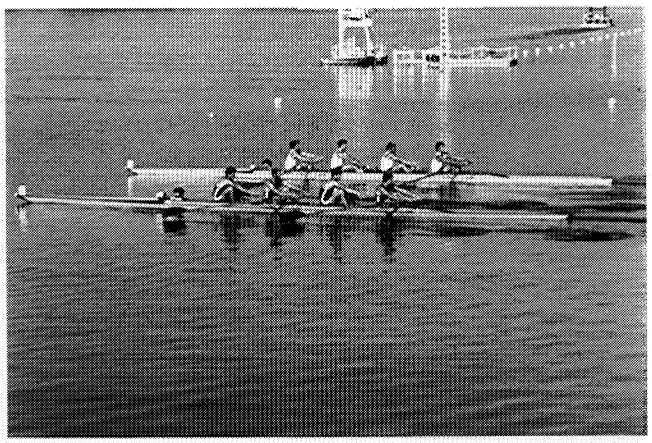
# Riblet Research



The far rowing shell at left is manned by the men's U.S. four-oar-with-coxswain crew that competed in last year's summer Olympics at Los Angeles, California. The team is shown in closeup in the middle photo, with the coxswain and coach Dietrich Rose (far right) on the dock. This group surprised the sports world by winning the silver medal in an event wherein no U.S. team had won a medal for many years. The silver medalists got an assist from NASA technology originally developed as a means of improving airplane fuel efficiency by reducing the drag caused by the friction of turbulent airflow over an airplane's skin. The technology offers similar advantages for vessels moving through water.

Langley has been working on reduction of skin friction drag since 1976. Most of the airflow over an airplane's surfaces is turbulent, and within the turbulent flow are violent eruptions called "bursts" that are responsible for most skin friction drag and nearly half the total aerodynamic drag on an airplane. Langley's aim is to reduce the intensity of these bursts and to achieve thereby a drag reduction that would translate into lower fuel consumption or higher airplane speed. Researchers at Langley's High-Speed Aerodynamics Division estimate that a turbulent drag reduction of 10 percent would afford fuel cost savings for the U.S. commercial airline fleet on the order of $200–300 million a year.

Experiments at Langley showed that small, barely visible grooves on the surfaces of an airplane can favorably change turbulent airflow and reduce skin friction by as much as 10 percent compared with ungrooved surfaces. The grooves—called "riblets"—are v-shaped with the angle pointing in the direction of the airflow; their depth is about like that of a scratch but they have a pronounced influence on air turbulence. In the Langley experiments, the riblets were machined into flat aluminum samples and tested in wind tunnels; at upper right, Michael J. Walsh, Langley's principal riblet researcher, is adjusting a flat plate preparatory to a wind tunnel run.

An issue of *Tech Briefs*, a NASA publication devoted to technological advances with potential for transfer to commercial use, described the Langley work. The article came to the attention of engineers at 3M Company, St. Paul, Minnesota, who contacted Langley with a suggestion: it would be simpler to mold grooves into a lightweight plastic film with adhesive backing and press it into place on an airplane. This technique would have an additional advantage in that riblet film could be applied to existing aircraft as a relatively economical retrofit measure. The company offered to design and produce test riblets in tape form.

Applying its expertise in producing decorative films for commercial uses, 3M's Decorative Products

Division developed experimental adhesive-coated plastic films with precisely machined riblet surfaces in a variety of designs. Tested at Langley, they were found to reduce turbulent drag as effectively or better than machined aluminum surfaces with the same groove shapes and depths.

Encouraged by the test results, 3M reported the development to The Boeing Company, Seattle, Washington, the world's largest producer of commercial transport aircraft. It interested Boeing engineers, among them Doug McLean, a member of the Flight Research Institute (FRI) in Seattle, a non-profit organization, supported by Boeing and the University of Washington, that provides members opportunities to participate in research projects of an avocational nature. With support from FRI, McLean and a small group of engineers undertook the project of testing the riblets on an Olympic rowing shell. At McLean's request, 3M agreed to provide riblet film for several shells. In a series of tests with a one-person racing shell, the FRI group measured a total drag reduction of about six percent—about what was expected, based on Langley tests. Armed with a number of grooved film sheets and data from their rowing tests, McLean and another FRI member journeyed to the Los Angeles Olympic compound, where they persuaded coach Dietrich Rose to try the riblets in the four-oar-with-coxswain competition. At bottom left, the film is being applied to a shell.

Earlier, when riblet research was already well advanced, Langley had found confirmation of grooving's efficacy in a clue from nature: it was learned that fast-swimming sharks have riblet-like projections on their skins. Called dermal denticles, they are made of the same material as sharks' teeth and typically have four or five tiny grooves on what appears to the naked eye to be a smooth surface. Nature's version of the riblet is shown in the closeup of a dermal denticle (right) magnified 3,000 times.

The Olympic silver medal story is, of course, only an interesting sidebar experiment in a Langley/3M research program of broad potential for the future of air transportation. Considerable research remains and Langley is preparing for the next step: flight test of a Gates Learjet business transport whose forward fuselage is being fitted with 3M riblet panels measuring approximately two feet by 13 feet. Interest is evident at Boeing and at Lockheed-Georgia Company, Marietta, Georgia, a major producer of military aircraft; both companies have initiated their own riblet research programs. Langley has set a long range goal of doubling the demonstrated 10 percent turbulent drag reduction, which would provide a dramatic five percent fuel saving for airlines.