Aircraft nursery

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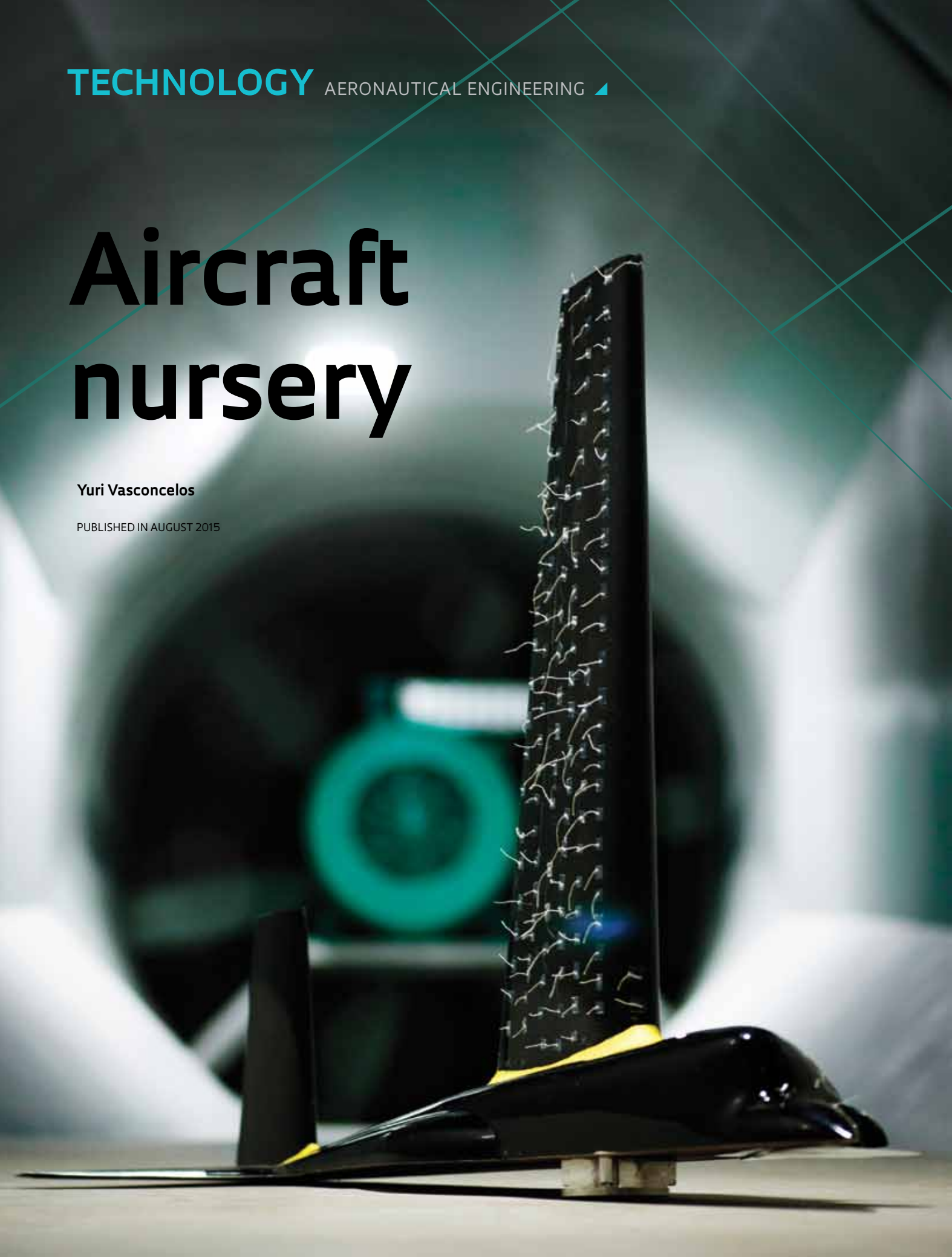


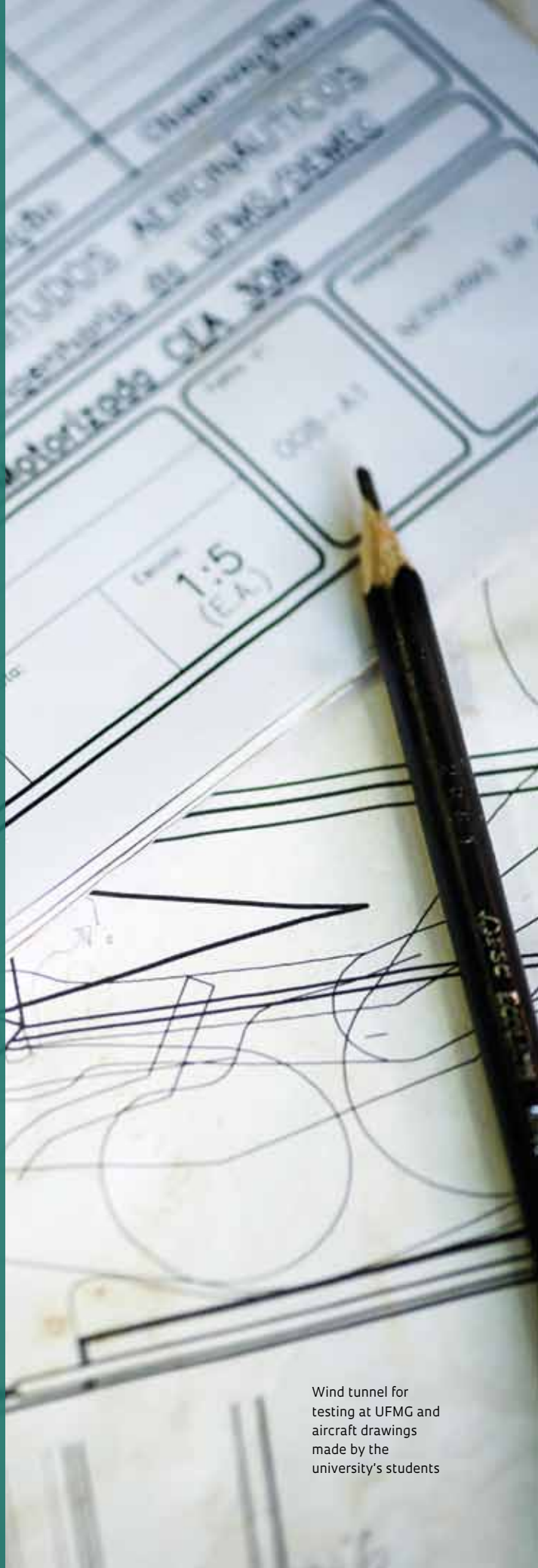
Approximately 20 manufacturers of small aircraft operate in Brazil, investing in innovation and collaboration with universities as a strategy for growth

In May 2015, an electric airplane flew for the first time in Brazil, earning this country a place among the select group of nations that have mastered the technology for building this type of aircraft. The flight occurred in the city of São José dos Campos, state of São Paulo, the site of Brazil's biggest aerospace industry hub and home base of Embraer, the world's third largest manufacturer of commercial passenger jets. The electric plane, called the Sora-e, is owned by ACS-Aviation, one of approximately 20 Brazilian builders of experimental or light sport aircraft (LSA), as classified by Brazil's National Civil Aviation Agency (ANAC). Light sport aircraft, classified by ANAC as a subcategory of experimental aircraft in 2011, can be sold fully assembled, whereas experimental amateur-built aircraft are uncertified lightweight planes sold in the form of assembly kits. At least 51% of the assembly of such planes must be performed by the buyer, usually a private pilot.

Half of all experimental aircraft manufacturers in Brazil are located in the interior of São Paulo State; the others are in Goiás, Rio Grande do Sul, Minas Gerais, Pernambuco, Santa Catarina, and Bahia. Brazil is the world's second largest market for experimental aircraft, after only the United States. As reported by ANAC, there were 4,958 experimental aircraft in Brazil in 2013. Designed mainly for amateur pilots who want to fly their own equipment, these planes are used for leisure, recreation, or personal transportation and cannot be used in any commercial activity. "Brazil is a country of continental proportions that can use this wide range of aircraft to meet a wide range of needs," explains Humberto Peixoto Silveira, chairman of the Brazilian Association for Experimental Aviation (Abraex). Experimental aircraft in Brazil sell for R$50,000 and up, while an LSA can cost as much as R$750,000.

Despite their small size and their limited capacity of two or four people, Silveira considers that experimental planes are technologically advanced vehicles. "All over the world, experimental aviation is a laboratory for major manufacturers like Airbus, Boeing and Embraer. These aircraft are born from innovative designs in terms of structure and aerodynamics. They are built using advanced production techniques, their structure is built with new materials, and they are equipped with digital avionics [the electric and electronic equipment used in aircraft] and powerful engines that allow some models to fly at more than 300 kilometers per hour [162 knots]," he says.

The flight of the Sora-e was the culmination of two years of work by ACS-Aviation managing partner Alexandre Zaramella, an aeronautical engineer with a degree from the Federal University



Wind tunnel for testing at UFMG and aircraft drawings made by the university's students

PHOTOS LÉO RAMOS

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of Minas Gerais (UFMG) (see *Pesquisa FAPESP* Issue No. 228). "There are half a dozen companies in the world that focus on the development of electric aircraft. And we are one of the few with a flight-tested plane," he says. The Sora-e – a version of the main model produced by ACS-Aviation, the combustion-engine Sora – was developed in partnership with the Center for Research, Development and Assembly of Vehicles Powered by Electricity (CPDM-VE) of Itaipu Binacional and received a R$500,000 subsidy from the Brazilian Innovation Agency (FINEP) for the design of an electric system for use in aircraft. The aircraft is equipped with two 35-kilowatt electric engines, powered by six 400-volt lithium-ion polymer batteries that can keep the plane airborne for up to one hour and 30 minutes.

COMPOSITE MATERIALS

Present-day aircraft manufacturers prefer to build their airframes from composite materials, such as metal-polymer or carbon-glass composites. These new materials are lighter and stronger than the traditionally used aircraft-grade aluminum. The European consortium Airbus, for example, has delivered its first jet with wings and fuselage made of polymers reinforced with carbon fiber. The A350 XWB, with seating for 366 passengers, was delivered to Qatar Airways in January 2015.

Scoda Aeronáutica, a Brazilian builder of light sports aircraft, has also embraced composites. Located in the city of Ipeúna, 195 kilometers from the state capital of São Paulo, the company builds an amphibian aircraft (that can land on and take off from both land and water) called the Super Petrel LS. The plane is an international hit. "We have already built 350 of the Super Petrel LS and its predecessor, the Super Petrel 100. They were sold to 23 countries, and we have clients in another four whose orders are about to be delivered," says Rodrigo Scoda, owner of the company. The list price of the Super Petrel starts at R$350,000.

Scoda is an aeronautical engineer who graduated from the São Carlos School of Engineering at the University of São Paulo (EESC-USP). He emphasizes that the success of his aircraft is due largely to its having won LSA certification in the United States and other countries. "We designed the Super Petrel LS to be compliant with Federal Aviation Administration (FAA) standards. This was our way of making a global product," he says. The FAA is the American regulatory authority for civil aviation. Its standards serve as a model for many countries, including Brazil.

1 Sora-e, the first electric aircraft built in Brazil

2 Super Petrel LS: landing on and taking-off from land or water

PHOTOS 1 ALEXANDRE MARCHETTI **2** LÉO RAMOS

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INFOGRAPHIC ANA PAULA CAMPOS

Diversity in the air

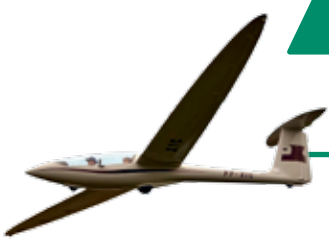
Noteworthy models produced by Brazil's leading manufacturers of light aircraft

CERTIFIED
Aircraft with no restriction as to number of pilots, crew, type, weight, models, and purposes, so long as they comply with the rules for certification, including rules related to pilot training, crop dusting, cargo transport, and passenger transport, among others

LSA
Acronym for light sport aircraft. This subcategory of experimental aircraft includes models that can be sold fully assembled. ANAC is still deciding whether to permit commercial use of these aircraft

EXPERIMENTAL
Uncertified light aircraft of less complex construction, sold as assembly kits or built from designs. By law, 51% of their assembly must be performed by the buyer, normally an amateur pilot. Cannot be used commercially

MODEL Company/Institution Location	Description	Innovative feature	Listed price
T-Xc Novaer São José dos Campos (São Paulo)	Single-engine four-seater	Large-scale use of carbon fiber in the airframe, reducing weight and increasing performance	R$ 2,5 million
SUPER PETREL LS Scoda Aeronáutica Ipeúna (São Paulo)	Two-seat amphibian aircraft	Built entirely from composites of carbon fiber and aramid fiber (Kevlar)	R$350,000
SORA-E ACS-Aviation São José dos Campos (São Paulo)	Brazil's first electric aircraft	Electric propellers in the engine are powered by lithium-ion polymer batteries	Currently undergoing tests; no listed price
QUASAR Aeroalcool Tecnologia Franca (São Paulo)	Single-engine two-seater	Use of laser cutting and laser drilling to build complex metal components, such as wings and surfaces	R$300,000
NEW CONQUEST Inpaer São João da Boa Vista (São Paulo)	Two-seat light aircraft	More aerodynamic wing tips, leading to better flight performance	R$300,000
WEGA 180 Wega Aircraft Palhoça (Santa Catarina)	Experimental single-engine two-seater	Built with composite materials, this acrobatic aircraft can fly at 350 km/h (190 knots)h	R$620,000
SUPER FLAMINGO Aeropepe Recife (Pernambuco)	Advanced ultralight high-wing two-seater	Wings with carbon fiber spars that reduce drag and increase speed	R$230,000
P-1 Technological Institute of Aeronautics (ITA) São José dos Campos (São Paulo)	Two-seat training glider	Wings with variable sweep (angle of the wing in relation to the fuselage) provide improved aerodynamics	R$280,000, if mass-produced
PEDAL-POWERED PLANE São Carlos School of Engineering/USP São Carlos (São Paulo)	Experimental pedal-powered manned aircraft	Made from carbon fiber and composite materials, the first of its kind in Latin America	No stated price, not currently built
ANEQUIM Center for Aeronautical Studies (CEA) at UFMG Belo Horizonte (Minas Gerais)	Racing aircraft with bold aerodynamics	Designed to be the fastest in its category, weighing 330 kg and flying at up to 575 km/h (310 knots)	No stated price, not currently built



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1 Quasar single-engine aircraft: 60 units sold

2 P-1, a pilot training glider designed and built at ITA

Built using a composite of carbon fiber and aramid fiber (Kevlar), the Super Petrel LS was inspired by the French amphibian aircraft known as the Hydroplum, from the 1980s. Scoda Aeronáutica handles 81% of its own production requirements, importing only the mechanical components. An unusual aspect of the development and certification process for the Super Petrel LS was that 90% of it was performed by 4th- and 5th-year students from the aeronautical engineering course at EESC-USP, working as interns on the project. "We work in partnership with universities whenever possible. Three of our eight engineers graduated from EESC," says Scoda. The company has a team of 100 collaborators, including technicians, engineers, mechanics, pilots and managers.

CERTIFIED MODELS

In addition to Scoda, the Indústria Paulista de Aeronaves (Inpaer) is also looking to certify its aircraft in an attempt to expand its market. Founded in 2002, the company changed hands two years ago when it was acquired by entrepreneurs Milton Pereira and Helio Gardini. "We have already invested R$40 million in Inpaer since 2013. We made important changes in the management process, reformulated the product portfolio, and expanded the staff from 60 to 115 people. We want to make Inpaer a global company, following in the footsteps of Embraer," says Pereira. The company's flagship product, the single-engine two-seater Conquest 180, has been modernized and renamed the New Conquest. "The New Conquest is being certified as a LSA. Our next goal is to start exporting," says Pereira.

With 230 aircraft already delivered since the company was founded, Inpaer has been working on two new models, the EZY300A and the EZY300B. Both planes will seat four people and will have the autonomy to fly 1,950 km (1,210 miles) without refueling. The difference between them is the position of the wings in relation to the fuselage: high-wing planes, such as the 300A, offer more panoramic views and fly at lower speeds, while low-wing aircraft, such as the 300B, are faster. "We want to certify these aircraft under Standard 23 of the Brazilian Register of Civil Aircraft (RBAC 23). This will allow their use for commercial purposes, such as pilot training and passenger and cargo transport," Pereira explains. The first prototype of the 300A took flight last year and is currently undergoing improvements, while the 300B is still in the design stage.

PEDAL-POWERED PLANE AND ETHANOL ENGINE

Many of the aeronautical engineers currently in charge of designing new aircraft in Brazil graduated from one of three institutions: EESC-USP, the Technological Institute of Aeronautics (ITA, managed by the Brazilian Air Force), or UFMG. "During their five-year undergraduate course,

PHOTOS **1** AND **2** PICASA **3, 4** AND **5** LÉO RAMOS

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3 The aeronautical engineering course at USP São Carlos focuses on aircraft maintenance

4 At UFMG, the emphasis is on prototype construction

5 Assembly of the Super Petrel LS amphibian aircraft

students learn to build a complete aircraft. Our emphasis on aircraft certification and maintenance sets EESC apart. As a result, the market covets our students," says Professor James Waterhouse from EESC-USP. "Building an airworthy aircraft is easy, but making one that complies with aviation standards and that is fit for certification is 100 times more difficult."

One of the most innovative projects developed at EESC was a pedal-powered manned aircraft, the first of its kind in Latin America. In the prototype, weighing only 42 kilograms and built from carbon fiber and composite materials, the pilot activates the propeller by moving pedals with his feet. The inaugural flight, covering only a few meters, was made three years ago. "The aerodynamics of a pedal-powered aircraft must be extremely refined, otherwise it won't fly. Right now, our students are improving the design for longer flights," says Waterhouse, who holds a doctorate in alternative aviation fuels.

In addition to teaching at USP, Waterhouse owns a company called Aeroalcool Tecnologia in partnership with aeronautical engineer Omar José Junqueira Pugliesi, who has a master's degree in engine engineering from EESC-USP. Installed in the city of Franca, 400 kilometers from São Paulo, the company was established in 2001 with the goal of maturing and marketing the technology for the ethanol-fueled aircraft engine designed in the early 1980s at USP São Carlos. "We were able to improve the technology, but market contingencies kept our ethanol-fueled aircraft engine from becoming a commercial product," Waterhouse says.

The partners decided to invest in designing their own aircraft, which they named the Quasar. "It was an aircraft designed from scratch, part by part. We made the wheels, brakes, and several other components that are normally imported. In

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2006, the Quasar had its maiden flight," recalls the researcher. Sixty Quasars have already been sold. The first eight to be built were exported to the United States.

Aeroalcool verticalized the production of its components and achieved a high percentage of Brazilian-made parts. "The engine, propeller and avionics are imported because it is not cost-effective to build them here," says Waterhouse. "Our biggest innovation was using laser cutting and laser drilling to build complex metal components, such as the wings and surfaces of the aircraft. I studied this technology during my master's degree studies, and it resulted in a successful PIPE project (Innovative Research in Small Businesses Program) from FAPESP. With this technology, we cut manufacturing labor costs by 80%, reduced the amount of physical space required, and achieved a higher degree of standardization and manufacturing quality."

GROUNDBREAKING GLIDER

ITA professor Ekkehard Carlos Fernando Schubert designed and built a two-seat glider called the P-1 for basic and advanced pilot training. The de-

An ambitious project

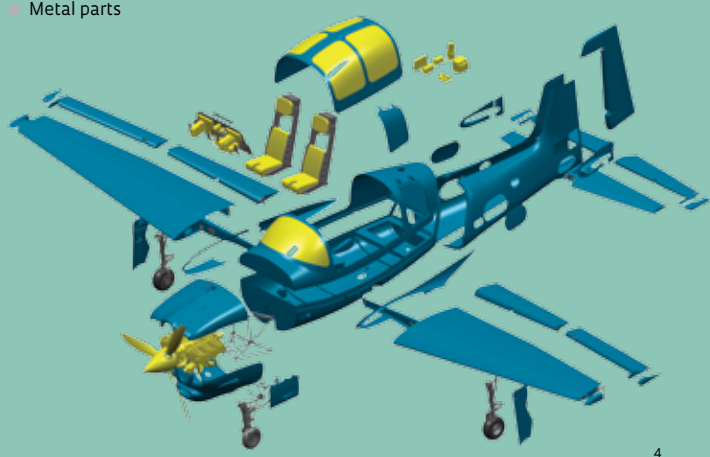
Novaer has plans to build a certified aircraft to compete against major international companies, such as American manufacturers Cessna, Piper, and Cirrus

Building more than 100 aircraft a year from the fourth year of production onward and exporting 75% of all its planes to the international market: this is the target established by Novaer, which is developing its first aircraft, provisionally called Project T-Xc. The plane had its maiden flight in August 2014 and is currently in the certification and testing stage, which should take another year. What sets Novaer apart from most Brazilian manufacturers is the fact that the T-Xc will be designed for certification under Standard 23 of the Brazilian Register of Civil Aircraft (RBAC 23). This certification will allow the aircraft to be used for air taxi services, cargo transport, and civilian or military pilot training – uses not permitted for experimental aircraft. "We will not have any competitors in Brazil. Our biggest competition will be international manufacturers such as Cessna, Piper, and Cirrus," says Novaer president Graciliano Campos.

The T-Xc will be built in two versions: utility and training. The first model, a four-seater, will be designed for passenger and light cargo transport. The training version, dubbed the Sovi, will have only two seats and will be used for air force pilot training. Both versions were inspired by the experimental aircraft K-51, designed by Hungarian-born, naturalized Brazilian engineer József Kovács, one of Brazil's foremost aircraft designers. The greatest innovation of the T-Xc project is the large-scale use of carbon fiber. "Many commercial planes are already being built with this material, but none of them to date have had 100% of their airframe made from carbon fiber, like the Novaer aircraft does," says Campos.

Currently based in São José dos Campos, Novaer is planning to transfer part of its operations to the city of Lages, in Santa Catarina, where the state government plans to establish an industrial complex for the aviation industry. Novaer wants to set up its T-Xc and Sovi assembly lines in Santa Catarina. Established in 1998, the company also develops aircraft components. For example, it supplies the landing gear for the T-27 Tucano, a training and light combat aircraft built by Embraer and used by the air forces of Brazil and 10 other countries.

- Carbon fiber
- Vendor-supplied items
- Metal parts



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velopment of the first P-1 prototype began in 1995 and was completed in 2002, when the aircraft made its first flight. "I decided to build a two-seat training glider because I thought Brazil needed to stop importing this relatively simple product. When I started the project, there was a possibility that the Civil Aviation Department [DAC, which would later be reorganized as ANAC] would place a large order for use by Brazil's aeroclubs, but they never followed through," says Schubert, a Brazilian born to German parents.

Gliders are engineless aircraft that ride on air currents. Therefore, they have to be built from lightweight materials with the proper aerodynamics. The P-1 was built from a composite of fiberglass, epoxy resin and rigid PVC foam. Wing geometry is among its biggest technological innovations: the P-1 has variable-sweep wings, that is, their sweep (angle between wing and fuselage) changes along the length of the wingspan. "This design makes the wing more aerodynamic and enhances flight efficiency," says the ITA professor. Schubert plans to certify the aircraft as an LSA to try selling it to aviation schools in Brazil and abroad.

In the 1960s, ITA students advised by Professor Guido Fontegalant Pessotti – who would later move on to become the technical director of Embraer in the 1980s – were already building gliders. They built the Urupema, which was then manufactured by Embraer for a short period, as well as a glider tow plane called the Panelinha. ITA offers six undergraduate engineering courses. Six thousand aeronautical, aerospace, mechanical, electronic, civil, and computer engineers have graduated from the institution since it was founded in 1950.

WELLSPRING OF NEW DESIGNS

UFMG also plays a prominent role in training Brazilian professionals to work in the aviation industry. Forty to 45 students complete its aerospace engineering course each year. The university's Center for Aeronautical Studies (CEA)

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1 Pedal-powered aircraft developed at EESC-USP

2 Instrument panel of New Conquest single-engine aircraft

3 Wega single-engine aircraft, built from an academic project

focuses on the design, development and operation of aircraft prototypes. "Few academic institutions in the world are able to work on building a plane. Since our first prototype, the Gaivota glider, which flew in 1964, we have designed and built 10 different aircraft," says aeronautical engineer and UFMG professor Paulo Henrique Iscold.

According to Iscold, UFMG's emphasis on prototype construction sets its undergraduate program apart from the rest. "Our students receive hands-on learning on how to build a plane. In this process, we continuously try to innovate and create something extra that can be adopted by the industry," says the engineer. Each aircraft takes five to six years to complete, and the students participate in designing the prototypes, making drawings and calculations, and assembling the airframe. The most recent model built at the CEA is the Anequim, a racing aircraft that weighs 330 kilograms and can fly at 575 km/h (310 knots). The Anequim had its maiden flight in November 2014, and now, in August 2015, its creators will try to break seven world records for speed. The flights will be monitored by the World Air Sports Federation (FAI), an entity based in Switzerland that certifies international aviation records.

The single-engine CEA-308, built in 2011 by UFMG, is recognized by the FAI as the world's fastest light aircraft (less than 300 kilograms in total weight, including pilot and fuel). The CEA-308 broke three world speed records – for 3-, 15-, and 100-kilometer flights – and one climb-rate record for ascent to three thousand meters. Two years ago, a four-seat aircraft project designed at the CEA won an international contest sponsored by French aircraft engine manufacturer Price-Induction.

According to Iscold, another noteworthy project designed at the CEA is the Triathlon, an acrobatic aircraft made of wood and composite materials, which started to get off the drawing board between 1997 and 2001, during the doctoral studies of professor and CEA founder Cláudio de Barros. This model was the inspiration for two other planes, which were built on an industrial scale by private companies – the Sora, by ACS-Aviation, and the single-engine Wega 180, by Wega Aircraft, based in the state of Santa Catarina.

Founded by aircraft mechanic Jocelito Wildner, Wega Aircraft is based in the city of Palhoça in the metropolitan area of Florianópolis. It is the first aviation company in Santa Catarina. In addition to the Wega 180 with its 180-horsepower engine, the company also builds the Wega 210 with a more powerful, 210-horsepower engine. "Our aircraft are built from carbon, glass and high-quality resin, have retractable landing gear, and follow international safety standards," says Wildner, who was trained at the school operated by the now-extinct Brazilian airline Varig. Wega has a production capacity of two units per year and has sold a total of eight aircraft so far.

The state of Pernambuco also has its own aircraft manufacturer, Aeropepe, founded in 1999 in the city of Recife. The company has sold 15 of its Flamingo and Super Flamingo high-wing single-engine aircraft that can fly at 200 km/h (108 knots). One of them was exported to Portugal. These planes have two main innovations: 100% of their airframe is made from composites, and their wings are built with carbon fiber spars that increase the structural strength and make it unnecessary to use splices and joints. "The aircraft has lower drag and reaches a higher speed while consuming less fuel," says company owner José Rodolfo Garrido Andrade, also known as "Pepe."

Pepe wants to launch three new aircraft models based on the same platform. The first, a certified LSA, was designed in partnership with Aeron, a spin-off that began life at the CEA-UFMG. "The engineers at Aeron were put in charge of making the aerodynamics calculations and designing the plane, which is still unnamed and has no estimated date of launch," says Pepe. The second model is a version of the LSA with electric engines, and the third is a high-performance aircraft equipped with retractable landing gear and a turboprop engine with variable-pitch blades. ■

PHOTOS **1** USP / PUBLIC DOMAIN IMAGE **2** INPAER **3** DANIEL POPINGA **4** NOVAER