LMS Virtual.Lab enables AVIC-1 FAI to meet tight design deadlines for the new ARJ21 regional aircraft

China's AVIC-1 FAI integrated a wide range of simulation tools and realized significant time savings in key simulation processes.

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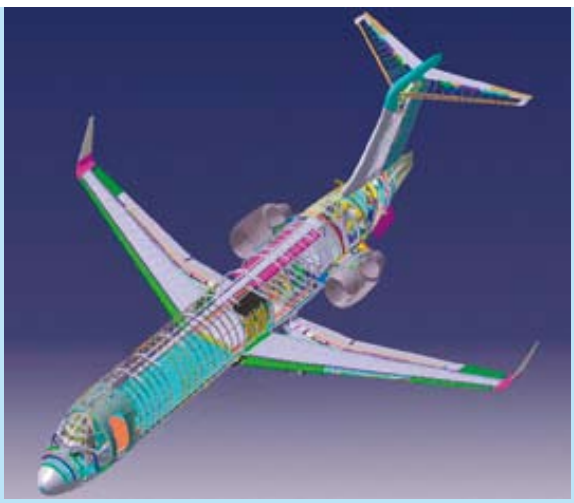
With their air travel growing swiftly, China is working on the ARJ21 turbofan aircraft – the first regional passenger jet designed and built in the country. But to regain the domestic market, manufacturer China Aviation Industry Corporation (AVIC-1) and its R&D subsidiary the First Aircraft Institute (FAI) must act fast in developing an entire new plane from scratch. They are meeting this challenge with the help of LMS Virtual.Lab, a unified suite of software used for a wide range of tasks in development of the aircraft including multibody system simulation, finite-element analysis, noise evaluation and design optimization.

LMS Virtual.Lab streamlines and compresses the development process by tightly integrating these simulation programs as well as other non-LMS software used by AVIC-1 FAI – including Dassault Systèmes CATIA V5 design software. In this way, engineers reuse models in different applications, work smoothly with a single simulation solution, share data easily across different disciplines and quickly refine the design to readily satisfy multiple performance attributes. The resulting increased efficiency and process integration based on LMS Virtual.Lab is saving considerable time, with stress analysis iterations for example performed significantly faster than before.

The suite of software has been particularly beneficial in developing the landing gear. LMS Virtual.Lab Motion multibody simulation is used to verify subcontractor designs, analyze components, and integrate the system into full models of the complete aircraft to study the plane's performance. Such an integrated design and simulation environment enables engineers to quickly study aircraft dynamics, explore more alternatives in less time, go into greater detail and refine the design up front in development long before the plane is built and flight tested. In this way, LMS Virtual.Lab is a key element in the high-stakes ARJ21 program, not only for its business value for the plane manufacturer but for the strategy of the Chinese in entering the global commercial aircraft market.

Entering the global aviation market

With the economy booming, tourism up, and people traveling more, passenger air traffic in China has increased at an unprecedented 95% in the last five years. According to industry analysts, China now ranks fifth in the world for total air traffic and will need 2,600 additional aircraft in the next twenty years to handle soaring passenger volume estimated to grow 8% annually, making the country the second largest future aviation market in the world.



LMS Virtual.Lab simulates the behavior of the plane and subsystems based on data from a CATIA V5 digital mock-up of the full aircraft.

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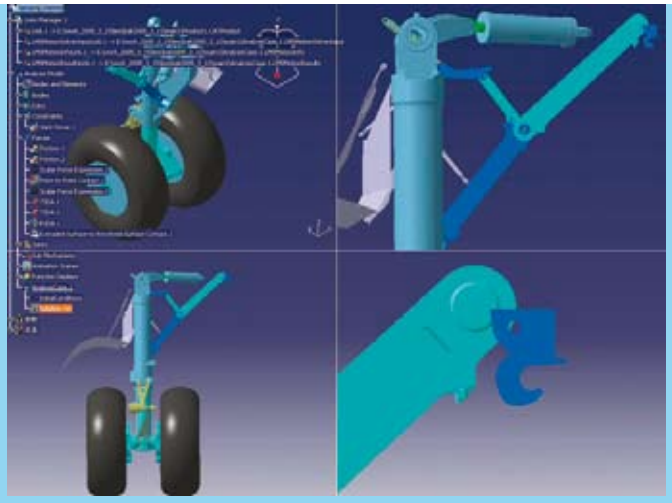
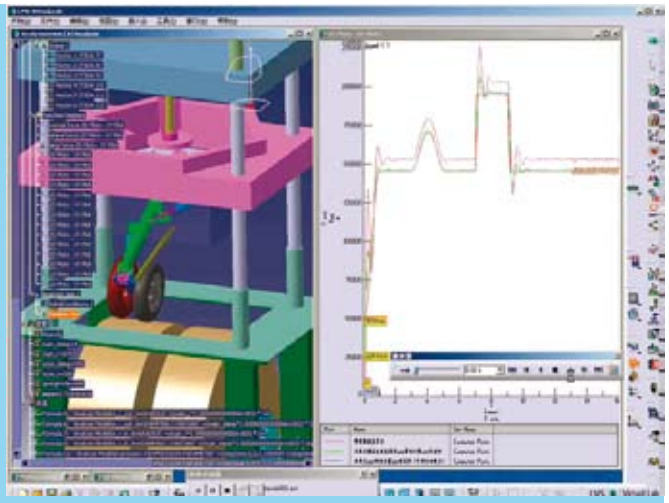


Draw-in and lock simulations with LMS Virtual.Lab Motion are used to study the way the landing gear system retracts into the bay of the aircraft and locks into position.



The operation of a test rig is simulated with LMS Virtual.Lab Motion so engineers can correct any problems before actual certification testing.

Currently, the overwhelming majority of planes for Chinese airlines are supplied by foreign manufacturers. As China's largest manufacturer of a wide range of aerospace products, AVIC-1 is focusing its attention on this large business segment and has far-reaching plans on becoming a major player in the global commercial market. "One of our goals for the next 20 to 30 years is to have sales of civil aviation products equal to that of our other aviation product sales," says AVIC-1 Vice President Tang Xiaoping. "And we would like our domestic and international markets to be equal."

For its initial entry into this market, AVIC-1 is focusing on regional jets: passenger planes with 100 seats or less covering short to medium distances less than a few thousand km. Small jets flying regional routes are expected to account for a third of China's total aircraft fleet in 20 years, according to the Aviation Industry Development Research Center of China.

The company's initial product for this market and the first regional jet to be designed and manufactured in China is the ARJ21 turbofan aircraft. The plane will be available in two variants with capacity between 70 and 100 passengers in stretch and extended-range versions. AVIC-1 company officials are confident they can win a big share of their domestic market for regional aircraft with the ARJ21. International certification of the plane will then bring the aircraft into global markets. So the stakes are high in the ARJ21program, not only for the business value of the plane for AVIC-1 but for China's strategy of entering the global commercial aircraft industry.

Time pressures for a complex aircraft design

Performance specifications for the ARJ21 are intended to meet the particularly demanding requirements of commercial flight in China, including high altitude and hot conditions in western provinces as well as powerful take-off and climbing capabilities to accommodate short runways.

The ARJ21 is being designed according to these and other stringent requirements by AVIC-1 FAI, and quick completion of the development cycle is essential in meeting a rigorous production schedule. According to Dr. Wu Guanghui, President of FAI and chief designer of the plane, a wide range of studies have confirmed the ARJ21 is meeting its designed flight characteristics. "Ninety per cent of the plane's components will be made by the end of this year," Dr. Wu says. The program started in 2002 and the aircraft roll-out is scheduled for Q4 2007, with the first flight slated for early 2008 and full-scale production to begin in 2009.

Clearly, the engineers and managers at FAI have had their work cut out for them in completing the design on time and in continuing to integrate the numerous subsystems into the overall aircraft.

"Because this is a new aircraft, the total design must be developed entirely from scratch, from nose to tail," says Dr. Ning Zhen Bo, Director of the Digital Office at FAI. "One of the major challenges in streamlining the process is eliminating the many inefficiencies of working with simulation software that ordinarily runs separately and produce isolated results."

He explains that considerable time typically is required in learning different interfaces, reworking models, duplicating meshes, transferring files, and translating data. Because of these cumbersome tasks, simulations typically are done by a separate analysis group, usually late in the development cycle to troubleshoot last-minute problems. Delays and difficulties are compounded by the fact that data must be shared between so many people involved in the process, with FAI developing the airframe, skin, and overall integration of numerous subsystems designed by 15 tier-one aerospace industry suppliers.

An integrated design and simulation environment

To reduce these delays, the company established a more integrated simulation approach through the deployment of LMS Virtual.Lab. FAI engineers use LMS Virtual.Lab Motion multibody simulation to study dynamic systems such as the landing gear. LMS Virtual.Lab Structures performs finite-element pre- and post-processing in determining

component stress levels. LMS Virtual.Lab Acoustics evaluates passenger cabin sound emission levels. LMS Virtual.Lab Optimization is used for evaluating alternatives and refining designs, particularly in finding part shapes that will provide the greatest strength and stress resistance for the least amount of weight.

LMS Virtual.Lab streamlines the simulation process – and thus compresses the aircraft development cycle – by closely integrating these programs as well as other non-LMS software used by FAI. Models are reused in a wide range of simulation applications, engineers work with a single integrated solution and data is easily shared between disciplines to optimize multiple performance attributes.

FAI particularly benefits from the tight integration between LMS Virtual.Lab and Dassault Systèmes CATIA V5 design software used extensively by FAI and its suppliers. The integration is fully associative, so data is conveniently shared between programs. FAI engineers can automatically create simulation meshes using V5 geometry, for example, and perform a complete range of analysis tasks in the same user environment. Mass data, component connections and boundary conditions are fully associative with geometry, so this information is easily imported from V5 into the simulation model.

This tight integration saves time and effort by largely automating tasks associated with creating meshes, setting up problems and performing modifications. “The various simulation applications working under the same environment with full integration in the V5 platform simplifies the analysis process, allows more design iterations, enables greater exploration of design alternatives, allows us to refine designs sooner and shortens the development cycle,” Dr. Ning explains.

Also, by working in this familiar V5 environment designers more readily perform simulations on their own component designs without the involvement of analysis specialists. “Designers now find it quite easy and exciting to perform component analysis, and we see significant gain in engineering efficiency with this approach,” he says. “Previously it would not have been possible for them to perform such analysis.”

“Process integration, advanced technology and the simplicity of using LMS Virtual.Lab for our engineers has greatly improved our simulation efficiency.”

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Landing gear development

The LMS solutions have been especially valuable in the development of the ARJ21 landing gear being designed and manufactured to FAI performance specifications by tier one supplier Liebherr Aerospace. The aircraft will have three twin-wheeled landing gears – one in front and one under each wing – equipped with Goodrich tires and brakes and a Parker Hannifin hydraulic system.

Using LMS Virtual.Lab Motion, FAI engineers verify that the Liebherr design meets the required performance requirements, analyze individual components, and integrate the landing gear design into full models of the complete aircraft. Accuracy of the simulation model is greater than is otherwise possible because of the capabilities of LMS Virtual.Lab Motion in efficiently representing the structural flexibility of the landing gear components as well as the airframe and wings. As a basis for many of these studies, LMS Virtual.Lab Motion dynamic models of the landing gear system are combined with the full-aircraft model to simulate the plane's behavior during take-off, landing and taxi maneuvers. The software enables the development team to determine the stability of the aircraft s well as loads on individual parts and assemblies during these critical maneuvers.

A wide range of simulations are performed to confirme the proper operation of the landing gear. Draw and lock studies determine the way the mechanical system retracts into the bay of the aircraft and locks into position. Similarly, deployment analysis shows how the landing gear unlocks and unfolds into the operational position for landing. These simulations analyze not only the kinematic motion of the complex landing gear system but also predict forces, displacements velocities and accelerations – even taking into account air pressure loading against the assembly.

"Completing these studies quickly and accurately relies on the capability of LMS Virtual.Lab Motion to co-simulate with hydraulic control simulation software in accurately representing the operation of the landing gear system," Dr. Ning says. "This allows us to do time-domain coupled analysis that shows the action of the hydraulics and the response of the mechanical assembly."

LMS Virtual.Lab Motion is also used in emergency drop studies evaluating the action of the landing gear in swinging down from the bay and locking into position from the force of gravity and inertia when a hydraulic failure occurs. Demonstrating such a capability is an important part of the aircraft certification process, so determining as early as possible if the emergency drop operates properly is critical to correct any problems before actual physical testing is begun.

Part of the landing gear certification process is done on a test rig, the operation of which is simulated with LMS Virtual.Lab Motion. "Simulation lets us know how the landing gear will behave in the rig, so we can correct any problems before actual certification testing," notes Dr. Ning. "This saves time and also ensures that the certification process will go more smoothly."

Throughout the simulation process, loads determined by LMS Virtual.Lab Motion are used as input to Nastran finite-element analysis for determining stress on individual parts. If stress concentrations are found, part geometry is readily modified, dynamics simulated again and new stresses computed, all very efficiently. Because of the process integration and LMS Virtual.Lab associativity, FAI notes that this iterative cycle is significantly faster than their former method of working with stand-alone software.

"Process integration, advanced technology and the simplicity of using LMS Virtual.Lab for our engineers has greatly improved our simulation efficiency," Dr. Ning relates. "This enables us to develop the best designs in meeting our critical development schedule for the ARJ21 aircraft." ■

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