



# Two Firsts for Flight Efficiencies

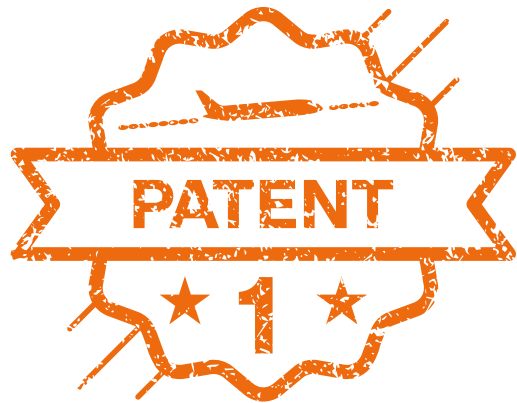
Boeing Brazil obtains in-country patents for innovations that predict and reduce fuel consumption

BY MICK BOROUGHS, BOEING WRITER

**Two inventions to measure and reduce fuel consumption are the first in-country patents to be granted to Boeing Research & Technology-Brazil.**

Brazil's National Institute of Industrial Property (INPI) has granted two patents related to flight operation efficiency to Boeing Research & Technology-Brazil. Both discoveries will help reduce fuel consumption in aviation and lower carbon emissions globally.

"Boeing is doing something for the country, and in the country," said José Fregnani, Boeing Research & Technology-Brazil technical manager. "To receive these two patents here in Brazil is big. After 10 years of operations in country, we're still growing, expanding our research and engineering efforts, and developing our technical workforce here."

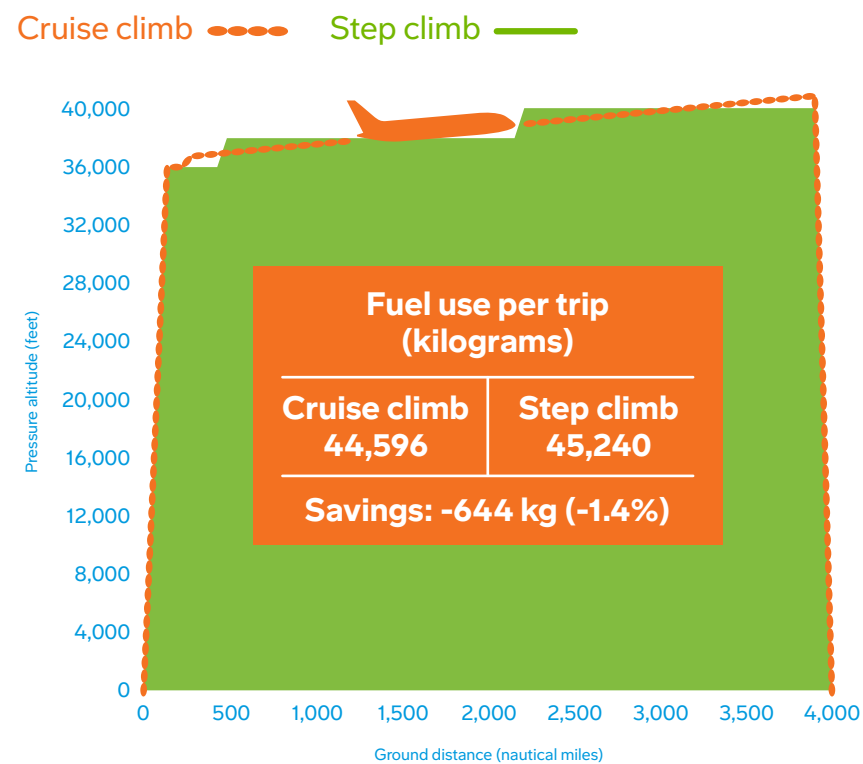


### Cutting fuel weight with continuous climb

The first patent INPI ever granted to Boeing describes a function that adds a continuous cruise-climb algorithm to the flight management system (FMS), thus allowing the system to track the optimum altitude climb.

On long-range flights, airlines want airplanes to perform a continuous climb. With the current system, pilots may only increase altitude incrementally, for example, taking the airplane from 35,000 feet to 37,000 feet (10,668 meters to 11,278 meters), then, hours later, climbing to a cruising altitude of 39,000 feet (11,887 meters).

### Optimum Cruise Climb



#### CLIMB OVER STEP

A simulated flight from Mumbai, India, to Perth, Australia, demonstrates potential fuel savings during a long-range flight. Climbing continuously by tracking the wind-based, optimum altitude would save fuel on flights of six hours or more.

GRAPHIC: BOEING

The technology would send continuous climb commands to the airplane's autopilot system while interfacing with the pilot. Following the commands offers the potential to provide up to 3% savings on fuel consumption, simultaneously lowering carbon emissions.

"On a flight from Brazil to Dubai, an airplane may consume 130 tons of fuel," Fregnani said. "Using continuous climb could save 1.5 tons of fuel, which is equivalent to the weight of 15 passengers and their luggage."

Boeing has checked the continuous climb function in simulations; the function is not in commercial use.

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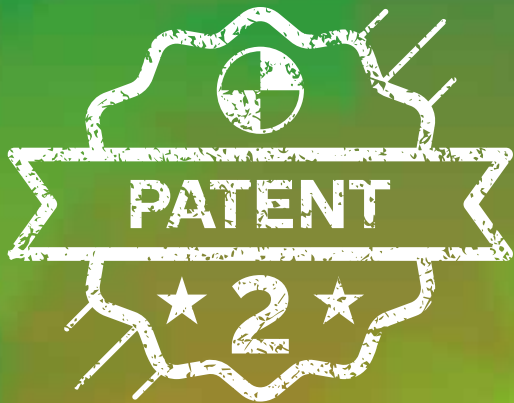
JOSÉ FREGNANI,  
BOEING RESEARCH & TECHNOLOGY-BRAZIL  
TECHNICAL MANAGER AND INVENTOR



#### LONG-RANGE SAVINGS

Using the continuous climb function could save fuel on long-range flights.

GRAPHIC: BOEING



### Watching and weighing gravity's balancing act

The second patent INPI granted to Boeing in 2023 describes the movement of an airplane's center of gravity, the calculation of fuel consumption during flight, and its impact on airplane drag.

"An airplane's center of gravity changes in flight while it consumes fuel," said Boeing engineer Geun Kim. "We want to better predict the fuel consumption by accurately predicting how the center of gravity changes in flight."

The process allows for more precise adjustments by the flight management and planning systems. By programming the function into the FMS, airlines can better predict those changes and be more accurate when refueling on the ground.

The United States Patent and Trademark Office, the European Patent Office and Brazil's INPI name Fregnani, Kim and retired Boeing engineer Tim Rohr as the inventors of these two patents. Since 2018, the trio has teamed up on three other patents in the U.S. on aircraft fuel efficiency and flight path optimization. Canada and China also have granted related patents.



**JOSÉ FREGNANI**  
PHOTO: COURTESY OF JOSÉ FREGNANI



**GEUN KIM**  
PHOTO: COURTESY OF GEUN KIM

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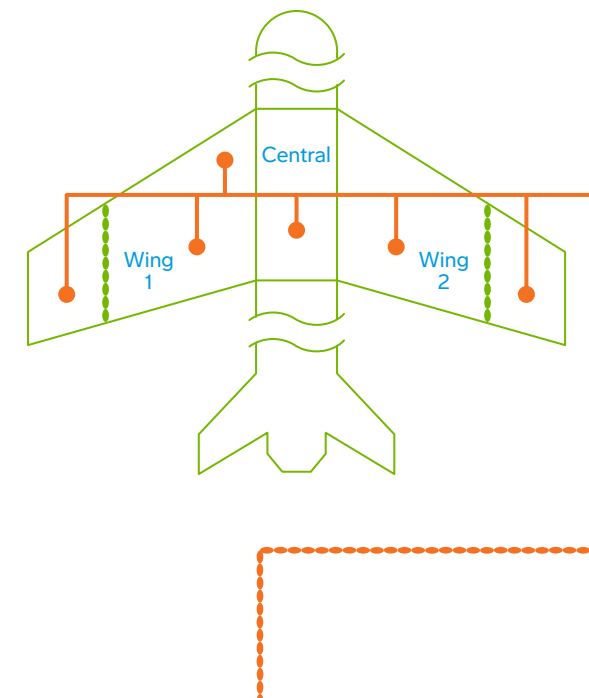
**GEUN KIM,**  
BOEING ENGINEER  
AND INVENTOR

### Center of Gravity Management

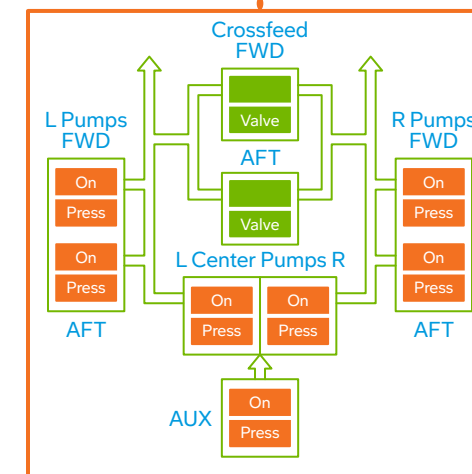
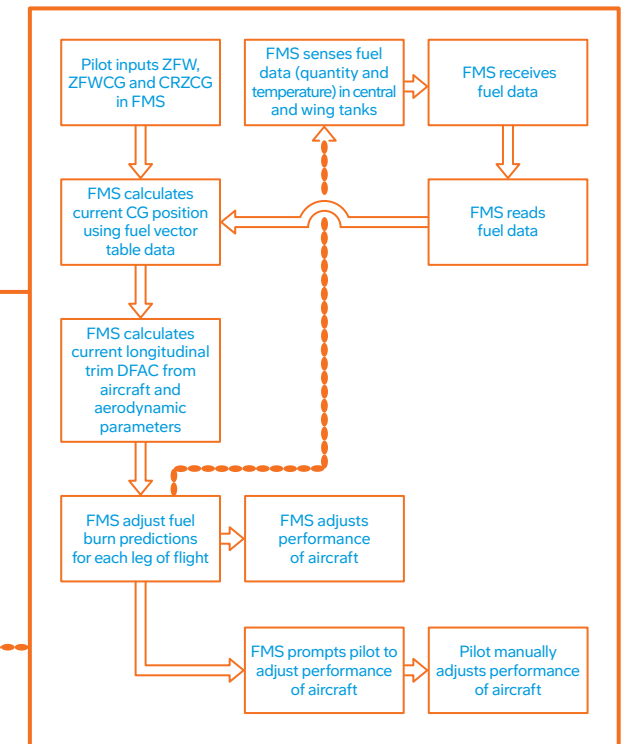
#### FUEL FLOW

The flowchart illustrates how an onboard FMS calculates an airplane's shifting center of gravity during flight. The pilot enters data for the airplane's zero fuel weight on the ground and center of gravity during the cruise phase.

GRAPHIC: BOEING

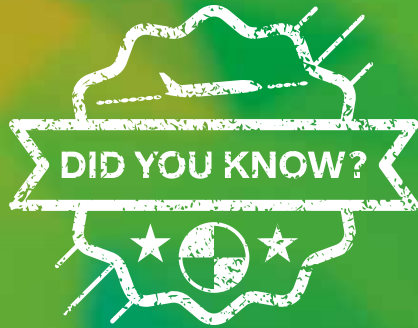


- Legend**
- ACT Actual
- CG Center of Gravity
- CRZCG Cruise Phase Center of Gravity
- DFAC Drag Factor
- ETA Estimated Time of Arrival
- FMS Flight Management System
- RTE Route
- WPT Waypoint
- ZFW Zero Fuel Weight
- ZFWCG Zero Fuel Weight Center of Gravity



	1	5	10	15	20	24	
1		ACT	RTE	1	DATA	579	
		ETA	WPT		FUEL	DFAC	
1R	3	0234Z	AAA		56-7	0-01	1R
2R	5	0301Z	BBB		51-2	0-02	2R
3R	7	0332Z	CCC		46-7	0-01	3R
4R	9	0357Z	DDD		44-2	0-00	4R
5R	11	0447Z	EEE		38-5	0-03	5R
6R	13	<LEGS					6R

Multipurpose Control and Display Unit



## Strength in numbers

Since 2014, Boeing Intellectual Property has recommended 34 inventions of the Boeing Research & Technology-Brazil team. Sixteen patents have been granted in the U.S. and other countries, including the first two from INPI in 2023.

“For more than 90 years, Boeing and the Brazilian community have partnered to leverage the technical skills and problem-solving capabilities of Brazilian engineers,” said Lynne Thompson, Boeing vice president of Engineering, Strategy and Operations. “Their expertise strengthens our commitment to engineering excellence and positions us to tackle the challenges of the next generation in our industry.”

That expertise is fundamental to achieving global aerospace sustainability goals, according to Boeing Research & Technology-Brazil director Eduardo Carrillo de Albornoz.

The weight and trim of an airplane affects how many passengers can board, where passengers should sit, and the allowable amount of luggage. Each airplane has a set limit, or maximum weight, for a safe takeoff.

Airlines calculate the airplane’s total weight — including passengers, cargo, baggage, water tanks and carry-on luggage — to determine each airplane’s center of gravity. Today, most airlines calculate passenger weight using average weights provided by the European Aviation Safety Authority.



### MAP IT

In partnership with the State University of Campinas, Boeing engineers are developing the third phase of the SAFMaps database. The software identifies Brazil’s most viable regions for feedstock production, fuel storage and airports. Offering insights into supply chain economics and available refueling processes, SAFMaps also integrates essential information about potential raw materials, aligning with international regulations to reduce greenhouse gas emissions.

PHOTO: TIM REINHART/BOEING

Among those efforts, Brazilian engineers are leading projects to discover biofuel feedstocks, sustainable aviation fuels (SAFs) and digital tools to reduce fuel burn and fuel emissions.

“The amount of available feedstock in Brazil is amazing,” said Carrillo de Albornoz. “Few regions in the world can provide for the future demand of SAF and achieve the SAF production capacity that is possible in Brazil.”

While assessing the challenges and opportunities associated with SAF development and commercialization, Boeing Brazil is investing in initiatives to maximize social, economic and environmental benefits to communities that develop feedstock for SAF production. **IQ**

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**LYNNE THOMPSON,  
BOEING VICE PRESIDENT,  
ENGINEERING, STRATEGY AND OPERATIONS**

### SUGAR STOCK

Brazil is the second-largest biofuel producer in the world. Sugar cane residue, abundant in the country, is a promising SAF feedstock.

PHOTO: TIM REINHART/BOEING

