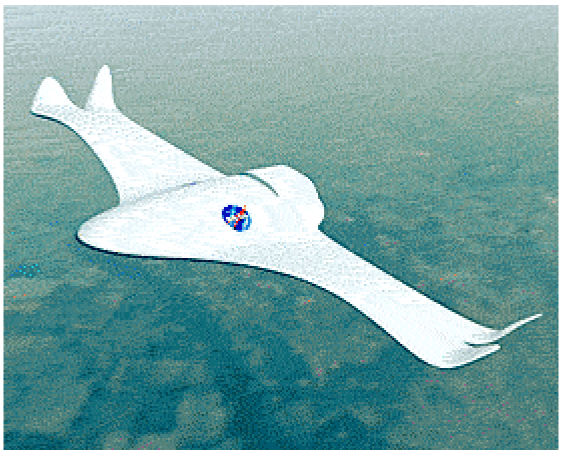
Research in space-age materials takes off with support from NASA

Steven Schultz

Princeton NJ -- The National Aeronautics and Space Administration has selected a consortium of research institutions, led by Princeton, to develop new generations of materials that could lead to dramatically more versatile and reliable airplanes and spacecraft.



Princeton scientists are participating in a NASA-funded project to develop "biologically inspired" materials that could be used in new generations of aircraft. This artist's rendering shows how, in 50 years, planes might be built with materials that allow them to change shape in reaction to varying conditions and demands.

NASA will fund the project with at least $3 million a year for up to 10 years. The award will establish an Institute for Biologically Inspired Materials to investigate and design materials that mimic the extraordinary structural and self-repairing properties of biological substances such as bone or sea shells.

"Our goal is to bring more 'smart' functions into spacecraft materials," said Ilhan Aksay, the Princeton professor of chemical engineering who leads the institute. "Some of these functions already exist in biology."

The institute consists of Princeton, the University of North Carolina-Chapel Hill, Northwestern University, the University of California-Santa Barbara and ICASE, a research institute operated at the NASA Langley Research Center in Virginia. In addition to conducting basic research and technology development, the institute will initiate an education and training program in collaboration with the North Carolina Agricultural and Technical State University.

The researchers also expect to develop partnerships with businesses that will translate laboratory discoveries into readily available products for American industry. NASA selected the consortium's proposal from among more than 100 initial submissions. The participants gathered for an initial workshop and planning session Sept. 25 on the Princeton campus.

The program in bio-inspired materials is part of a broader effort by NASA to expand its relationship with academia by establishing seven

Princeton Weekly Bulletin

October 14, 2002
Vol. 92, No. 6
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The Bulletin is published weekly during the academic year, except during University breaks and exam weeks, by the Office of Communications. Second class postage paid at Princeton. Postmaster: Send address changes to Princeton Weekly Bulletin, Office of Communications, Princeton University, 22 Chambers St., Suite 201, Princeton, NJ 08542. Permission is given to adapt, reprint or excerpt material from the Bulletin for use in other media.

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university-based institutes, each of which will develop an area of technology of "long-term strategic interest to the agency and the nation." While two of the NASA institutes will focus on bio-inspired materials, the other five will work in areas such as propulsion or reusable launch vehicles.

Princeton has strengths in developing practical techniques for synthesizing new materials as well as in creating theoretical models and computer simulations of how these materials would be likely to behave, said Aksay. Other participating researchers from Princeton are Jeffrey Carbeck, Robert Prud'homme and Dudley Saville of the chemical engineering department; Roberto Car of the chemistry department; and Jean Prevost from the civil and environmental engineering department.

Creating composites

Much of the consortium's work will focus on creating innovative composites of organic and inorganic compounds. "Many of the strongest materials in nature derive their unique properties from such combinations," said Dan Morse, a biologist who leads the Santa Barbara team. In bone, for example, fibers of organic collagen provide great strength under tension, while inorganic crystals allow bones to withstand compression.

"We try to understand how biology makes a complex material such as a sea shell, and then, rather than imitating that, we try to extract the fundamental principles we see," said Morse. His group already has discovered interesting mechanical properties in sea sponges that make fiberglass needles and use them to construct intricate structures.

"In making such composites," said Manny Salas of ICASE, "the researchers may be able to coax the raw materials to assemble themselves into microscopic structures and even repair themselves on command." A spacecraft's skin, for example, might be able to send warnings about defects and then repair them and report the results.

"Advanced materials may also be capable of changing their shapes, which would be particularly valuable for airplane wings," said Salas. "Today this is all done with hydraulics. It's a very slow process and a very heavy mechanism. You pay a dear price for carrying all that equipment. If we could find materials that change shape on command we could improve airplanes tremendously."

"Beyond their use in aerospace, the new materials could be used in cars, trains, containment structures even in tape and other adhesives," said Rod Ruoff, who leads the Northwestern team, which will contribute expertise in fabricating and measuring the mechanical properties of hybrid materials.

Achieving such results will require expertise from many specialties. Each participating institution brings a strong background in different aspects of the project, which spans several disciplines, said Ed Samulski, who leads the team at the University of North Carolina.

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Deadline. In general, the copy deadline for each issue is the Friday 10 days in advance of the Monday cover date. The deadline for the Bulletin that covers Nov. 4-10 is Friday, **Oct. 25**. A complete publication schedule is available at deadlines or by calling (609) 258-3601.

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"It's a rather ambitious thing to design materials that can not only recognize when they've been damaged but can indicate the exact site and take steps to repair it. In a sense it's at the fringes of science fiction," said Samulski. "These so-called 'self-healing' materials could be critical to space exploration, because a meteor particle even as small as a grain of sand could puncture the hull of existing space vehicles."

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