Flights of the future

Embraer is investing in partnerships to develop biofuels and cabin innovations

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Embraer is the world's third-largest manufacturer of commercial jets, ranking behind only giants Boeing of the United States and Airbus of the European Union. Embraer was founded to transform science and research projects into technology products. "Knowledge is in the company's DNA," said Mauro Kern, vice president for engineering and technology at Embraer, where he started 30 years ago. According to Kern, a mechanical engineer who graduated from the Federal University of Rio Grande do Sul (UFRGS), "in the post-war period there was a vision that the aviation industry could serve as a major driver of technology in Brazil," he says.

The first move in this direction was the creation of the Technological Institute of Aeronautics (ITA), in partnership with the Massachusetts Institute of Technology (MIT) of the United States, to train aeronautical engineers. Then came the Aerospace Technical Center (CTA), which, in the 1950s and '60s, carried out projects to create a technological knowledge base. One of these projects paved the way for the aviation industry in 1969. "Embraer was established to produce the Bandeirante airplane," according to Kern. New projects followed on the heels of this one, such as the Ipanema single-engine agricultural aircraft in the late 1960s that was mass-produced beginning in 1972. "This was the world's first aircraft certified to fly with biofuel, and it is still being manufactured today", Kern said.

Between 1983 and 1984, Kern spent six months in Italy working on the AMX program, a line of military aircraft developed in cooperation with two Italian companies to build Brazilian industrial capacity in systems integration. Andrea Barp, an electronics engineer who graduated from ITA and works in systems simulation and modeling for Embraer, also spent some time in

Left to right: Alexandre Filogonio, Paulo Anchieta, Fernando Fernandez, Allan Pereira, Mauro Kern and Andrea Barp, at the Embraer headquarters in São José dos Campos

LÉO RAMOS

Italy in 1983, along with other young researchers. "The degree of integration and the complexity of onboard aircraft systems was considered advanced for the time, mainly because of onboard software," he says. Embraer's challenges were overcome with a substantial amount of research, and five years later, the knowledge acquired during this period enabled Embraer to produce the onboard software for the AMX aircraft.

Embraer's true goal was to acquire autonomy at every stage of aircraft development and construction. For example, when Kern returned to Brazil, he was assigned to an Embraer subsidiary created to develop skills in landing gear and fine hydraulics. "I was the first engineer in the technical unit of this subsidiary," Kern said. There were several cooperation and development programs between then and 1996, when Embraer certified the landing gear for the ERJ 145, a 50-seat regional jet. This was the first regional jet that Embraer developed entirely on its own. In 1999, Kern transferred to Embraer's headquarters, where he focused on the Embraer 170 and 190 projects. These are commercial jets with capacities of between 70 and 120 seats. Initially, he worked as chief engineer on the 190 project; next, he was transferred to manage the 170 and 190 series programs. He then became vice president for commercial aviation. Eighteen months ago, Kern was named vice president of engineering and technology, a position that encompasses all of Embraer's aviation programs.

Barp was working with aircraft for military defense use and was also called upon to join the Embraer 170 and 190 regional jet programs in 2000. Barp noted: "My job was to assist in integrating the simulation models with the testing devices, an activity which to that point had been nearly stagnant." A realistic simulation of flight conditions is necessary to prepare the

Commercial jet assembly line

aircraft for its first test in the air. At that time, Embraer had delegated the responsibility of integrating and developing the onboard software for the jets to vendors, whose task was to link everything together in the airplane and to put in place a series of functionalities important for the competitiveness of the product and the services associated with it. This, however, created development issues. In 2005, Barp began to study the basic reasons for these obstacles. To turn this situation around, he focused on methods, procedures, tools and environments, including testing, certification and customer support, that extended the use of mathematical modeling and system simulation throughout the aircraft manufacturing value chain.

At Embraer, the research and development (R&D) area is divided into competitive research and pre-competitive research. Beginning in the year 2000, the competitive research division was responsible for the 170, 175, 190 and 195 family of commercial jetliners, known as E-Jets, with capacities between 70 and 120 seats, as well as the Legacy 600, which heralded Embraer's breakthrough into the executive aviation market, the Phenom 100s and 300s, which are small executive jets that seat as many as 11 passengers, and the Lineage 100, an executive jet whose interior measures 120 square meters and is offered with a choice of several passenger environments. Now under development are the Legacy 450 and 500 and the KC 390. The KC 390 is a military cargo plane that is the "the biggest in its category and the largest ever designed by Embraer," according to Kern. "This jet has very interesting performance features, such as the ability to land on very short runways and in-flight refueling capability," he said. In selecting the portfolio of technology development projects, the interaction between commercial aviation, executive aviation, and defense and security aviation is very intense. In 2011, Embraer's net revenue was R$9.8 billion, 63.6% of which came from the commercial aviation segment.

There is an interaction between commercial aviation, executive aviation, and defense and security aviation

There is no product currently in the pre-competitive development pipeline, but there are technologies that could be used in future projects, such as friction welding, a solid-state process for producing welds by rotating or moving compressed parts. "This welding permits a reduction in weight that is of interest to the aviation industry," said Fernando Fernandez, a mechanical engineer who graduated from the São José dos Campos School of Industrial Engineering and who holds a Master's degree from the ITA. Fernandez worked on this technology from 2003 to 2011. For now, friction welding will be used only for a small dashboard on the Legacy 500 aircraft, which will be in the air by the end of the year. For the last year, Fernandez has been analyzing technologies "looking out to 15 or 20 years from now."

Embraer has a number of projects under way in cooperation with research institutes, universities and other companies. One example is the Comfort Engineering Center, a project being

conducted in partnership with the University of São Paulo (USP), the Federal University of Santa Catarina (UFSC) and the Federal University of São Carlos (UFSCar), with support from FAPESP and the Brazilian Innovation Agency (Finep). The purpose of research being conducted in the nearly 300-square-meter comfort laboratory is to upgrade aircraft interiors and increase passenger comfort.

Under the project funded by FAPESP titled *Silent aircraft: an investigation of aeroacoustics*], a group of 70 researchers from Embraer, USP, the University of Brasilia, UFSC and the Federal University of Uberlândia (UFU), is developing noise-reduction methods and equipment. The first discussions that led to the project began in 2003, with Allan Kardec Pereira, 47, an aeronautical engineer who graduated from the Federal University of Minas Gerais (UFMG). Pereira's post-doctoral studies in mechanical engineering at the University of Campinas (Unicamp) addressed the link between vibration and internal noise in airplanes. Pereira worked at Embraer at two different times, the first of which was in 1989, in the area of product development.

R$9.8 billion

The company's net revenue in 2011

In the early 1990s, Pereira returned to Minas Gerais, where he obtained a Master's degree in the area of optimization at the UFMG and then a PhD in vibration control at Unicamp. When he returned to Embraer in 2001, he worked in the area of product development and drafted a proposal for a project in which he would be in charge of developing the preliminary design for a new product. "I worked on the first Phenom 100 and 300 and Legacy 500 projects," Pereira said.

In April of this year, an Embraer project conducted in partnership with a consortium of Portuguese companies and the Institute of Industrial Engineering (Inegi), affiliated with the University of Porto Engineering School, won the Crystal Cabin Award in the Visionary Designs category. This is an international award for innovation in airplane interiors. Known as "Life," this project introduces a new design for the executive aircraft of the future, with materials such as cork and leather, optical fibers and light-emitting diodes (LEDs).

LESS CARBON

Embraer is also a participant in consortiums with other companies in the sector as well as research institutions for the purpose of developing new manufacturing technologies, composite materials, metal structures and onboard systems. "We have different types of projects under way on several fronts," Kern said. Among these are biofuel development projects, one of which is being conducted in partnership with two US firms, Amyris and GE, as well as Azul Linhas Aéreas, and is focused on producing jet biofuels made from ethanol and sugar cane. Another such project, being conducted in cooperation with Boeing with funding from FAPESP, seeks to identify sustainable alternatives for developing and producing biofuels for commercial aviation in Brazil.

Technicians working on various stages of manufacturing, such as the installation of the acoustics (below)

PHOTOS LÉO RAMOS

Testing laboratory and materials checking (left) and the Legacy 450 dashboard (above)

PHOTOS 1 AND 2 LÉO RAMOS; 3 TO 6 EMBRAER

Monitoring serves as a preventive tool for analyzing airplane components

"Biofuels made from renewable sources are not just an alternative to kerosene-type jet fuels made from petroleum, but they also contribute to reducing carbon emissions," said Alexandre Tonelli Filogonio, who graduated in mechanical engineering from UFMG and did post-graduate work in economic engineering at the Dom Cabral Foundation, where he heads a group that focuses on alternative fuels in the area of pre-competitive technological development. According to data from the Intergovernmental Panel on Climate Change (IPCC), commercial aviation accounts for 2% of all carbon dioxide (CO_2) emissions generated by human activities. The challenge is to curb emissions so that by 2050 they are half of what the sector emitted in 2005, in accordance with the commitment the industry made in April 2008 and ratified in March 2012.

One noteworthy area for Embraer is aircraft health monitoring. The coordinator of Embraer's efforts in this area is Paulo Anchieta, 46, who has had a unique career path. He began working at Embraer at age 26 as a mechanic and then transferred to the engineering department, where he prepared mathematical data that engineers used to evaluate aircraft structures. A graduate of a trade school, Anchieta then decided to study mathematics at Salesian University in Lorena, located in the interior of São Paulo State. "Because of those courses, I had the opportunity to assist engineers in areas in which they were not proficient," he said.

Monitoring serves as a preventive tool for analyzing aircraft components so that future problems are averted. The technology of managing the health of systems, known as PHM (prognostics and health management), was tapped in 2009 as one of the 10 most promising technologies for aviation by the American Institute of Aeronautics and Astronautics (AIAA).

Anchieta's experience with military aircraft was his passport to receiving an invitation to work on a project to monitor the health of commercial airplanes. Anchieta drew the comparison that "the structure of a military airplane is monitored in the same way as a medical check-up for humans." Anchieta studied mechanical engineering in night classes at the Engineering School of São Paulo State University (Unesp) in Guaratinguetá so that he would be able to work in areas that were more in line with his knowledge and experience.

NAMES OF INSTITUTIONS FROM WHICH EMBRAER RESEARCHERS GRADUATED

Mauro Kern, Vice President of Engineering and Technology	**UFRGS** – undergraduate degree
Andrea Barp, systems modeling and simulation	**ITA** – undergraduate degree
Fernando Fernandez, materials and processes development	**School of Industrial Engineering** undergraduate degree; **ITA** – Master's
Allan Kardec Pereira, technology development	**UFMG** – undergraduate and Master's degrees **Unicamp** – doctorate and post-doctorate
Alexandre Tonelli Filogonio, alternative fuels	**UFMG** – undergraduate degree **Dom Cabral Foundation** – post-graduate studies
Paulo Anchieta, aircraft health monitoring	**Salesian University of Lorena and Unesp of Guaratinguetá** – undergraduate studies

Phenom 100 executive jets (left) and Lineage 100 (above) and an artist's rendering of the KC 390 military cargo jet (right) under development

The financial crisis of the early 1990s, which brought about drastic layoffs at Embraer, turned into an apprenticeship for Anchieta. "I had to wear several hats," Anchieta said. At the time, just 30 people were responsible for all the engineering tasks related to structural analysis. Today, there are more than 17,000 employees, with 4,000 in engineering, including engineers and aeronautical design technicians. In the 1990s, with incentives from the company, Anchieta took several post-graduate courses at the ITA. These studies considerably improved the range of his theoretical knowledge.

When he took over the leadership of the aircraft health monitoring team, he looked for partners to develop innovations for commercial aviation. He began by contacting the Mechanical Engineering School at the UFU and the Unesp Engineering School at Ilha Solteira. These cooperative efforts were expanded to include the Pontifical Catholic University of Rio de Janeiro, the Polytechnical School of the Federal University of Rio de Janeiro, and researchers from UFMG and the Campinas Telecommunications Research and Development Center (CPqD). Some projects have already been completed and produced encouraging results.

EARLY DETECTION

The research partnership with the Federal University of Uberlândia produced a new project to develop a mass-produced structural monitoring system. "We are developing a software and hardware system, based on what is termed electromechanical impedance technology, to perform the work of sensors in airplanes," Anchieta said. Based on vibration results, the sensors will detect the locations and severities of faults. The system will be used first for testing aircraft fatigue. "The gains will be tremendous, because a crack detected in its initial phase will prevent future damage that would occur if it gets bigger." The next step is to qualify the sensor system for in-flight use, for military as well as commercial and executive aircraft.

In July of this year, a technology conference was held at the European Structural Health Monitoring (SHM) Workshop in Dresden, Germany, and Anchieta won the annual award established by Stanford University astrophysics professor Fu-Kuo Chang. Anchieta was selected as the winner of this award by an international committee consisting of 120 people from academia, the government, industry organizations such as NASA (the US space agency), and US, European, Australian and Japanese research centers, in addition to professionals from Airbus, Boeing and Bombardier. ■