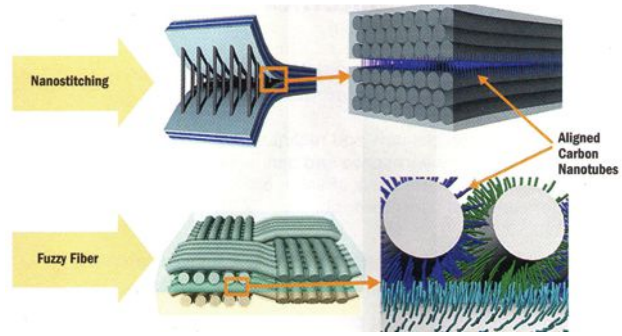
Structures

The Advanced Composite Cargo Aircraft program at Wright Patterson AFB Laboratories designed, developed, and manufactured the X-55A airframe during 2007-2009. The X-55A is a highly modified Dornier Do 328; the fuselage aft of the pilot cabin and the vertical fin have been redesigned and manufactured using advanced composite material featuring primarily bonded assembly. The redesigned fuselage is approximately 20% larger than that of the original Do 328 because of a widened cargo area and an aft-opening cargo door. The aircraft features widespread use of MTM-45 out-of-autoclave resin composite.

During the summer of 2010, the X-55A completed 12 basic envelope expansion flights, finishing 263 of 266 planned test points, and accumulating approximately 25 hr on the airframe. Aircraft flight performance was very much as expected, with minor deviations from the baseline Do 328 attributed to the cargo door/beavertail configuration. Structural performance was monitored during these flights, and no anomalies were noted. The X-55A is currently in storage and will be available for future test efforts. Plans to manufacture and test durability, damage tolerance, and residual strength on a full-scale fatigue test article based on the X-55A fuselage, and using identical out-of-autoclave materials and manufacturing processes, were deferred to 2012 because of manufacturing and budget issues.

The Air Force Institute of Technology's Department of Aeronautics and Astronautics is continuing research on development and testing of flapping wing micro air vehicles (FWMAVs). To determine control forces and moments, the FWMAV prototype is tested on a micro six-component balance. Each wing is individually controlled using a piezo actuator and novel control technique: biharmonic amplitude and bias modulation control, which consists of three independent wing stroke parameters per wing. Various micromanufacturing techniques were developed to create wing structures, hinge mechanisms, piezoelectric actuators, and support assembly. The control effectiveness of the prototype is currently being evaluated, with a near-term goal of tethered controlled flight demonstration. Structural dynamic features of the wing are also being evaluated from a nonlinear point of view.



This two-level laminate nanoengineered composite is made from hybrid materials with aligned carbon nanotubes.

An MIT/Airbus/Boeing cooperative team is developing composite materials to replace metal flight structures and decrease production costs. Carbon nanotubes (CNT) are cylindrical carbon molecules a few nanometers in diameter, 50 times stronger and 10 times lighter than steel, with hundreds of times the electrical conductivity of copper and three times its thermal conductivity. They are being used in development of conductive composites and multifunction materials to provide high strength/weight ratio structural components where carbon fibers provide dual structural and electrical functions. These materials are being manufactured by inserting nanoparticles into substrates and then chemically growing nanotube forests. Other project phases deal with spinning microfibers from CNTs to produce hybrid fibers in nanotubes.

At the NASA Langley Engineering and Safety Center, efforts to develop improved new shell-buckling knockdown factors will result in vehicle weight savings and more reliable failure conditions for launch vehicles. Extensive large-scale tests of composite structures are under way in cooperation with Boeing and Northrop Grumman. Typical of these experiments are shell-buckling tests of a 27.5-ft-diam. space shuttle external tank barrel conducted at NASA Marshall. The purpose is to validate the scalability of the new analytical design factors.

At the University of Illinois at Urbana-Champaign, in cooperation with Boeing's Advanced Structures R&D Group at Huntington Beach, California, research programs on analyses of designer materials and geometries are leading to optimized efficient lightweight structures. These tailored/engineered materials are being specialized for direct application to the PRSEUS (pultruded rod stitched efficient unitized structure) composites.

by **Harry H. Hilton**