SIEMENS
Ingenuity for life

Aerospace and defense

Aeronautics Institute of Technology

University uses Simcenter Amesim to improve ability to assess aircraft brake system behavior in case of failure

Product

Simcenter

Business challenges

Troubleshoot operational failures in aircraft brake system

Help predict system-degraded performance caused by failures

Identify strategies to contain detrimental effects

Keys to success

Conduct academic research by doing computational modeling of robust technology

Provide a new methodology that facilitates early prediction of system behavior in case of operational failure

Introduce student engineers to system simulation

Results

Simplified and sped up ability to assess aircraft brake system behavior and performance response in case of failure

Prepared newly graduated engineers to strengthen the competitiveness of the Brazilian aeronautical industry

Validated verification process of system compliance with performance and safety requirements

Siemens PLM Software solution helps the Aeronautics Institute of Technology prepare new engineers to strengthen Brazilian aircraft industry.

Brazil invests to strengthen research-industry links

A recent report from the Institute for Defense Analyses (IDA) indicates that Brazil's national innovation system is still maturing, and the link between research and industry needs to continue to improve. In the past, the quality and extent of Brazil's science, technology, engineering and mathematics education suffered in comparison to peer countries. So over the last decade there has been an aggressive push that has resulted in improvements in education. During that time, the graduation numbers in the engineering and science fields have doubled. Compared to trends in other emerging countries, Brazil is now well positioned for the future.

This recent push also enabled Brazil to strengthen the links between research and industry. The aim is to conduct basic research that aligns with domestic industry and the private economy.

One example of a strong link between research institutions and industry is the Brazilian aerospace industry. One of the

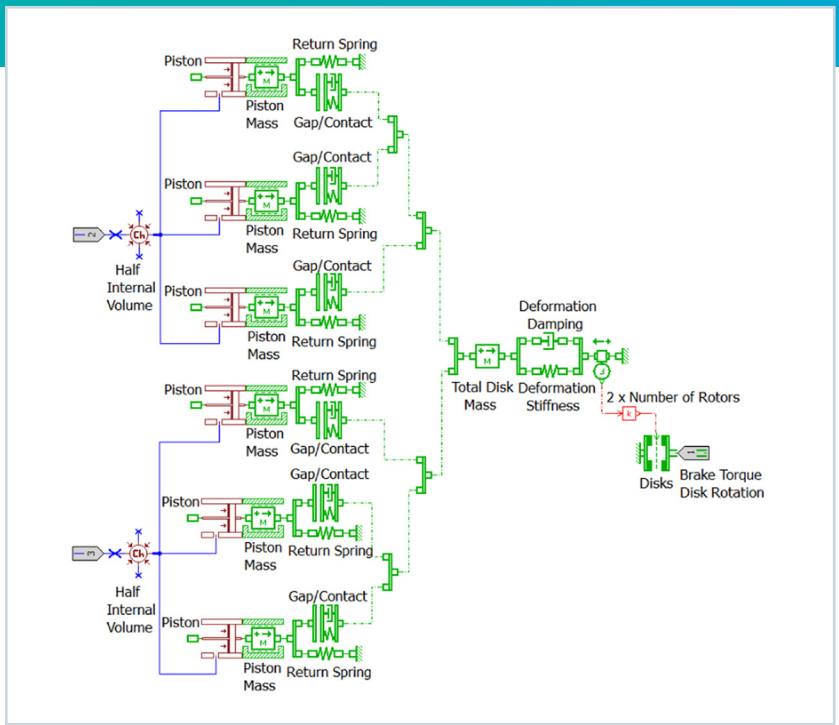
hubs of that partnership is São José dos Campos, the home of Embraer as well as the Aeronautics Institute of Technology (Instituto Tecnológico de Aeronáutica, ITA), one of Brazil's strongest institutions for higher education and advanced research in the aerospace field.

ITA's mechanical engineering department, led by Professor Dr. Luiz Góes, conducts research on topics related to current industrial needs. One of these topics was braking-system performance and the antiskid technology in normal and failure modes.

Keep improving the aircraft braking-system performance

The brake system is obviously critical to the safe operation of aircraft. However, the definition of acceptable performance and reliability has become stricter over the last few decades as aircraft landing weights and speeds have increased substantially, and regulatory authorities have improved their certification requirements, aiming for safer operation.

Therefore, brake-system design, architecture and functionalities have evolved through the years and the development of the antiskid system, part of the brake system on several aircraft since 1940s, marked an important milestone in the industry. In addition to the main function of preventing the locking of braked wheels, the antiskid system is also normally responsible for other secondary functionalities in the brake system.

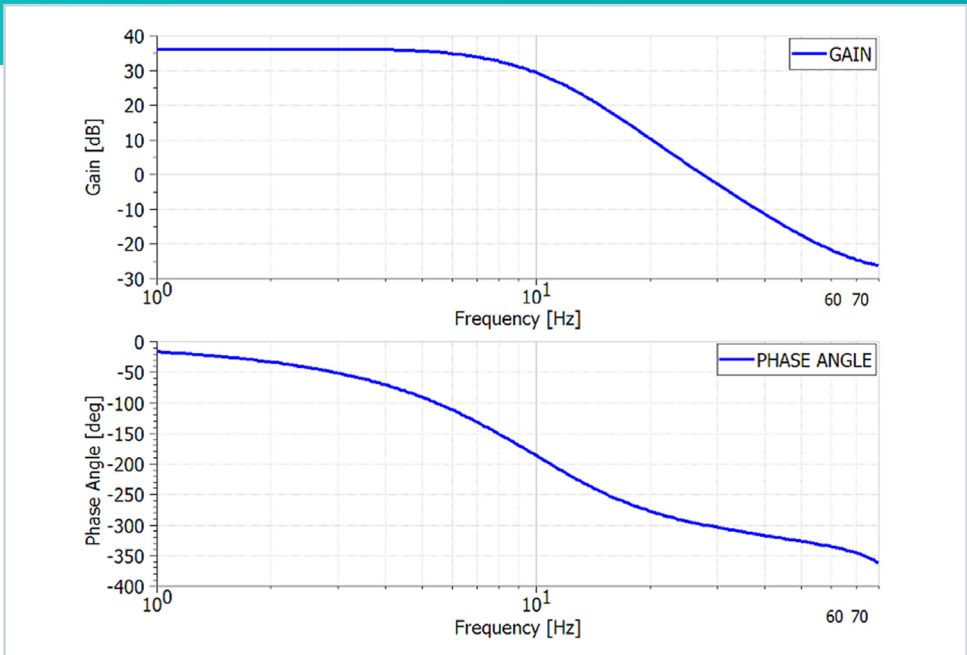


Brake assembly model in Simcenter Amesim.

Aerospace original equipment manufacturers (OEMs) and suppliers work with mature and trusted braking-system technology. Nevertheless, it remains crucial to consider all the typical failures that can impact braking-system performance and antiskid capabilities, and how the system reacts and compensates for such losses.

"Simcenter Amesim is a great tool for quickly creating system models, mainly due to its facility for dealing with the physical blocks found in its libraries."

Mario Maia Neto
PhD candidate
Aeronautical Technology Institute



Simcenter Amesim model used to investigate aircraft braking-system performance and antiskid technology in normal and failed modes.

"The opportunity provided by Siemens PLM Software to open access to the basic features of the multi-physics energy port environment simulation in the Student Edition of Simcenter Amesim has been a great way to introduce the students to the important features of this advanced simulation methodology."

Professor Dr. Luiz Góes Head of the Mechatronics Engineering Department of Aeronautics Institute of Technology

ITA uses system simulation

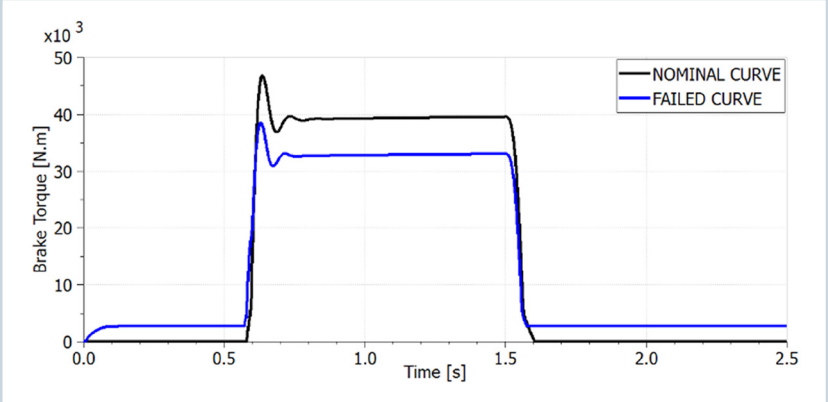
To provide an alternative option, the mechanical engineering department of research at ITA, especially Góes and Mario Maia Neto, a PhD candidate, have researched this issue. They proposed a complementary approach that would enable aeronautical engineers to accomplish a quicker preliminary assessment by troubleshooting typical failure impacts on aircraft braking system behavior.

The traditional way of assessing brake system performance is by conducting rig tests and flight test campaigns. But this process is laborious, time-consuming and expensive. That's why Neto and Góes worked on a new methodology based on computational simulation of the aircraft hydraulic brake system. Their academic study aimed to demonstrate the usefulness of system simulation to design and validate the model of a hydraulic brake system in order to assess the behavior of system-relevant variables in normal operational conditions, and the potential effects of typical failures in system performance. It could be in the industry's interest to complement its systems design activities with safety and reliability assessments.

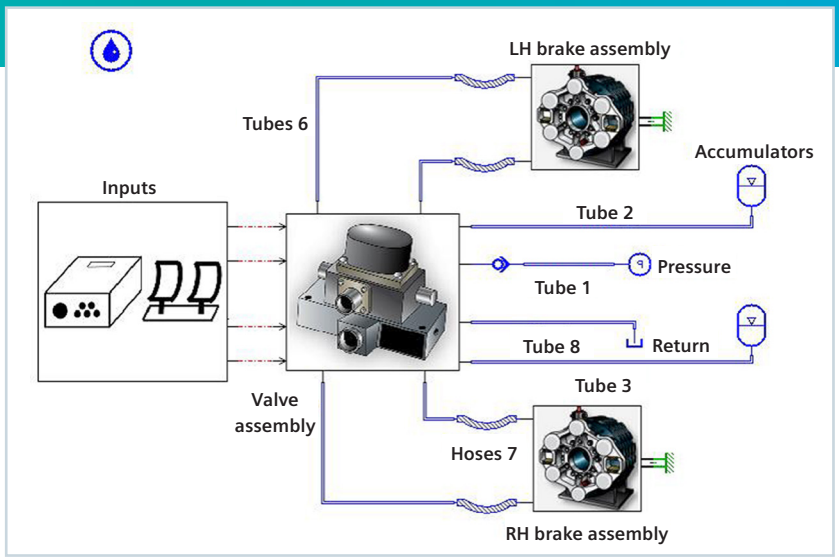
Neto and Góes used Simcenter Amesim™ software, part of the Simcenter™ portfolio, to model the hydraulic design of the braking system.

An efficient modeling tool

Prior to modeling the complete hydraulic brake system, it was important for Neto and Góes to know what the system was comprised of and how it worked. Then they were able to transpose it properly into a model and reach the right design solution decisions.



Brake torque response (nominal versus failed case) in Simcenter Amesim.



Brake hydraulic system model in Simcenter Amesim.

Neto and Góes based their research for this study on one type of braking system. This brake system is supplied by the aircraft hydraulic power generation system, which is later duplicated to independently provide hydraulic power for each brake assembly. In each subsystem line, a hydraulic accumulator is installed to allow the brakes to be applied in emergency conditions or with the main hydraulic system turned off. Antiskid valves and metering valves, required by the system architecture and responsible for modulating the braking demand applied by the pilots, are located inside a unique valve assembly. The metering valve consists of a control pressure valve; its output pressure is directly proportional to the force applied by the pilots on the brake pedals.

Once the input signal is received from the antiskid system control unit, a new force balance is established in both stages of the antiskid valve, leading to control of the hydraulic pressure in the brake assemblies. Finally, each brake assembly is supplied by both hydraulic subsystems, existing in total segregation between the piston chambers operated by each subsystem in the interior of the brake assembly.

The next step is to model the system with Simcenter Amesim. The model is composed of three elements with well-defined boundaries: the valve assembly, brake assemblies and input blocks. Components associated with the hydraulic generation and distribution system, represented by the power source, reservoir, accumulators, tubing, hoses and a check valve, are also part of the model.

According to Neto, “Simcenter Amesim is a great tool for quickly creating system

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models, mainly due to its facility for dealing with the physical blocks found in its libraries. Since preliminary assessments of system behavior could be done, as an engineer that improved our confidence in the design solution decisions."

Predicting system behavior in case of typical failures

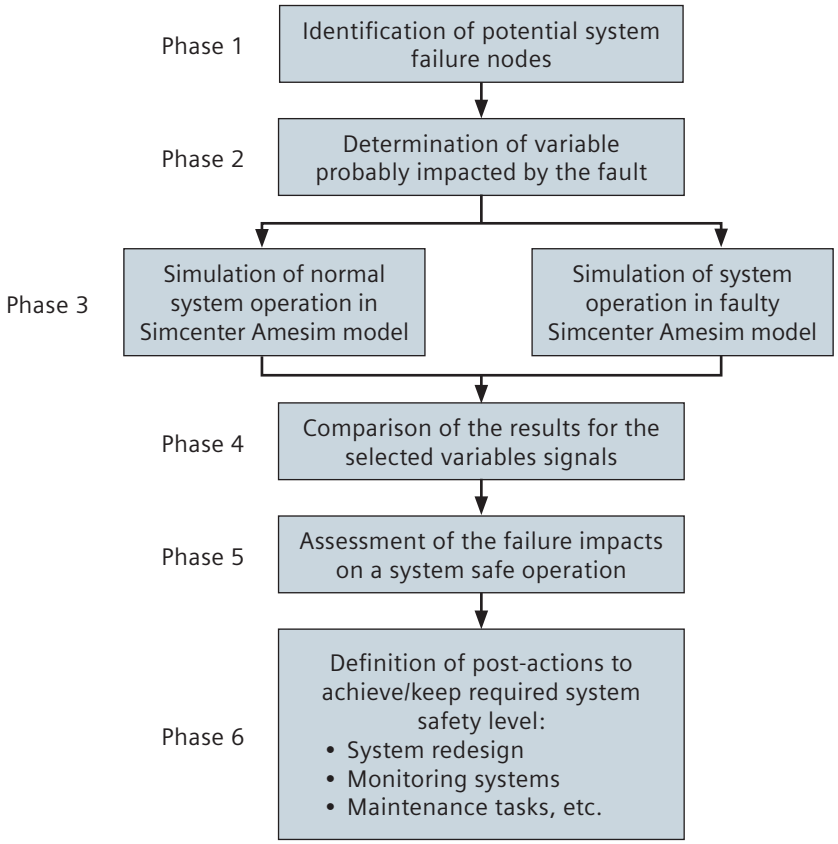
Once the model was designed and validated, the goal of Neto and Góes was to arbitrarily choose three major typical failures. Anticipating these failure cases enables the user to evaluate which strategies can be implemented to compensate for the failure effects so the antiskid brakes can continue to perform their primary functions.

Neto says, "Using Simcenter Amesim helped us develop a computational, parametrized model for the aircraft hydraulic brake system to assess the behavior of its relevant variables in normal operational conditions and when typical failures are simulated.

"Due to the fast simulation time of a physical modeling software like Simcenter Amesim, the present approach could represent a good solution for a quick, preliminary assessment of system behavior in particular conditions."

One example of failure consisted of the jamming of a piston part of the brake assembly acting on a brake disc. Implementing this failure mode in Simcenter Amesim model is straightforward. In fact, it is achieved by just changing the numerical value of a component parameter.

Afterwards Neto compared the behavior of the two simulated modes and tried to find the right way to address the performance loss due to the failure mode. The researchers found the piston jam condition might be responsible for a reduction in the available torque (loss of 16.5 percent in the torque value) of a brake assembly, as well as for the existence of residual torque on it. As a result, the overall aircraft stopping distance in landing might be jeopardized by the first effect and an adverse condition referred to as dragging brake might occur due to the second effect.



Model-based fault assessment approach in system operation.

A dragging-brake condition may eventually lead to inadvertent yaws on the ground or even a tire bursting due to the generated heat.

For the last step of this computational methodology, the strategy was to define post actions to maintain the required system level, such as iterate on the existing design and introduce specific maintenance tasks.

Satisfied with the use of the Simcenter Amesim platform, Neto explains that, "The

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Solutions/Services

Simcenter Amesim
www.siemens.com/plm/simcenter-amesim

Customer's primary business

The Aeronautics Institute of Technology (ITA) is an institution of higher education and advanced research with emphasis on aerospace science and technology. It is administered by the Brazilian government with the support of the Brazilian Air Force. The institute is located in São José dos Campos, and is one of the country's elite engineering schools.
www.ita.br

Customer location

São José dos Campos
Brazil

physical modeling with Simcenter Amesim is easy to implement. Being able to click, drag and connect the physical blocks found in its several libraries allows the creation of complex models without the need for writing entire mathematical formulations for every subsystem in the model. The integral causality, numerical algorithms compilation and execution are also fast."

Ensuring performance analysis, fault detection and diagnosis

The work led by Neto comprised an academic study addressing a hydromechanical engineering topic with no quantifiable benefits.

However, Neto explains that, "Some of the qualitative good points of using simulation models in product development cycles are highlighted in the article, such as the reduction of aircraft system development cycles, the help in predicting system operational problems and the support for troubleshooting activities to identify the root causes of real field issues.

"In the current context, modeling and simulation has the potential to improve the execution of several design development activities, such as system architecture study, requirements validation, performance analysis and optimization, safety and assessment, fault detection and diagnosis."

Teaching system simulation to future engineers

Brazil invests and counts on its future generations in order to strengthen the competitiveness of its industry with an emphasis on engineering and science education. One strategy covers the need to know how to manage the main engineering tools of the industrial players. That is a vision proposed by the ITA and supported by Góes:

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ITA and Embraer partnered in 2000 to develop a professional master's program, which serves as a pipeline of aeronautical and aerospace engineers to meet Embraer's needs. This requires dedicated teaching in order to ensure future graduates can manage software used by Embraer, such as Simcenter Amesim.

"Having the capacity to develop system models and run simulations will help our students improve their understanding about system behavior, allowing the execution of post activities that will help them develop better products and systems in the future, like system optimization and sensitivity analysis," says Góes.

Góes appreciates the partnership between ITA and Siemens PLM Software: "Providing the students with a bundle of advanced software tools such as Simcenter Amesim has made a big difference. Opening access to the basic features of the multi-physics energy port environment simulation in the Student Edition of Simcenter Amesim has been a great way for Siemens PLM Software to introduce the students to the important features of this advanced simulation methodology."

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