CASE STUDY

MSC Software: Case Study - Aerovironment

Optimizing Aircraft Performance

The Global Observer is an unmanned aircraft with the wingspan of a Boeing 767 but less than 10% of the weight designed to provide communications and sensing for flights lasting up to one week at up to 65,000 feet. With a maximum wing loading of only 3.5 pounds per square feet, the wingtip deflects greater than 22 feet at its design limit load.

MSC Nastran was utilized to develop nonlinear stress, structural dynamic and aeroelastic finite element models. The structural dynamics model was correlated to a ground vibration test, both of which had to accommodate the apparent mass of the air, which is atypical. The ultimate test of the nonlinear stress model was correlation with the static wing load test, performed last summer. “Correlation with static load testing was so good that at first I did not believe it,” said D.J. Taylor, Principal Engineer for AeroVironment, the company developing the Global Observer. “All of the NASTRAN models have proven valuable for addressing the various modifications and design changes inherent in a proof of concept / prototype effort and will be even more useful in optimizing a production version.”

Unusual Design Provides Unique Capabilities

The Global Observer completed its first flight August 5 at Edwards Air Force Base. The hybrid-electric aircraft flew for the first time under battery power and will ultimately carry a liquid hydrogen-fueled propulsion system to power it through a high altitude, long endurance joint operational utility assessment planned for 2011. The Global Observer aircraft is designed to fly

Key Highlights:

Industry

Aero

Challenge

Wing load testing to demonstrate that the wing can withstand the stress experienced as a result of normal operation in turbulent air as well as requisite aircraft maneuvers.

MSC Software Solutions

MSC Nastran is used to develop nonlinear stress, structural dynamic and aeroelastic finite element models.

Benefits

- Extensive Composites Modeling
- Parametric Design Solutions
- Optimized Design Performance

"Considering the magnitude of the analysis challenge and the potential for error in both the analyses and the test, the correlation is excellent."

D.J. Taylor, Principal Engineer, Aerovironment

at an altitude of 55,000 to 65,000 feet for 5 to 7 days. In addition to flying above severe weather and conventional aircraft, operation at this altitude permits communications and sensor payloads on the aircraft to service an area on the surface of the earth up to 600 miles in diameter. The system is intended to provide mission capabilities that include persistent communications relay, robust observation over areas with little or no existing coverage, the ability to relocate as required by theater commanders, dedicated communications support to other unmanned aircraft systems and tactical, on-station weather monitoring and data support.

The unique capabilities of the Global Observer are provided by its unusual design in which a plane with a 175 foot wingspan is propelled by less than 100 horsepower. The complex design of the primary structure provides maximum strength and tailored stiffness at minimum weight, but also presents an enormous analysis challenge. The primary structure utilizes several combinations of graphite-epoxy, honeycomb and foam core materials that are highly tailored to meet the strength and stiffness requirements while simultaneously minimizing weight. The wing was tested to design limit loads and the fuselage tested to destruction.

"We selected MSC Nastran to model the Global Observer because of NASTRAN's unique aeroelastic capabilities," Taylor said. "Most important in this project is providing an aeroelastic solution that is coupled to a high fidelity structural model. Overall, MSC NASTRAN is a very good product that is upgraded regularly. Just as important is the quality of the support. Our MSC application engineer visits us at least once a month to see how we are doing and help us with any issues. When necessary, we can talk to experts like Dean Bellinger, Technical Engineer at MSC Software, who helped us with this model on several occasions. Our ability to model this plane was enabled by the support, on-site visits and consulting services provided by MSC "

Modeling the Global Observer

The first step was importing the solid CAD models into the Patran modeling environment. MSC FlightLoads was used to generate aerodynamic loads for input into the stress model. For the ground-generated loads, an optimized composite landing gear model was used. The generation of the various structural models relied heavily on the extensive composites modeling capabilities of MSC Patran. In general, standard elements and standard modeling techniques were used throughout. Composite shell elements with offsets were used to model the thin laminate structure. Solid elements were used for thick laminates and for the core. During this process it was discovered that MSC Patran was limited to post-processing only 100 lamina in a

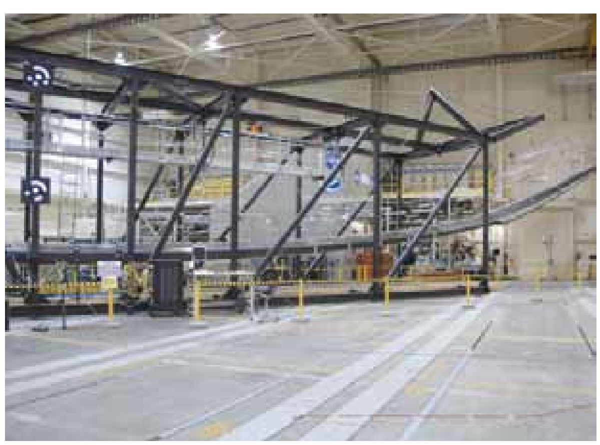

Figure 1: 175 Foot Wingspan of the Global Observer

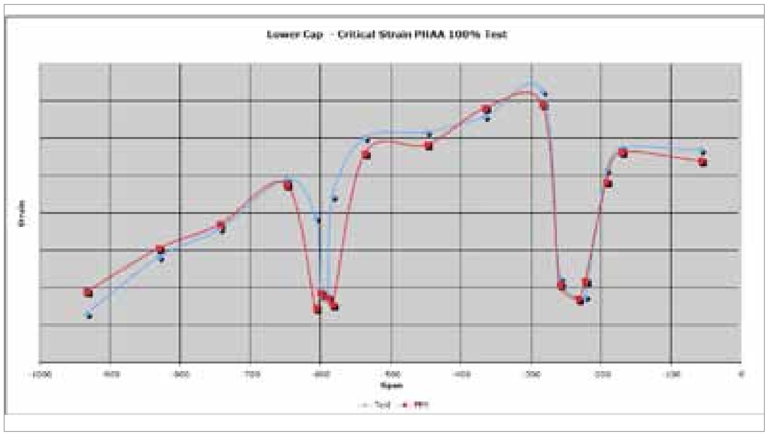

Figure 2: Physical measurements and finite element analysis predictions for strain on the lower spar cap

single composite element. Fortunately, MSC quickly fixed this limitation and provided a special release that allowed up to 500 lamina. This enhancement was later extended to the production version of Patran.

Breakout models were used for the rib-skin, rib-spar interfaces, control surface interfaces and motor mount interfaces as well as others. The software automatically interpolates between the relatively coarse mesh density of the global model and the much finer mesh density of the breakout model. This approach greatly increased the accuracy of the results while keeping solution time at a reasonable level.

A Department of Defense (DoD), National Aeronautics and Space Administration (NASA) and AeroVironment team performed a series of wing load tests using a specialized fixture to apply loads to the 175 foot wing. The purpose of wing load testing was to demonstrate that the wing can withstand the stress experienced as a result of normal operation in turbulent air as well as requisite aircraft maneuvers. Figure 2 shows the finite element analysis predictions compared to the physical measurements of the strain along the length of the spar caps.

Correlation Demonstrates Accuracy of Model

"The correlation between the simulation prediction and the physical measurements was extremely good considering the complexity of the structure," Taylor said. "The difference between the predictions and measurements was higher at the wing joints at spans -223, -583 and -697 inches because the global wing nonlinear model did not attempt to capture the detailed features of the structure at these locations. Disregarding these points, the error averages about 5%. This is remarkable considering the potential error of the instruments used to measure strain in the wing tests and the complexity of the structure and materials. The difference between the simulation and physical measurements for the strain of wing skin was slightly higher. The skin is harder to model accurately. Considering the magnitude of the analysis challenge and the potential for error in both the analyses and the test, the correlation is excellent."

The MSC NASTRAN models of the Global Observer have been used extensively during the test program. "We are making changes regularly to address issues that surface during the various test programs," Taylor said. "The NASTRAN models have helped considerably in addressing these issues. For example, we might need to drill an unplanned hole for instrumentation at various locations on the structure and need to know if it may have any structural implications. Before we perform any modification, we look at the analysis or rerun the analysis with the proposed modification to ascertain the structural implications. As we transition to production the NASTRAN models will be used even more extensively, specifically in an optimization sense.

The correlated NASTRAN models give us a high level of confidence for our future design efforts on Global Observer and we fully intend to vigorously exercise the parametric design and optimization tools built into the MSC environment to take weight out of the aircraft to further enhance its performance."

About MSC Software

MSC Software is one of the ten original software companies and the worldwide leader in multidiscipline simulation. As a trusted partner, MSC Software helps companies improve quality, save time and reduce costs associated with design and test of manufactured products. Academic institutions, researchers, and students employ MSC technology to expand individual knowledge as well as expand the horizon of simulation. MSC Software employs 1,000 professionals in 20 countries. For additional information about MSC Software's products and services, please visit www.mscsoftware.com.

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About MSC Nastran

Accurate, Efficient & Affordable Finite Element Analysis

MSC Nastran is the world's most widely used Finite Element Analysis (FEA) solver. When it comes to simulating stress, dynamics, or vibration of real-world, complex systems,
MSC Nastran is still the best and most trusted software in the world – period. Today, manufacturers of everything from parts to complex assemblies are choosing the FEA solver that is reliable and accurate enough to be certified by the FAA and other regulatory agencies.

Engineers and analysts tasked with virtual prototyping are challenged to produce results fast enough to impact design decisions, and accurate enough to give their companies and management the confidence to replace physical prototypes. In today's world, nobody has time or budget to spend evaluating the accuracy of their FEA software – you need to know it's right.

MSC Nastran is built on work done by NASA scientists and researchers, and is trusted to design mission critical systems in every industry. Nearly every spacecraft, aircraft, and vehicle designed in the last 40 years has been analyzed using MSC Nastran. In recent years, we've applied some of the best and brightest scientists in CAE to extend MSC Nastran's power and efficiency, resulting in its continued status as the world's best, most trusted, and most widely used FEA software – period. New modular packaging that enable you to get only what you need makes it more affordable to own Nastran than ever.

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