Composite aircraft materials

Understanding aircraft aging

While the average age of a commercial aircraft in the US is fifteen years, the age of a plane in the US Air Force fleet is twenty-three years on average—and the age of many transport aircraft and aerial refueling tankers is over forty years. Under current plans, some planes may be in use for as long as eighty years before being retired. And, since the price for next-generation planes has risen faster than inflation, average aircraft age will continue to climb.

The long-term durability of the composite materials commonly used in military and civilian aircraft, however, is somewhat of a mystery. Many aircraft are made at least partially out of polymer composite materials—very strong carbon fibers embedded in a polymer matrix.

Greg Odegard is using multiscale modeling tools to simulate the process of aging in polymer composite materials. “These materials are tough and lightweight, which is important for safe and fuel-efficient aircraft,” says Odegard. “But exposure to long durations of elevated temperatures and harsh environments can take a significant toll on polymer composites, limiting the lifetime of aircraft structural components.”

Odegard and his research team are simulating motion and interaction of individual atoms, as well as the resulting performance of large-scale structural aircraft components. “This process links the molecular aging mechanisms with predicted bulk-level mechanical behavior,” he explains.

The team runs molecular simulations continuously on several high-performance computers. Individual simulations can take up to several days to complete. “Although these simulations only predict events on the nanosecond time scale, they can provide a tremendous amount of physical insight into the influence of aging on mechanical behavior when combined with experimental data,” he adds.

“During the aging process, polymer composites can absorb moisture, become densified, and/or chemically break down via oxidation. All of these mechanisms work to weaken the material. A better understanding of key aging processes could lead to improved material design and performance. Over the next couple of decades, these research results could be used by commercial and military aircraft manufacturers, the US Air Force, and NASA to guide improved aerospace material development and aircraft material inspection procedures.”