CORNELL Theory Center

Case Study

Aging Aircraft

Computational Materials Institute, Cornell University

Background

The US commercial and military aircraft fleets are aging. The average commercial jetliner is more than 15 years old; some existing military aircraft are slated to fly until 2040. As aircraft age, they become subject to structural fatigue, the initiation and growth of cracks in their primary load carrying members, like fuselages and wings. How can one assure that such aircraft will continue to be safe when they were originally designed for far fewer flights and far shorter lifetimes?

Challenge

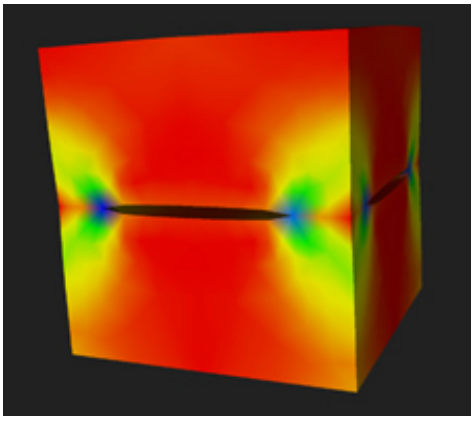
In partnership with Boeing Commercial Airplane and Northrop Grumman, researchers at the Computational Materials Institute (CMI) at the Cornell Theory Center combine their expertise in Materials Science, Computer Science, and Physics to create simulation systems that can predict when and where cracks will start, how fast they will grow, and how they affect aircraft safety. These simulations require solutions at the atomic scale where condensed matter physics applies, at the microstructural scale of the metals involved where materials science tools are needed, and ultimately at the scale of the structural component, where traditional structural engineering concepts can be used.

Solution

A solution at any of these scales can involve millions of unknowns and require massively parallel computers. Interconnecting the solutions between scales requires innovative computational science approaches to information creation, averaging, and transfer. CMI's collaborative projects are creating: a teraflops-capable, scalable, parallel computing system for simulation of crack growth and strength evaluation at the component scale; new parallel analysis engines for simulation at the atomic and microscale; a statistical framework for predicting failure; and a smart, adaptive simulation environment that can accommodate processor failure(s) in the massively parallel system.

Results

"We are looking at ways to predict remaining life and failure in the materials used in aging aircraft to allow their continued safe use," says CMI director Anthony Ingraffea. CTC's Velocity + based on Dell, Intel, and Windows 2000 technologies is the powerful and cost-effective computing resource behind these activities. Benchmarking on key problems has already shown more than a hundredfold increase in efficiency over previous serial computations on a powerful workstation. "The Windows environment is allowing us to scale up from desktop scenarios to complete multi-scale simulations that solve millions of equations hundreds of times per run."



CMI computer simulation of a crack used to predict failure in aircraft parts.

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