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TLG Aerospace

Aerospace engineering services company uses Simcenter STAR-CCM+ to reduce aircraft certification cost

Product

Simcenter

Business challenges

Minimize testing requirements in certification process for on-time compliance

Reduce certification cost for customers

Bid for projects with greater scope

Keys to success

Use Simcenter STAR-CCM+ to more efficiently build accurate aero database

Use flexible licensing and elastic computing to run detailed simulations on models of any size under an hour

Results

Utilized CFD data with FAA approval to show compliance, eliminating some testing requirements

Saved certification cost by reducing test conditions, predicting potential hazards, enabling testing at lower loads and removing test requirements at extreme conditions

Reduced cost per simulation, lowering certification cost and helping win projects with greater scope

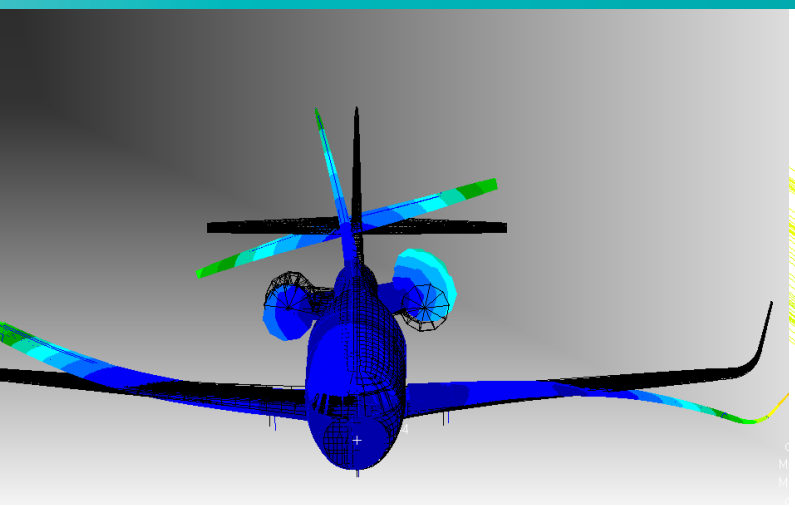
TLG Aerospace deploys Siemens PLM Software solution for faster, cost-effective certification by analysis

Certifiably cheaper

"Our goal was to have the most boring flight test program we've ever seen," says Wayne Tygert, chief engineer, Boeing, in describing one of the 787-10 Dreamliner test flight programs used for certification.

Boring usually isn't the first word that comes to mind when describing something that took 900 hours across three test aircrafts, thousands of regulations, upwards of 4,000 documents and millions of dollars. And what is the 787-10? A simple extension in the midsection of the already certified 787-9 to accommodate 40 more passengers. The original 787 Dreamliner took eight years from application to certification for the new design, clocking 4,645 flight hours in flight testing, more than 200,000 hours in Federal Aviation Administration (FAA) experts' time and a much higher certification cost.

Getting an aircraft certified, whether new or modified, is a long, expensive and bureaucratic process, albeit one that has led to the safest mode of transportation. From the largest aircraft in history to small two-seaters made of steel and fabric, every plane needs to prove airworthiness and compliance and be certified by regulatory authorities before operation.



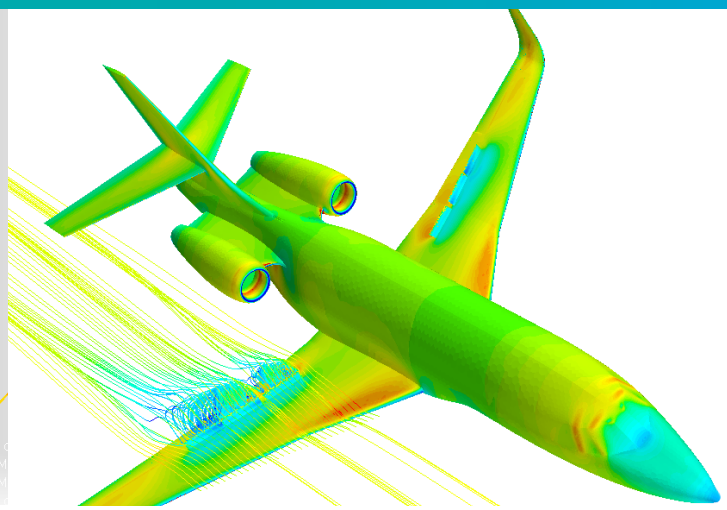


Figure 1: For airplanes where structural flexibility is important, a coupled aerodynamic and structural certification-by-analysis approach is needed.

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Andrew McComas
Engineering Manager and Aerodynamicist
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The massive cost of certification

Certification is estimated to cost $1 million for a primary category aircraft (three seats or less), $25 million for a general aviation aircraft and upwards of $100 million for a commercial aircraft. Certification costs and delays can run into millions of dollars, sometimes burning up as much currency as it costs to develop the aircraft. This process can often decide profit or loss.

Program delays, missed delivery dates, cost overruns and safety issues due to designs not meeting certification requirements and requiring expensive redesign and flight testing frequently occur. How do companies reduce certification cost and time? Can you reduce expensive testing while still proving airworthiness?

With 45 years of combined experience in aircraft design, development and certification, Robert Lind and Andrew McComas of TLG Aerospace are no strangers to these challenges. Occupying one floor of an unassuming, six-story building on Seattle's Lake Union, their modest office belies the experience and expertise that has a client list reading like a who's who of modern day aviation. TLG Aerospace has helped numerous customers receive FAA certification in the U.S. at a low cost and in a short time, something they have achieved with surprising efficiency.

Certification by analysis

FAA aircraft certification involves three stages: design certification, production certification (PC) and airworthiness certification (AC). The design certification stage involves the approval of design safety, operability and durability, with type certificate (TC) for new designs and supplemental type certificate (STC) for modified designs. The PC stage gives approval to manufacture parts, components and systems, while the AC stage gives approval to operate the aircraft.

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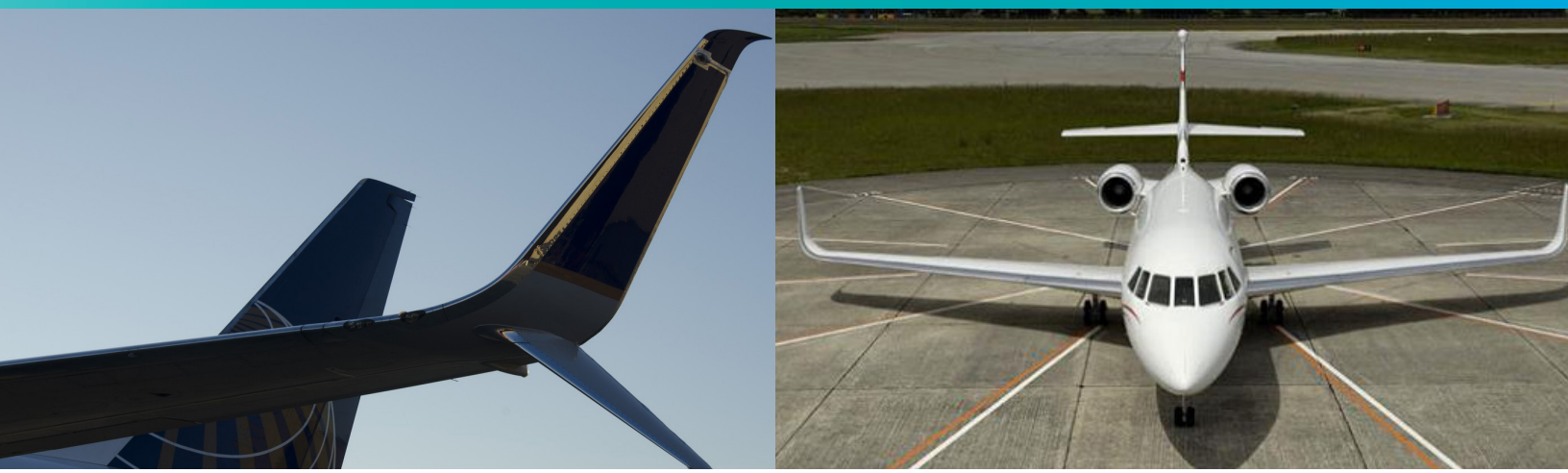

Figure 2: Certified with TLG Aerospace – (Left) 737NG Split Scimitar Winglets (Right) Falcon 2000 business jet.

The process is similar for other worldwide regulatory agencies. The FAA requires certification by test or by analysis validated by test. The industry calls it certification by analysis (CBA). These analyses are made using a full vehicle model that is validated by a flight test over a specified range of the flight envelope, as agreed upon in advance by the certification authority. The full vehicle model includes:

- Aerodynamics: A combination of computational fluid dynamics (CFD), low order methods, wind tunnel and handbook analysis validated by pressure and strain measurements in flight test
- Structures: Finite element analysis (FEA) and handbook calculations validated by ground vibration testing (GVT) and static load in ground test
- Mass properties: Computer-aided design (CAD) and weights bookkeeping validated by weighing
- Flight controls: Laws of flight control validated by integrated simulation and flight test

The integrated full-vehicle model is ultimately validated by the flight test and must be shown to be accurate or conservative. The certification authorities ensure that the analysis will yield a safe result. The original equipment manufacturer (OEM) is typically concerned about limiting conservatism to avoid excess weight and missed performance.

The TLG Aerospace approach to certification with CFD

"What has changed is the balance between how much analysis you can do and how much you can use in the certification process," says Lind, director of engineering, FAA flight analyst designated engineering representative (DER), FAA flutter DER, TLG Aerospace. "This is a really exciting development in my 30 years in the industry. As CFD codes and computers have become more capable, we can certify faster and cheaper."

Most of Lind's work involves getting customers to type certification with analysis. As one of TLG Aerospace's four resident DERs, he can sign for certain certification functions on behalf of the FAA. TLG Aerospace uses Simcenter STAR-CCM+™ software from Siemens PLM Software for CFD analysis and MSC Nastran® software for FEA to develop full-vehicle certification models for loads, flutter and handling qualities, modeled appropriately for the entire flight envelope.

Andrew McComas, engineering manager and aerodynamicist, TLG Aerospace, notes, "We utilize Simcenter STAR-CCM+ in a certification environment which is different from design. There is a great role for CFD in the certification process. We don't use CFD to get an answer that the FAA signs off on. We use CFD to build a full-scale aero/structure/controls model so we can simulate vehicle response and produce loading and handling information."

"For TLG Aerospace, Simcenter STAR-CCM+ has all the tools built in to do these calculations without other third-party software."

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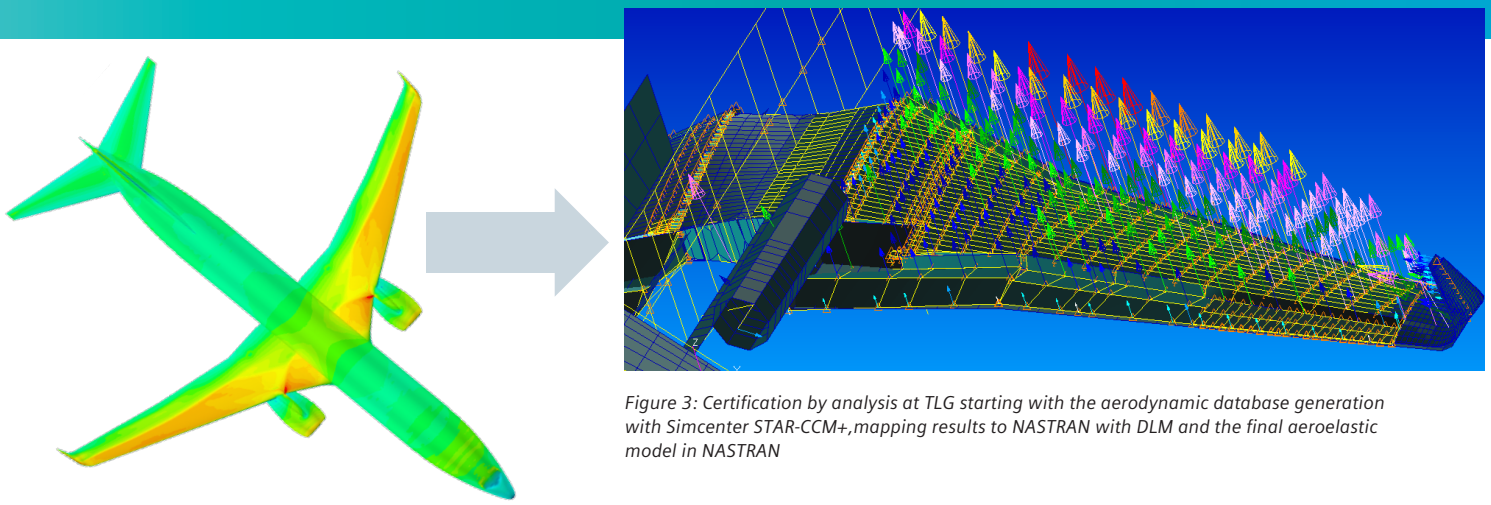

Figure 3: Certification by analysis at TLG starting with the aerodynamic database generation with Simcenter STAR-CCM+,mapping results to NASTRAN with DLM and the final aeroelastic model in NASTRAN

To certify a new aircraft, an aerodynamic database is required. To build the entire analysis database would require data for hundreds of thousands of conditions to be available in a short amount of time. The aerodynamic properties of the vehicle are calculated at design and at flight envelope extremes using CFD. The CFD results are mapped to a reduced-order aerodynamic model within the aeroelastic process. TLG Aerospace calibrates the aeroelastic model to develop full-vehicle aeroelastic solutions that are underpinned by the rigid CFD. The final aeroelastic model will reproduce full-vehicle integrated and distributed aerodynamics in rigid mode and yield a converged aeroelastic solution in seconds.

The predictions are now in place to show regulations are met at certain conditions. Flight testing then validates the analysis models. This validation may be limited to something less than the full flight envelope to reduce risk for in-flight testing. Once validated, it can be used to show compliance at other flight conditions. Having a high-fidelity pre-flight test model significantly reduces the amount of required post-flight test model adjustments and calibrations.

Reducing certification cost with Simcenter STAR-CCM+

McComas credits Simcenter STAR-CCM+ and Amazon Web Services (AWS) for the breakthrough in certification cost reduction.

"Simcenter STAR-CCM+ runs robustly, accurately and repeatedly with simple processes and best practices," says McComas. "That has given companies confidence that the code can be used as a source for aero database generation. Elastic computing from AWS, with Siemens' power-on-demand licensing, helps run multiple simulations on multiple compute clusters simultaneously on the cloud in a secure way. If we did not have the POD licensing model, we wouldn't have the capability to take full advantage of elastic computing resources and would incur the large cost of annual licenses."

In short, the entire aero database is built in a shorter time with cost-effective licensing. The added benefit? Reducing wind tunnel tests.

CFD or wind tunnel? The answer is both With experience in over 100 wind tunnel test campaigns at low and high speeds, TLG Aerospace possesses a significant experimental background in testing. Has wind tunnel testing fallen out of favor then? Not at all.

In common parlance, wind tunnel is still king – but a king who is now increasingly delegating a fair share of royal duties to the trusted advisory council of CFD. Wind tunnel tests are still used for aero database development for new aircraft configurations. However, CFD is supplementing tests at some conditions and replacing testing at others, leading to huge savings. Figure 4 is a notional comparison of legacy CFD codes

	Model costs	Usage rate (per hour)	Engineers (per hour)	Productivity (conditions/day)
Low speed wind tunnel	$165k	$600	X2	800
High speed wind tunnel	$315k	$4500	X3	600
Legacy CFD	$15k	$250	X1	20
Simcenter STAR CCM+	$15k	$100	X1	80

Figure 4: A notional comparison of wind tunnel versus CFD as seen by TLG Aerospace.

and Simcenter STAR-CCM+ compared to wind tunnel testing as seen by TLG Aerospace. For a minimal investment, Simcenter STAR-CCM+ can reduce and replace some testing requirements. Considering the usage rate and model cost for wind tunnel tests, this can translate into significant time and cost savings.

Wind tunnel testing is still best suited for incipient separation regimes like high-angle of attack and sideslip handling analysis. CFD works best for moderate angles of attack and detailed flow-field investigations.

"Large databases can be run in Simcenter STAR-CCM+ today at a fraction of the cost and schedule of legacy methods and wind tunnel testing," says McComas. "That was not possible only a decade ago."

With elastic computing and cloud licensing, there is no technical limitation to running large numbers of CFD cases simultaneously. TLG Aerospace is also able to regularly run large, fully detailed simulations, with most models running in under an hour, no matter their size, something which was not previously possible.

Using elastic computing with AWS, TLG Aerospace saves 75 percent of the total cost per CFD simulation. The technology behind this is the Amazon EC2 Spot Instances, an Amazon offering to utilize unused computing capacity on the AWS cloud at steep discounts.

CFD is not a one-trick pony for certification

Modifications and additions to existing type certified aircraft will affect regulations. Taking older airframes to the limits of the flight envelope with new modifications is hazardous, expensive and time-consuming. The FAA allows CFD as a means to show the compliance of the original aircraft hasn't changed due to modifications. Companies like TLG Aerospace have adopted this wholeheartedly, utilizing CFD to generate supporting data and arguments to show compliance.

"In the past, engineers had to go to test without any question for any modifications done. Now CFD gives the data to try and eliminate some test requirements," says McComas.

Other CFD applications in certification include pressure loading on secondary structures, fairings, antennas and radomes, ice accretion, air-data system location, internal flows, winglets and more.

"Simcenter STAR-CCM+ has contributed to the receipt of numerous FAA-approved certificates."

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Solutions/Services

Simcenter STAR-CCM+
https:www.plm.automation.siemens.com/global/en/products/simcenter/STAR-CCM.html

Customer's primary business

TLG Aerospace, LLC (TLG) is an aerospace engineering services company dedicated to providing customers with reliable, efficient design, analysis and certification for new and modified aircraft and related aerospace products.
www.tlgaerospace.com

Customer location

Seattle, Washington
USA

Here's a scenario: Imagine a new radome is fixed onto the aircraft. To comply with regulations, the manufacturer now has to prove that if the structure comes off the airplane, it will separate safely without impact. Good luck breaking off a radome in flight test! Similar challenges exist in proving icing on the new structure doesn't affect compliance and operational safety.

"The only feasible option here is to use a validated analysis to show the structure meets safe separation criteria," says McComas. "For TLG Aerospace, Simcenter STAR-CCM+ has all the tools built in to do these calculations without other third-party software."

In addition, the onslaught of new, innovative aircraft such as drones and air taxis, military aircraft, the born-again supersonics and others will also benefit from certification by analysis.

The 'C' in CFD stands for certification

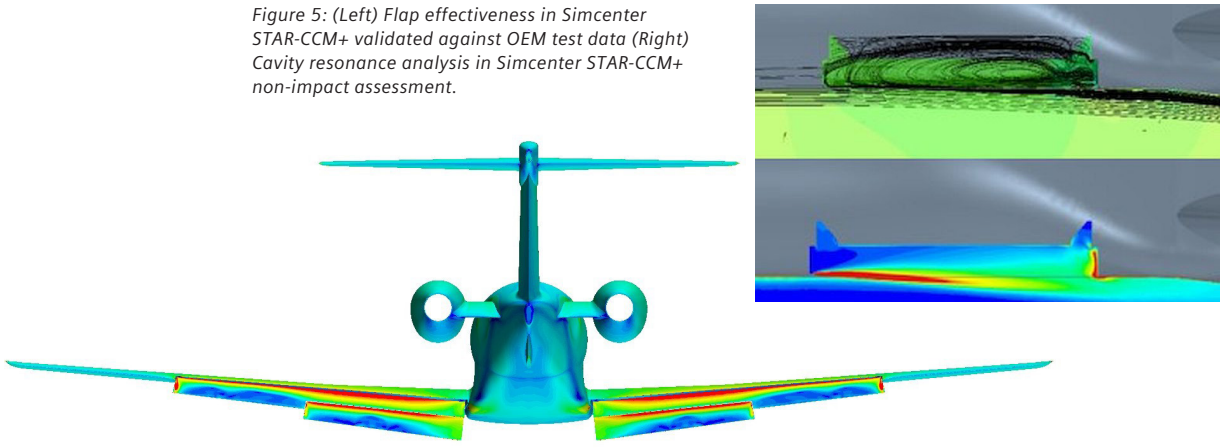
"Simcenter STAR-CCM+ has contributed to the receipt of numerous FAA-approved certificates," says McComas. "It has a role in every single certification program at TLG Aerospace."

It is unlikely that CFD will ever completely replace wind tunnel testing as computers, codes and licensing continually evolve. Nevertheless, the role of CFD in certification will only increase over time to supplement and complement flight testing.

For now, companies like TLG Aerospace have found a reliable workhorse in CFD for certification, one that can do the heavy lifting of proving compliance at the extremes of flight envelopes, reduce the number of flight test conditions, enable tests to lower loads and predict potential testing hazards. Flexible licensing and elastic computing are further solidifying the case for certification by analysis.

"We can now bid on projects that have greater scope, be more competitive, pass on the savings to our customers and do much more with our dollar," says McComas.

Figure 5: (Left) Flap effectiveness in Simcenter STAR-CCM+ validated against OEM test data (Right) Cavity resonance analysis in Simcenter STAR-CCM+ non-impact assessment.



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