Web-Delivered Engineering Resource Can Cut Time to Design Airframe Surface Features up to 50%

Cessna Citation Excel

The ESDU web-delivered collection of engineering design methodologies is helping engineers at Cessna Aircraft Company, Wichita, Kansas, reduce the time required to design many airframe surface features by up to 50%. In the past, it took considerably longer to design rudders, ailerons, horn balances, scoops, holes, etc. using formulas from a handbook. The ESDU web tool provides charts that incorporate theory and real-world data. Engineers are able to access these charts from their desktops, eliminating the need to walk or drive to the central library facility. "A typical design problem that would take four days using formulas, takes me only two days on the web," said Ray Woodson, Supervisor of Advanced Aerodynamic Design for Cessna.

Now in its 73rd year, the Cessna Aircraft Company has delivered nearly 190,000 aircraft, including 24,000 twin-engine airplanes, 2,000 military jets and over 3,000 Citations – the largest fleet of business jet aircraft in the world. More than half of all aircraft flying today carry the Cessna logo. Worldwide, Cessna employs nearly 12,000 people in the design, manufacturing, sales, and service of general aviation aircraft and is registered as an ISO-9001 company in recognition of its quality systems and processes.

Managing trade-offs in design

The job of designing a safe, economical and high-performing aircraft boils down to thousands upon thousands of subtasks that are assigned to individual engineers. For example, the engineer might be asked to design an opening to ventilate a wing in case fuel fumes are present. The engineer must balance a complicated series of opposing requirements. Ventilating the wing requires a certain minimum mass flow rate. However, from an aerodynamic standpoint, the engineer wants to keep the wing as clean as possible in order to avoid changing its lift distribution. From this standpoint, of course, no hole at all would be ideal. So the task is to determine the type of opening that will provide the required flow while minimizing local air disturbance.

Previously, Cessna engineers used engineering handbooks and in-house-derived formulas to address this type of problem, such as by evaluating different types of scoops, ducts and holes. The problem is that the theoretical approach is a good approximation but it almost never perfectly describes a real-world situation. This meant that engineers needed to make different types of assumptions, each of which necessitated some margin for error. Often there are other complicating factors such as the need to consider whether water or foreign objects could enter the opening and cause a potential service problem. A screen would address this issue but at the cost of raising drag. It typically took about four days to solve this type of problem using this approach.

230 volumes of engineering data

A number of years ago, many Cessna engineers began using a different approach. The engineering library purchased a collection of engineering design methods and data from Engineering Sciences Data Unit (ESDU), London, United Kingdom. Almost 60 years ago, the British Royal Aeronautical Society assembled a group of experts in avia-

tion to present data in a simple format for use in aircraft design by less skilled personnel who had been redeployed for the war effort. Over the intervening period, this activity has grown and grown and now represents the pooled resources and research of many experienced aviation professionals and has created a vast library providing easily accessible information on aeronautical design. This resource has been continually updated over the years, and today includes more than 230 volumes of validated design and analysis data and methods, with over 160 associated computer programs.

The full collection of ESDU's engineering documents were recently made available on the web so engineers can work with the data at their desktops with their favorite browser. Using Citrix WinFrame engineers can even run the codes that are an essential part of this engineering tool without the need to install any software. The ESDU Web site is hosted by Information Handling Services (IHS) at their state-of-the-art hosting center in Englewood, Colorado.

Advantages of going on-line

"We have used the ESDU paper manuals for many years and found them to be a valuable reference," said Rhonda Inman, Engineering Librarian for Cessna. "The problem that we were running into was that we only had a single copy of the documents at our engineering library. On the other hand, our engineers are located at a number of different facilities. The majority are located at our campus in Wichita, but many had to walk up to one quarter-mile to reach the library. Other engineers are at our Pawnee facility, which is about a 30-minute drive. So, we were very happy when ESDU made their material available over the web. Our engineers save time because they can use any design tool from their desktop. The web tool is continually updated, which frees up the time that I used to spend inserting pages for more valuable research activities."

Designing control surfaces

At Cessna, Woodson now commonly uses the on-line design tool to design control surfaces. Woodson said, "The basic issue is frequently developing a surface that will provide the desired aerodynamic response while generating the right level of force in the cockpit. This type of design problem is extremely difficult to address with formulas because there are so many factors that you have to take into account to do a thorough job. Wind tunnel data is more useful in this type of problem because the very nature of experimental data greatly reduces the number of assumptions that must be made by the designer. The on-line resource that I use is based on the collapse of a huge amount of test data into simple curves that provide information for guidance on the effect of first, second and third order design criteria."

The first-order information in the charts provides a quick method of calculating the lift generated by the wing in relationship to its size. Second- and third-order information expands on this basic information by indicating the relationship of other design factors such as the shape of the leading and trailing edge. Using these tables, Woodson can tailor the forces produced by the control surfaces in order to provide enough resistance to avoid over-control while ensuring that forces are not unbearable when operating on the outer edges of the flight envelope, such as in a crosswind. He can also tailor forces to achieve desirable handling characteristics, such as slightly increasing control forces as the plane moves faster.

Parametric analysis of design factors

"Recently, I used the web to design a horn balance, the small control surface that protrudes forward from the rudder," Woodson said. "This part can be difficult to design because it's so small that its losses are relatively high in relation to its aerodynamic impact. The web site provides a cookbook for parametrically identifying the impact of changes in the span, cord, leading edge balance and other geometrical factors. For example, one chart shows what percentage of the total length of the surface leading to the trailing edge is turned into a movable surface at various control angles. The charts made it possible to easily determine the effectiveness at any speed of every design that I considered."

"It's important to note that this engineering resource does not provide final and absolute answers," Woodson said. "Every aerodynamic design that we create is carefully tested, first in a wind tunnel and later on operating aircraft. The value of the engineering reference tool is that it helps us move much more quickly to the correct answer. On the average, we have reduced the amount of time required to design aerodynamic surfaces by 50% compared to the traditional approach. The answers that we obtain using the ESDU methods also tend to be more accurate because they are based on a combination of theory and experimental data, rather than theory alone.