
# Simulation Streamlines Aircraft Door Development

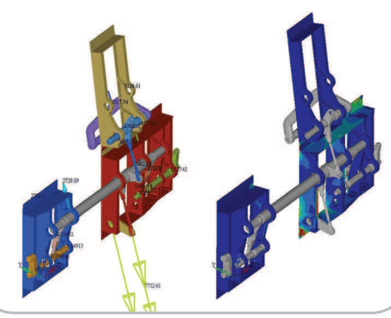
The **Eurocopter Group** leverages analysis to **cut design time** and **automate the process** of developing **safe aircraft closures**.

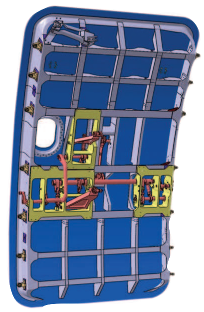
*By* **Michele Macchioni**

The Eurocopter Group, owned by the European Aeronautic Defense and Space (EADS) Company, develops commercial and military helicopters for the global market and is also involved in European Airbus programs through its aircraft doors and fairings business unit. The company was created in 1992 through the merger between the helicopter division of Aerospatiale-matra (France) and DaimlerChrysler Aerospace (Germany).

Eurocopter products and services involve many disciplines including design, production, flight tests, continuing airworthiness, training, maintenance and quality. The main objective for all disciplines is to ensure the safety of the aircraft.

Equally important is to deliver innovative products to meet customers' needs in some 150 countries. As part of this focus on innovation, the company looks for ways to increase the performance and efficiency of aircraft components, including closure systems. Eurocopter's implementation of state-of-the-art software helps to ensure safety and to improve performance while automating the door analysis process.





Simulation enables engineers to analyze forces on door components (above left) and von Mises stresses (above right).

## Door to Door

Closure systems are complex, with many integrated parts. Whether they are being developed for helicopters or other aircraft, the doors must open, close and work in emergency situations.

From product to product, we cannot start with the same hypotheses. Door systems are built according to each aircraft's size and governmental regulations.

The development process entails balancing different requirements. The closure systems must be robust in capabilities but light in design. The design must fulfill customers' requirements, even as these requirements change. And, development must be completed on time to be in sync with client critical-path program milestones.

In general, the company must meet requirements for reliability, packaging, weight, manufacturability and cost. Drilling down, engineers evaluate structural and kinematic properties of the doors with the objective of harmonizing the constraints and delivering doors that are designed to operate for the service life of the aircraft and safely in evacuation situations. Simulation tools enable Eurocopter to virtually assess the performance and robustness of designs through an iterative design analysis process.

## Stepping through Development

When you think of an aircraft door, consider its structural components as well as interfaces to the fuselage. Structural components include the door frame, beams and edge

## Optimizing a Door Support Arm

In addition to stress engineers employing simulation tools, Eurocopter's engineering team includes optimization specialists whose job it is to investigate innovative designs for aircraft doors and components. A case in point is a recent door support arm for the Fairchild Dornier 728 aircraft. Using Altair's structural optimization software, engineers achieved a weight reduction of approximately 20% in its design.

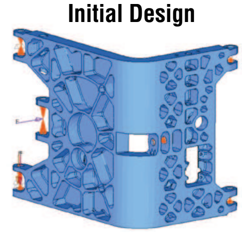
Altair OptiStruct topology optimization technology was used within the Eurocopter design process. Engineers were able to create design concepts – taking into account performance and product objectives – without having to develop, evaluate and iterate on multiple CAD design proposals.

The initial door hinge design provided by OptiStruct maximized the stiffness for three load cases: door blocking, emergency opening and damper hit. In addition, draw direction constraints were included as part of the optimization, yielding a design tailored to the specific method of manufacture. Secondary analyses further reduced the part mass by optimizing the shapes and sizes of ribs for all load cases and a maximum allowable stress level.

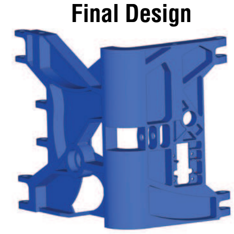
The results were impressive. Eurocopter reduced the door support arm weight by approximately 20% without compromising the stiffness of the part. In addition, the turnaround time to develop and validate the new door support arm design was reduced from three months to three weeks.

Also, Eurocopter has successfully applied optimization tools on other projects. For example, engineers have simulated stop brackets and hinge arms as well as optimized the weight of the entire door system on a regional jet.

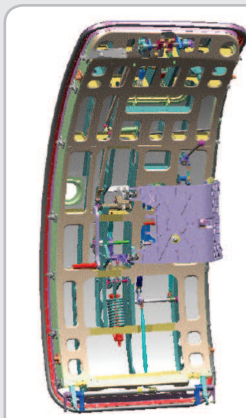
Initial Design



Final Design



Eurocopter reduced the door support arm weight by ~ 20% and cut design time by 75%.



Passenger door with support arm


**The Eurocopter Group is involved in European Airbus programs through its aircraft doors and fairings business unit.**

members, which add rigidity and stiffness for sealing the door to the fuselage. Stops, guide arms and support arms interface to the fuselage; guide rollers and sealing represent other parts of the structure.

Development begins with a baseline design to fulfill the customer's requirements, typically defined in terms of material and weight range. Our first design iteration is that of a stand-alone door. Later, we receive additional data from the customer, such as the flight loads and fuselage specifications, enabling door refinement.

The justification methods, set by customers as well as company guidelines, are complex. For the various components, we evaluate structural considerations such as stress results, stability criteria against buckling and stiffness.

All the parts must fulfill the stress tests, and we deliver a single report for door certification. Eurocopter has certain stability criteria that are taken into account for a door's global performance including closure of the seals, aerodynamic properties and stop-load distribution. In addition, parts must withstand stability criteria for buckling, crippling and inter-rivet buckling.

Certain parts must fulfill extra stiffness requirements. For example, interfaces to the fuselage must carry the door including the guide rods, hinge arm and brackets. The stops must carry all the loads acting from the door to the fuselage and vice versa.

In addition, we perform kinematic studies. The door frames must withstand the kinematic loads, which act on the door in the opening process. However, altering the kinematic forces changes the interface loads and has an impact on the structure. Therefore, structural and kinematic requirements need to be synchronized at regular milestones.

## Smart Simulation

The overall process of evaluating an aircraft door in software can be represented with an "optimization" task/loop. The door system is the so-called design space. In a 2D shell modeling criteria, several shell thicknesses are assigned as design variables.

## Thinking without Limits

EUROCOPTER
AN EADS COMPANY

The Eurocopter group, a division of the European Aeronautic Defense and Space (EADS) Company, reported a 49 percent market share in the civil and parapublic sectors last year. In 2010, its revenue approached US$6.9 billion, and it held orders for 346 new helicopters.

With a tag line of "Thinking without limits," Eurocopter has had a rich history of innovation, from pioneering the world's first gas turbine helicopter (jointly with Turbomeca) to delivering the first fly-by-light (optics) flight. The company holds approximately 2,300 patents, and its ambition is to launch a new helicopter, a new version or a technology demonstrator every year.

One of its most recent innovations is the proof-of-concept demonstrator, X3, which is being used to validate the high-speed hybrid helicopter ($H^3$) – a new type of aircraft that can perform vertical takeoffs and landings and obtain cruising speeds of approximately 220 kts. The X3 performed its maiden flight last September.

It's equipped with two turboshaft engines that power a five-blade main rotor system, along with two propellers installed on short-span fixed wings. This hybrid configuration creates a transportation system that offers the speed of a turboprop-powered aircraft and the full hover flight capabilities of a helicopter. It is tailored to applications – including long-distance search-and-rescue missions, coast guard duties and passenger transportation – where operational costs, flight duration and mission success depend directly on the maximum cruising speed.


Reducing weight is the objective, and components must be optimized by fulfilling all of the requirements. These are formalized by means of constraints – such as stiffness and stress – among the selected load cases. Manufacturing constraints, such as the maximum shell thickness or type of material to be used, are also considered. This concept is valid when referring to global calculations or to a single component.

As part of the process, we develop three types of finite-element models (FEMs). For example, the global FEM represents the global structure, which is provided by the airplane manufacturer and is a coarse model. The intermediate FEM is typically used to evaluate load cases; these models are more refined. The detailed FEMs, for stress analysis, are very refined and created for local investigations.

Depending on the component, we define the connections and the material; then, we decide which type of model to run. Altair's modeling and visualization simulation tools, HyperMesh and HyperView, allow us to rapidly respond to changes in design specifications and loads and make revisions very quickly.

Our previous pre- and post-processing solutions did not enable us to process models as quickly. One of the primary drivers to migrate to the Altair HyperWorks suite was to keep on track in terms of our deadlines.

In making the move, we also discovered the customization capabilities of the software. In the framework of creating global models of the door system, for instance, we leveraged HyperWorks' scripting language to support the automation of batch meshing and the model organization process for specific analyses and solvers.

Being able to tailor HyperWorks for our workflow processes and environment has resulted in several benefits. For example, we have more control over parameters such as material and rivets, for which we have constructed proprietary databases. HyperWorks also provides a homogeneous pre- and post-processing environment. Together, these have contributed significantly to reducing our CAE cycle times.

The gains that we have made in the Stress Department – in creating models to specific standards in weeks vs. months – have been recognized by other engineering departments within Eurocopter. In fact, an initiative is under way to transfer these best practices to other parts of the company as Eurocopter works toward harmonizing its tools and processes.

Through the HyperWorks open-architecture and scripting language, Eurocopter has reduced development time by automating repetitive tasks, even as designs have changed late in the process. We have also established a framework to build models to standards, thus helping to enable quality assurance and reliability.

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**For more information on HyperWorks, visit www.altair.com/c2r.**