officially delivered the first KC-390 to the FAB on September 4, 2019. The aircraft (msn 3900004) made its first flight in late May 2019 as PT-ZNX, before receiving the military serial 2853. It had arrived at Anápolis on September 1. "The incorporation of the KC-390 into the Brazilian Air Force is a milestone in military aviation," stated the commander of the FAB, Lieutenant-Brigadier Antonio Carlos Moretti Bermudez.

The transport was the fourth KC-390 built and the second series production example, as the first (2852/PT-ZNG, msn 3900003) was retained by Embraer for use in the flight test campaign alongside the second prototype, replacing the initial prototype after it was badly damaged on May 5, 2018.

In order to maximise the operational availability of the KC-390 fleet to fulfil its missions, the FAB and Embraer Services & Support signed a comprehensive five-year services and support contract. Under the agreement, Embraer's service provider TechCare became responsible for logistical and engineering support, maintenance control, component repair, support staff for the aircraft's entry into service and materials supply, plus an additional package that included structural analysis, maintenance bulletin development, and aircraft painting, among other services.

ABOVE • ***Assembly of a KC-390 at Embraer's facility at Gavião Peixoto.***

BELOW • ***The first prototype trailing hoses from the underwing Cobham 912E refuelling pods.***

In Service

The second KC-390 for the FAB was delivered to Anápolis on December 13, 2019. It was joined by the third on June 27, 2020, and the fourth by the end of the year. On the early morning of January 12, 2021, KC-390 2855 (msn 3900006) departed Anápolis





for Alexandria Airport in Louisiana, with stops at Boa Vista and in Puerto Rico. The flight marked the start of the aircraft's participation in its first international exercise. 'Culminating' was a combined training exercise involving the Brazilian Army's Airborne Rifle Company and United States troops held at Fort Polk, which included airborne operations. The exercise continued until February 22.

By April 2021, the four KC-390s (2853 to 2856) delivered to the FAB had accumulated 2,500 flight hours in service. The aircraft were used to transport aid to Beirut in the Lebanon following the explosion of a huge stockpile of ammonium nitrate in the Port of Beirut on August 4, 2020. The transport was also used to deliver emergency aid to Haiti in August 2021, after that country suffered a devastating earthquake.

By November 2021, the fleet had flown over 4,100 hours, including extensive use transporting equipment and medical supplies across Brazil urgently needed to address the COVID-19 situation in the country. Since the beginning of the COVID-19 outbreak, the FAB has operated the KC-390 on logistical air transport missions, carrying tons of essential supplies to fight the pandemic in Brazil. Jackson Schneider confirmed the role played by the aircraft during the pandemic: "The airlifter has played an extremely important role in a series of humanitarian missions within the Brazilian territory and even abroad." Speaking about the delivery of the fourth aircraft in late 2020, the commander of the FAB, Lieutenant-Brigadier Antonio Carlos Moretti Bermudez, stated that: "This platform has already demonstrated great capacity, mainly in the transport of supplies and materials during Operation COVID-19."

ABOVE • ***The view from a Northrop F-5M Tiger II fighter conducting dry-contact trials of the aerial refuelling system.***

The fifth KC-390 was delivered to the FAB before the end of the 2021, and in December the transport was used to support Brazil's Antarctic programme for





the first time. Between December 13 and 15 the aircraft carried both equipment and personnel between Brazil and Punta Arenas in Chile on the third logistical support flight for *Operation Antarctica XL*. Seven researchers and 16 members of the 'Polaris' Base Group were ferried to Chile for onward transfer to the Comandante Ferraz Antarctic Station, where they will remain for 13 months. At that point, the KC-390 had yet to be certified for operations from the ice runway in Antarctica.

In response to Russia's invasion of Ukraine on February 24, 2022, the FAB placed two KC-390s on standby, ready to conduct an emergency evacuation of Brazilians from Ukraine. According to the Brazilian government, it asked around 500 Brazilians in Ukraine to contact its embassy in the country. A FAB spokesman stated: "Under the guidance of the Ministry of Defense and co-ordination of the Ministry of Foreign Affairs, we put two KC-390 Millennium aircraft on standby for the possible transport of Brazilians evacuated from Ukraine." On March 7, a KC-390 departed for Warsaw in Poland carrying humanitarian aid donated by Brazil, carrying Brazilian citizens home on the return flight.

ABOVE • ***Tests to confirm the safe exit of parachutists from the rear ramp were undertaken using the second prototype KC-390.***

BELOW • ***The second prototype joined the flight test programme on April 28, 2016.***



Questions about the eventual size of the FAB's KC-390 force were first raised in May 2021, when the government indicated that it could reduce its order for 28. At the time Jackson Schneider reported that: "We have not been formally notified by the federal government, so we cannot comment on any specific point at this moment. What we can reinforce is Embraer's commitment to the KC-390/C-390 Millennium project, as well as its belief in the export potential of this product."

By November 2021, the FAB said it would cut its order to just 15 KC-390s. However, on February 9, 2022, Embraer announced that a deal had been reached with the FAB for it to reduce its order by just six, to 22 aircraft, and to add compensation clauses to the contract. The move decreased Embraer's order backlog by $500m. It was also reported that deliveries were to be stretched out, with the final aircraft for the FAB due to be handed over in 2034, instead of 2027 as originally expected. While the reduced production tempo will add costs to the programme, it means that the assembly line will remain open for another seven years, increasing the window for Embraer to secure additional customers for the transport.

Export Potential

When Embraer launched the KC-390 it envisaged a potential market of 728 aircraft in 77 countries. The company expected to be able to sell between 140 and 210 KC-390s, primarily as replacements for C-130 Hercules. Early interest in the aircraft was expressed by Correios, the Brazilian postal service, which wanted five in 2007 to replace commercial freight services. Although this was increased to 15 in May 2011, no further progress was reported, and Embraer was not expecting to sign an order by 2016.

The potential of an order by France was mooted in the late 2000s, linked to the prospects of the Dassault Rafale being selected for Brazil's F-X fighter requirement. The rival Saab JAS 39 Gripen proposal was supported by an offer to evaluate the KC-390 as a potential TP84 (C-130H) replacement for the Swedish Air Force in late 2009. The Gripen was eventually selected for Brazil's F-X and although a KC-390 prototype was demonstrated at Gothenburg in Sweden in June 2017, the decision was taken to update the Hercules instead.

Three South American nations confirmed interest in the transport during 2010, with Argentina looking at six in October, Chile six in August and, in September, Colombia stating it intended to order 12. Also in September 2010, the Czech Republic expressed a need for two KC-390s. All four countries later signed letters of intent for the aircraft, along with Portugal, which wanted six.

Embraer began marketing the KC-390 to potential customers in Europe, the Middle East, and Latin America on April 9, 2013. The KC-390 was also offered to Canada for its Fixed Wing Search and Rescue (FWSAR) requirement, equipped with an electro-optical/infrared pod and a search radar that, although mounted in the nose, could provide 360° coverage. The contract was eventually won by the Airbus Defence and Space C295W, which was announced as the winner by the Canadian government on December 8, 2016.

Five KC-390s were offered to New Zealand after it released a request for information for a strategic and tactical airlift capability to replace its elderly ✈

C-130H and Boeing 757 transports. The Royal New Zealand Air Force Future Air Mobility Capability requirement sought delivery of the first aircraft by February 2020 and an initial operating capability a year later. An order for five Lockheed Martin C-130J Hercules was announced in June 2020.

The Royal New Zealand Air Force also had another requirement for a future air surveillance capability (FASC) platform to replace its Lockheed P-3K2 Orions. Fernando Ribeiro de Queiroz said Embraer proposed a maritime patrol version of its E190-E2 airliner for the FASC competition. He also stated that if the technical requirements were relaxed slightly, it could offer a KC-390 with a nose-mounted search radar and palletised mission system. New Zealand eventually opted for the Boeing P-8A Poseidon.

Portugal

The first export customer was the Força Aerea Portuguesa (Portuguese Air Force), making good on its original letter of intent for six aircraft. Portugal announced plans to acquire five, plus an option for a sixth, on June 11, 2017, and on July 11, 2019, confirmed purchase of "five KC-390 airframes, along with logistic sustainment services for the aircraft, its flight simulator and the acquisition of electronic warfare equipment." A formal contract signing ceremony was conducted at Évora on August 22, 2019. Commenting on the deal at the event, Jackson Schneider, president, and chief executive officer of Embraer Defense & Security, stated: "This is the high [point] of a careful selection process that makes us proud, representing the entry of the KC-390 into the international market. The KC-390 will meet Portugal's operational needs, ensuring the ability to integrate with allied nations for decades to come."

"This contract strengthens the industrial partnership between Portugal and Embraer," continued Jackson Schneider, "contributing to the development of the engineering and aeronautics industry in Portugal." Portuguese industry has been involved in the KC-390 since signing a declaration of intent on September 10, 2010, to confirm participation in the programme. It participated in the design phase, while a substantial percentage of the airframes' components (sponsons, central fuselage, and elevators) have been produced by OGMA at Alverca since 2013 and Embraer´s Portuguese branch in Évora (wing skin and horizontal stabilisers). OGMA is also slated to become the European maintenance centre for the KC-390. The Portuguese Government invested some €EUR50m in the development programme between 2012 and 2017, which was closely monitored by Portuguese Air Force officers.

The KC-390s will be used to replace the four operational C-130H Hercules operated by Esquadra 501 from Air Base 6 at Montijo. Portugal intends to use them primarily to transport cargo, passengers, and paratroopers, but the aircraft will also support search and rescue and casualty evacuation missions, while secondary roles will include air-to-air refuelling and firefighting missions. The C-130 fleet will receive minor upgrades – mainly concerning navigation and communications systems – to keep them viable until the KC-390 becomes operational. The Portuguese government also considered dedicating the C-130s to the firefighting role once the KC-390s assume the transport role.

It was originally expected that the aircraft would achieve its initial operational capability at the end of 2021, but negotiations between



ABOVE • ***Different payloads were airdropped by the KC-390 during a series of tests that were eventually concluded at the end of 2019.***

BELOW • ***An artist's impression of a KC-390 departing a rough airstrip.***





Embraer and Portugal took longer than expected and delivery of the initial KC-390 was pushed back to February 2023. The remaining aircraft are expected to arrive at the rate of one a year, with the last due to be delivered in 2027. While no delay to the schedule of the Portuguese KC-390 programme arising from the COVID-19 pandemic has been revealed, it is possible that delivery dates have been revised slightly.

During October 2020, teams from the Portuguese armed forces and Embraer concluded the Critical Design Review (CDR) for the KC-390 configuration ordered by Portugal. CDR defined the aircraft's technical requirements according to FAP demands, enabling Embraer to finalise the configuration of the aircraft. Assembly of the first aircraft was underway in late 2021, with 'power on' for the first achieved at the Gavião Peixoto factory on September 21.

The achievement was closely monitored by the FAP KC-390 programme's Missão de Acompanhamento e Fiscalização (MAF, Monitoring and Inspection Mission), a multidisciplinary team of Portuguese military personnel comprising FAP crews, engineers, and maintenance technicians. The first aircraft – serial 26901 – was already structurally complete and painted in FAP colours and markings by the time of 'power on'. The MAF team at Gavião Peixoto will monitor the production and testing activities for all five aircraft ordered by Portugal. In preparation for receiving the first aircraft, a FAP crew of two pilots and two loadmasters began training on the KC-390 on September 14, 2021, with 1° GTT of Ala 2 at Anápolis.

SkyTech

On February 6, 2018, the opening day of the Singapore Airshow, Embraer revealed it had received a letter of intent for up to six KC-390s from SkyTech, a civilian aviation services company partnership between HiFly of Portugal and Adagold Aviation Services of Australia. The company currently uses a fleet of Airbus A320s, A330s and A340s for military and cargo transport operations, as well as providing other services. The KC-390s were intended to be used for multiple defence projects.

SkyTech and Embraer also agreed a potential strategic collaboration to jointly explore new business opportunities. According to SkyTech's president, Paulo Mirpuri: "We have been following the KC-390 programme since its inception and believe it will be a game-changer in the medium-sized airlift category, as well as a multi-role platform." However, no further details of SkyTech's interest in the KC-390s – such as a firm order – had been revealed by early 2022.



RIGHT • ***Embraer offered a KC-390 equipped for search and rescue to Canada as a replacement for its last de Havilland Canada CC-115 Buffalos. The aircraft was not down-selected for the requirement.***

BELOW • ***The initial task of the first prototype was to confirm flight characteristics and expand the flight envelope. It is seen here during high angle-of-attack trials, fitted with tuffs on the upper surfaces of the wing to allow the airflow to be visualised.***



Vexed Partnership

Embraer and Boeing originally signed an agreement to share technical knowledge and market information to support the KC-390 in 2012. As part of a wider partnership, established in February 2019, Boeing agreed to take an 80% stake in Embraer's

commercial airliner business which would form the core of Boeing Brasil-Commercial. The deal was expected to close in June 2020.

A separate arrangement covered Embraer's defence activities, with Boeing to assume a larger role in marketing the KC-390 in America, while plans were also made to help with KC-390 production in the United States. On November 18, 2019, a joint venture known as Boeing Embraer-Defence was announced to promote and market the KC-390, which was henceforth to be known as the C-390 Millennium (with KC-390 retained for tanker-configured aircraft). Embraer was to hold 51% of the new venture and Boeing the rest.

Plans for both Boeing Brasil-Commercial and Boeing Embraer-Defence were unilaterally terminated by Boeing on April 24, 2020, when the US company found itself in the midst of a crisis caused by crashes that resulted in the grounding of the worldwide Boeing 737 MAX fleet. The end of the agreement had an immediate impact on Embraer, which had begun to restructure in line with the new corporate identity. Instead, it had to contemplate 'going it alone' again in the increasingly cut-throat regional airliner market, facing stiff competition for its E2 family after Airbus acquired the CSeries programme from Bombardier. It also eliminated the prospect of being able to rely on Boeing's powerful marketing department to promote the C-390 to potential US and overseas customers.



ABOVE • ***The first prototype taking off from Gavião Peixoto. It was written-off after running off the end of the runway in May 2018.***

Hungary

Embraer's marketing of the C-390 in Europe again bore fruit in late 2020. On November 17, the Hungarian government signed a contract for a pair of KC-390s. In addition, the contract included training for pilots and technicians, as well as other services and support, as part of a programme to strengthen the Hungarian Defence Forces capabilities in the tactical airlift, air-to-air refuelling, and medical evacuation roles, as well as other missions. Deliveries were scheduled to start in 2023 but had been pushed back by one year by late 2021.

BELOW • ***The KC-390 has a hold that is 60ft 8in long, including the 19ft ramp, on which pallets can be transported.***

Commenting on the order, Gáspár Maróth, the Hungarian government commissioner responsible for defence development, stated that: "Following the procurement of personnel air transport capabilities in 2018, we will see the arrival of KC-390 aircraft to Hungary in 2023-24, able to deliver large military loads in an operational environment, as well as providing air-to-air refuelling services. We are acquiring a multi-role transport fleet for the Hungarian Defence Forces to fulfil the widest possible range of tasks within the national framework."

The KC-390s will be equipped with a probe and drogue refuelling system so that they can support the Hungarian Saab JAS 39 Gripen fleet. They will also



Embraer KC-390

Length	115ft 6in 35.20m)
Wingspan	115ft (35.05m)
Height	38ft 10in (11.84m)
Cabin length, including ramp	60ft 8in (18.50m)
Cabin length, excluding ramp	41ft 7in (12.70m)
Cabin width, at floor	11ft 4in (3.45m)
Cabin height, forward cargo hold	9ft 8in (2.95m)
Cabin height, aft cargo hold	10ft 6in (3.20m)
Standard payload	41,888lb (19,000kg)
Max payload	50,706lb (23,000kg)
Max concentrated load	57,320lb (26,000kg)
Max fuel weight	23,900kg (52,690lb)
Max allowable Mach number	Mach 0.80
Max cruise speed	470kts (870km/h)
Ceiling	36,000ft (10,973m)
Range	1,140nm (2,111km) with 26 tonne payload, 1,520nm (2,815km) with 23 tonne payload
Ferry range	3,310nm (6,130km), 4,600nm (8,519km) with tanks in fuselage tanks
Take-off distance	5,000ft (1,524m) with 23 tonne payload
Standard landing distance	3,280ft (1,000m)



ABOVE • ***The KC-390 was designed from the outset to be equipped with a probe to extend its range.***

BELOW • ***The KC-390 provides the Brazilian Air Force with a more modern and capable transport with higher performance than the C-130 Hercules it is replacing in service.***

be the first to incorporate an intensive care unit for the medevac role.

On November 11, 2021, Embraer announced that it had successfully completed the CDR for the Hungarian KC-390 and had begun structural assembly of the first aircraft. A ceremony was held at the company's Gavião Peixoto facility, witnessed by Hungarian government and Embraer representatives, to mark the start of production of the initial aircraft for the country.

Hungary in unlikely to be the last country to replace its turboprop transports with the KC/C-390. Jackson Schneider confirmed in late 2021 that Embraer was engaged in 'meaningful conversations' about the aircraft with several countries, including nations in the Middle East. With many air arms seeking replacements for aging turboprop transports, it is likely that additional orders for the C-390 will be announced in the near future. ●



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E-Jet: Embraer's Graceful Airliner

Bernie Baldwin and Mark Ayton provide an overview of the original E-Jet.

The late 1990s saw several regional aircraft manufacturers studying larger aircraft models. Bombardier had its BRJ-X, Fairchild Dornier had the 728/928 family and BAE Systems was working on the Avro RJX upgrade for its three models – the RJ70, RJ85 and RJ100. Embraer had also been studying this market and decided to launch three four-abreast, narrow-body, short-to medium-range twin engine models carrying 66 to 124 passengers: the ERJ 170, ERJ 190-100 and the ERJ 190-200.

Like the BRJ-X and 728/928, these large ERJs were clean sheet designs, as the ERJ/Brasilia fuselage could not be viably stretched further. However, unlike its competitors, Embraer developed a different solution with respect to the fuselage by creating a 'double-bubble' cross-section.

Customer Input

From a series of airline advisory board meetings came arguably the biggest airline-led decision for the new family. At one point, Embraer had two aircraft designs – a four-abreast family and a five-abreast family (the latter being the choice of Bombardier and Fairchild Dornier). Discussions with some 50 carriers resulted in the majority choosing a four-abreast configuration – a distinction that proves popular with passengers to this day.

Further detailed discussions assisted with decisions in areas such as the avionics. In choosing which type of flight management system (FMS) to offer, the company moved away from a regional aircraft-style FMS after talking with potential customers more familiar with bigger examples.

E-Jet Launch

Although the industry had known of the original three-model programme for a few months, the official launch came on June 14, 1999, at the Paris Air Show, some ten years after the ERJ family's launch at the event. In a packed, airless conference room, Embraer CEO Mauricio Botelho not only unveiled details of the family, but sitting alongside him was Crossair CEO Moritz Suter: the pair announced a launch order from the lauded Swiss carrier for 30 ERJ 170s and 30 ERJ 190- 200s plus 100 options from across the family.

Immediately, this brought forth questions about the short-field performance of the ERJ 170, as services into London City Airport were key revenue providers for the airline and the Embraer aircraft would be replacing Avro RJs on those routes. Luis Carlos Affonso, at that time Embraer's senior vice-president of engineering and new product development, admitted to journalists that the demands were "very stringent", but that the company was confident of meeting the requirements.

Production

Parts for the prototypes and test airframes entered production in July 2000. The first prototype (PP-XJE) rolled out from the São José dos Campos plant on October 29, 2001 and its first flight occurred 119 days later on February 19, 2002, marking the start of a multi-year flight test campaign.

Just prior to the ceremony, it was announced that the ERJ 170 would be known as the Embraer 170 (or E170 for short). The ERJ 190-100 would become the E190, and the E190-200 would be the E195. Additionally, a new model was launched, the E175, a stretch of the E170.

No major roll-out ceremony was held for the E175, but the first aircraft took to the air in June 2003.

The flight test programme for the E-Jet family involved one of Embraer's biggest investments, with a new industrial site at Gavião Peixoto in São Paulo featuring a 16,400ft runway. Alongside the flight

BELOW, OPPOSITE ABOVE AND BELOW • ***E170, E175 and E195 E-Jet models in Embraer's corporate colours.*** EMBRAER S.A.





test centre, manufacturing facilities for both military and business aircraft are now located there. The modern site allowed Embraer to reduce costs by not having to do as much work in the US at specialised airports. Having an airfield close by for flight tests increased the speed of the programme, especially as Gavião Peixoto boasts an average of 360 days of clear weather each year.

Full-rate production at a new factory at the Sao Jose dos Campos base began in 2002.

Further Milestones

February 2004 was a momentous month for Embraer, with the company rolling out the first E190 to much fanfare and, just a few days afterwards, having type certification granted to the E170 by the authorities in Brazil (ANAC), the United States (FAA) and Europe (EASA).

A month later – after being blessed on the tarmac at Warsaw-Chopin – the first E170 to enter service carried fare-paying passengers of LOT Polish Airlines to Vienna on March 17, 2004.

Of the original two launch customers, after its takeover of Swissair, Crossair ceased to exist, and Régional Compagnie Aérienne deferred its order until 2006.

The first US carrier to operate the E170 was MidAtlantic Airways, a subsidiary of US Airways, whose CEO at the time was David Siegel, the man who placed the ERJ 145 order for Continental Express back in 1996.

Following a series of orders for E-Jet family aircraft, Embraer launched the E175 featuring a 5.8ft stretch of the E170 fuselage – its first flight took place in June 2003.

The first deliveries of the other models followed. The E175 entered service in July 2005 with Air Canada, the E190 with JetBlue Airways, also in 2005, and finally the E195 with Flybe in September 2006.

E-Jet to E2

In the early 2010s, new engine variants of the Airbus A320 and Boeing 737 MAX families were being mooted, in particular because of Pratt & Whitney's Geared Turbofan PW1000G family of engines. Once Airbus and Boeing launched their respective NEO and MAX families, the industry looked to Embraer for its response, despite the E-Jets being only seven or eight years old and being the leader in their market segment.

While recognising the value the new engines could bring, the Brazilian company took its time. When a move was finally made, the result was much more than a simple new engine programme. Announced at the 2013 Paris Air Show, the Embraer E-Jets E2 family comprised just three models with the E170 size being dropped. Once again, customer feedback was key to the programme, which led to the E175-E2 having one extra row of seats and the E195-E2 having three additional rows, while the E190-E2's size was kept the same as its predecessor.

The E2 aircraft maintain a common type rating with the original E-Jets (now referred to as the E1s).

Along with the E2 launch, 2013 also saw, on September 13, the 1,000th E-Jet delivery. Republic Airways Holdings is currently the world's largest E-Jet operator, operating 212 190 E170 (62) and E175 (166) aircraft.

The E-Jet's applicability to serve low-demand routes while offering all the mod cons of a bigger jet is a big factor in the type's commercial success with regional and mainline carriers, not least in the United States. ●



Embraer's E2 The New Gen

The popular Embraer E-Jet regional airliner family has been refreshed with more modern versions of the E175, E190 and E195. David Willis describes the E2 series, which is challenging Airbus in the sub-150 seat market.

Family: eration



The prototype of the third and final member of the second-generation E-Jets, the E175-E2, made its first flight on December 12, 2019, at São José dos Campos, Brazil. EMBRAER/ CLAUDIO CAPUCHO

There are two generations of Embraer E-Jets. The first comprises the Embraer 170, 175, 190 and 195 (the -E1 suffix was later adopted) and can be configured for 70-80, 78-88, 98-114, and 108-122 passengers, respectively. The series proved to be popular with the world's airlines: the 1,000th, an E175 for Republic Airlines, was delivered on September 17, 2013, less than a decade after the first entered service.

The second generation, known as the E2, consists of the Embraer 175-E2, 190-E2 and 195-E2. The trend for airliners with a greater passenger capacity eliminated consideration of an enhanced E170; none remained to be delivered in early 2020. Production of both generations continues side-by-side, although the aim is to eventually discontinue the E1 family. That may be some time off, however, as in recent years the E175-E1 has proven popular with US regionals seeking an efficient, three-class, scope-compliant airliner.

Embraer began to consider what would follow the E-Jet in the late 2000s. At the time it was believed that Airbus and Boeing would vacate the sub-150 seat sector of the market towards the end of the decade rather than invest in replacements for the A320 and 737 NG families. This assumption was shattered when Airbus launched the A320neo family – including the 124-passenger A319neo – in December 2010, followed by Boeing with the 737MAX in August 2011. Instead of opting for a new airframe, as Bombardier had with the C Series, Embraer investigated enhancing the E-Jet with the aim of reducing fuel burn by 15%, initially as the E-Jet EV (for evolution) and later G2 (generation two), announcing details of its plan in November 2011. The key to greater fuel efficiency (and



ABOVE • ***The first E190-E2 was handed over to Widerøe on April 4, 2018. It became the first jet to be operated in the Norwegian airline's history.*** EMBRAER





lower maintenance costs, noise, and emissions) was a new engine. Proposals from General Electric (NG34), CFM International (a scaled-down LEAP), Rolls-Royce (based on Advance 2 studies) and Pratt & Whitney (PW1000G family) were evaluated, and selection of the latter was announced on January 8, 2013.

The PW1000G was the first high-powered geared turbofan to be offered on the market. Turbofans normally have their fans/ compressors and turbines on the same shaft, but as the former works best at low rotational speeds and the latter when turning quickly, both sections are outside their optimum operating conditions. A reduction gearbox between the two allows both to rotate at optimum speeds, improving efficiency but increasing complexity. The PW1700G, with a fan diameter of 56in, was chosen for the E175-E2, while the PW1900G for the E190-E2 and E195-E2 have a 73in unit, both larger than the General Electric CF34-10E of the E1s. Ground clearance necessitates an 18in longer trailing-arm main landing gear.

ABOVE • ***Swiss airline Helvetic Airways ordered 12 E2 aircraft (eight E190s and four E195s) and took delivery of the first HB-AZA (msn 19020022) on October 31, 2019. AirTeamImages/Jan Ostrowski***

BELOW • ***Embraer's E2 prototypes have appeared in a variety of liveries with a 'Profit Hunter' branding. The E195-E2 'Tech Lion' was displayed at the Paris Air Show in 2019.*** KEY/DINO CARRARA

New Systems

Embraer took the opportunity to revise many of the structures and systems for the E2s. These included a new wing and a closed-loop fly-by-wire system, adding control of the ailerons to that for the elevators and rudders, and feedback input for the pilots, with full envelope protection in all phases of flight. Honeywell supplied Primus Epic 2 avionics, with four 13x10in screens and head-up display (replacing the five-tube Primus Epic) and a next-generation flight management system. The Pratt & Whitney AeroPower APS2600(E) auxiliary power unit superseded the APS2300.

Unveiling of the new family occurred at the Paris Air Show on June 17, 2013. Lessor ILFC was the launch customer for both the E190-E2 and E195-E2, with letters of intent for 25, plus options for 25 for each. (AerCap Holdings later bought ILFC and relinquished its launch position). SkyWest Inc, parent company of SkyWest Airlines of Utah, assumed lead for the E175-E2, ordering 40 plus 60 conditional and purchase rights for 100 more.

The E190-E2 (known for certification purposes as the ERJ 190-300 STD) was the initial focus of the development programme. The prototype (registration PR-ZEY) rolled out at São José dos



Campos on February 25, 2016, and Captain Mozart Louzada, first officer Gerson de Olivira Mendes, and flight test engineers Alexandre Figueiredo and Carlos Silveira, made its first flight over 3hrs 20mins on May 23. It was joined by the second (PR-ZFU) on July 8 and third (PR-ZFV) on August 27, all three carrying test equipment to record various parameters of the flight envelope. The fourth (PR-ZGQ), fitted with a full passenger cabin, joined the flight test campaign on March 17 the following year. Collectively, they accumulated 2,200 flight hours prior to the award of type certification by ANAC of Brazil, FAA, and EASA on February 23, 2018. Flight testing demonstrated a reduction in fuel consumption of 17.3% compared to the E190-E1, which translates to a range increase of 450nm. Embraer soon adopted the tagline 'Profit Hunter' for the E2 family to highlight the savings in operating costs.

The E190-E2 retains the fuselage of the E190-E1, with seating for 97 passengers in a three-class configuration, typically 106 all-economy or 114 in a high-density layout. Embraer updated the 'look and feel' of the cabin for the E2s, installing thinner (by 1in) sidewalls and deeper (by 3in) overhead bins, with space for IATA-standard wheeled cases. New, high-aspect ratio wings – a total of 16ft 1in longer than its predecessor's – have raked wingtips with a marked dihedral that, along with the higher landing gear, provide sufficient clearance for the engine nacelles. Overall, the E190-E2 is only five inches taller than its predecessor. Power comes from a pair of PW1919Gs or PW1922Gs, both rated at 20,305lb at sea level for maximum continuous use but with the latter having more thrust available for take-off, mounted on redesigned pylons. Other changes include single-slotted flaps instead of the double-slotted units of the E1, and doors for the main landing gear. The adoption of a full fly-by-wire control system allowed the centre of gravity to move slightly aft, permitting a small reduction in the span of the horizontal stabiliser.



ABOVE • ***The prototype E190-E2, PR-ZGQ, in 'Shark' livery completed a world sales tour in December 2018.*** EMBRAER

Stretched 195

The Embraer E195-E2 (ERJ 190-400) accommodates three additional rows of seats, for up to 146 passengers in a single-class, high-density layout, but 132 is more typical, plus a cabin crew of three. The increased capacity was achieved by adding fuselage plugs totalling 9ft 7in to the E195-E1. Initial plans for a common wing for the E190-E2 and E195-E2 were abandoned by early 2016 and a revised design, aerodynamically like that of the E190-E2 but with some structural changes and a new tip, increased span by 4ft 7in. Engine options are the PW1921G, PW1923G or PW1923G-A, all producing 21,805lb maximum continuous thrust with different normal take-off ratings.

BELOW• ***On September 12, 2019, the first E195-E2 was delivered to Azul Linhas Aéreas Brasileiras. The Brazilian low-cost carrier has ordered 51 of the type.*** EMBRAER/SERGIO FUJIKI





ABOVE • ***Air Kiribati took delivery of the first E190-E2 in the Asia-Pacific region in December 2019.*** EMBRAER/ CLAUDIO CAPUCHO

The prototype (PR-ZIJ) rolled out on March 7, 2017, and pilots Márcio Brizola Jordão and José Willi Pirk, along with flight engineers Celso Braga de Mendonça and Marcos Ito, completed the inaugural flight on March 29. It was allocated to aerodynamic and performance evaluation, while the second aircraft, PR-ZIQ, which flew that November 18, was committed to validating maintenance procedures and the cabin fittings. Certification by Brazilian, European, and US authorities, was achieved simultaneously on April 15, 2019. Compared with the E195-E1, Embraer claims a 25.4% reduction in fuel consumption per seat and 20% lower maintenance costs.

Azul Linhas Aéreas Brasileiras was the initial operator, after lessor AerCap received PR-ZUU on September 12, 2019, and handed it over to the airline as PR-PJN, wearing a special 'Company Values' scheme.

Flight testing of the E175-E2 (ERJ 190-500) commenced on December 12, 2019, when the prototype (PR-ZXM) was taken aloft from São José dos Campos, commanded by Captain Mozart Louzada. The first metal, a wing stub, was cut at Embraer's facility at Évora, Portugal in late June 2016 and assembly of the first (of three) prototypes began in April 2019. When the E2 was conceived, airlines wanted aircraft that could take more passengers and Embraer responded with a longer fuselage to accommodate an extra row of seats. It can carry up to 88 passengers in a single-class layout with a seat pitch of 31in, or alternatively 90 with 50 seats at 30in and 40 at 29in pitch. A three-class layout accommodates 80 seats, comprising 12 at 36in three-abreast, and 16 at 34in and 52 at 30in, two each side of the aisle. As business and premium economy seating brings in more revenue than economy, the three-class configuration can be more profitable than higher-density layouts.

Third Version Deferred

On December 1, 2016, Embraer announced it was deferring service entry of the E175-E2 by a year, to the first half of 2021. That target was not met, and in mid-February 2022 the company suspended work on the E175-E2 for another three years with service entry openly targeted for the latter part of the 2020s.

The original decision to defer service entry was triggered by Delta Air Lines pilots' acceptance of a new, four-year contract retaining existing scope clauses. Scope clauses between the pilots' unions and employers limit the number and seating capacity of aircraft that US carriers can outsource to third parties, as well as their maximum take-off weight. American Airlines, Delta, and United Airlines have scope limits of 76 passengers and 86,000lb. When Embraer launched the E175-E2 it gambled these would be relaxed, which has not happened, and it currently exceeds both.

SkyWest Airlines, a Delta regional partner was the original launch customer with a June 2013 order for 100 aircraft and options for another 100, valued at more than US$9bn. The order was cancelled in Q3 2018 when it stood as the sole commitment for the E175-E2. It was removed from Embraer's backlog by September 30, 2018. ●

The Small Airline with The Big Heart

Delivery of the first E190-E2 marks the start of an exciting new chapter for Norwegian regional carrier Widerøe, as James Ronayne found out.



When Widerøe received its first Embraer E190-E2, it was a significant moment in more ways than one. Not only was the Norwegian carrier taking centre stage as the launch operator for the E2 family, but it was also embarking on jet flying for the first time in its history.

Established in 1934, the airline has grown into an integral part of Norway's transport infrastructure, connecting communities big and small across the country. Widerøe conducts more than 450 flights every day, with 40% of its flying on public service obligation (PSO) routes. Norway's geography makes travel by train or road, expensive and time consuming and in some places it's not even possible; the same journey by air can be completed much quicker. Widerøe CEO Stein Nilsen explained: "The route from Bodø to Stokmarknes takes around 20 minutes [flying]; if you drive it takes five hours."

ABOVE • ***Delivery of the first E190-E2 to Widerøe marked the start of jet operations for the first time in the airline's history.*** AIRTEAMIMAGES/KIM VANIK

Reaching these isolated settlements can prove challenging because of the harsh weather and rudimentary airfields that are prevalent in the Arctic Circle but for many people living or visiting these regions, flying is the only option. "We have developed a unique network over decades, serving our customers from nearly every airport in Norway, not because it is easy but because it is an important part of the transportation infrastructure," said Nilsen. "The areas we are flying into



are very specialist. Most of the airports along the coastline require a short take-off and landing [STOL] capability to serve them; some of the runways are down to 2,500ft. This is combined with a tough flight ops environment, which makes it a special network – it is the backbone of the public transportation network in Norway."

Canadian and Brazilian

Prior to the E2's entry to service, Widerøe was an all-Dash 8 operator, flying the -100, -200, -300 and Q400 variants of the Canadian-built turboprop. While the Dash 8-100 plays a key role flying in and out of short landing strips, it lags the E2 in terms of technology, fuel burn and passenger comfort. Therefore, the arrival of the Brazilian-built jet marked a major step change for the airline and its employees and required months of meticulous preparation.

"The E2 represents not only a major change in our service offering but also a massive change to the entire Widerøe organisation," admitted Nilsen.

While the Q400 is much closer to the E2 in terms of modern technology and passenger experience, the difference is still sizeable. Widerøe put the E2 into commercial service on the Bergen to Tromsø route, a journey it can complete 20 minutes faster than the Q400.



ABOVE • ***Embraer employees Ricardo Tadeu Costa and Bruna Marcelino Rosa deliver the ceremonial key to the first jet.*** EMBRAER

LEFT • ***Senior management teams from Embraer and Widerøe celebrate the handover of the first E190-E2.*** EMBRAER

Andreas Aks, Widerøe's deputy COO and the project manager for the E2, revealed: "To benefit the most from the [E2's] fuel efficiency, we will not be flying at full speed. We're going to fly as economically as possible, but it will still lower the flight time a lot compared with the Q400."

Selecting the E2

The airline's decision to acquire the E2 was influenced by two key factors. The first because it fits with the airline's right-sizing strategy, matching the capacity of the aircraft to the demand on a particular route, which Nilsen

admitted was key for making the economics work in the niche markets Widerøe serves.

"What we see in some of our route network is that we need new technology, and we need more seats," Nilsen explained. "The flexibility of Embraer's E2 family was a perfect fit for our strategy and our markets. If you are going to get good economics as a regional carrier you need to have right-sizing."

The second factor in Widerøe's decision to opt for Embraer was to combat Norway's increasingly high taxes, some of which have increased on certain sectors by as much as 70% per passenger. Nilsen explained: "This development has been tough for the shorter routes with the smallest aircraft, and it's been a real challenge to further develop the network in rural areas of Norway. To strengthen profitability and to be able to develop more new offers for the market we needed an aircraft with more than 100 seats." By using a 114-seat E2 instead of a 70-seat Q400, Widerøe lessened the impact of those taxes on air fares by spreading the cost across more passengers per flight.

Spreading its Wings

Widerøe uses the E2 to establish more connections between the west coast of Norway and the far north. The Northern Lights and Norway's natural beauty is fuelling greater demand from tourists on a year-round basis and there are also growing business links between the two regions.

However, at present most passengers must fly into Oslo to connect between the two. Initially the jet was deployed from Bergen on core connections to Tromsø and Bodø.

While the rudimentary facilities in northern Norway will remain the staple of the STOL Dash 8-100s and -200s, some communities are planning bigger airports with longer runways and Widerøe believes the E2 puts it in a good position to take advantage.

"Airport infrastructure in Norway is changing. The number of airports is getting fewer and some of the smaller airports are getting bigger. These are areas and customers that Widerøe knows extremely well. It is also a segment where a new, fast regional jet is perfect. With the E2, Widerøe has a tailor-made aircraft for those markets and is a much better fit than, for instance, the 737 or A320."

Widerøe also uses the Brazilian-built jet in the wet lease ACMI market. The Norwegian carrier secured its first such contract on behalf of Finnair, using an E2 on a daily service between Bergen and Helsinki.

Widerøe is also using the E2's size for leisure markets, which don't have the demand to fill larger aircraft, such as the Boeing 737 or Airbus A320. It secured its first contract for a tour firm, connecting Bergen to Antalya, Turkey.

Passenger Experience

Widerøe says its cabin is designed for 'Generation Z'. Nilsen expanded: "It is set up to create a new customer in-flight experience, taking the digital age into aviation for real."

The carrier opted to configure its aircraft in a high-density, 114-seat layout with a 29in pitch. Each seat has a tablet holder and high-voltage power outlets so passengers can bring their own devices on board and keep them charged. Widerøe said it chose traditional power sockets because the fast-changing nature of USB technology means such ports will soon be obsolete.

Discussing the high-density configuration, Andreas Aks said: "We spent a lot of time with Embraer producing the newly developed seats with increased leg room. I think they've done a really good job, making the seats from stronger, thinner materials and creating as much space as possible. What I find when I sit on the aeroplane is that it is surprisingly good for a 29in pitch. We've succeeded in producing a product that is efficient yet comfortable."

Widerøe selected a high-speed internet package from Panasonic. Aks



BELOW • ***Stein Nilsen (third left), John Slattery (centre) and Carol Benzie, managing director, Aberdeen International Airport (third right), pose with cabin crew ahead of the final leg of the delivery flight.*** KEY/JAMES RONAYNE



revealed: “The aircraft is set up, pre-wired and everything was ready for the new Panasonic system.”

Leading the Way

Embraer Commercial Aviation president and CEO at the time, John Slattery invited Widerøe to be the launch operator for the type after visiting Norway and getting a better feel for the airline’s operation, its history, and its capabilities.

Slattery explained: “After spending time with Widerøe, it dawned on me this is not simply an airline; this is a hybrid airline, engine, and airframe OEM [original equipment manufacturer] and MRO [maintenance, repair, and overhaul provider], working in some of the harshest parts of the planet, inside the Arctic Circle. I took many flights on Widerøe as a regular passenger to experience the operation first-hand and I could not think of a customer I would rather have as our launch operator.” Nilsen said the airline was “honoured” and “proud” to be invited and the decision to accept the offer was an easy one to make. ●

BELOW • ***A traditional water cannon salute greeted the aircraft on its arrival at Bergen.*** AIRTEAMIMAGES/KIM VANIK

Helvetic Airways

During and after the Covid-19 pandemic, Andreas Spaeth and Mark Ayton each spoke with Helvetic Airways' CEO Tobias Pogorevc.

An iconic white cross on a bright red background, the Swiss national emblem makes for great branding. Usually only the national carrier will reference a country's flag in its branding, as BA does in the UK, for example. In Switzerland, however, almost every carrier of size puts the national flag on its aircraft tails – regional airline Helvetic Airways is one.

Small But Ambitious

"We are often called the biggest Swiss airline in Swiss hands," joked the CEO, in reference to the national carrier being owned by Germans, while Helvetic is fully owned by Swiss investor/banker Martin Ebner. Despite operating just 16 Embraer regional jet aircraft, Helvetic's achievements are remarkable. By late 2021, the airline was the world's biggest operator of the Embraer E2 family, with 12 brand-new aircraft in service – eight E190-E2s and four larger E195-E2s.

Helvetic embarked on an ambitious fleet renewal programme back in 2018, when it ordered a dozen E2s at the Farnborough Air Show, an investment of approximately US$750m. Helvetic Airways Group owns all 12 aircraft, a rare and privileged position in the airline industry these days.

Not Your Average Airline

Helvetic is unusual in other ways, too. At present, it doesn't offer its own flights on its own network, as was the case before the pandemic, when destinations such as Bordeaux, Kittilä, Olbia, Palma de Mallorca, Shannon, and Tromsø were served from Zurich or Bern. Now it only flies for others. "We don't position ourselves as a low-cost carrier, we offer good quality for a fair price. We have a conservative business model with the biggest part being ACMI [aircraft, crew, maintenance, insurance], wet leasing aircraft and crews to other airlines, then we do charter flying for tour operators," reported the CEO. "We don't currently offer our own flights as we did before the pandemic, when we flew to the Mediterranean, for example."

Instead, Helvetic Airways has another interesting niche: "We play in the Champions League in special charters, quite literally, as we fly many teams to the matches. This part of our portfolio was extremely important in the times of the pandemic, because it generated a lot of business for us and helped us tremendously," Pogorevc said.

Missions and Records

During the pandemic, Helvetic also undertook a mission on behalf of the Swiss foreign ministry, repatriating Swiss citizens from Africa in April 2020. "Not many Swiss lived there, so it wasn't warranted for the ministry to send a wide-body aircraft. With the range offered by the E2, however, we could offer a product perfectly matching the ministry's requirements," explained the CEO. Some tricky flight planning was needed to pull it off, as was the involvement of eight crew members – three pilots, four cabin crew and a mechanic.

First, E190-E2 registered HB-AZB flew empty from Zurich to Accra in Ghana

BELOW • HELVETIC AIRWAYS



in six hours and 22 minutes – one of the longest non-stop flights for this aircraft type. There, the flight received some passengers before shuttling on to two other West African destinations, first to Abidjan, Ivory Coast, and finally stopping at Ouagadougou, Burkina Faso. By that stage, about 100 passengers were on board. The aircraft then flew 3,293 miles non-stop to Zurich in just five hours and four minutes.

ABOVE • ***Compared with the previous generation of Embraer E-Jets, the E2 has a reduced fuel consumption.*** HELVETIC AIRWAYS

In addition to this record-breaking repatriation flight, a further 300 passengers were brought home on other special missions to the Canary Islands and Algeria.

In July 2020, delivery of E190-E2 registered HB-AZE, coincidentally Embraer's 1,600th E-Jet overall, achieved an unplanned record. Usually, deliveries from Embraer's assembly line in São José dos Campos, near São Paulo, are routed via Recife then go via Las Palmas in Gran Canarias to Switzerland. HB-AZE's flight, however, took a different route, flying first from São José to Natal in Brazil's far northeast, and then over the south Atlantic. The aircraft made it not only to Geneva non-stop, as was the plan, but all the way to Zurich. As there were just five crew members on board and no cargo, and as the weather – especially the wind – proved to be favourable, the aircraft covered the distance of 3,940nm (1,079nm above its range with payload) in nine hours and ten minutes, in one stretch.

Applying the Brakes

The pandemic may have been favourable in terms of special missions but, of course, the global grounding

of flights affected Helvetic as much as any other carrier. “In spring of 2020, we were still in growth mode. Our goal was to increase our staff to 550, to operate all 16 aircraft, and we already had a staff of about 470,” recalled Pogorevc.

In spring 2020, Helvetic swiftly reversed its earlier growth mode, deferring aircraft deliveries and cutting staff. “There was only one motto: costs down. It was like emergency braking on a short runway,” said the CEO. “That was extremely demanding, but thanks to the support of our owner we could continue our fleet modernisation, which was extremely important, giving Helvetic the most modern regional fleet after the crisis.” He admits that this was an essential motivating factor during the bleak days of no flying and lots of uncertainties.

One arrangement that has been very much to Helvetic’s advantage during the pandemic is its wet-lease agreement – which dates to 2006 – with national carrier Swiss. Almost miraculously, the co-operation remained almost unchanged during the pandemic, despite the Lufthansa Group immediately terminating all its other wet-lease agreements as soon as the crisis hit. The arrangement involves having Helvetic aircraft plus crews available to Swiss and has been a major factor behind Helvetic’s fleet renewal.

Staff at Swiss were not happy about this, as up to 780 of their colleagues lost their jobs while the airline continued to use Helvetic’s services. Neither carrier talks about it, but it’s commonly accepted that the regional carrier pays lower salaries but offers very innovative and flexible working contracts. Helvetic claims this has led to a higher ratio of female pilots.

During the crisis, this stable relationship with Swiss was a blessing for Helvetic, a lifeline, even. But isn’t it also dangerous to tie one’s fate to just one partner? “Yes, that is the case,” Pogorevc openly admitted. “But we have a well-founded business case with Swiss, as our aircraft complement their portfolio. That is a big benefit for them in this phase of ramping up operations, when we are enabling them to deploy efficient aircraft on secondary markets for which the A320 is too big.”

Such is Helvetic’s confidence, that, on October 29, 2021, Pogorevc posted an advert on LinkedIn for new cabin crew members, in advance of the 2022 summer season.

Helvetic’s Evolution



ABOVE • ***Helvetic engineers undertake inspection of the lower cargo hold in the company’s hangar at Zurich International Airport.*** HELVETIC AIRWAYS

It’s interesting to look back at Helvetic’s evolution. Operations began in 2003 with one MD-83 from charter carrier Odette Airways (the aircraft itself taken over in 2002 from former Crossair) and another MD-82 briefly leased from Swiss. In November 2003, Helvetic officially launched as Switzerland’s first low-cost carrier, with one Fokker 100 and three destinations. A year later, the fleet increased to seven Fokker 100s. At the time, Helvetic did not sport the Swiss cross in its livery, which instead consisted of bright pink aircraft with



white lettering.

The operation was accumulating heavy losses. Banker and investor Martin Ebner took over in March 2006, after being a passenger on a Helvetic flight and being persuaded by his wife to help the company out of its dire straits, so the legend goes. Tobias Pogorevc joined in 2007, initially as CFO. As a stopgap measure, the fleet was reduced to four Fokker 100s by June 2006. The LCC-style branding was dropped, a white livery with grey lettering plus the Swiss cross on the tails was introduced, and a new three-way business model of scheduled flying, wet leases and charter flights was implemented. After an initial investment of more than £40m, the airline became profitable within two years, Ebner revealed at the time.

The Swiss Connection

Back in 1999, the second biggest carrier in Switzerland – after venerable Swissair, which went bankrupt in 2001 – was Crossair, based in Basel. Regional carrier Crossair was run by a patriarch, and adversary of Swissair, named Moritz Suter. He wanted to be cutting edge in his airline's offerings and to always be a step ahead in his own country. As it happened, he found a congenial counterpart in the then-CEO of Embraer, Mauricio de Botelho, and the two men found they had more in common than just their first names.

In a hotel in Basel, the duo worked out a deal that resulted in today's Embraer E-Jets. At the time, the idea was to create the world's most comfortable regional jet (this was in an era when only cramped Canadair Regional Jets were available) – and Suter's mantra was: 'No middle seats'. So, that's how Embraer conceived its original Embraer 170 and 190 models.

Crossair became the launch customer, with an initial order for 50 aircraft signed at the Paris Air Show in June 1999. But then, coinciding with the roll-out of the first Embraer 170 in October 2001, Crossair ceased to exist as an independent carrier and provided the air operator certificate for what became Swiss Air Lines, successor of the failed Swissair. It may have been an order from Switzerland that launched the type, but it wasn't until December 2014 that the first Embraer E190 finally flew for a Swiss airline, when Helvetic took over its first Brazilian regional jets from Austrian LCC FlyNiki (now part of Lauda, itself a Ryanair subsidiary).

"Between Switzerland and Brazil as well as between Helvetic and Embraer, there are extremely innovative, familiar relations, with each side pushing the other ever higher," Pogorevc explained. "It's a win-win, we could provide a lot of input for the E2, and it's fair to say the evolution of the E-Jet family continued thanks to input from Switzerland."

However, Pogorevc insists the decision to buy the aircraft was a rational one, and not at all a given due to the Swiss role at its inception. "We knew then that our seven Fokker 100s would reach the end of their lifecycle, and we were able to grow by taking over seven E190s, formerly operated by FlyNiki, from our lessor." This was a major waypoint, as it turned out: "When we later looked at the entire Embraer portfolio, we decided for ourselves that the E2 was the right aircraft for the next period. It's an aircraft of the latest generation, for the next 20 to 30 years," stressed Pogorevc. "Although it's almost a completely new aircraft, there's a great overlap between E1 and E2. That's extremely important for us, also that both types can be flown by all our pilots, which makes it highly efficient." Add to that the range increase to about 2,860nm and the green credentials – more than 20% less fuel burned than the E1, as well as substantial reductions in CO2 emissions and noise – and it is clear why Helvetic considers itself lucky to be the world's biggest E2 operator.

Beating the Pandemic

Highlighting the main benefit of aircraft ownership, Tobias Pogorevc said: "We don't have any obligation to a third-party creditor. Faced with the pandemic it was our lifesaver though we put an immediate stop to our aggressive growth plan but undertook a restructure and now think we have a solid company with no debts to third parties."

Commenting, he said of the selection: "We opted for the E2 for two reasons. One, high commonality between the E1 and the E2, so we knew training of experienced pilots would be straightforward. Two, the E2 is a future-oriented aircraft providing fuel savings and reduced CO2 emissions, and lower noise levels. The oldest E2 aeroplane we currently operate is two years and five months old which has lived-up to the promises made by Embraer."

Discussing the E2's acceptance in 2021, Pogorevc said it was not certified to fly steep approaches at that time, "so Helvetic implemented the service bulletin for steep approaches which



RIGHT • ***Helvetic Airways' E190-E2 HB-AZE was Embraer's 1,600th E-Jet.***
HELVETIC AIRWAYS



LEFT • ***Helvetic Airways' livery is straightforward but striking.*** HELVETIC AIRWAYS

Embraer certified. Consequently, the E2 is now able to land at London City airport. That is very important, because as a company, Helvetic Airways fly to several airports which are quite challenging, and the most important one is London City where we started operations with the E2 in the summer of 2021."

Pandemic Recovery

Pogorevc believes the airline industry faces two major challenges as it continues to emerge from the toughest days of the pandemic: "One, a lot of companies have their fleets stored which requires time to return to operational status. Two, a lot of cabin crew left the aviation industry, so it's a major challenge to fully crew each aircraft. Helvetic has enough pilots and cabin crew though we are still recruiting. It was important to the management and the owner, that all its pilots were kept current during the pandemic with intense simulator sessions and are current as the summer 2022 timetable starts which I think gives us an advantage."

When asked if the E2 was the right choice for Helvetic in a world now clawing back from the pandemic and faced with increasing fuel prices Pogorevc replied: "Given the high price of fuel the E2 offers advantages: it uses less fuel than the E1, and for charter work it's much more attractive to use a modern aircraft with less fuel consumption than one that is 15 years old, which uses 40 to 50% more fuel. Currently the cost of a new aircraft is more than compensated for by the high savings on fuel consumption. That's why we are optimistic for this year because we have the right size of aircraft for a lot of the routes and are not having to fly routes that cost more than we earn from that service. It makes economic sense to use a regional aircraft offering 20 to 30% fuel savings with a high load factor on certain routes."

Citing fuel consumption measured in kilogrammes per seat on three routes from Zurich to Berlin, Budapest, and Larnaca. Pogorevc said that compared to the E1 the E190-E2 uses 20 to 23% less fuel per seat and up to 30% with the E195-E2.

Pogorevc showed the author noise contour diagrams for aircraft departures from Zurich International Airport. "The contour is 28% larger for the Airbus A319 and 60% for the Airbus A320 compared to the E195-E2. The ability to affect fewer people with noise is so important as more housing is built around airports."

According to Pogorevc, Helvetic uses each of its E-Jet aircraft for 280 hours per month but throughout the pandemic its capacity did not exceed 40% with peak times occurring in the summer season.

Charter Business

Ahead of the 2022 summer season, Helvetic is planning, in addition to the long-term wetlease-operation for Swiss, charter flights to several tourist destinations from Zurich. The six jets operating for Swiss are operated

RIGHT • ***E190-E2s and E190LRs inside Helvetic Airways' hangar at Zurich International Airport, a facility used for servicing and maintenance. Line maintenance and fault rectification is conducted at the Bern site.*** HELVETIC AIRWAYS

BELOW • ***E190-E2 HB-AZD parked on a stand at Zurich International Airport.*** HELVETIC AIRWAYS



by Helvetic with its cabin crew and maintained by its engineers, but the product and everything on the plane is from Swiss.

Additionally, Helvetic's special charter business was heavily utilised throughout the last 24 months when business aviation services were almost completely sold out. Helvetic flew to several destinations that it does not usually operate.

Pogorevc says that Helvetic is happy with the reliability of its E2s and the support provided by Embraer. Describing the company's operations, he said: "We operate the aircraft, we maintain the aircraft, and we have our own flight academy where we train our pilots and engineers all from Zurich. That's why we believe we have a deep knowledge of this aircraft from training to operation to maintenance, so from this point of view, we can clearly say we are the E2 competence centre in Europe. It's still a new aircraft, we're still testing it and still gaining experience. That takes time, but we are very happy with the E2." ●

E-Jet Freighters

Mark Ayton overviews the first information to come to light about Embraer's E-Jet passenger to freighter conversion initiative.

Embraer has forecast a market potential for freighter conversions from passenger E190 and E195 aircraft totalling 470 aircraft over the next ten-plus years. Within 20 years, the Brazilian framer forecasts a further requirement for 250-plus aircraft requiring direct replacement, and a level of market growth of over 450 additional aircraft through the same period.

No surprise that the company launched the E190F and E195F Passenger to Freight Conversions (P2F) on March 7.



BELOW • ***Embraer's vision of an E195 Passenger to Freighter conversion.***
EMBRAER

E-Jet Freighter

Dubbed E-Jet freighters, Embraer says the nascent types are designed to meet the changing demands of e-commerce and modern trade that require fast deliveries and de-centralised operations.

Speaking at the announcement, Arjan Meijer, president and CEO of Embraer Commercial Aviation said: "Positioned to fill the gap in the freighter market between turboprops and larger narrowbody jets, our P2F E-Jet conversion will enter the market as the demand for airfreight continues to grow, and as e-commerce and trade in general undergoes a global structural transformation,"

The P2F conversion is now available for pre-owned E190 and E195 E-Jet aircraft with early 2024 stated as the entry into service date for the first customers.

The company says its P2F programme addresses the following opportunities:

- Current small narrowbody freighter airframes are old, inefficient, not environmentally friendly, and well within their retirement window.
- Transformation of commerce, trade, and logistics have created unprecedented demand for airfreight, especially for same day deliveries and de-centralised operations.

Embraer says that E-Jets aircraft which entered service between 15 and 10 years ago are now exiting their long-term leases, a procedure that will continue throughout the coming decade. Embraer views this situation as having two commercially attractive opportunities; passenger to freighter conversions which will extend the aircraft's life by another 10 to 15 years; and for new orders from operators who seek to replace their mature E-Jets with more efficient, more sustainable, and quieter aircraft. Though not obligatory, Embraer will hope such operators select brand new E2s.

Commenting on the commercial opportunities, Johann Bordais, president and CEO of Embraer Services and Support said: "E-Jet air freighters will provide fast, reliable, and cost-effective service to freight forwarders, extend the revenue earning life of E-Jets, support E-Jets' asset values, and create a strong business case encouraging the replacement of earlier aircraft with modern, more efficient, passenger aircraft. With more than 1,600 E-Jets delivered globally, customers of this new freighter will benefit from well established, mature, global services network, in addition to a comprehensive portfolio of products ready to support their operation from day one."

Work activities in a P2F conversion include installation of a main deck front cargo door; a cargo handling system; floor reinforcement; a rigid cargo barrier, a 9G-rated barrier with an access door; a cargo smoke detection system, including class-E extinguishers in the upper cargo compartment; and air management system changes such as cooling and pressurisation. Embraer says that conversions will be performed at its facilities in Brazil. ●



EMBRAER E-JET FREIGHTER CLAIMS

Over 50% more volume capacity than large cargo turboprops.

Three times the range of large cargo turboprops.

Up to 30% lower operating costs than narrowbody jets.

Optimized loading configuration capability.

Maximises efficiency by matching capacity to demand.

Offers greater frequency and better operating economics in the smaller markets compared to larger aircraft.

Range and payload capacity of the E195F is similar to the B737-300SF over a near-2,500nm range though the aircraft is expected to burn less fuel, generates fewer emissions, and have lower maintenance and cash operating costs.

The E190F and E195F introduce right-sizing to the air cargo market by tapping the gap between turboprop and larger narrow body freighters.

E190F or E195F freighters deployed on the right routes at the right frequency with the right economics will open new smaller markets.

Based on max payload vs total cargo volume, the E190F and E195F sit between the ATR72-600 and the Boeing 737-300SF.

Preliminary E-Jet Freighter Characteristics

	E190F	E195F
Payload	23,600lb (10,704kg)	27,100lb (12,292kg)
Max gross structural payload	28,990lb (13,149kg)	31,525lb (14,299kg)
Cargo volume	3,632ft^3 (102.84m^3)	4,171ft^3 (118.11m^3)
Range	2,300nm (4,259km)	2,190nm (4,055km)

EV for Ev

Mark Ayton provides an overview of the latest Phenom 100EV executive jet.

olution

EMBRAER S.A.

The development of Embraer's Model 500 very light jet was approved by the board in April 2005. Named the Phenom 100, the type made its first flight from São José dos Campos on July 26, 2007. Brazil's National Civil Aviation Authority awarded the Phenom 100 its type certificate on December 9, 2008, and the first customer aircraft was delivered to fractional jet ownership company AirShare on December 24 of that year.

Embraer produced a follow-on version dubbed the Phenom 100E, E for 'enhanced' featuring minor updates and multi-function spoilers, which was followed in 2016 by the current production standard designated the Phenom 100EV – EV for evolution.

Embraer says the EV is one of the most disruptive entry-level jets ever designed and every system has been reinterpreted and leading technologies incorporated.

Designed with weight savings, higher thrust, and an updated flight deck to meet the expectations provided by customers through an extensive feedback process, Embraer first publicly displayed the Phenom 100EV at the NBAA Business Aviation Convention and Exhibition in Orlando, Florida in early November, 2016.

Pratt & Whitney PW617F1-E

Pratt & Whitney Canada's modified PW617F1-E provided more thrust and Garmin's G3000-based Prodigy Touch is the updated flight deck avionics suite, previously introduced on the Model 505 Phenom 300.

Embraer and Pratt & Whitney improved the PW617F-E engine by changing the engine control software to yield a 10% thrust increase. This additional thrust provided several benefits:

- It increased the high-speed cruise from 389kts to 406kts at 33,000ft.
- Reduced the time-to-climb to 41,000ft from 33 to 25 minutes.
- Increased the maximum take-off weight from 10,582 to 10,703lb.
- And improved the aircraft's hot and high take-off distance by 15%.

The Pratt & Whitney PW617F1-E uses a low-speed rotor spool consisting of a single-stage low pressure compressor (LPC) driven by a single-stage low pressure turbine. The high-speed rotor spool comprises a two-stage high pressure compressor (HPC) with both a mixed flow and centrifugal rotor driven by a single-stage high pressure turbine. The combustor is of the reverse flow type with hybrid (start flow and main burn flow) fuel nozzles fed by an internal fuel manifold. A fuel oil heat exchanger and an air-cooled oil cooler are part of the basic configuration. The engine features a full-length bypass duct incorporating a forced exhaust mixer, and full authority dual channel FADEC control.



ABOVE • ***The Phenom 100EV has the largest entrance door on a VLJ category aircraft with optional handrail and LED step lighting.*** EMBRAER S.A.

BELOW • ***Looking aft through a Phenom 100EV cabin.*** EMBRAER S.A.

The PW617F1-E is a higher thrust version of the PW617F-E with the higher thrust achieved by an N2 redline limit increase, a software revision, and a change to the fuel metering unit maximum stop setting. N2 is the rotational speed of the high-speed spool comprising the HPC and the high-pressure turbine.



The PW617F1-E engine has a maximum diameter of about 750mm, measures 1,360mm in length and weighs 379lb.

Prodigy Touch Flight Deck

Embraer and Garmin upgraded the avionics suite from the original Prodigy Flight Deck 100 to the G3000-based Prodigy Touch flight deck.

Touchscreen-controlled, the Prodigy Touch flight deck is optimised for single-pilot operation with automatic and reduced checklists and offers a more intuitive man-machine interface. According to Embraer, the touchscreen-controlled flight deck anticipates the pilot's every need, minimises workload, and increases situational awareness.

According to Garmin, the G3000 suite revolutionises the interface between pilots and their avionics by:

- Streamlining menu structures.
- Eliminating visual clutter.
- Replacing mechanical knobs, buttons, and selector switches.
- And centralising data entry in one easy-to-access location.

Consequently, the pilot has more focused control with less wasted motion and effort.

The flight deck is dominated by three 14.1in diagonal WXGA high-resolution cockpit displays with extended 16:9 width-to-height ratio. They can function as either a primary flight display (PFD) or a multi-function display (MFD) – or in reversionary mode as both. When used as the pilot's PFD, the wider screen provides more visual area for the simulated 3-D perspective topography presented by Garmin's Synthetic Vision Technology (SVT) – as well as enhanced peripheral cues from an extended horizon line.

Using the G3000's terrain alerting database to create a detailed graphical landscape, the SVT provides a virtual perspective view of ground and water features, obstacles, and traffic – all shown in relative proximity to the aircraft. Instead of a flat blue-over-brown representation, the pilot sees a realistic visual depiction of flight data so he or she can picture what lies beyond the nose of the aircraft, even in solid IFR, night, or marginal VFR conditions. A large inset map allows more traffic and terrain/obstacles data to be accommodated on the PFD to further improve situational awareness.

Garmin's wide WXGA viewing format provides room for two separate vertical pages to be viewed side-by-side on the MFD – along with the aircraft's EIS strip for engine and fuel data. This split-screen functionality enables the pilot to pair, for example, the airway chart and the approach plate.

Graphical synoptics for airframe, electrical and fuel systems offer the pilot easier monitoring and faster

ABOVE • ***One of the Phenom 100EV's design features is an eye-catching nose.*** EMBRAER S.A.

BELOW • ***Stowable tables offer plenty of room for working or dining.*** EMBRAER S.A.



PHENOM 100EV DESIGN ASPECTS

Configuration
Eye-catching nose.
Low, swept wings with winglets.

Flight Systems
Synthetic vision system.

An optional GWX70 weather radar allows precise visualisation of cloud cells with vertical scan, ground clutter suppression and turbulence detection functions. The latter gives a precise and colourful picture of rain and turbulence ahead of the aircraft.

A stall warning sounds at 96kts followed by a pitch down momentum invoked at 87kts by the stick-pusher system to cause an immediate recovery.

Controller-pilot datalink to reduce voice communications at busy airports.

Terrain Collision Avoidance System II.

Transponder with ADS-B.

Graphical flight planning.

SurfaceWatch system coupled to a land surface database offers effective protection against ground collision.

Visual and audio windshear alerts are sounded upon detection of a windshear condition.

Cabin Systems
Largest entrance door on a VLJ category aircraft with a handrail and optional LED step lighting.

Oval Lite fuselage cross-section provides more head and legroom than any other VLJ jet.

A new straight line floor sill design to increase the aisle area

Relocated power outlets with USB chargers.

Largest windows in the VLJ aircraft category which illuminate the cabin in natural light.

Largest-in-class refreshment centre or an optional wardrobe.

Stowable tables offer plenty of room for working or dining.

Reclining seats feature enhanced headrests, retractable armrests, and adjustable thigh bolsters.

Inflight entertainment system.

Premium cabin management system.

Inflight phone and datalink system.

Cabin altitude of 8,000 feet as most typical airliners.

Two distinct temperature zones for pilot and passenger comfort.

70ft^3 baggage compartment aft of the lavatory.

Optional belted lavatory seat, certified for taxi, take-off, and landing.

Performance
15% more thrust at hot-and-high airports.

Similar operating costs to a turboprop.

Operations
Delivers high dispatch reliability.

SmartProbes and a fully integrated Central Maintenance Computer reduce downtime.

Single-point refuelling.

First VLJ category aircraft with externally serviced lavatory with easy operation and short turnaround times.

Low-intervention task-orientated maintenance methodology, coupled with a 35,000-hour economic life, make the aircraft easy to maintain.

Low operating and maintenance costs.

troubleshooting. While the high-aspect-ratio Garmin displays allow for enhanced viewing and management of multiple sensor inputs – thus making the MFD even more multi-functional.

GWX 70 Weather Radar

Garmin's GWX 70 weather radar has an advanced solid-state transmitter design which eliminates the need for life limited magnetron tubes. It also has a full-colour, storm cell tracking, Doppler-capable weather avoidance tool that combines effective range and adjustable scanning profiles with precision target definition — for accurate, easy-to-interpret, weather analysis on the flight deck. Using pilot-adjustable horizontal scan angles of up to 120°, the pilot can easily focus scanning of the required areas, while vertical scanning allows the pilot to focus on storm tops, gradients, and cell build-up at various altitudes. A function called Weather Attenuated Colour Highlight can identify areas beyond the radar's capability that may contain even more hazardous areas of precipitation.

On compatible displays, altitude compensated tilt in the GWX 70 reduces the pilot's workload with a single manual adjustment to the radar's required tilt and the radar automatically adjusts with any change in altitude. When interfaced with the aircraft's analogue gyro or AHRS system, the GWX 70 offers full radar stabilisation to 30° of pitch and roll.

The weather radar also has a ground mapping mode that can assist in several applications - including navigation. The feature provides a real-time depiction of the terrain below the aircraft.

Solid-state technology used in the GWX 70 maintains a consistent weather picture throughout its entire lifecycle.

Ground clutter suppression identifies radar ground returns and removes them from the display taking the guesswork out of interpreting what's displayed on the screen. Optional turbulence detection can determine areas of turbulence that might contain particulate, like rain or hail.

Customer Support

Embraer's worldwide support network extends across more than 70 owned and authorised service centres manned by technicians to guarantee the best quality of service and their customer support contact centre offers global support 24/7.

Embraer invests in sustainable technologies and contributes to the long-term development of its surrounding communities.







LEFT • ***Garmin's G3000-based Prodigy Touch flight deck.*** EMBRAER S.A.

As a result, the Phenom 100EV is equipped with remarkably powerful yet efficient engines, which offer a reduced noise footprint as well as better fuel burn and fewer emissions.

Embraer opened a joint biofuel research centre in São José dos Campos, Brazil with Boeing, and performed joint tests as part of the ecoDemonstrator Program – a research initiative using specially modified aircraft to develop and test aviation technologies aimed at reducing carbon emissions, fuel consumption, and noise.

Phenom Programme

Embraer had dual launch customers for the EV: Mexican business aviation service provider Across, and the Emirates Flight Training Academy - the first flight training organization in the world to train cadet pilots using the Phenom 100EV.

Since 2015 the Phenom 100, Phenom 100E and the latest EV version have been built at Embraer's production facility in Melbourne, Florida. And as of April 1, 2022, Embraer Executive Aircraft had produced 429 Phenom 100-series aircraft which have been delivered to corporate flight departments, charter companies, consortiums involving fractional ownership, flight academies and military services. The Phenom 100 is deemed ideal for instructing student pilots for multi-engine jet operations, and is used by the Finnish Aviation Academy, Emirates Flight Training Academy, Etihad Aviation Training, and the Royal Air Force. ●



Phenom 100EV Characteristics

Length	42ft 1in (12.83m)
Height	14ft 3in (4.34m)
Wingspan	40ft 4in (12.29m)
Horizontal stabilizer span	17ft 6in (5.33m)
Cabin width	5ft 1in (1.55m)
Range at cruise Mach 0.68	1,145nm (2,120km)
Range at cruise speed	1,178 nm (2,181km) with NBAA IFR reserves and four occupants
Max speed	Mach 0.70
Max cruise speed	406kts (752km/h)
Basic operating weight	11,583lb (5,254kg)
Max ramp weight	10,747lb (4,875kg)
Max take-off weight	10,703lb (4,855kg)
Max landing weight	9,998lb (4,535kg)
Max payload	1,775lb (805kg)
Max usable fuel	2,804lb (1,272kg)
Payload with max fuel	646lb (293kg)
Min take-off distance at sea level, ISA	3,190ft (972m)
Min landing distance at sea level, ISA	2,430ft (740m)
Max operating altitude	41,000ft (12,496m)
Seats	1 pilot, 6 passengers
Engines	Two Pratt & Whitney PW617F1-E each rated at 1,730lb at sea level

E for Enhanced

Mark Ayton provides an overview of the latest Phenom 300E executive jet.

Like all executive jets, the marketing terms used to describe the Phenom family of next-generation aircraft are not for the faint hearted. Challenge, create, and outperform are just three used by Embraer to sum-up the design principles applied to developing the Phenom family back in 2005. Embraer designers sought to introduce innovative solutions that would redefine the standards for performance and comfort and use advanced technologies throughout the aircraft which had only previously been used on larger executive jets.

In January of 2020, Embraer announced the new and enhanced Phenom, the 300E posting the E on its designation to differentiate. Embraer Executive Jets achieved a triple-certification by Brazil's ANAC, Europe's EASA, and the FAA in March. The company then delivered the first Phenom 300E to fractional jet ownership company AirShare in June 2020.

In comparison to the original 300, Embraer states that the latest E version provides more performance, comfort, and technology, and flies up to Mach 0.80 with a quieter cabin.

ABOVE • EMBRAER S.A.

Cabin

Looking exactly like a Phenom 300 on the outside, changes made to the 300E were all internal, primarily to the cockpit and cabin, and based on customer feedback. One of the prime customer suggestions was to improve the cabin's comfort.

Consequently, Embraer's design team opted to completely redesign the cabin interior and fit with new tables, seats, ceiling panels, and the same window-shade system used on the Legacy series of aircraft. Unlike the original system fitted to the 300 the new shade system is controlled by a small handle at the base of the window.

Retractable armrests, thigh supports and the ability to pivot the seats away from the cabin by mounting them on tracks, a feature intended to avoid a feeling of being hemmed into the seat, are included. Each seat houses a 12in-deep drawer beneath, a size large enough to meet the stowage needs of the most gadget-laden executive.

Seats can be arranged in the standard configuration featuring six seats and a refreshment centre, one featuring a seventh seat and a belted lavatory seat, or a nine-occupant layout featuring a two-place divan and a belted lavatory seat.



Federal Aviation Administration regulations limit the number of passengers carried on a 300E to nine.

Whatever the passenger payload, their luggage is stowed in four compartments, each with a weight limit: one in the nose (110lb), one adjacent the entry door (44lb), one in the lavatory (33lb) and an optional heated rear compartment (463lb).

The cabin is fitted with a high-definition networked management and inflight entertainment system built by Lufthansa Technik. The German system includes touchscreen controls in the side panels, multiple USB charging points and two seven-inch flip-down video screens housed in the ceiling near the forward cabin area.

Lufthansa Technik also produces an audio and video on demand service housed in a stand-alone unit to which passengers can load audio and video media while on the ground and later accessed through the entertainment system during flight.

ABOVE • ***Like the Phenom 100EV, the Phenom 300E has a large entrance door with optional handrail and LED step lighting.*** EMBRAER S.A.

BELOW • ***Embraer and Garmin integrated the G3000-based Prodigy Touch flight deck to meet the requirements for single-pilot operation.*** EMBRAER S.A.



Pratt & Whitney PW535E

Pratt & Whitney Canada's PW535E is a dual spool, axial flow, medium bypass turbofan. The PW535E engine has a three-stage high pressure compressor (two-stage axial and single-stage centrifugal) driven by a single stage high pressure turbine, and a two-stage low pressure turbine driving an integrally bladed fan and axial boost compressor stage. The two rotor spools are not mechanically connected and rotate at different speeds. Control is provided by a dual channel FADEC system.

A derivative of the PW535B, the PW535E has an aircraft mounted electronic engine control box, full span fan stator and modifications to the high-pressure blade material.

The PW535E engine has a diameter of 42 1/2 inches (108cm), measures 66 inches (167cm)in length and weighs 699lb (317kg).

Prodigy Touch Flight Deck

Embraer and Garmin integrated the G3000-based Prodigy Touch flight deck to meet the requirements for single-pilot operation. The Phenom 300E was the first type of business aircraft to be equipped with the system, also used in the Phenom 100E.



LEFT • ***The Phenom 300E design features low, swept wings with winglets.*** EMBRAER S.A.

Embraer undertook extensive research of pilots' behaviour and actions to determine the regularity by which they use equipment and reference information during a flight.

Touchscreen-controlled, the Prodigy Touch flight deck is optimised for single-pilot operation with automatic and reduced checklists and offers a more intuitive man-machine interface. It is claimed that the interface anticipates the pilot's every need, minimises workload, and increases situational awareness.

According to Garmin, the G3000 suite revolutionises the interface between pilots and their avionics by:

- Streamlining menu structures.
- Eliminating visual clutter.
- Replacing mechanical knobs, buttons, and selector switches.
- Centralising data entry in one easy-to-access location.

Consequently, the pilot has more focused control with less wasted motion and effort.

The flight deck is dominated by three 14.1in diagonal WXGA high-resolution cockpit displays with extended 16:9 width-to-height ratio. They can function as either a primary flight display (PFD) or a multi-function display (MFD) – or in reversionary mode as both. When used as the pilot's PFD, the wider screen provides more visual area for the simulated 3-D perspective topography presented by Garmin's Synthetic Vision Technology (SVT) – as well as enhanced peripheral cues from an extended horizon line.

Using the G3000's terrain alerting database to create a detailed graphical landscape, the SVT provides a virtual perspective view of ground and water features, obstacles, and traffic – all shown in relative proximity to the aircraft. Instead of a flat blue-over-brown representation, the pilot sees a realistic visual depiction of flight data so he or she can picture what lies beyond the nose of the aircraft, even in solid IFR, night, or marginal VFR conditions. A large inset map allows more traffic and terrain/obstacles data to be accommodated on the PFD to further improve situational awareness.

Garmin's wide WXGA viewing format provides room for two separate vertical pages to be viewed side-by-side on the MFD – along with your aircraft's EIS strip for engine and fuel data. This split-screen functionality enables the pilot to pair, for example, the airway chart and the approach plate.

Graphical synoptics for airframe, electrical and fuel systems offer the pilot easier monitoring and faster troubleshooting. While the high-aspect-ratio Garmin displays allow for enhanced viewing and management of multiple sensor inputs – thus making the MFD even more multi-functional.

Flight deck integration is created by the GTC 570 glass touchscreen controller, which serves as the primary point of entry for the G3000 system. Featuring a desktop-style, icon-driven interface built on a shallow menu structure, the GTC 570 enables the pilot to access more systems and sensors with fewer keystrokes or page sequences. Its user interface is entirely software-based so future enhancements, applications and system growth capabilities can be accommodated without physically altering the mechanical controls.

BELOW • ***A Phenom 300E demonstrator parked outside the Embraer factory at Melbourne, Florida.*** EMBRAER S.A.

BOTTOM • ***Looking forward through the Phenom 300E's cabin.*** EMBRAER S.A.





PHENOM 300E DESIGN ASPECTS

Configuration
Eye-catching nose
Low, swept wings with winglets

Flight Systems
Synthetic vision system.

Runway overrun awareness and alerting system provides a warning if the approach is too steep or too fast — the first technology of its kind to be developed and certified in business aviation.

Optional GWX70 weather radar allows precise visualisation of cloud cells with vertical scan, ground clutter suppression and turbulence detection functions. The latter gives a precise and colourful picture of rain and turbulence ahead of the aircraft.

Controller-pilot datalink to reduce voice communications at busy airports.

Terrain Collision Avoidance System II.

Transponder with ADS-B Out.

Graphical flight planning.

SurfaceWatch system coupled to a land surface database offers effective protection against ground collision.

Visual and audio windshear alerts are sounded upon detection of a windshear condition.

Cabin Systems
Largest entrance door on a LJ category aircraft with a handrail and optional LED step lighting.

Oval Lite fuselage cross-section provides more head and legroom than any other LJ jet.

Largest windows in the LJ aircraft category which illuminate the cabin in natural light.

Stowable tables offer plenty of room for working or dining.

Reclining seats feature enhanced headrests, retractable armrests, and adjustable thigh bolsters.

Inflight entertainment system.

Premium cabin management system.

Inflight phone and datalink system.

Cabin altitude of 6,600 feet.

A quieter cabin.

Optional premium interior featuring piano black surfaces, carbon fibre accents and Embraer's exclusive Ipanema sew style.

Two distinct temperature zones for pilot and passenger comfort.

A fully enclosed lavatory with two full-size windows and certified for take-off and landing.

A wardrobe and refreshment centre.

Fully enclosed, externally serviced aft lavatory.

One of the largest baggage compartments in the LJ jet category.

Performance
Best climb and field performance in the LJ jet category.

More thrust at hot-and-high airports.

Similar operating costs to a turboprop.

Operations
Delivers high dispatch reliability.

SmartProbes and a fully integrated Central Maintenance Computer reduce downtime.

Single-point refuelling.

During pre-flight checks, the pilot can run the right engine as a power source for the avionics, environmental systems, and cabin lighting.

First LJ category aircraft with externally serviced lavatory with easy operation and short turnaround times.

Low-intervention task-orientated maintenance methodology, coupled with a 35,000-hour economic life, make the aircraft easy to maintain.

Low operating and maintenance costs.



ABOVE • ***Looking aft through the Phenom 300E's premium interior featuring piano black surfaces, carbon fibre accents and Embraer's exclusive Ipanema sew style.*** EMBRAER S.A.

Responsive, icon-identified touch-keys on the GTC 570 controller make functions easy to locate and access with fewer hand/eye movements in the cockpit. In addition to full NAV/COMM radio management and simplified page navigation on the multi-function display, the pilot can also use the 5.7in high-resolution GTC 570 screen to control the remote audio/intercom system, as well as changes in frequencies, navigation functions, the EGPWS, the TCAS, transponder codes and idents, electronic checklist entries, flight plan entry and editing, plus optional synoptic data and other selected mapping, traffic, weather, entertainment, and custom display options.

Handy BACK and HOME keys on the display let the pilot quickly retrace steps or return to the desktop from any page – so they never get lost in the software or need to memorise lengthy user sequences.

The GTC 570 retains a single set of mechanical concentric knobs, along with a volume control knob and dedicated map joystick. At the pilot's option, the dual knobs can be used in lieu of the touchscreen to enter frequencies for selected radios or to toggle between Comm 1 and Comm 2. The current function of these knobs

BELOW • ***Like the Phenom 100EV, the Phenom 300E features a nose that's quite distinguishable from the style of many business aircraft.*** EMBRAER S.A.



Phenom 300E

Length	52ft 2in (15.9m)
Height	16ft 5in (5m)
Wingspan	53ft 2in (16.20m)
Cabin width	5ft 1in (1.55m)
Range at cruise Mach 0.68	1,971nm (3,650km)
Range at cruise speed with five occupants and NBAA IFR reserves	2,010nm (3,722km)
Max speed	Mach 0.78 or up to Mach 0.80 making it the fastest single-pilot jet in production
Max cruise speed	385kts (713kp/h)or 464kts (859kp/h)
Basic operating weight	11,583lb (5,254kg)
Max ramp weight	18,497lb (8,390kg)
Max take-off weight	18,387lb (8,340kg)
Max landing weight	17,042lb (7,730kg)
Max payload	2,637lb (1,196kg)
Max usable fuel	5,353lb (2,428kg)
Payload with max fuel	1,561lb (708kg)
Min take-off distance at sea level, ISA at MTOW	3,138ft (956m)
Min landing distance at sea level, ISA	2,621ft (799m)
Max operating altitude	45,000ft (13,716m)
Seats	1-2 pilots, 9 passengers
Engines	Two Pratt & Whitney PW535E each rated at 3,360lb at sea level





TOP AND ABOVE: ***Looking forward through a Phenom 300E cabin styled in a light grey colour.*** EMBRAER S.A.

is always clearly identified in the touchscreen window above them to avoid confusion as to which knob is doing what.

Phenom 300EV Programme

On September 3, 2021, Embraer delivered a Phenom 300E to Haute Aviation, a Swiss company offering charter, brokerage, and aircraft management based at Saanen-Gstaad airport. That aircraft was the 1,500th business aircraft delivered by Embraer Executive Jets; a milestone achieved in two decades versus 34 years, the current industry average to reach this mark.

On February 23, 2022, the General Aviation Manufacturers Association (GAMA) released sales quantities for various aircraft. Quantities showed the Phenom 300 series to be the world's best-selling light jet for the tenth consecutive year and the most delivered twinjet of 2021, with a 56 aircraft tally. With over 640 deliveries to that point, the Phenom 300 series has enjoyed an average annual delivery rate of 50+ jets since the type entered the market in December 2009. Such achievements can be attributed to Embraer's policy to continually improve its aircraft types with best-in-class range, speed, and cabin pressurisation capabilities, and use of leading technology.

Commenting, Michael Amalfitano, president and CEO of Embraer Executive Jets said: "Reaching this milestone secures the aircraft's lead position in the light jet segment and recognition of our outstanding performance, technology, comfort, and support. Since inception, we have made continuous improvements to the aircraft based on customer feedback, and we will continue to innovate and improve it in the coming years."

Today, Phenom 300 series aircraft operate in 39 countries with a fleet accumulation of nearly 5.5 million flight hours. ●



Praetor: Embra

Rod Simpson and Mark Ayton detail Embraer's Legacy and Praetor mid-size and super-mid-size executive jets.



In 2000, Embraer entered the business jet market by launching its Legacy 600, based on the Embraer ERJ135 regional jet. It then proceeded to build a range of business jets, adding two versions of the Phenom followed by the larger Lineage 1000 based on the Embraer 190. Staring at a gap in the mid-size sector Embraer announced two models of the new Legacy jet at the 2007 NBAA Convention in Atlanta.

In April 2008, the framer formally launched the MLJ (Mid-Light Jet) and the MSJ (Mid-Sized Jet) which became the Legacy 450 and 500, respectively.

Their first prototype was the larger Model 500. This differed from the Model 450 by having a longer cabin, due to two extra fuselage sections, ahead of and behind the wing, adding 4ft 6in to the overall length.

The Legacy 500 has a range of 3,000nm with four passengers and two crew, sufficient to fly from London to New York, eastbound, and the Legacy 450 is a shorter-range aircraft at 2,900nm, which still allows it to fly non-stop from New York to Los Angeles.

Design development of the aircraft took some time because of the complex fly-by-wire system, but the first of three Legacy 500 development aircraft (PT-ZEX) made its inaugural flight on November 27, 2012, followed by the second and third aircraft (PT-ZEY and PT-ZFV) in February and March 2013, respectively. Later that year, on December 28, the prototype Legacy 450 (PT-ZIJ) took to the air. For certification purposes, the Legacy 500 is designated EMB-550 and the Legacy 450 as EMB-545.

ABOVE • ***The Praetor 500 looks everything the executive jet with good-looking lines.*** ALL IMAGES EMBRAER S.A.

Embraer received FAA certification for the Legacy 500 on October 21, 2014, followed by the Legacy 450 on August 26, 2015. The first production delivery was a Legacy 500 handed over in December 2015.

Fly-by-wire

A key feature of the two Legacy jets was the advanced flight deck ergonomics and flight controls. The flight deck is fitted with the Rockwell Collins Pro Line Fusion integrated avionics system comprising a four-screen display, a Rockwell Collins Head-up Guidance System (HGS) and Embraer's Synthetic Vision Guidance System (SVGS).

Legacy jets are fitted with sidesticks, an auto-throttle and have fly-by-wire flight controls for the elevator, ailerons, rudder, and spoilers, replacing conventional cable and control rod linkages.

er's Roman Jet



The fly-by-wire system provides the advantages of weight savings, improved performance, and smoother flight. Most importantly, it offers improved safety through reduced crew workload and by determining the limits at which the aircraft can be flown so that in extreme conditions of high stress, the crew is unable to accidentally stall or over-rotate the aircraft.

Legacy cabins are spacious with greater headroom than competitors such as the Citation XLS+ and Hawker 750 and feature a flat floor rather than a dropped centre aisle: a common feature in this category. The Legacy 500 has one extra cabin seat, but there are several interior configuration options including side-facing divans to replace single seats, which gives a maximum capacity for up to 12 passengers in the Model 500 and nine in the Model 450. The standard Legacy 500 has eight fully reclining and swivelling seats in two club-four groups. Additionally, seats can be berthed to provide four beds.

The Legacy 500 cabin is well illuminated by seven large windows on each side. Pressurisation for the cabin is set at 5,800ft and it is equipped with Honeywell's Ovation Select Cabin Connection Suite which can be controlled from an iPad and provides surround radio and a full high-definition video system. There is Ethernet and voice and data connectivity through Iridium, Inmarsat or Aircell's Go-GoBiz system.

A fully enclosed lavatory with an optional belted seat shears the aft cabin space with a large 110ft^3 externally accessible baggage compartment.

Standard on the Legacy 500 (and optional for the 450) is a large wet galley with a stone-tiled floor.

In today's COVID-19 world, Embraer has fitted a HEPA (High-Efficiency Particulate Air) filter which is reckoned to capture 99.97% of all bacteria, virus, and fungus particles.

Additionally, the manufacturer offers a MicroShield360 preventative coating system for application to aircraft interiors, which continuously inhibit the growth of microbes on surfaces.

In 2012, Embraer opened its factory in Melbourne, Florida to handle the final assembly of the Phenom business jets. With primary airframe fabrication conducted in Brazil at Botucatu and São José dos Campos and some completion at the Gavião Peixoto facility, Melbourne has taken over the completion of aircraft for the United States and other main export markets.

Orientation of the assembly lines has changed to accommodate the Legacy 450 and Legacy 500. The first aircraft rolled-out, a Legacy 450, made its first flight on April 10, 2016.

Praetor

Held in Orlando, Florida during November, the 2018 National Business Aviation Association (NBAA) Convention was the venue where Embraer announced a major revision to its Legacy 450 and 500 jets, with the new Praetor name and a new model number.

The super-mid-size Legacy 500 became the Praetor 600 with new winglets, more powerful Honeywell HTF7500E engines each rated at 7,528lb and an additional second ventral fuel tank, giving it a 3,900nm range. The mid-size Legacy 450 became the Praetor 500 also with more fuel capacity, giving it a 3,250nm range, and redesigned winglets. Performance is the differential between the two models.

Legacy 450 aircraft can be upgraded to Praetor 500 standard by Embraer's service centres at Fort Lauderdale, Florida; Windsor Locks, Connecticut; Sorocaba, Brazil; or Le Bourget, France.

Each model shares the same fuselage and wings as its Legacy predecessor and features redesigned interiors and upgraded Rockwell Collins Pro Line Fusion integrated avionics.

The first development Praetor 600 (PR-ZTX) made its maiden flight on March 31, 2018, followed by the Praetor 500 (PR-ZTQ) on September 13 that year.

Deliveries got underway on December 23, 2019, when Praetor 500 (N422FX) was delivered to Flexjet.



ABOVE • ***The Praetor's futuristic flight deck features the Rockwell Collins Pro Line Fusion integrated avionics system with three displays and side stick controllers.***

Never short of uplifting words. Embraer marketeers describe the Praetor as the world's most disruptive and technologically advanced mid-size and super-mid-size business jets featuring advanced technologies on the flight deck and in the cabin.

Honeywell HTF7500E Engine

The HTF7500E is a turbofan engine configured with four axial compressor stages, a single-stage centrifugal compressor, an effusion-cooled combustor, a two-stage high-pressure turbine and a three-stage low-pressure turbine driving a high-efficiency fan, a bypass duct and exhaust mixer. The HTF7500E is 2.46m long, 1.34m wide, has a 34.2in fan and a bypass ratio of 4.2.

Fuel controls and power management are provided by a dual channel full authority digital electronic control or FADEC in conjunction with a hydro-mechanical unit incorporating an integral fuel pump.

The engine weighs 1,364lb including all basic components. Components certified as part of the aircraft, but mounted on the engine, are not included in the weight.

Honeywell supplies the HTF7500E to Embraer as an integrated powerplant system including nacelle, thrust reverser and all engine mounted accessories.

The engine is offered with an on-condition maintenance programme from the first day in service.



BELOW • ***The cabin of a Praetor 500 looking forward.***

Pro Line Fusion Integrated Avionics System

Pro Line Fusion's open system architecture enable new technologies, upgrades, or modifications to be installed within the flight deck or through a software download throughout the avionics life cycle. New technology systems such as surface management, synthetic vision, predictive wind shear, and next generation airspace capability.

The flight deck has four multi-function displays from which the aircraft is operated through the flight management system with autopilot,





ABOVE • ***The Praetor belly fairing is a prominent feature of the aircraft under fuselage design.***

LEFT • ***The cabin of a Praetor 600 looking forward.***

auto-throttle and closed-loop control and monitoring of fly-by-wire flight controls.

The pilot's interaction with the system is intuitive via tap and drag gestures of the full touch screen or with the trackball interface. Advanced graphics, intuitive icons and display window configurability make it easy for the pilot to get the right information at the right time.

The flight management system user interface organises data by phase of flight, which reduces workload, minimises distractions, and speeds operation so the pilot can concentrate on the task at hand. Tools to support this include 14- or 15-inch liquid crystal displays with advanced graphics; interactive map symbols; point-and-click or touch-screen navigation; a fully integrated control display unit; and graphical flight planning.

The system provides the pilot with extensive situational awareness and the ability to manage the aircraft systems, complete checklists, and track flight progress, while minimising the amount of time looking into the displays.

Rockwell Collins' Ascend flight information solutions offer a suite of services, online tools and personalised support designed to streamline pre-flight, in-flight, and post-flight elements by removing costly task redundancy and time-consuming flight, maintenance, and cabin service activities.

Pro Line Fusion Tools

- Graphical flight planning with interactive map symbols to enable the pilot to undertake point-and-click navigation on a full moving map display.
- A Rockwell Collin RTA-4100-series multi-scan weather radar providing hands-free, automated weather detection and analysis out to 320nm.
- Head-up guidance system with synthetic vision integrates the terrain database with real-time flight information for a perspective view of the outside world, bringing extensive situational awareness with natural, eyes-forward flying.
- Touch-control flight displays used for, for example, flight planning, aircraft performance monitoring, hazard avoidance capability with intuitive icons.
- Head-up guidance system provides features and benefits once only available to large executive or aircraft.
- Primary flight display with configurable windows enables the pilot to display full, half and quarter window configurations for a customisable level of on-screen information. Reconfiguration is quick and simple.

Rockwell Collins RTA-4100 MultiScan Radar

The Rockwell Collins RTA-4100 series MultiScan weather radar provides comprehensive weather analysis and threat detection capability to pilots. The system provides a 320nm

BELOW • ***Both Praetor models have new bolt-on winglets which cant out further adding 50in to the wingspan and 22in in wingtip height.***



RTA-4100 MULTISCAN RADAR FEATURES AND MODES FEATURES

Automatic operation.

Clutter-free, real-time weather detection from the aircraft

nose to 320nm.

Variable temperature-based gain.

Overflight protection.

Geographic weather correlation.

Certified turbulence detection.

Enhanced ground clutter suppression .

TrueZero automatic antenna misalignment compensation.

Path attenuation compensation (PAC) and PAC alert.

SmartScan rapid update technology.

Exceptional transmitter-receiver system performance.

Active gain in all modes.

Full split function operation.

High reliability.

Available Modes

MultiScan automatic operation.

Ground map.

Weather.

Weather plus turbulence.

Turbulence detection.

Test.

Manual operation.

clutter-free weather display and enhanced effectiveness as a threat detector. The system comprises a pulse repetition frequency or PRF transmitter, a receiver, and a flat plate antenna.

Capabilities include MultiScan automatic operation, geographic weather correlation, OverFlight protection and turbulence detection which accurately depict weather- and weather-related hazards. Turbulence detection provides the pilot with warnings out to 40nm.

The system automatically scans ahead of the aircraft and combines the returns through advanced digital processing and analysis algorithms to accurately display precipitation rates and actual

PRAETOR DESIGN ASPECTS

Configuration

Eye-catching fuselage and belly fairing.

Low, swept wings with new bolt-on winglets which canted out further adding 50in to the wingspan and 22in in wingtip height.

Flight Systems

Rockwell Collins Pro Line Fusion integrated avionics system with a new software load provides an instinctive interface between pilot and aircraft.

An RTA-4218 multi-scan radar provides vertical weather scan, predictive windshear, and ground-clutter suppression.

The dark and quiet flight deck is designed to reduce pilot fatigue and minimises workload.

Synthetic vision guidance system aids the pilot to execute safer take-off, landing and in-flight operations.

Optional E2VS enhanced vision system with HGS-3500 head-up display and enhanced video system, inertial reference system and synthetic vision guidance system extend the pilot's situational awareness.

Fly-by-wire system with side-stick controls reduce pilot workload and provide a safer, smoother flight experience with active turbulence reduction capability.

Terrain Collision Avoidance System II.

Transponder with ADS-B.

Cabin Systems

One of the healthiest cabin environments, featuring best-in-class cabin altitude and standard HEPA filters.

Six-foot-tall flat-floor cabin.

Embraer's Bossa Nova interior features carbon fibre materials, piano-black colouring, and diamond stitching.

Fully reclining seats with full berthing capability and placement beside spacious windows.

Stowable tables offer space and open flush with the side ledge.

Luxurious stone-floored galley equipped with a microwave, conventional oven, refrigerator, and coffee brewer.

Generous baggage compartment and a practical amount of internal storage space.

Honeywell Ovation Select Cabin Management Suite provides full 1080P HD video streaming and immersive audio.

Viasat Ka-band satcom.

Gogo AVANCE L5 datalink.

Wi-Fi connectivity.

Touchscreen panel displays flight status information with cabin environmental and lighting controls.

Operations

Delivers high dispatch reliability.

Low-intervention task-orientated maintenance methodology, coupled with a 35,000-hour economic life, make the aircraft easy to maintain and at coordinated intervals for less routine maintenance.

Equipped with quiet and efficient engines and new technology for lower emissions.

Certified for day-night, visual and instrument flight rule conditions.

Certified for Reduced Vertical Separation Minimum (RVSM) airspace within which air traffic control vertically separates aircraft by a minimum of 1,000 feet between the altitude block from 29,000 and 41,000ft.

Certified for operating in known icing conditions.

Flying over water for extended periods.

Flying Category II instrument landing system approaches.

Operating from airports at altitudes up to 13,800ft.

Conducting steep approach operations.

weather threats and turbulence hazards while reducing the pilot's workload and training requirements.

Legacy to Praetor Conversion

During the summer of 2020, Embraer completed the first conversion of a Legacy 450 to Praetor 500 configuration at its Bradley International Airport, Connecticut service centre.

During a month-long programme of work, the conversion involved increasing the wingspan from 63 to 71ft, reinforcing the wing ribs, replacing, or moving elements to the fuel-measurement system and fuelling ports, updating the flight control systems, and loading new software for the flight deck. Work also included fitting the Praetor's swept winglets and replacing all interior placards and logos.

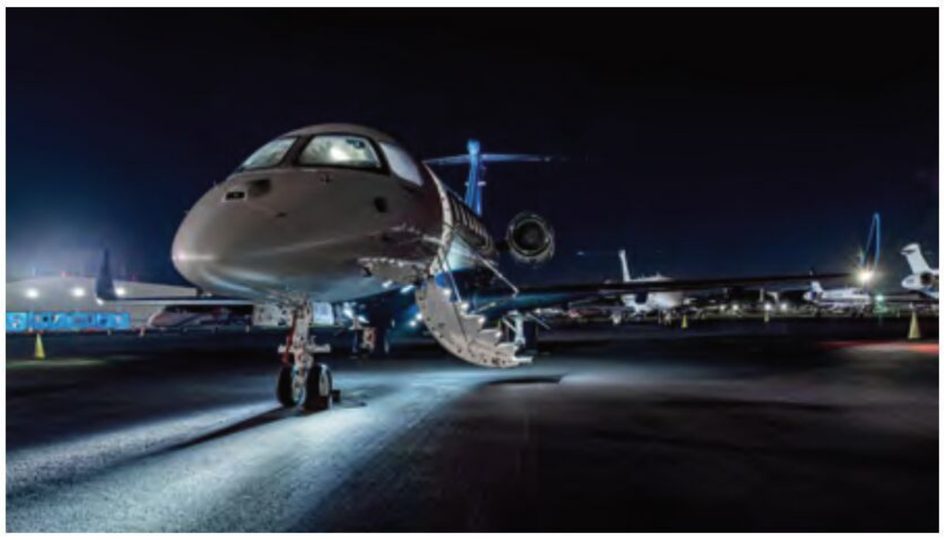
According to Embraer Executive Jets, the conversion is a cost-effective solution for Legacy 450 operators with greater range and payload mission requirements.

Praetor Programme

On October 21, 2019, during the 2019 NBAA Convention and Exhibition in Las Vegas, fractional jet ownership provider and lessor Flexjet announced a US$1.4bn order with Embraer Executive Jets for Praetor 500 mid-size, Praetor 600 super-mid-size, and Phenom 300E light jets.

Accepting delivery of the Praetors represented the fourth time Flexjet had introduced new Embraer aircraft to the fractional market. Previous introductions were the Legacy Executive in 2003, the Phenom 300 in 2010 and the Legacy 450 in 2016. In addition to receiving new Praetor aircraft, Flexjet is converting its entire Legacy 450 fleet into Praetor 500s.

Flexjet accepted delivery of the first Praetor 600 aircraft in its European-based fleet on November 20, 2020 - a significant milestone in the expansion of the company's global business. The company is currently the only shared-ownership/fractional provider of the Praetor 600. ●



Praetor 500 and Praetor 600 Characteristics

	Praetor 500	Praetor 600
Length	64ft 7in (19.68m)	68ft 1in (20.75m)
Height	21ft 1in (6.43m)	21ft 2in (6.45m)
Wingspan	70ft 6in (21.49m)	70ft 6in (21.49m)
Wing area	482.8ft^2 (44.85m^2)	482.8ft^2 (44.85m^2)
Basic operating weight	22,908lb (10,390kg)	25,360lb (11,503kg)
Max payload	2,921lb (1,324kg)	3,300lb (1,496kg)
Max take-off weight	37,567lb (17,040kg)	42,858lb (19,440kg)
Fuel payload	13,058lb (5,923kg)	15,986lb (7,251kg)
Cabin altitude	5,800ft (1,768m)	5,800ft (1,768m)
Cabin length	24ft (7.31m)	26ft10in (8.18m)
Cabin width	6ft 10in (2.08m)	6ft 10in (2.08m)
Cabin height	6ft (1.83m)	6ft (1.83m)
Max speed	Mach 0.83	Mach 0.83
High cruise speed	466kts (863km/h)	466kts(863km/h)
Take-off distance with four passengers and NBAA IFR reserves for max range	4,222ft (1,287m) 2,842ft (867m) on a 1,000nm mission	4,436ft (1,353m)
Landing distance with four passengers and NBAA IFR reserves	2,086ft (636m)	2,270ft (692m)
Range at high cruise speed with four passengers and NBAA IFR reserves	3,340nm (6,185km)	4,018nm (7,441km)
Ceiling	45,000ft (13,716m)	45,000ft(13,716m)
Crew	2	2
No of passengers	7 to 9	8 to 12
Baggage capacity	150ft^3 (4.24m^3)	155ft^3 (4.38m^3)
Powerplant	Two Honeywell HTF7500E each rated at 6,540lb	Two Honeywell HTF7500E each rated at 7,528lb with software update
Flight testing commenced	September 13, 2018	March 31, 2018
National Civil Aviation Agency Brazil certification	August 2019	By April 2019
EASA and FAA certification	End of September 2019	By May 2019
First delivery	December 23, 2019	June 28, 2019

Insight on Em New Turbopro

Gordon Smith spoke with Embraer's Martyn Holmes and Rodrigo Silva e Souza to discuss one of the industry's hottest topics – a new turboprop aircraft.

ABOVE • ***Could this new platform disrupt the turboprop market?*** ALL IMAGES EMBRAER UNLESS STATED

BELOW • ***The EMB-110 Bandeirante helped establish Embraer within international markets.***



braer's p Project



An Air Littoral Bandeirante in flight. The French carrier was an early operator of Embraer turboprop aircraft.

Do airlines, airports, and passengers like turboprop aircraft? They're noisy, they vibrate, they don't sell well. Yet an Embraer team claim there is a market for the turboprop – especially one that offers a 'jet-like' passenger experience. Embraer highlights the all-important 50-seater market in the United States, and enormous opportunities for TP aircraft further afield as current types start to reach the end of their service lives.

Back to the Future

Giving extra credibility to its business case is the fact that this is Embraer's space – the company started with the pioneering EMB-110 Bandeirante five decades ago. The firm argues that it knows this market better than anyone and it is ripe for disruption.

Speaking exclusively to the author, Martyn Holmes, Embraer Commercial Aviation's chief commercial officer offered some helpful parameters to the company's TP thinking: "Shorter sector lengths naturally suit turboprops and longer ones better suit jets. We've always been clear that there's a market for both."

This was echoed by Rodrigo Silva e Souza, Embraer's VP of marketing, who claimed the status quo is overdue a major change: "When we started looking at the TP opportunity, we noticed the market was becoming an ATR monopoly, as the value proposition of the Q400 was not as valid as it was previously – it falls in between a good jet and a good turboprop and isn't optimising anything. We saw a monopoly with a product that has technology and design from the 1980s – it represented a good opportunity for Embraer to enter this sector."

For Silva e Souza, the TP platform also offers the chance for Embraer to boost its brand awareness within underserved markets: "From a geographic point of view – our main footprint nowadays is in the Americas and Europe, with some parts of Africa – but we're not as strong as we would like in Asia. At least 40% of the turboprop market sits there – so the TP represents an opportunity for us to extend our presence in the region. The other thing to consider is stage length – we understand that by offering a TP and a jet, it offers the possibility for operators to optimise their fleet strategy for both short and longer sectors. This then creates a synergy, where the TP can perhaps boost, for instance, the E2 market and vice-versa."





Embraer's latest concept images for the TP show engines mounted at the rear of the aircraft. If realised, this would represent a step-change from conventional wing-mounted powerplants, and arguably a return to a principle not seen since the DC-9 and CRJ – although even those types were jet-based.

The Embraer team is keen to emphasise that aft-mounted engines was one of many options originally considered, and there is sound logic behind the move, incorporating present-day considerations such as air-bridge compatibility combined with future-proofing the platform: "In parallel [with the TP] we are studying the evolution of future propulsion technologies; electric, hybrids and hydrogen. For this size of aeroplane, we believe that hydrogen will be the final answer, and when we consider an aircraft that needs to fit a hydrogen tank, the ideal configuration is to have the tank closer to the engine.

"The result is an aircraft that is ready for these new technologies," noted Souza. "The TP is the first concrete step towards a more sustainable aviation industry within this new wave.

"Of course, we've always designed aircraft with the lowest fuel burn possible, but we will create this TP from day one to be compatible with sustainable aviation fuel.

"The rear-mounted engines are about looking forward to what will be the next breakthrough in technology, we believe that is important."

Even using current fuel technology, Embraer forecasts that airlines operating the new TP could see 20% lower operating costs versus current types of turboprop aircraft, never mind the jets that they might replace.

With the TP programme yet to be launched, it's not surprising that Embraer has yet to confirm an engine provider. But the longer this ambiguity lasts, the more creeping speculation will mount that Embraer could break rank with Pratt & Whitney – the current dominant supplier for turboprop engines globally – and opt for a possible competing model by GE Aviation.

Need for Speed?

Looking beyond the engines themselves, what about wider performance? Could the proposed Embraer TP match the fastest turboprops of today? "One of the first things we learned after talking to potential customers is that the speed of the Q400 isn't required, but they do want something faster than the ATR, with optimised economics," said Souza. "Another important element which we discovered speaking to clients in Asia in particular, was the desire to have a bigger turboprop aircraft. If you look at recent Q400 and ATR deliveries in the region, you'll see many of them arriving in the highest density configurations. The third thing we learned was the importance of the passenger experience. Some operators told us that the TP market could be bigger if the passenger experience was better. This means a larger cabin, more space for carry-on baggage, more reliability and reduced noise and vibration.

"We considered all of this and that helped how we're positioning our aircraft. It is a large turboprop which goes up to 90 seats, so it offers a capacity bigger than an ATR, but with better economics."

While specifics are still to be confirmed, expect Embraer's TP to have a range of around 800nm, with the type most efficient on hops of approximately 200nm to 300nm. Elsewhere, fans of Embraer's unofficial USP – the two-and-two seating configuration – will be glad to hear that the programme team expect the interior of the TP to be almost identical to the firm's flagship E2 jets. This may fundamentally be a turboprop in terms of technology but according to Souza, it'll be farewell to tiny overhead storage bins and uncomfortable seats, and hello to a jet-like journey: "The cabin itself is designed to be the same as an E2 – the reason for this is not only to address the passenger experience, but also to optimise our development costs and maximise the commonality for operators. For instance, the same seat that fits into an E-Jet will be able to fit into the TP. From a passenger perspective, it'll be absolutely the same cabin."

Pressed on just how similar the fuselage will be between the E2 and the TP platform, Souza confirmed that to the untrained eye, it will look the same. However, technical requirements and specifications for turboprop flying mean the materials involved will differ: "It will be the same cross-section, so if you see the contour, it will be the same as an E2. However, the structure itself is different as it needs to be lighter – it doesn't need to go to 41,000ft, it doesn't need to withstand the loads of an E195-E2 with 146 seats. It will be an optimised structure. However, the envelope is the same, so many part numbers [from other Embraer types] will fit."

American Interest

During the author's discussion, both Holmes and Souza mentioned a marked difference in tone from American carriers over recent months towards the TP platform – a market that has historically been hostile towards anything but a jet. "Suddenly the US market went, 'oh, this could work', as there was an understanding of the economics and sustainability benefits that this platform will offer. Then realising that technology has moved on, we will get a jet-like experience on this TP, and passenger prejudice against TPs will vanish," said the Embraer CCO.

"They'll look at it as an aircraft that will go from point A to B, with exceptional

ABOVE LEFT • ***The Embraer EMB-120 Brasilia proved popular with US regional carriers.***

ABOVE RIGHT • ***A concept image of how the proposed turboprop platform could look.***

BELOW • ***Subject to board approval, the project could be formally launched in the second half of 2022.***





economics and customer experience. That dawning and realisation has shifted things quite significantly. We've had quite a lot of unsolicited interest from customers contacting us about the TP," revealed Holmes.

Although far from exclusive to the US market, the issue of continuity of product on multi-sector itineraries is a passenger and airline bugbear. A traveller flying regionally to a hub to then transfer internationally on a first or business class ticket will often find themselves crammed into a tiny jet for the first stage of their trip. However, take Embraer's proposed TP in a multi-class configuration, and US airlines will get their magic 50 seats and be able to provide passengers with comfort and experience throughout the journey.

For Souza, along with a notable shift in sustainability efforts, the chance for North American carriers to upgrade their smallest jets was transformative: "The Canadian market was a target for us since the beginning, but the difference has been talking to some US airlines. There was a different level of interest when they noticed the opportunity to replace 50-seaters, because although we talk about a 70 and 90-seater, that refers to a typical configuration, which is single-class, 29-inch pitch. We're looking within the US at a possible three-class setup with 50 seats. That value proposition is tremendous because now you have an aircraft that is much more economical than a [comparable] jet but offers a much better passenger experience. This change in response from the US led us to reconsider some of the configurations which we had visited before."

Overdue Arrival

So, why has it taken until now for another player to shake up the turboprop status quo? According to Souza, the answer comes down to resource and knowledge: "It is tough for any OEM to make a business case for a new development within this market. I would say that Embraer is probably the only company able to do it because you must have the expertise to design the new aircraft. You must also consider the cost of development and how that is compatible with a market that isn't as big as those for narrowbody [jets]. It is difficult to imagine Boeing being able to close a business case for a turboprop – the same for Airbus. For ATR, it's also difficult because they have the monopoly today, so why would they invest when they already have 80-90% of the market?

"Until recently, we were focused on the E2 and, of course, in 2020 we had the pandemic, which delayed our plans a little bit, but now we are back to full throttle to make this programme work."

Talking Timings

So, when should we expect a formal unveiling of the new TP platform? "The target is to launch this product – with formal board approval – in the second half of 2022," revealed Souza. "We've a lot of work to do between now and then, and one of the main things is discussing partnerships. We have many industrial partners interested in this project, some of them are from Asia where we want to have a stronger presence – so having a partner there makes sense for us. We're considering all possibilities with the idea to make it a more solid programme, to share a little bit of the risk and optimise our investments."

Souza confirmed that significant progress was being made in talks with potential partners: "We have an initial understanding of what would be the participation of each partner. We have discussed the concept and we are now going into the details – what would be the investment, the contribution of each partner? We're about 40% of the way there." ●



BELOW • ***Embraer has showcased another form of turboprop, its electric Impanema demonstrator.***

RIGHT • ***Passengers flying on Embraer's nascent TP aircraft can expect a cabin almost identical to the flagship E2 jet.*** HELVETIC AIRWAYS

BELOW RIGHT • ***Embraer hopes to recreate a jet-like experience onboard its new turboprop aircraft.***



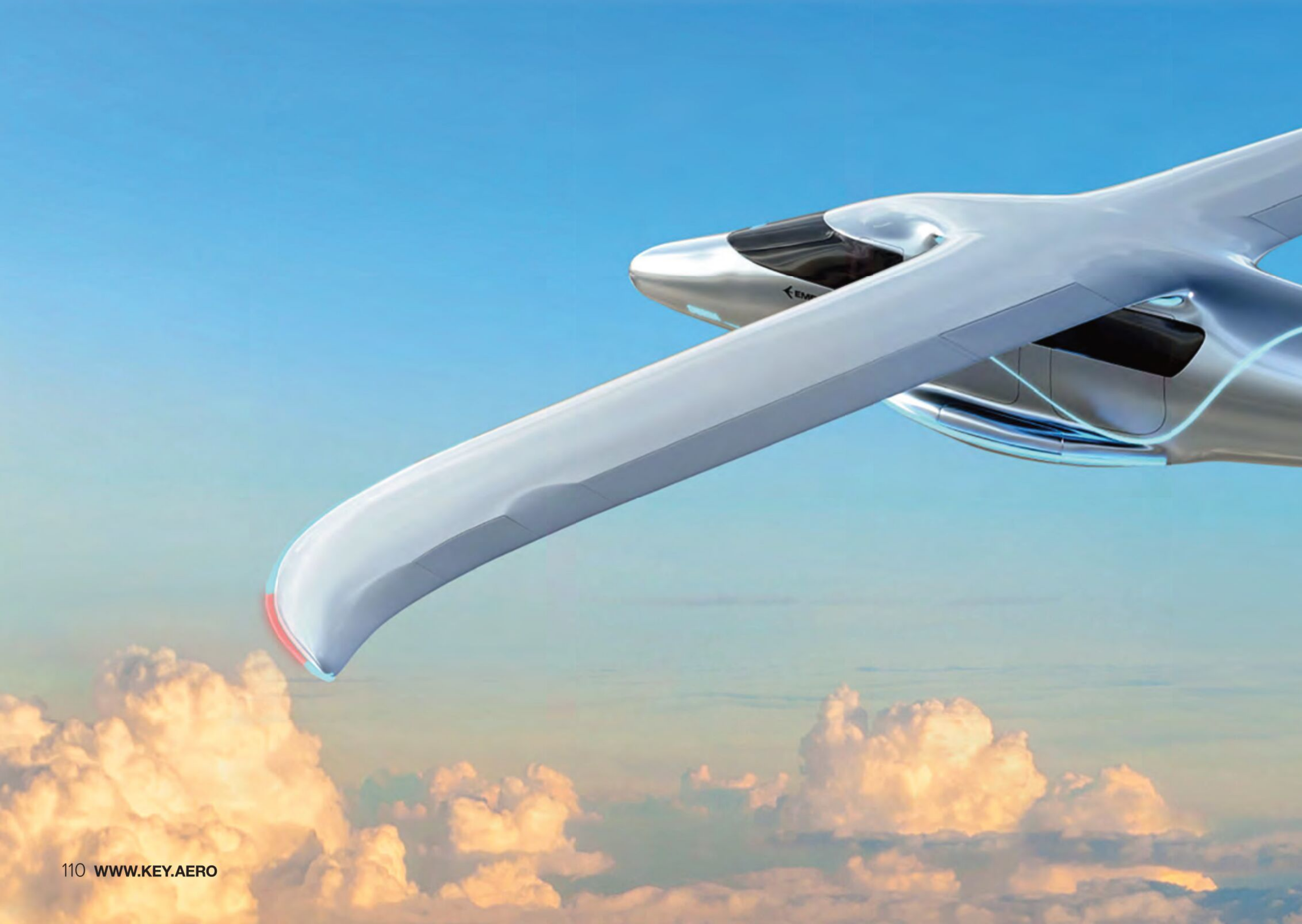


Research and Technology

Mark Ayton spoke with Maurilio Novaes Junior, Embraer's head of research and technology about the ongoing work to develop new power systems and a next generation of aircraft.

Research and technology within Embraer are the primary tasks of its engineering unit. Engineering itself is the discipline from which the company gets its strength which resides in its individual engineers and employees. That's a well-recognised fact in Brazil so a lot of engineering students want to work for the company. That increases competition for graduate placement, a fact that recruiters take advantage of to select what they believe are the best young engineers. Once appointed by Embraer, a young engineer can expect to be moved between business units like commercial aviation, defence, and executive aviation and during their time working at any one of the units can work on product development or projects.

The engineering unit comprises various departments, one of which is the chief engineer department whose staff monitor the expertise and skillset of each business unit and move individuals between the units to ensure people specialised in one technology can move to a different business unit to use and share their experience on different challenges. For example, different aeronautics teams supporting commercial aviation and defence, often share their experience and solutions to spread



BELOW • ***An artist's impression of the Energia Electric E9-FE with tail-mounted contra-rotating propellers.***

state-of-the-art knowledge around the company.

The advanced design department supports all the business units and the research and technology department hold responsibility for increasing the maturity level of each technology to eventually be applied to products and services in the company. A maturity level is also referred to as a Technology Readiness Level or TRL.

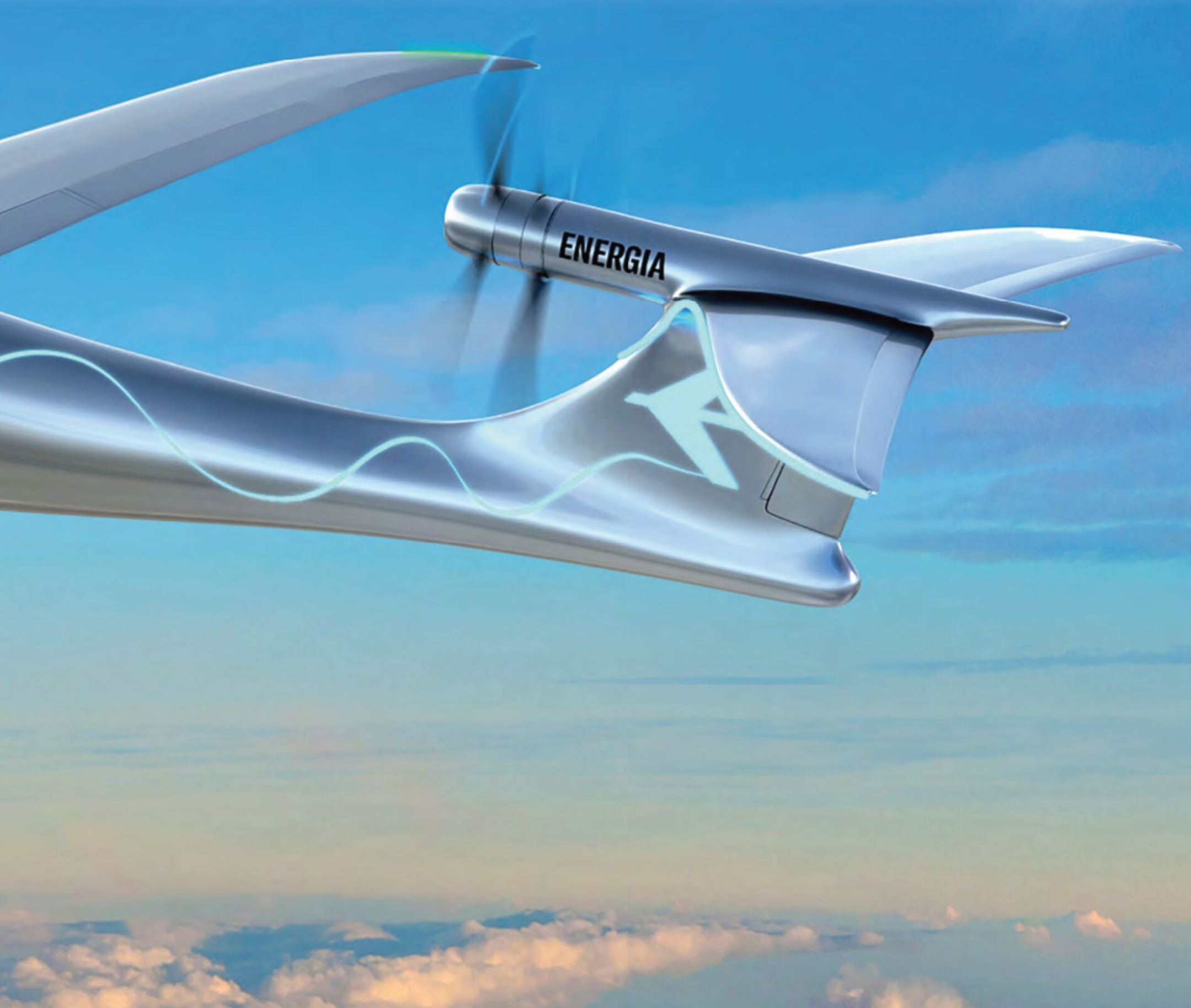
Discussing a major Embraer project undertaken by the research and technology department, which was used on new aircraft types, Maurilio Novaes Junior cited the fly-by-wire system as a leading example. He said: "The fly-by-wire system started with the research and technology team with the belief that we could get more efficient airframes based on the technology. In support of that effort, we also started important partnerships with the Brazilian government which funded some of the studies, and with universities and industry, trying to work together. We first applied a fly-by-wire system to the E-Jet but not the full fly-by-wire concept. The research and technology team continued its work to evolve the fly-by-wire concept and subsequently applied a full concept fly-by-wire system to the Legacy 500 executive jet followed by the C-390 transporter. We eventually applied the fly-by-wire system to commercial, defence and executive products. Our fly-by-wire philosophy and concepts represent a competitive differentiation."

Ongoing Research

That's in the past, today the research and technology department is focused on the technologies linked to the Energia and zero emissions. Electric propulsion and hydrogen are one focus. Sustainable aviation fuel that can be applied not only to future products, but also in the current fleet is another.

Detailing more projects, Maurilio said: "We are also working on autonomous flight and how it can bring sustainable products and allow us to change the future of urban air mobility. We expect a lot of aircraft flying in the urban arena but not every single air vehicle will have a pilot. As a department we are always trying to improve our products in terms of efficiency, aerodynamics and the use of environmentally friendly materials, more light materials, that will be less expensive to operate. We need to account for the lifecycle of all products from the start of a project, especially the end phase of the lifecycle and consider how we can recycle materials at the end of its life."

Discussing Embraer's electrically powered aircraft projects, Maurilio said Embraer had flown a full electrically-powered EMB-203 Ipanema demonstrator from its airfield at Gaviao Peixoto in July 2021. The maiden flight was part of efforts to develop electric technologies for use in future aircraft projects. During a series of initial flights, the research and technology department evaluated the electrically-powered aircraft's power, performance,



control, thermal management, and operation safety. Subsequent flights sought to demonstrate how the aircraft performed in real conditions compared with those modelled with computational simulations, lab tests and integration of technology on ground-based test rigs.

WEG, a Brazilian electric-electronic equipment company, which develops solutions in energy efficiency and electric mobility, supplied Embraer with the electric powertrain system used for the Ipanema. This was part of a 2019 cooperation agreement between Embraer and WEG which sought to jointly develop technologies to enable electric propulsion of an aircraft.

Batteries and charging technologies were supplied by the Brazilian division of energy company Energias de Portugal as part of a 2020 partnership with Embraer.

Despite the flight test programme, Maurilio told the author the electrically-powered Impanema will not be put into commercial production.

Elaborating, he said: "We need to do more evaluation with other companies about high voltage, batteries, energy density, and the challenges we have with thermal management."

Energia

In its introduction to the Energia project, Embraer outlines the need for aviation to have a lower impact on the earth listing lower emissions, lower noise levels and lower fuel consumption as three primary aspects of cleaning up aviation.

The company says: "To achieve our goals, we're exploring a wide range of bold but viable aircraft designs in our Energia concepts – reimagining and conceptualizing everything from the aircraft's power source to the shape of the airframe – all to achieve the industry-wide goal of net carbon zero by 2050."

Embraer's research and technology department is exploring a range of sustainable concepts to carry up to 50 passengers by considering several energy sources, propulsion architectures and airframe layouts to reduce carbon emissions by 50% starting from 2030. To date, Embraer has released details of four Energia concepts: Hybrid, Electric, H2 Fuel Cell and H2 Gas Turbine.

Energia Hybrid E9-HE

By combining a mix of technologies, Embraer hopes that hybrid-electric propulsion will enable it to harvest the benefits from maximising thermal and electric engines synergies. The concept includes parallel hybrid-electric propulsion, an engine's usage strategy optimised for each flight segment, superior aerodynamic performance, 100% SAF compatibility, and rear-mounted engines with optimised propeller design and low noise.

Technology readiness	2030
Range	500nm
Seats	Nine passengers
Noise	60% lower external noise
Carbon emissions	50% less CO2 with jet A1 and 90% less CO2 with SAF

ABOVE • ***An artist's impression of the Energia Electric E9-FE with ultra-efficient glider-inspired aerodynamics.***



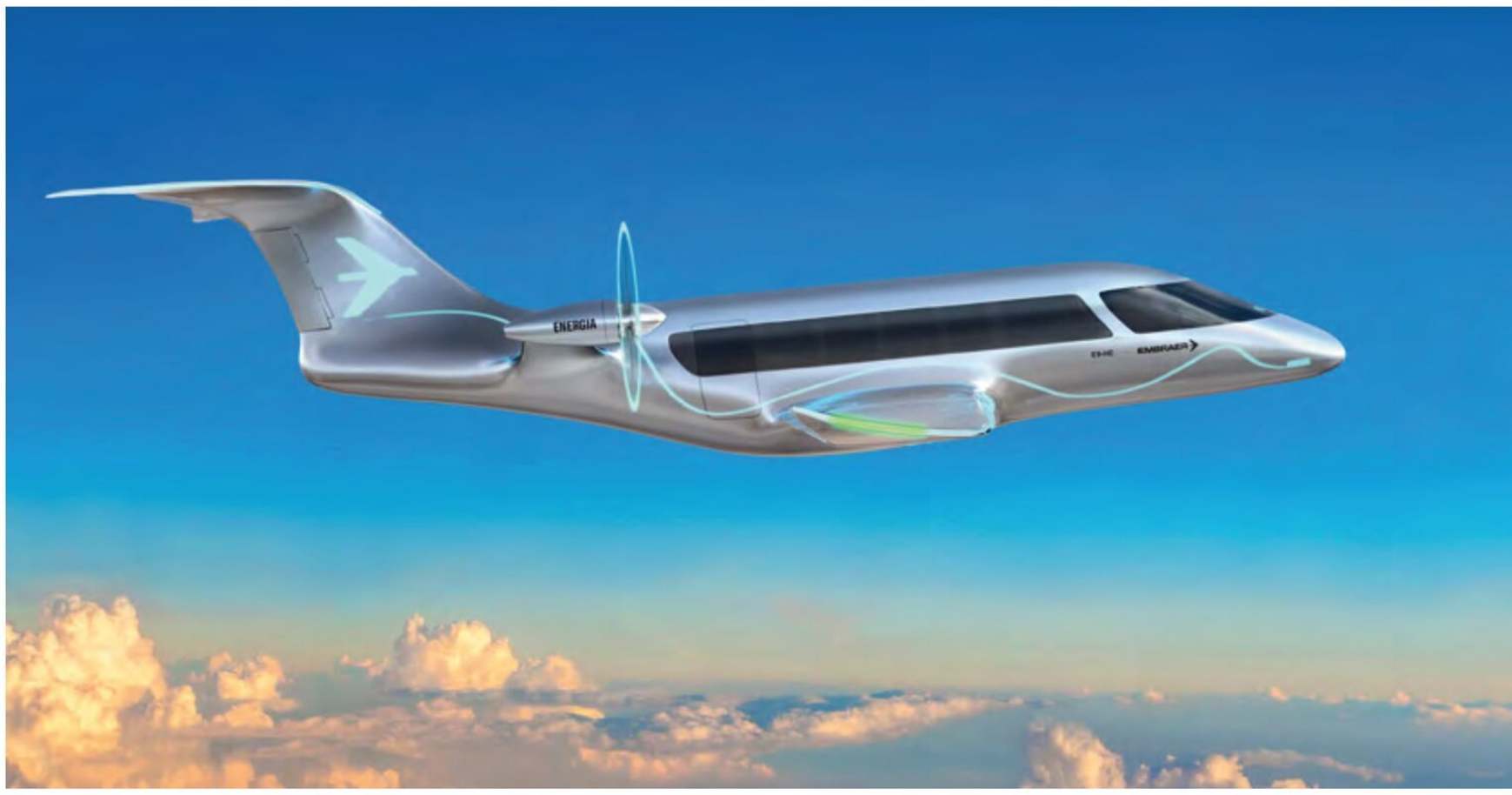
Energia Electric E9-FE

Embraer believes by developing higher capacity and longer-lasting batteries, a full-electric aircraft, designed for short-range missions, could reduce the aircraft CO2 emissions to zero. The concept includes full electric propulsion, optimised batteries for mission and reserves, high efficiency and lower noise tail-mounted contra-rotating propellers, and ultra-efficient glider-inspired aerodynamics.

Technology readiness	**2035**
Range	**200nm**
Seats	**Nine passengers**
Noise	**80% lower external noise**
Carbon emissions	**Zero CO2**

Energia H2 Fuel Cell E19-H2FC

Embraer rates hydrogen as a highly promising area in its journey to achieve zero emission flight – enabling thrust to be generated while reducing carbon emissions to zero. Hydrogen fuel cells have the potential to either run as a single power source or as a hybrid with gas turbines or batteries. The concept includes hydrogen powered electric propulsion, high-performance, high specific power fuel cell, high specific energy liquid hydrogen tanks, clean wing and fuselage with maximum aerodynamic performance, and rear-mounted electric engines with optimised propeller design and low noise.



Technology readiness	2035
Range	200nm
Seats	19 passengers
Noise	70% lower external noise
Carbon emissions	Zero CO2

ABOVE • ***An artist's impression of the Energia Hybrid E9-HE with rear-mounted engines and optimised propeller design and low noise.***

The concept includes dual fuel gas turbine propulsion, 100% hydrogen energy for typical routes, SAF or JetA used for reserves and range extension, hydrogen storage customised according to operators' specific needs, clean wing and fuselage for maximum aerodynamic performance, and rear-mounted engines with optimised propeller design to decrease noise.

Energia H2 Gas Turbine E50-H2GT

Dual-fuel enables a gas turbine to be powered with two different fuel sources (SAF or Hydrogen), to maximise operational flexibility and reduce aircraft weight. Using a modified gas turbine, adapted to these new fuel sources, Embraer hopes to increase range and passenger capacity.

Technology readiness	2040
Range	350 to 500nm
Seats	35 to 50 passengers
Noise	60% lower external noise
Carbon emissions	Zero CO2

BELOW • ***An artist's impression of the Energia Hybrid E9-HE with parallel hybrid-electric propulsion and superior aerodynamic performance.***



Challenges

Discussing how the research and technology department is approaching how to make an electrically-powered aircraft become reality within 15 years given the challenges of range and the time taken to recharge an electric car's batteries, Maurilio said it was a very good question and then replied: "As you mentioned, the automobile has challenges. For aircraft, the challenge is even greater because we must generate lift, so weight is key. In terms of the batteries, we face not only challenges regarding weight, but also a huge challenge regarding the cost and the life cycle of batteries. Those are key points for us, and the technology needs to evolve a lot. Energy density is another challenge. Right now, energy density is 200, maybe 250-Watt hour per kilo. In our view, to make it more viable to provide a product capable of carrying up to 20 passengers over

200 nautical miles we need energy density of about 800-Watt hour per kilo.

"We also have a huge challenge in terms of the battery's life cycle, otherwise it will be necessary for commercial aircraft, for instance, to replace the batteries twice, or three times a year. Batteries are very expensive. When you fill the tank of your car, you drive several journeys on that tank of fuel. But in aviation, the tank, or the batteries, are sized to be able to do one mission, so one mission is equal to one battery cycle as well. We cannot size the battery bigger than that, otherwise, the aircraft will be unable to carry the necessary weight. We also face challenges with airport infrastructure and the capability to charge batteries at the speed required.

"The battery, energy density, the weight, the price, the life cycle, airport infrastructure and re-charging capability are huge challenges, so we need to evolve all those parameters together with other partners and institutions. But we don't foresee an aircraft the size of an E-jet powered only by batteries. We don't perceive that to be possible. We also don't foresee it is possible to go from the south of Brazil to the north of Brazil in an aircraft powered by electric power only, nor do we foresee the capability to carry 20 passengers over 200 kilometres becoming a reality before 2035 or so."

A further challenge of installing heavy batteries into an aircraft is the effect on the aircraft's centre of gravity. On current aircraft the centre of gravity changes as the fuel load burns down. That's not the case with batteries, which will influence the handling of the aircraft.

Explaining, Maurilio said that centre of gravity is a huge problem, so the research and technology department's concept is to locate batteries in different parts of the aircraft and not concentrated in one point: "Batteries need to be to be accounted for in the centre of gravity and the centre of gravity will remain the same."

New Design Configurations

One positive impact of new propulsion technologies is the enablement of new design configurations as Maurilio explained: "With electric propulsion, it is more feasible to take advantage of distributed propulsion, for instance, a single engine that can distribute power to different propellors, changing conventional configurations to non-conventional configurations.



"Because we don't have a silver bullet for every single size and mission of aircraft, we're considering a hybrid configuration using batteries when a lot of power is required during take-off and during climb and use another energy source such as a soft fuel like hydrogen during cruise.

"We also have a roadmap and a plan to use a demonstrator to accelerate our knowledge of hydrogen. We will start by considering a fuel cell concept, gas hydrogen and then further on move to liquid hydrogen powering a gas turbine. We will face challenges regarding the hydrogen storage infrastructure, weight, the fuel cell at volume, and management of temperature which is key for hydrogen. We must also consider the chance of producing green hydrogen, which is a key requirement."

Maurilio confirmed the research and technology department is working on the type of materials used to build the Energia-style aircraft. Its challenge is to make and use lighter materials requiring less power to propel: "Ultimately the materials used need to be more environmentally friendly throughout the aircraft's lifecycle not just during its service life and its end-of-life re-cyclability, but also during production by minimising the amount of raw material used. We are optimising the structures and therefore the material used."

The curved form used for the wing, winglets, fuselage, and the wing to fuselage joins on the concept images released to date, shows that Embraer is using powerful design tools to devise those shapes. But design is only part of the task, the materials used and the ability to form and produce those shapes is crucial.

Maurilio confirmed that new types of material are under development, along with conceptual studies of hydrogen, electric and hybrid power propulsion, different technologies, and different architecture concepts. ●

ABOVE • ***An artist's impression of the Energia H2 Gas Turbine E50-H2GT with clean wing and fuselage for maximum aerodynamic performance.***

BELOW • ***An artist's impression of the Energia H2 Gas Turbine E50-H2GT with rear-mounted engines with optimised propeller design to minimise noise.***

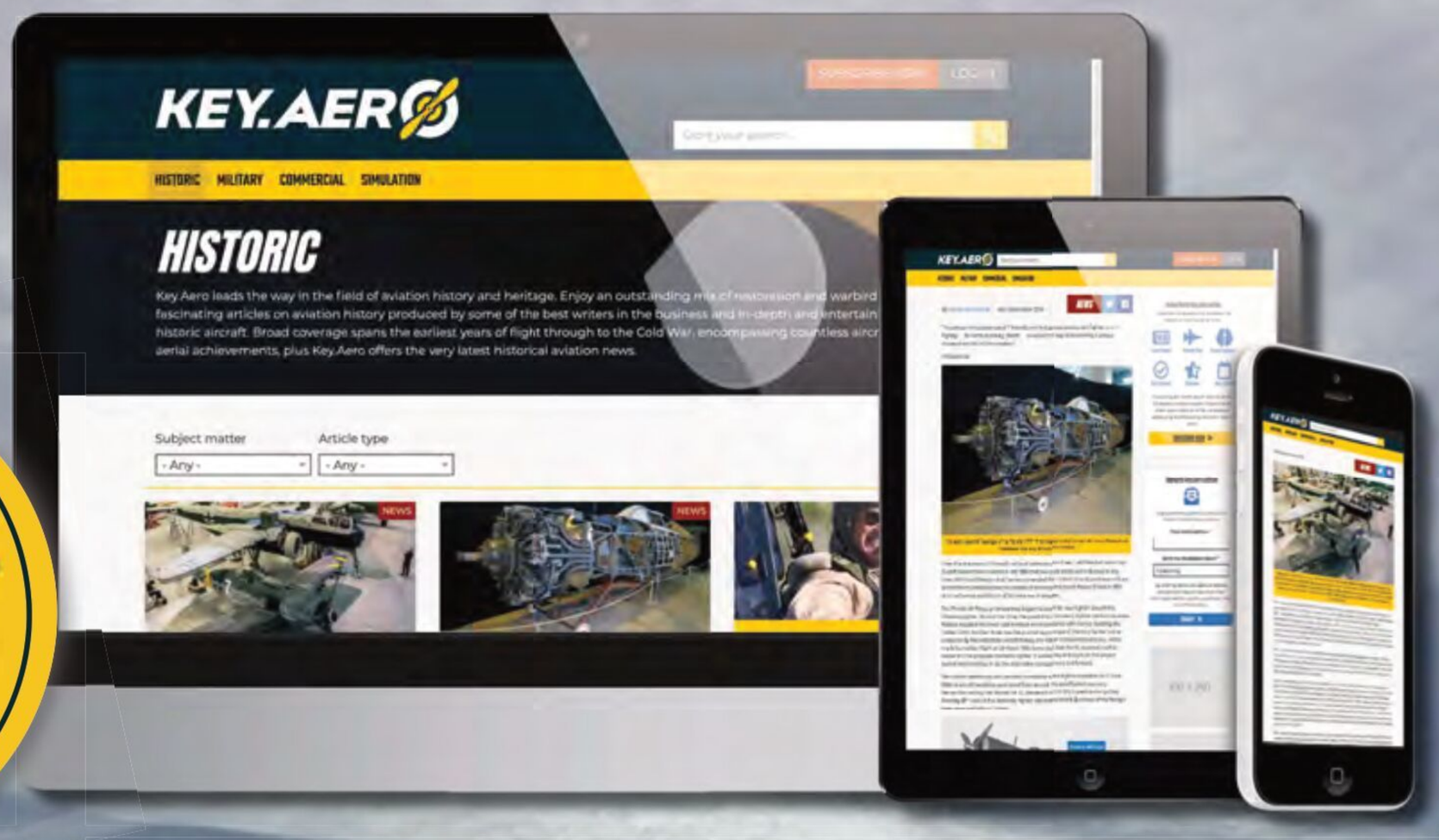


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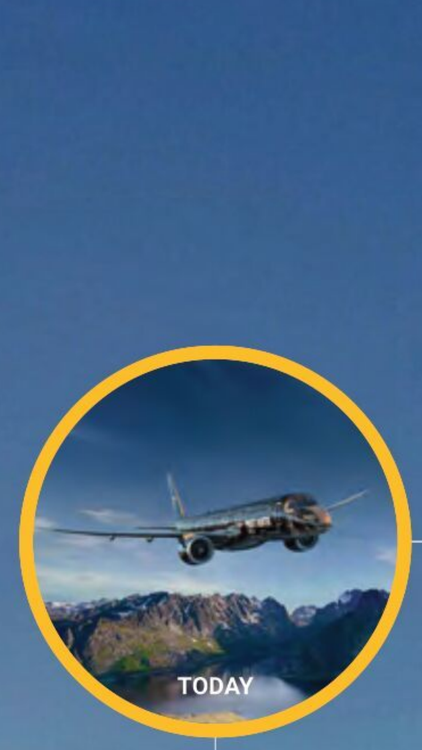
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Energia H2 Fuel Cell



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SUSTAINABILITY IN ACTION.

Net zero carbon emissions by 2050. Making regional aviation cleaner and quieter. Our sustainability roadmap and product development plan have been constructed to help us achieve these goals. Our new generation E2 is the most fuel efficient single-aisle aircraft in the market today with a potential reduction of CO2 emissions up to 30%. In 2025 we are planning the first flight of our hydrogen-powered electric demonstrator.

Between 2027 and 2030 expect to see our next generation turboprop and E2 flying 100% SAF compatible. By the mid-2030s we are planning to introduce the sustainable Energia family of aircraft, powered by revolutionary propulsion architectures. 2045 will likely see the flight of our first hydrogen-powered turboprop and finally, in 2050, a hydrogen-powered E2 or similar sized aircraft will take to the skies.

Undoubtedly these are bold and ambitious steps, but with over 50 years of market knowledge and expertise behind us, we are confident that we will deliver what we set out to do, transforming the way we all fly.