

Airbus

Using model-based systems engineering to develop the next-generation A350 XWB

Product

Simcenter

Business challenges

Tackle technological novelties

Address lessons learned from the A380 and A400M programs

Incorporate new suppliers into the extended enterprise strategy

Keys to success

Use model-based systems engineering projects to describe systems' functional and logical architecture

Use Integrated modeling and simulation process to assess the physical system performance under specific operational conditions

Results

Developed innovative airplane that meets future market needs: efficiency, comfort and environmental envelope

Implemented design processes that facilitated the use of the best possible materials and technologies

New generation of airliners, such as the A350 XWB, push model and simulation engineers to review their standards, making traditions obsolete

An innovative airplane range

The first A350 was conceived as an additional member in the Airbus long-range family, along with the A330 and A340. But airline customers demanded Airbus be much more innovative and reach further in its ambitions. The first project was therefore withdrawn and replaced in 2006 by a much more ambitious program: the A350 XWB.

With the A350 XWB program comprising -800, -900 and -1000 model variants, Airbus proposes an innovative airplane range that responds to the current and next decades' market needs in terms of efficiency, comfort and environmental envelope. The A350 XWB is designed using the best possible materials and technologies for every possible application. As head of the modeling and simulation deployment, Christian Bénac focused on possible modeling and simulation (M&S) techniques to support wins in development lead times, industrial ramp up and maturity expectation at entry into service (EIS).

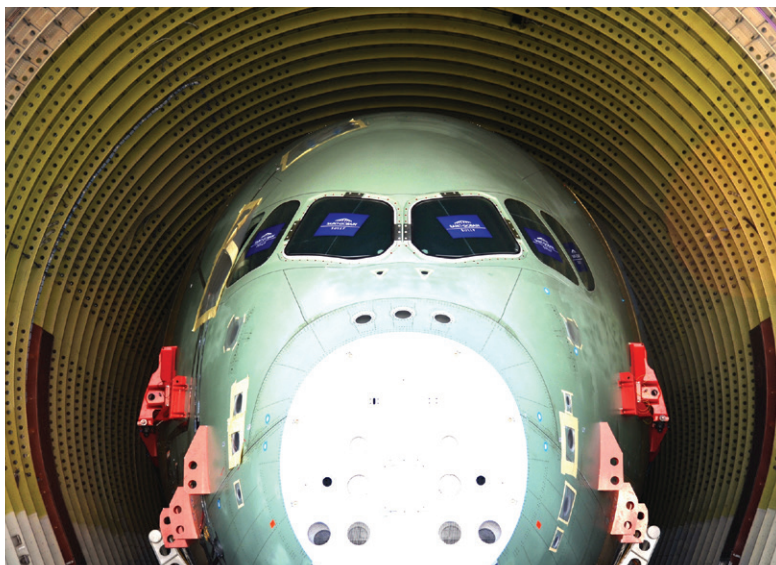


Photo Credit: AIRBUS S.A.S. 2012 Photo by e'm company / H.GOUSSÉ.

"You can't say we have reinvented aircraft engineering, but we're certainly obliged to use all our available expertise and accumulated know-how. The A350 XWB airframe combines completely new technologies on a scale never witnessed before."

Christian Bénac
Head of Modeling and
Simulation Deployment
Airbus

With the first flight of the A350-900 scheduled for mid-2013, Bénac looks back on the way the A350 XWB program required him to rethink the way that he works.

"We also have to develop three aircraft variants within a 6½-year timeframe," says Bénac, "and we have to reach a high maturity level at EIS.

At the start of the program, we knew we could re-use the advanced technologies developed already for the A380 and that we could still optimize them even further, but it was also very clear we would have to

introduce completely new approaches in order to make more precise predictions and enhance design performance."

Bénac notes, "Additionally, our efforts were largely focused on the product verification phase, in particular on securing the airlines' expectations in terms of operability.

"Given the contractual time and maturity level constraints, it was very important to put extra effort on design verification, on the development of a mature design consolidated early in the definition phase."

"Our simulation models make it possible to know beforehand whether we have reached the performance targets so we can prepare the test phase with more insight."

Christian Bénac
Head of Modeling and Simulation Deployment
Airbus



Fuselage transfer of the A350 XWB MSN1 at the A350 XWB final assembly line in Toulouse. Photo Credit: AIRBUS S.A.S. 2012 Photo by e'm company / H.GOUSSÉ.

Models used to communicate requirements

A dedicated team was set up to drive specific modeling and simulation use cases selected to strengthen the design in the early development stages.

"Our criteria to set up projects was first to tackle technological novelties, second to address lessons learned from the A380 and A400M-program and third to incorporate new (Tier 1) suppliers into our extended enterprise strategy," Bénac says.

It's his team's goal to ensure specification quality in the design cycle, to use M&S to work on a well-defined behavior for that part of the system and to foster clear communication with equipment suppliers and customers.

"We manage a portfolio of 66 M&S projects," Bénac says.

This portfolio is split into two project types: a first group containing model-based systems engineering (MBSE) projects focused on building models to describe the intended functional and logical architecture of systems or

functions; these models rely on graphical formalism and focus on early validation of functional sequences depending on relevant operational scenarios. The second group is more focused on modeling and simulation to assess the physical performances of intended systems under specific operational conditions.

Simulating power-up of the airplane

"We performed simulations on all preceding Airbuses, but real MBSE didn't exist," says Bénac. "This is completely new. For the A350 XWB, we performed an electrical power test on the iron bird one month ago (summer 2012), but thanks to MBSE, we were able to simulate this power-up two years ago, while still in the design phase, and avoid potential clashes three years beforehand.

"The power-up model we've developed is a timing functional model. It includes every electrical part of any system of the aircraft. Thanks to this power-up model, these analyses were performed in the early phases of the development cycle time and the quality of the specifications systems was significantly improved."



Major components and sections of the A350 XWB are manufactured at Airbus facilities in Germany, Spain, France and the United Kingdom, then shipped to the final assembly line in Toulouse, France. Photo Credit: AIRBUS S.A.S. 2012 Photo by e'm company / H.GOUSSÉ.

"Simcenter Amesim has certainly made our lives easier. Especially on a landing gear project, for example, Simcenter Amesim has proven to be very useful, enabling us to better predict performance and hence to enlarge validation scope of the design at an early stage. We are very happy that it exists."

Christian Bénac
Head of Modeling and
Simulation Deployment
Airbus



The 10-meter tall, composite vertical tail plane of the first A3 50 XWB that will fly (MSN1) has just come out of the paint hall in Toulouse wearing the well-known Airbus blue and white livery. The vertical tail plane is produced at Airbus' Stade site in Germany. Photo Credit: AIRBUS S.A.S. 2012 Photo by e'm company / H.GOUSSÉ.

"We also created, for example, a thermal simulation environment of the airplane in which we have integrated models from our suppliers," Bénac says. "The grand idea is to build MBSE models dedicated to a specific theme, share these models with our suppliers and demonstrate how their systems react versus changes during operation, for example, during the electrical power-up of the airplane. This enables our suppliers to optimize their system and improve test coverage. All of this is not new; we did it before, on a much smaller scale, much later in the development cycle and not in an integrated aircraft environment."

"We have developed MBSE models describing the comportment of systems and how they influence one another's behavior. By making better and earlier predictions using functional, dedicated, full airplane MBSE models, the airplane is optimized more

efficiently and the amount of undesired side effects is drastically reduced. Our simulation models make it possible to know beforehand whether we have reached the performance targets so we can prepare the test phase with more insight. These productive results will, of course, be checked on the test rig."

Mastering problems and complexity

"Before, when an unexpected behavior was discovered during the test phase, people were often in the dark about the root of the problem: was it a cable, a design fault, the test rig itself? Almost anything could be causing the malfunction," Bénac says. "Now, not only are we able to foresee an unexpected effect in an early development phase, but if a malfunction appears during a test, we are able to support analysis and classify it with more insight. Problems have become transparent."

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Airbus' successful first power-up of the A350 XWB 'MSN1' flight deck is an important step leading up to the jetliner's complete power-on and maiden flight. Photo Credit: AIRBUS S.A.S.2012 Photo by e'm company / H.GOUSSÉ.

Without an advanced M&S approach, it would be impossible to manage the A350 XWB's complexity.

"Through different aircraft generations, from the A310 to the A350 XWB, complexity has increased with a factor of 100 to 1000," Bénac says. "For a human, even an expert, it's no longer possible to master and oversee this complexity. It's not the technology itself that has become complex, but the accumulation of technologies and systems, the volume of data and the amount of interdependencies. It has become impossible to master the development of an aircraft, given the pressure to shorten the development cycle and to generate an almost 100 percent maturity rate upon EIS, without MBSE help."

Connecting models to predict global performance

"The need to perform global end-to-end analysis and, to that end, line up and connect different models will only increase, because it's the only way to predict global performance," says Bénac. "I really recommend that model builders adopt this end-to-end philosophy from the moment they start building a model. This doesn't mean that all functions need to be available right from the start, but that you have to work keeping the end-to-end philosophy in mind and implement it step-by-step. Early deployment generates early benefits.

"The intuitive aspect of Simcenter Amesim has been very powerful. It has opened the eyes of people to the use of external

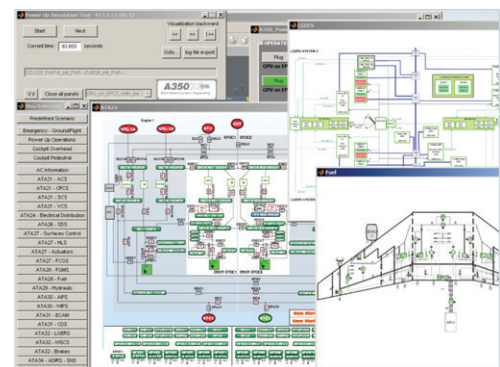
off-the-shelf products. And with that, it has opened the minds to more internal and external collaboration opportunities. It also enables our colleagues to communicate in the same engineering tongue."

Digital bird

It's obvious that digitalization and simulation have become a major driver for production and cost efficiency in the aeronautical industry. Airbus' aircraft programs involve, for example, a geographically extended eco-system of production facilities and suppliers. The creation of one single virtual work environment has made it possible for engineers to work seamlessly together, as a virtual team, no matter where they are located.

For the composite and structural sizing of the A350 XWB, Airbus uses the Improved Structural Analysis through Multidisciplinary Integration (ISAMI) platform that integrates all structure analysis into a single computer-aided engineering (CAE) framework, embedding the computation processes, methods, software tools and data. ISAMI is based on Caesam™ software from Siemens Digital Industries Software. Airbus also created a virtual mockup (DMU) of the aircraft and its systems. This tool serves as a master reference for the entire team working on this next-generation jetliner.

Whether digitalization and simulation eventually will make prototypes redundant, Bénac remarks, "The 'aircraft -1' still corresponds to a need for product



Aircraft power-up model.

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Simcenter Engineering
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Caesam

Customer's primary business

Airbus is an aircraft manufacturing subsidiary of EADS, a European aerospace company. With 59,000 employees and fully owned subsidiaries and spare parts centers throughout the world, Airbus relies on industrial cooperation and partnerships with major companies and a network of some 1,500 suppliers. The company produces approximately half of the world's jet airliners.
www.airbus-group.com

Customer location

Toulouse
France

verification. Our target is the full digital aircraft in which the different MBSE models are connected and communicate with each other. This digital bird is not serving as a prototype, but as a means to make integration a lot easier and faster. That's our purpose.

"You could easily say that the possible connection of the various model types is currently limited. This limit is an issue hindering our MBSE and higher-level digital progression. Physical and functional tools are mature enough and the computing power is available. The next step will be to connect several model types (e.g., thermal and functional, or CFD and thermal). Therefore, tool editors should engage in working on a next generation of standards allowing this interoperability."

How is simulation used in the certification process? "We already use simulation as a credit for certification," answers Bénac. "But it's a step-by-step process and progression largely depends on your model maturity. First, we have to convince ourselves about the fidelity of our models and our process. Second, we have to convince airworthiness officials and increase external trust. The difference with a physical test is that instead of running two or three scenarios, officials will ask you to run an extra multitude of alternative scenarios."

"In the case of MBSE, there are several mature COTS-tools available. Simcenter Amesim has shown us we could model within an 'object' vision, in an integrated mode, just as you would design an electronic circuit."

Christian Bénac
Head of Modeling and Simulation Deployment
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