The NASA Langley Research Center and the Northrop-Grumman Corporation conducted the first successful combined-loads structural tests of a 5 by 6ft integrated, toughened graphite/epoxy composite cryotank shell segment section at the NASA Langley Cryo-Pressure Box Facility under the Next Generation Launch Technology (NGLT) program. Cryogenic internal temperatures (-300°F) with a simultaneous inner mold line (IML) pressure of 30psig produced limit strain values. The cryogenic pressurized test simulated a ground hold condition for the representative reusable launch vehicle (RLV) concept. Additionally, sequence of hot test cases were also investigated which are relevant to the re-entry phase of the concept vehicles performance. Additional performance details of the composite shell segment include an evacuated core pressure value of 0.85 psia during the simulated ground-hold condition as well as simulated pressure loads on specific metallic thermal protection system (MTPS) hardware attachment sections. Cryo-insulation was also utilized on the outer mold line (OML) of the tested article to reduce heating effects. The test results show that composite cryotanks are viable pressure vessel concepts for RLV type applications.

Arizona State University researchers are developing an efficient method to couple high fidelity CFD and CSD tools using reduced order modeling. The reduced order models are superposed state-space aeroelastic models and Volterra kernel convolution integrals that increase computational speed by five orders of magnitude compared to classical coupled field approaches.

This group is also investigating high velocity impact of composite structures utilizing multiscale procedures and a micromechanics model based on higher order laminated plate theory to simulate the mechanical response of composite plates and shells under high strain rate loadings. Significant rate dependency and inelastic behavior is observed. Transverse shear stresses were found to play an important role at both macro and micro levels. Additionally, a structural health monitoring protocol for characterizing and detecting damage in composite structures using sensor/host structure coupling, sensing capability and sensitivity is being developed. The optimal acoustic sensor placement strategy is based on the characterization of the sensors' sensing region and performance.

Boeing Commercial Airplanes is working with partners Alenia Aeronautica, Kawasaki Heavy Industries, and Vought Aircraft to develop composite fuselage primary structures for the new 7E7 Dreamliner. These teams are working to develop state-of-the-art systems, structural materials and manufacturing methods and nonlinear FEA for use on the 7E7. More data and structural concepts were evaluated prior to program launch than on any previous Boeing airplane program. The Boeing 7E7 project is preparing for the future of commercial jet aviation building on the world’s latest technology in cooperative development with partners. The intense development schedule has not slowed since the decision
to use composite materials for the fuselage, wing, and empennage primary structure. Composite structure is a great substitute for metals in aircraft construction when high strength-to-weight and/or stiffness-to-weight ratios are required, and when weight is of major concern. The approach emphasizes structural innovation and simplification, reduced part counts, and the elimination of joints and other costly design features. There is also potential for enhanced health monitoring and other advances. Toughened resin systems similar to the one used on certain 777 primary structural elements will be used on 7E7 structures, making these components more tolerant of impact damage than previously used resin systems. Composite structures are better than metallic structure in corrosion resistance, fatigue performance, and resistance to crack growth. Trade studies conducted by Boeing and 7E7 partners showed composites superior to advanced metals for empennage, wing, and fuselage primary structures. The choice to build the next all new Boeing jetliner from composite materials was driven largely by the great potential for seen in reducing weight and life cycle costs. The 7E7 has set aggressive cost and weight targets for the airframe. The targets require substantial improvements in the processing as well as significant cost reductions for both composite and metallic structures. Significant work must be completed utilizing all of the talents provided by Boeing and partners to realize these benefits.

Reusable composite cryotanks have been verified in structural test and scaled up in size with new manufacturing materials and processes. A six-foot diameter composite tank has been successfully cycled with pressure, thermal, and structural loads (representative of a large scale launch vehicle environment). Advanced structural health monitoring instruments (fiber optic) display the thermal and strain environments in real time. On a 10.5 foot diameter tank, non-autoclave compaction materials and processes have been demonstrated and verified with advanced non-destructive inspection tools. (NASA-NGLT, Northrop Grumman, Foster-Miller, ATK)

Under the DARPA-sponsored program “Next Generation Morphing Aircraft Structures,” NextGen Aeronautics, Inc. of Torrance, CA, is developing revolutionary, shape-changing UAV designs which optimize performance for multiple, drastically-varying flight conditions. These designs will demonstrate wing area changes of 145%, aspect ratio changes of 440%, and t/c changes of 280%. NextGen is working towards a wind tunnel test of a half-scale morphing wing in November 2005, and a flight test of an autonomous morphing UAV expected in 2007.

The Deployable Structures Laboratory at the University of Cambridge has developed a novel, lightweight Large Deployable Reflector for Earth Observation missions, in collaboration with EADS-Astrium Ltd. The reflector structure is formed from ultra-thin sheets of carbon-fiber reinforced plastic. A 4 meter long half-scale demonstrator that stows in a volume of 1 meter by 1.6 meter by 0.2 meter was exhibited at this year's Farnborough Air Show. It has been shown that a flight quality antenna would weigh about 1 kg per meter square.
At the Air Force Research Laboratories/Space Vehicles Directorate (AFRL/VS), advances are being made to develop next generation deployable structures. Future DoD space systems require large, lightweight, highly compactable structures. This will require a major evolution in size and compaction ratio. The Innovative Space Aperture Technology Satellite (ISAT) is one of these types of space systems. This space based radar satellite being developed by DARPA and AFRL/VS requires a 300meter long radar antenna boom to be deployed from a 5meter diameter rocket fairing. To help understand and transition advanced structures to future operational systems, AFRL/Space Vehicles Directorate’s Deployable Structures Experiment (DSX) will fly subscale representative structures in a 6000 km x 12000 km orbit to study deployment kinematics, deployed precision, dynamics and radiation environment effects. DSX will observe deployment kinematics of three on-board structures and the deployed positions. Over the 1 year mission, periodic System Identifications will be performed to identify changes caused by the space environment. The on-orbit structural behavioral data will be compared with analytical and FE model predictions, and used to identify error sources introduced by ground testing and packaging. DSX is planning for launch in 2009.

Under a program funded by NASA (Space Vehicle Technology Institute (SVTI)), University of Michigan researchers are studying metallic foam core sandwich panels for use in hot structures. Applications include actively cooled airframe and engine structures. The thermomechanical response of thermal protection systems subjected to heat shorts is also studied.

Researchers at the University of Illinois at Urbana-Champaign are developing inverse analytical tools for designer materials tailored to perform specific structural tasks under constraints of probabilistic high strength, lifetime and lightweight considerations.

Research programs at NASA Glenn demonstrate that probabilistic approaches can be used to avert unexpected catastrophes by setting-up and solving probabilistically multi-scale, multi-disciplinary problems. The computational protocol is iterative through the assumption of different standard distributions and corresponding scatter ranges, carrying out probabilistic finite element computations, and comparing orders of probabilistic sensitivities with cumulative distribution functions until convergence is achieved.
Three of the optimized morphing configurations for high lift, high efficiency, and high speed. (NextGen Aeronautics)
Composite Structures on Boeing 7E7 Dreamliner Commercial Aircraft