Study Improves F-22 Fighter Flight Worthiness

By Gary Sivak and Dinah Luneke

This high priority HPCMP project was run at the ASC MSRC by Mr. Brian Bohl of the F-22 Structures Certification IPT-Loads and Criteria team, Lockheed Martin Corporation, supporting the F-22 Aircraft Directorate at Wright-Patterson Air Force Base. System Utilization: 10,000 hours on the SGI Origin 3900.

An enemy fighter jet in hot pursuit gains on an F-22 every second. The pilot instinctively pushes on the stick and the rudder pedals for a 90-degree turn to break away. The 9-G plus forces tax the body of the seasoned fighter pilot, but will these stresses damage the body of an F-22 aircraft? Mr. Bohl's F-22 load analysis project answers these questions to eliminate any unforeseen operational surprises.

The Need for Speed

"Due to schedule setbacks, our in-house computing resources were insufficient to complete the project on time," explained Mr. Bohl. "Our Wright-Patt based F-22 SPO counterparts, Faustino Zapata and William Buckey, recommended the ASC MSRC. After we reviewed this Center's high performance computing capabilities and its top-rated service operation, we submitted this project to run there. We selected the SGI Origin 3900 system as we were familiar with that platform. With the 10,000 high priority hours assigned to us, along with the ASC MSRC's HPC capability, our project was completed on schedule."

Mr. Bohl's team runs were focused on generating the structural loads or forces due to flight. They were run using Flutter and Matrix Algebra System (FAMAS), a Lockheed Martin company code that they ported to the ASC MSRC's Origin 3900. "Co-investigator Jackie Jung deserves tremendous credit for accomplishing the computational work at ASC," Mr. Bohl stated.

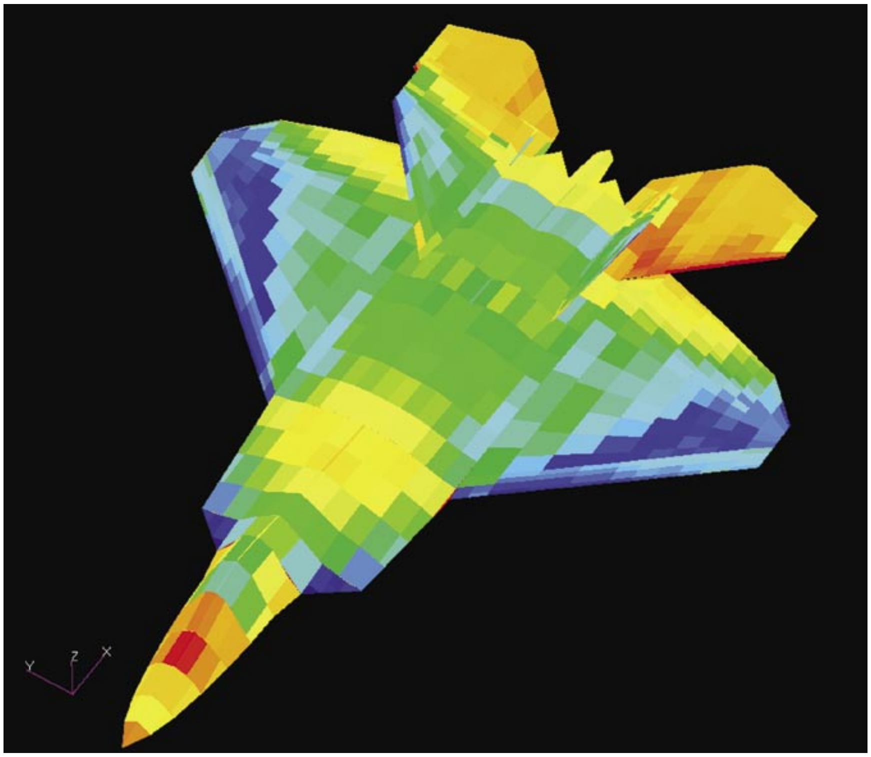
Analysis Products

This analysis project's goal was the release of the Final Engineering Manufacturing Development (EMD) certification loads for the F-22 fighter airframe. EMD completion certifies to the customer that the aircraft meets design requirements, and is safe for flight. The EMD process drove airframe design and manufacturing development.

"Certification loads define the structural capability required of the airframe," according to Mr. Bohl. "Aerodynamic loads, such as lift, are combined with inertial loads, such as those due to G-forces to produce the total load acting on the airframe for a given maneuver."

Project Strategy

The F-22 Loads development began with computational fluid dynamics (CFD) analysis. The CFD analysis was followed by measured wind tunnel loads, and finally real-world measured flight test loads were used to correlate the wind tunnel based model. The correlated wind tunnel data was then used to perform a full survey of the aircraft operational flight envelope resulting in the final EMD certification loads. The final EMD loads account for the critical loads measured in flight and also identify other areas of the flight envelope where critical loads may exist which were not necessarily tested in flight. The benefit of

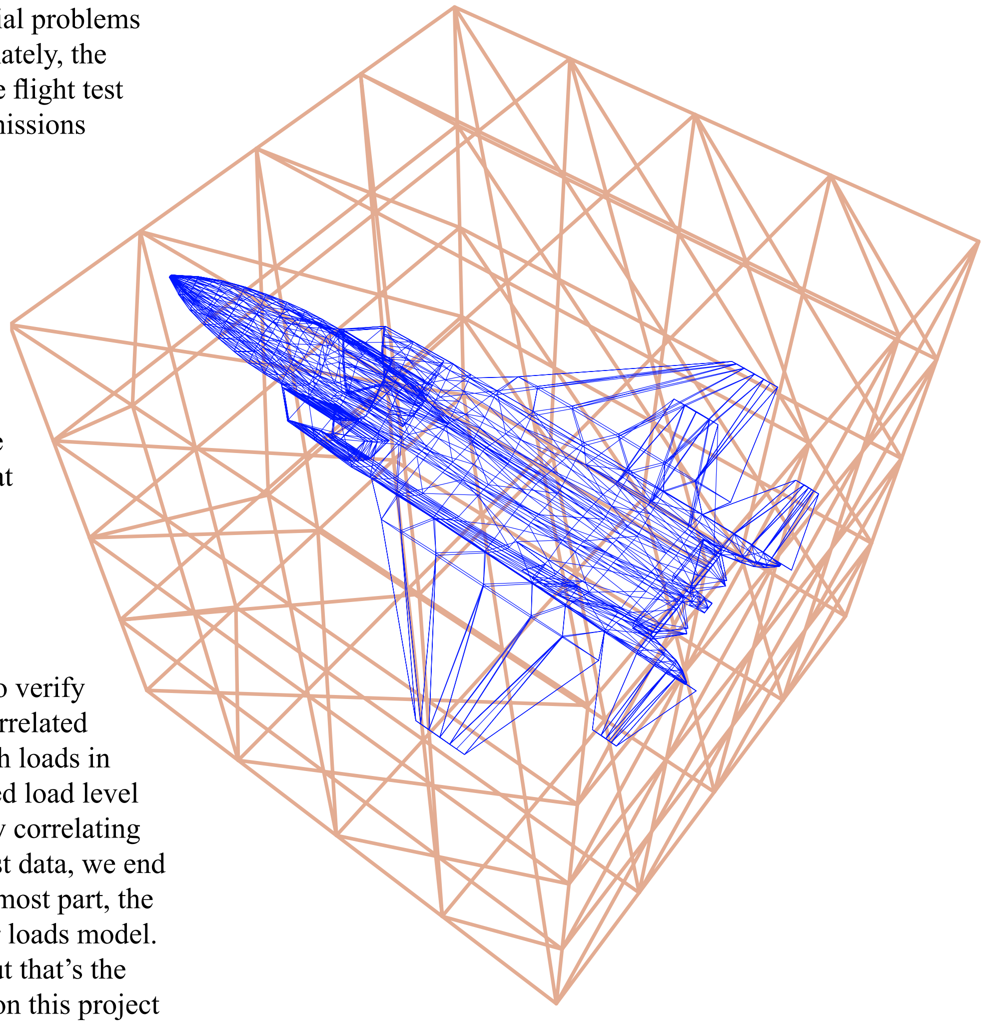


Typical pressure distribution resulting from a symmetric pull-up maneuver. Color key: blues and greens - suction pressures; reds and oranges - crushing pressures; purple symbol - coordinate system for the aircraft - X, Y and Z.

this process is that it helps to identify potential problems before they become issues in the field. Ultimately, the correlated loads model helps to reduce future flight test requirements as the F-22 incorporates new missions and capabilities.

Project Details and Outcomes

The F-22 design loads evolved from CFD loads, to measured wind tunnel loads and ultimately to wind tunnel loads correlated with measured flight test data. The final EMD certification loads based on the correlated wind tunnel model were run at the ASC MSRC. The external loads database that Mr. Bohl and his team produced include the critical loads from flight test plus any additional loads the correlated model now identifies as critical.



As Mr. Bohl explained, "Flight test is used to verify each structural item's critical load. The uncorrelated analysis model tells us where to look for high loads in flight. Flight test either validates the predicted load level or points out shortfalls in the analysis. So, by correlating the analytical model with measured flight test data, we end up with a much more robust model. For the most part, the flight test program gave us confidence in our loads model. There were some surprises along the way, but that's the reason why you flight test." The work done on this project ultimately helped clear the F-22 fleet for flight operation and enabled completion of the critical Initial Operational Capability (IOC) milestone, in December 2005.

For more information, please contact the ASC MSRC Service Center at *msrchelp@asc.hpc.mil*, or (888) 677-2272 or (937) 255-1094.