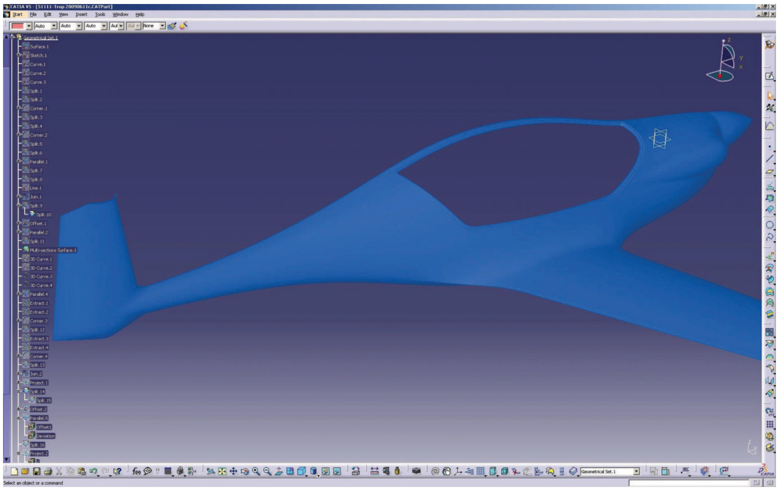
3-D Composite Design Gives Pipistrel Lift

Using CATIA composites, Pipistrel models both mechanical systems and aircraft shape to achieve optimal aerodynamics

BY BETH STACKPOLE, CONTRIBUTING EDITOR, SOFTWARE/HARDWARE

Pipistrel, founded more than 22 years ago as the first private producer of aircraft equipment in Yugoslavia, made its name manufacturing ultra-light hang gliders before moving into lightweight aircraft, including gliders, motor gliders and high-efficiency cruising planes, in reaction to market demands. While the company's models and types of aircraft have evolved over the years, the consistent theme for Pipistrel is producing planes that are both fuel-efficient and high performance. To do so, the manufacturer has invested in and refined a product development process that leverages composite materials and advanced 3-D design techniques to achieve optimal aerodynamics.

"The main challenge in aviation is how to produce an airplane that has the most possible lift while producing a minimal amount of drag," says Tine Tomazic, research and development at Pipistrel. Given that the selection of engines for Pipistrel's chosen types of aircraft is limited, it's not engine choice that defines a particular model, but rather the outside shape that becomes the key differentiator. "When you start to define the shape of a plane, it becomes evident that even measurements below one tenth of a millimeter can make a difference," Tomazic explains.



The Virus SW was fully designed using the new 3-D composite tools.

HUMAN-LIKE PRECISION

The Pipistrel engineering team began aggressively working to address this challenge about seven years ago. At the time, the firm used 3-D MCAD to design mechanical systems on the aircraft; but the system fell short of leveraging the 3-D tools to do any type of shape or surfacing work because of what the team considered a precision deficiency. "Aerodynamics and shapes were drawn by hand and produced in physical form by hand because the naked eye and human hand were still the most precise instrument when judging the fluidity of lines," Tomazic says.

While the hands-on method was deemed more precise, it was also quite limiting in terms of how the Pipistrel engineering team could evolve designs. Traditionally, the engineer or aerodynamic specialist would manually describe to the CNC milling machine operators creating the physical prototypes what kind of curve or shape they needed. Not only was the engineering team limited by the creativity and technical skills of the person responsible for building the physical shape, there was too much room for misinterpretation around the design, often leading to miscues and false starts. "The engineer or aerodynamic specialist had to describe what they wanted to the person who was going to produce it and there were often differences between the description and the executed form," Tomazic says. "We couldn't make the shapes as complex as we would have wanted to simply because the workers didn't understand what we wanted. It was touch and go every time."

Soon afterward, the Pipistrel team began experimenting with another 3-D MCAD tool, this one with an integrated module specifically for composite design — Dassault Systèmes' CATIA PLM Express with the Composites Design option. Using this tool, the Pipistrel engineering team was able to transition its manual shaping and physical prototyping process for an aircraft into a digital prototyping method that ensured consistency while allowing the team to more fully explore a range of design options.

While composite materials deliver superior aerodynamic qualities, they introduce complexities into the design, particularly around blending surfaces between two adjacent parts and in accurately determining the thickness of component parts. Prior to using CATIA and the integrated Composites Design tool, the Pipistrel team struggled with blending a surface such as a sharp wing structure with a round surface like that associated with a fuselage. Traditionally, in an example like that, the team would produce the wings and fuselage separately and then join them together by hand. Because the process was so complex and nearly impossible to replicate in a drawing, designers were stuck with more of a trial-and-error process, which was time consuming and often didn't produce the desired results. "The fact that we can define the outside aerodynamic shape on the computer versus describing what we want technically to build a part has tremendous benefits," Tomazic explains. "There's no more problems with fitting — if parts fit on the computer, they fit in real life."

Pipistrel's Virus plane won a NASA award for performance.

Having the master shape defined in CATIA also aids in constructing the layers of composite materials underneath. Take, for example, the cockpit of the aircraft. The design challenge is to create a space that is large enough to comfortably accommodate the people without jeopardizing the aircraft's aerodynamic shape — a task that becomes more complex given the properties of designing with composites. "With composite materials, it's often difficult to judge the thickness because the thickness of the walls and structure varies," he says. Since composite parts are made of plies, sometimes having too many bends or corners makes it difficult to estimate a part's size. "CATIA integrates the ability to see how thick a part or material will be regardless of whether it's made of composites or something solid," Tomazic adds.

MCAD-ENABLED POTENTIAL

In the two years since Pipistrel deployed the new approach, it has achieved a number of significant milestones. Its Virus and follow on Virus SW (Short Wing) cruise aircraft both won the NASA Challenge, winning accolades for their fuel efficiency and performance. From a product development perspective, the changes had a notable impact on improving Pipistrel's ability to get aircraft models to market faster. Specifically, Tomazic said the manufacturer has cut the time it takes to get a plane from concept to market by 40 percent — an achievement he attributes to being able to explore more design iterations since both the mechanical design and shape work are performed in the same package. In addition, because the composite models created in CATIA are so precise, the time required for testing of parts and components is also greatly reduced — in some case as much as 25 percent. "Instead of people producing shapes, machines are producing much more precise shapes and there are no more mistakes with testing," he explains. Previously, every part was subjected to force and measurement tests, but now simple parts can be tested in the computer environment and the test results are accurate, Tomazic adds.

Moving forward, Pipistrel is in the midst of transferring its existing materials database from another software package into CATIA — a move Tomazic says will streamline engineering change orders. In addition, it will create an integrated environment whereby all relevant parties are notified of pertinent changes and all corresponding documentation and files are updated from a single CATIA model.

While aircraft designs two years and older will continue to be produced and evolved with the company's traditional product development model, the Virus SW aircraft, a forthcoming four-seater unit, and any new designs will take advantage of the new 3-D driven composite design approach. Says Tomazic: "Any kind of clean book design we're setting up in the new system right from the start. Now we're able to design everything on the computer — not only the systems, but the shape and structure of the plane."

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