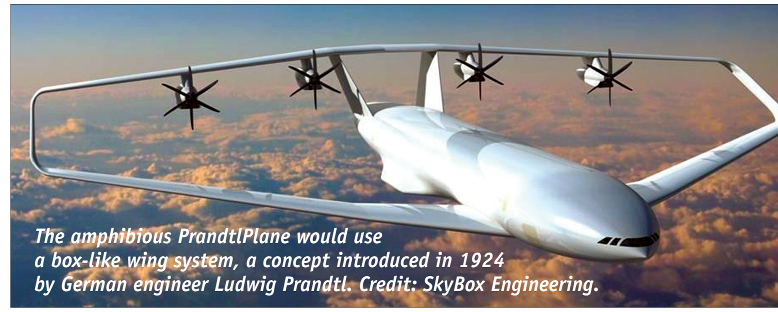
Lighter, stronger, *safer*

by Harry H. Hilton

*The **Structures Technical Committee** works on the development and application of theory, experiment, and operation in the design of aerospace structures.*


The amphibious PrandtlPlane would use a box-like wing system, a concept introduced in 1924 by German engineer Ludwig Prandtl. Credit: SkyBox Engineering.

MIT's advances in synthesis, manufacturing, and modeling are bringing nanomaterials closer to readiness for use in aerospace structures. **Nanocomposites** and **carbon nanotube-based materials**, both used in the Lockheed Martin F-35, are on their way to Jupiter's moon on NASA's Juno mission. These and other materials, including **nanoclay-reinforced polymer nanocomposites**, continue to draw attention, while **graphene** has become this decade's material of prime interest for its light weight, high strength, and conductivity.

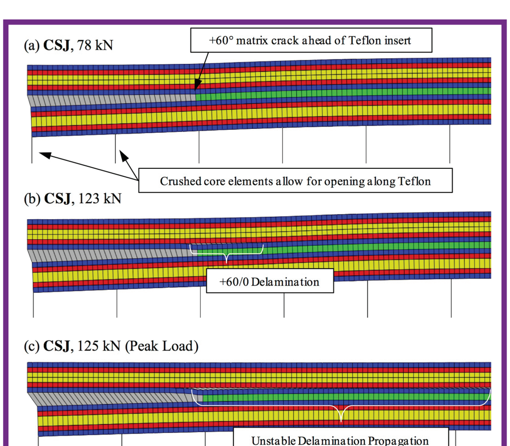
The Aerospace Engineering Dept. at **Mississippi State University** is developing original concepts for shielding spacecraft from impacts by micrometeoroids and orbital debris. The longer a missions lasts, the greater the likelihood of these impacts, which can be catastrophic. Mississippi State is using novel materials and designs to devise shielding that offers not just impact mitigation but also thermal conductivity, environmental barrier formation, and radiation shielding. The researchers are using a two-stage light gas gun for hypervelocity impact testing of these concepts.

The Aerospace Systems Directorate at the **Air Force Research Laboratory** has partnered with Vanderbilt University, Miami University, the University of Massachusetts, Materials Sciences, and the University of Utah to study composite damage progression. This work has yielded several advances. The lab recently showed Vanderbilt's **multiscale damage progression** simulation accurately captures both matrix cracking and delamination as a function of monotonic loads.

Miami and Massachusetts completed an experimental comparison of **z-pinning and flocking**, two different through-thickness reinforcement techniques. It showed that z-pins perform better in Mode 1 loading (where a crack's surfaces move directly apart), while flocking performs better in Mode 2 (where the crack's surfaces slide over each other).

Materials Sciences and Utah developed a new experimental method that enables **compression-after-impact** test samples to be efficiently scaled up to large-sized stiffened structural elements, aided by the team's damage progression tool.

Researchers used finite-element method analysis to determine the evolution of failures in a conventional splice joint. Credit: NASA, North Carolina State University, and Boeing.



Project Idintos, financed by the Tuscany regional government in Italy, is designing the **PrandtlPlane**, an amphibious light aircraft. It would have a box wing in the front view, with proper design of the horizontal and vertical wings; horizontal wings are loaded by the superposition of constant and elliptical lift distributions, and the lift on the vertical wings is butterfly shaped. The hull was designed using computational fluid dynamics codes with a biphasic fluid, taking a dozen parameters into account. Results were verified in the water tank of INSEAN-CN, a naval research organization in Rome. The project includes scaled model wind tunnel tests.

Ball Aerospace developed a method for passively moving modes of complex structures away from critical frequencies and **reducing on-orbit jitter**. The team designed tunable spring masses that fit a small standard interface and envelope. These are tunable to a range of frequencies and can also survive test and launch environments. During testing the devices have shown great success for use on complex structures.

The **Air Force Institute of Technology** Aeronautics and Astronautics Dept. began studying a **lighter-than-air craft** with an internal vacuum. Initial research has shown that for certain designs it is possible to achieve a weight-to-buoyancy ratio of less than one. The group also studied isogrid spheres and craft with two rotating cylinders.

NASA Johnson tested advanced carbon fiber composite and **inflatable prototype habitable modules**. Designed and fabricated in-house, they were proof tested to 8.30 psig (pounds per square inch gage) internal pressure.

NASA Langley, North Carolina State, and Boeing are studying modeling of **progressive damage, including failure, in durable bonded composite joints**. Details are available in three 2013 papers of the Society for the Advancement of Material and Process Engineering.