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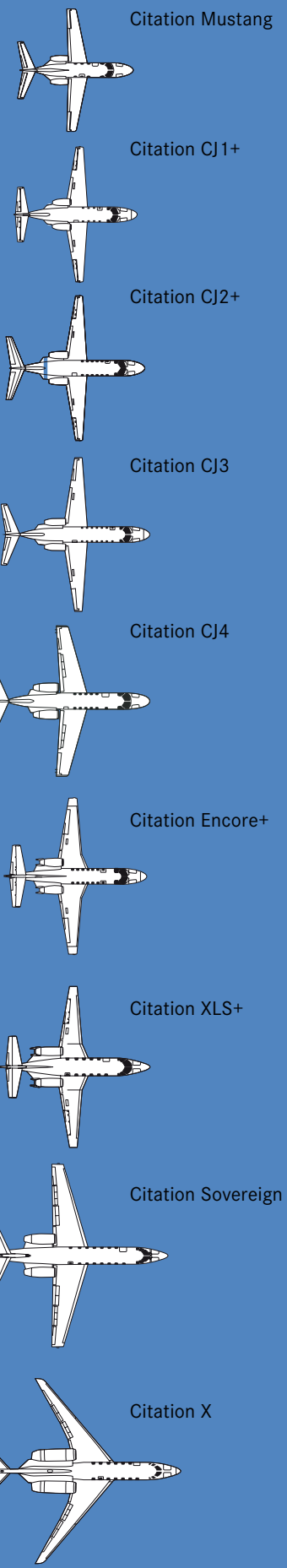
The making of the Cessna Citation Columbus...

Set to enter service in 2014, the Cessna Citation Columbus is a pinnacle plane for the 80 year-old Wichita, Kansas aviation company. Sure it is the largest in its class, but more importantly for Cessna, it represents a change of production concepts. It is the first time that Cessna is focusing on integrating and assembling rather than just constructing. To do this successfully, the company is investing a smooth $780 million to build the Citation Columbus including a brand new assembly and engineering plant. But jets like the Columbus just don't happen overnight. Planning, engineering, design, testing and certification take months if not years.

Right now, behind closed doors in the engineering department, the team at Cessna is putting the final touches on what will be one of the largest, longest-range, most comfortable, most advanced Citations in Cessna's history. And they are working faster and more efficiently than ever before. Part of the secret to their success is LMS Virtual.Lab Motion and other LMS tools that help the team make 100% sure that every piece of the Columbus puzzle fits together perfectly.

Cessna Citation Family



The Cessna Citation Columbus: the going-global bizjet for businesses going global

With a non-stop potential of 7408 kilometers and maximum cruising speed slightly under Mach .85 (that is roughly 904 km/h for you non-aviators) the Cessna Citation Columbus promises to be a new kind of business jet. Destined for transcontinental travel, the $27 million Columbus seats 8 adults and a crew of two with ample space for baggage. With a 1.86 m high ceiling, one can comfortably stand up and take a stroll around the 11 m cabin or perhaps catch a few well-deserved winks before that morning meeting in Munich.

With thousands of Citations flying the skies worldwide, Cessna is clearly the leader in the business jet market. So when creating a new airplane bigger, faster and greener were critical defining factors. The Cessna team also put a lot of time and effort into defining what their customers wanted. They strived to define exactly who would put the Cessna Citation Columbus on the top of their shopping list and more importantly why?

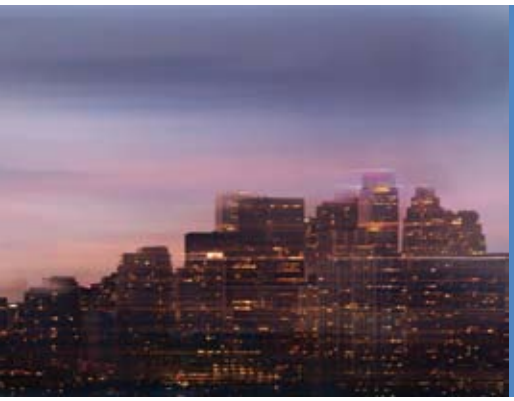
“The large majority of Columbus customers will be Citation owners who want to step up to coincide with expanded mission profiles. They already have an extremely high expectation of Cessna, and we intend to delight them with this airplane. Those customers will enjoy significant commonality between the Columbus and previous Citations. They’ll see it in the systems, whether it’s flight control, handling qualities or simply the flight characteristics of the airplane,” said Joe Hepburn, Senior Program Manager.

Planet-friendly power

In today’s world, eco-friendly, sustainable travel is not a factor to be overlooked. When designing the Columbus, Cessna extensively used CFD analysis to isolate any and every point relevant to airflow across the aircraft’s surface, and then gauge the effects of even the smallest changes in contour. The result is an aerostructure shaped and formed to achieve the best of all possible performance combinations – the highest speeds with the least amount of drag and the greatest efficiency.

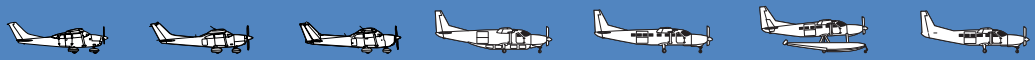
Excellence in aerodynamics makes the perfect combination with high-performance engines from Pratt & Whitney Canada, a long-time Cessna supplier who built the engine for the original Citation back in the early 1970s. For the Columbus, Pratt & Whitney Canada built a brand-new engine using the latest high-efficiency technology without compromising power. The two new Pratt & Whitney Canada PW810 FADEC-controlled turbo-fan engines, pylon-mounted on the rear fuselage, are economical to operate and cleaner for the environment. The Columbus is at its most efficient running at the highest power setting. This means that pilots don’t have to give up speed as the Columbus sails around the globe.

“On the Columbus, we’re only going to lose a couple hundredths of a Mach number of our speed and still achieve our 4,000-nautical-mile range. We’ll save our customers a lot of time as well as operating costs,” adds Tom Dwier, Senior Engineer Specialist.



The Cessna Family

Based on unit sales, Cessna Aircraft Company is the world's largest manufacturer of general aviation airplanes. In 2007, Cessna delivered 1,272 aircraft, including an astounding 387 Citation business jets. Since the company was originally established in 1927, some 190,000 Cessna airplanes have been delivered to nearly every country in the world.



What does the customer want? Just ask.

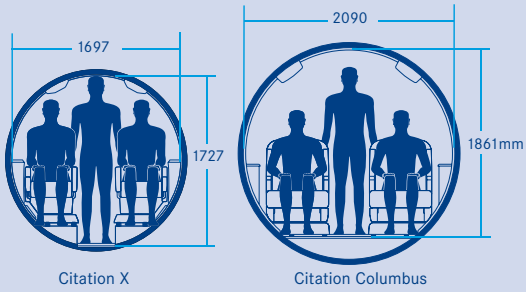
Cessna owners are treated like family members so it is not surprising that the team took passenger comfort very seriously. Like most leading global companies, Cessna is delivering exactly what the customer wants by simply asking them. This wasn't such a tough job since 80 percent of Citation buyers are repeat customers. The team conducted a 12-month "comfort" study, working with everyone from the world's top automotive manufacturers to the foremost technological and medical experts and different folks, like flight attendants and technicians.

"Because we asked a lot of the right people a lot of the right questions, we feel we have the basis for a tremendous number of the right solutions. We discovered that the biggest key for everyone concerned is flexibility, and the interior of this aircraft is designed for maximum flexibility," stated Cindy Halsey, Vice President, Interior Design Engineering and Development.

The global effect is galvanizing

Clearly the Cessna Citation Columbus aims to please the key players in the global business arena, a 24/7 game where time and distance no longer matter much. In this world, getting from A to B quickly and efficiently is becoming an essential competitive edge. The Columbus is set to deliver this advantage, but according to Cessna's CEO it is just the icing on the cake.

"The Citation Columbus will enable our customers to do business around the world a lot faster, more conveniently and much more easily than in the past. An aircraft of this size with these capabilities sends a strong message to the market and the world that we are not standing still. These are some of the most exciting days in Cessna's history. We're going to continue to grow and to offer products in every market segment that we possibly can. The sky isn't even the limit for us. Who knows what's next? I just don't believe we should ever have any limits on where we can go," concluded Jack Pelton, Chairman, President & CEO, Cessna Aircraft Company. ■



A unique cabin design gives Columbus passengers a degree of head and shoulder room that is remarkable even for this class of business jet. The low, flat floor is perfectly suited for the long-range, multi-continent missions the Columbus is destined to accomplish.

Avoiding high-priced hiccups

Using LMS Virtual.Lab Motion and other key LMS solutions to guide the design of the biggest business jet ever built, Cessna makes sure that major aircraft systems all work together properly with no costly surprises along the way.

The Columbus is a huge step forward for Cessna. Not only in terms of size and complexity but also in terms of how the Kansas company develops its planes. With business booming across all product lines and staff and facilities incredibly busy, Cessna needed to find a structured solution to handle a program of this magnitude. Instead of going about business as usual and designing and manufacturing most of the aircraft in house, Cessna borrowed a chapter from the makers of large commercial airliners and decided to integrate and assemble co-developed subsystems and supplied parts to create the Columbus.

The real challenge for Cessna was to meet a tight development schedule while simultaneously coordinating design plans for dozens of suppliers and internal groups co-developing major subsystems. It was vital that everything worked together perfectly when finally pieced together. There is little room for error in the aviation business, and mistakes late in the game can carry a huge price tag.

“In the aircraft industry, ‘hiccups’ in the middle of plane development can cause big problems in terms of time and cost,” explained Robert Howes, Cessna’s Senior Manager of Loads, Acoustics and Structural Dynamics. “Our job is to avoid these problems with extensive use of simulation and high-fidelity models, especially up front in design.”

He explains that based on these tools, they develop load envelops for critical-path parts, such as the landing gear, wings and propulsion system – assemblies that drive the design for most of the plane. Early in development, these elements are combined into a full aircraft model, which is modified and optimized along the way as detailed designs are finalized. When completed, this simulated model eventually becomes an essential element in the aircraft certification process.

A “traffic cop” for critical data flow

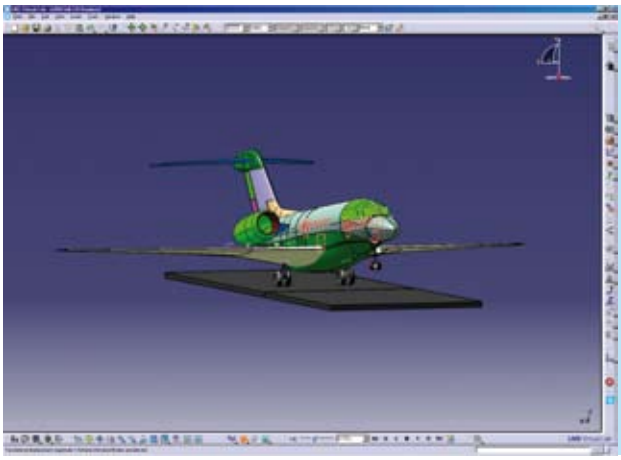
As with other Cessna aircraft designs, the loads group counts on LMS Virtual.Lab Motion multibody simulation software to represent the complete aircraft as well as major systems dynamics. LMS Virtual.Lab Motion predicts loads at attachment points for main components, such as the landing gear, wings, tail section, flight control surfaces and the engines.

A key advantage of LMS Virtual.Lab Motion is that it can exchange data directly with other software packages. Users avoid cumbersome – and often error-prone – data translations and conversions. In this way, LMS Virtual.Lab Motion is tightly integrated not only with other LMS tools and third-part software but also with the in-house codes developed by Cessna for specialized tasks.

“Simulating the entire plane throughout the whole development process is a collaboration between several big pieces of software,” said Robert Howes. “LMS Virtual.Lab Motion is a powerful multibody simulation tool, and the goal is for the software to serve as an essential data-exchange bridge – and often a traffic cop – coordinating the information flow between programs in different disciplines including design, aerodynamics, stress, fatigue and damage tolerance.”

The heart and soul of Cessna simulation

Indeed, LMS Virtual.Lab Motion is at the heart of various LMS solutions that are part of the completely integrated advanced system used extensively at Cessna. “Truly interoperable, LMS tools work so well together – and with other software,” adds Robert Howes. He noted in particular that LMS Virtual.Lab Motion has direct interfaces with CATIA V5 for



Cessna deployed LMS Virtual.Lab Motion to analyze dynamic loading of a complete aircraft including system dynamics such as landing gear, wings & propulsion systems

“Simulation solutions such as LMS Virtual.Lab Motion are essential to Cessna’s continuing success in the bizjet market”

Timothy Seitz, Structural Dynamics and Loads Manager, Cessna

importing part geometry from CAD and two-way integration with NASTRAN and Elfini FE codes used by Cessna engineers. "To develop all our aircraft – especially the Columbus program – we rely heavily on a wide range of LMS tools."

He pointed out that LMS Virtual.Lab Motion load data together with Elfini stress data is fed into LMS Virtual.Lab Durability software to determine component fatigue life. LMS Virtual.Lab Correlation can extract stiffness attributes and mass properties from NASTRAN. FE models can be validated and correlated via modal tests performed in LMS Test.Lab. LMS Test.Lab is vital to ground vibration testing – essential to the certification process especially when considering aircraft flutter.

Thanks to the close integration between LMS Test.Lab and LMS Virtual.Lab, data can be transferred directly without universal file conversions that often fail to fully represent critical data. Cessna also uses LMS Virtual.Lab Acoustics simulation software to predict interior cabin noise from natural frequencies determined from FEA.

A "big win" for LMS Virtual.Lab Motion: true real-world behavior

"When designing the individual systems as well as the entire aircraft, it was especially important for us to step up the fidelity of the multibody models to predict true real-world behavior of the Columbus," said Robert Howes. "In this respect, the flexible body capability of LMS Virtual.Lab Motion was critical to model not only the Columbus but all its flexible components, such as tires, struts, trunnions and trailing links. If you add in the stiffness matrix for flexible parts, you pretty much have a 'big win' case scenario for LMS Virtual.Lab Motion."

LMS Virtual.Lab Motion lets Cessna engineers change simulations quickly especially when exploring various parameter variations and sensitivities to design changes. By changing key parameters, engineers can simply rerun the simulation instead of recreating models from scratch. They can also perform consecutive parametric analyses automatically to quickly explore alternative designs and 'what-if' scenarios. This way, the Cessna engineers can run multiple simulations to predict airframe loads under different flight conditions and different plane weight configurations like light, heavy, forward-weighted, and aft-weighted.

A major shortcut: fast airframe design

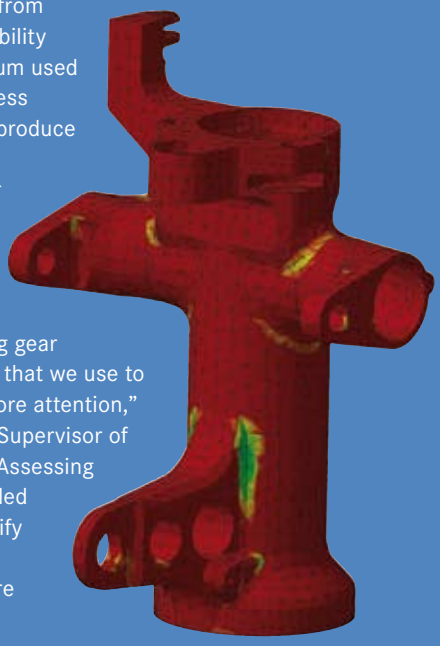
Thanks to LMS Virtual.Lab Motion's ability to run multiple simulations using a flexible multibody model, the Cessna structures group could cut serious design time from the airframe timeline – just a few weeks were needed instead of the typical four to five months normally allotted. Likewise, landing gear loads were determined within a week or two fairly early in design instead of several months later in the cycle. Rapid simulation enables engineers to know how landing gears and other parts would behave long before these parts were actually tested.

"In the past, Cessna used simulation mostly for troubleshooting problems we uncovered during testing," explained Structural Dynamics and Loads Manager

How long will parts last?

Determining component fatigue life is one of the top priorities in aircraft development and certification, particularly for critical systems, such as the landing gear that may fail quickly if a crack develops. Fatigue damage comes from large loads experienced as wheels touch down during landing as well as smaller often-repeated loads felt by parts when braking and taxiing on rough runways. Engineers are challenged to design components strong enough to withstand these various loads while not being overdesigned with excess material that adds weight to the plane.

Previously, Cessna used an in-house Excel-based macro code to compute fatigue life. This took weeks of time and effort and was applicable for only a limited number of points on each part. Today, Cessna uses LMS Virtual.Lab Durability to complete the task in just a few days. Using dynamic loads from LMS Virtual.Lab Motion, the durability module creates a damage spectrum used in combination with FE-based stress data and material parameters to produce output plots showing color-coded detailed damage distribution over the entire part.



"LMS Durability software allows us to quickly move from our CAD representation of landing gear parts to finished fatigue analyses that we use to determine hot spots that need more attention," explains Tom Harrison, Cessna's Supervisor of Fatigue and Damage Tolerance. "Assessing fatigue life so fast in such a detailed manner allows engineers to identify problems early and optimize durability performance long before physical prototypes are built and tested."

Timothy Seitz. “Now we apply simulation to guide the design throughout development so there is less risk of surprises later. With a complex aircraft like the Columbus, we don’t have the luxury of designing plane parts in serial fashion. Rather, multiple disciplines, groups and suppliers must collaboratively work in parallel from the same full-aircraft simulation model. Everybody is playing in the same sandbox, so to speak. LMS Virtual.Lab Motion is the common link that lets many different areas work together.”

Not just another planemaker

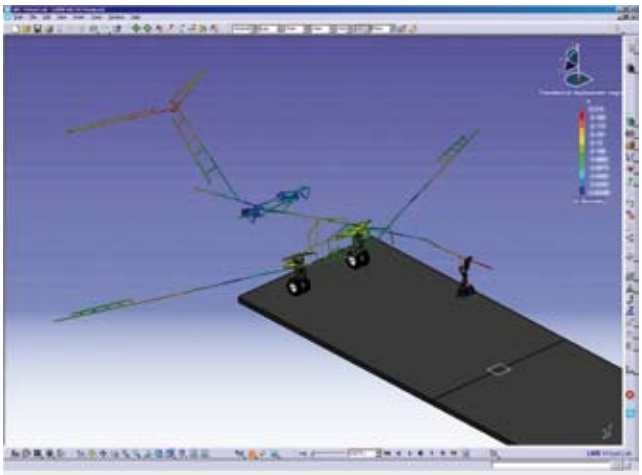
Working in a different manner, Cessna maintains an aggressive schedule for the Columbus. The first prototype flight is anticipated in 2011. FAA certification is expected by 2013. This is one of the most time-consuming aspects of the development process where simulation results must be produced to demonstrate Columbus’ safety and air-worthiness during take-off, landing, taxiing, braking and ground-handling. Results must also be provided for static loads on the airframe as well as dynamic flight loads for conditions such as maneuvering, turning, flight into turbulence and engine failure.

Calculating these various loads at so many points on the airframe can be done quickly and accurately with LMS Virtual.Lab Motion. Moreover, the certification process is facilitated because FAA administrators are assured of the simulation accuracy based on detailed flexible body models. “Because of its overarching use in determining loads throughout the aircraft quickly and accurately, LMS Virtual. Lab Motion is pivotal for our plane certification,” notes Timothy Seitz.

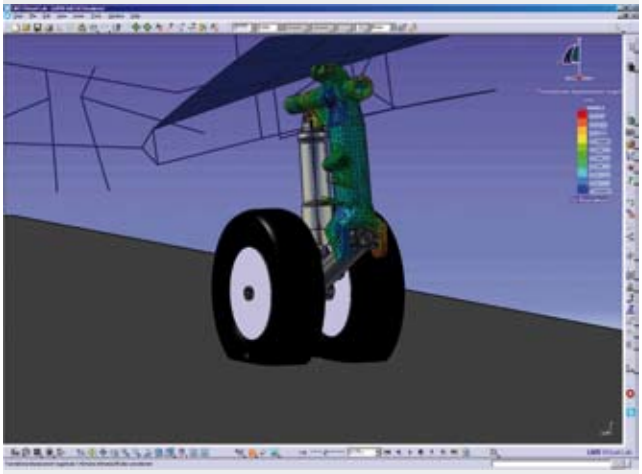
Cessna is already taking orders for the Columbus, which is expected to enter into service by 2014. “To meet this and other program deadlines, simulation solutions such as LMS Virtual.Lab Motion are essential to Cessna’s continuing success in the bizjet market and critical to our commitment to deliver planes on time with the performance stated at the beginning of the program,” explained Timothy Seitz. “At Cessna, it’s not just a program schedule, it’s a commitment. Not a specification but a promise. Without this sense of pride, the use of advanced technology and the expertise of some of the top engineers in the field, we’d be just another plane maker.” ■

The flexible body capability of LMS Virtual.Lab Motion was critical to model not only the Columbus but all its flexible components. If you add in the stiffness matrix for flexible parts, you pretty much have a ‘big win’ case scenario for LMS Virtual.Lab Motion.”

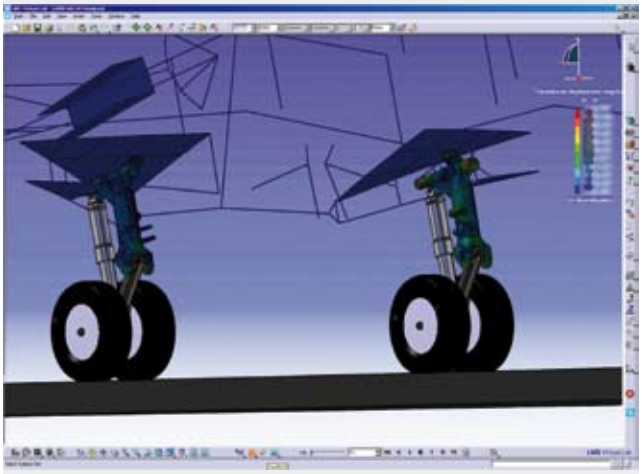
Robert Howes, Senior Manager of Loads, Acoustics and Structural Dynamics, Cessna



For a variety of tests a wireframe representation of the plane's body together with detailed modeling of the landing gear is used enabling fast dynamic simulation while taking flexibility into account.



The landing gear template can be used for easy set-up of a landing gear system including flexible bodies for incereased simulation accuracy.



Predict loads at attachement points of the main components (landing gear, wings, etc..) during a set of manuevers such as take-off, landing, taxiing and braking.

Tuning models and predicting flutter

Cessna relies on LMS for Ground Vibration Testing

Cessna's Citation Mustang, one of the first aircrafts to take advantage of LMS Virtual.Lab Correlation. Only two weeks were needed to predict flutter speed instead of 14 to 16 weeks.

The increasing use of simulation in aircraft development at Cessna doesn't diminish the importance of physical testing. In fact, the company verifies and tunes analysis models by comparing predicted results with frequency response and modal measurements taken by LMS Test.Lab in Ground Vibration Testing (GVT) of parts – even entire airframes – hung on bungee cords and vibrated by electrodynamic shakers.

These studies are particularly focused on predicting and avoiding flutter: an aerodynamic instability where wings and other flight surfaces vibrate excessively above a certain speed. Tests are run and models tuned as early as possible in the development cycle so certification can proceed without a hitch. "In this sense, proper testing and simulation help Cessna engineers get designs right the first time," said Cessna Dynamics Specialist Craig Mundt.

In the past, engineers would visually compare measurement plots and simulation results side by side: a tedious, time-consuming and error-prone process. Although flutter prediction was absolutely necessary, the process was a major bottleneck in development and certification. Mundt relates that "in the old days" three to four months would be required to interpret test data in this manner. Moreover, just as much time would be spent setting up tests before the right locations for sensors and shakers were determined.

Today, pre-test features in LMS Virtual.Lab Correlation point out the best locations for sensors and shakers. The software then combines test and predicted results into a single dynamic model, compares the two sets of data with tools such as a Modal Assurance Criterion (MAC) matrix that shows where data align and where they diverge, indicating where the dynamic model must be adjusted. The model is modified until results match up, and the final model is ready for processing to accurately compute flutter airspeed. This model tuning also provides critical stiffness attribute data imported by LMS Virtual.Lab Motion to create flexible body representations of the airframe and individual components.

With the development of Cessna's Mustang aircraft – one of the first to take advantage of LMS Virtual.Lab Correlation – only two weeks were needed to accurately predict flutter speed instead of the traditional 14 to 16 weeks, enabling Cessna to significantly shorten the time for "go fast" certification testing when the plane is flown at the edge of its speed envelope. "This was pretty much unheard of at the time," said Craig Mundt. "Now we perform highly accurate correlation routinely in a fraction of the time previously required and plan to pursue this capability extensively to meet the stringent Columbus certification requirements." ■

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