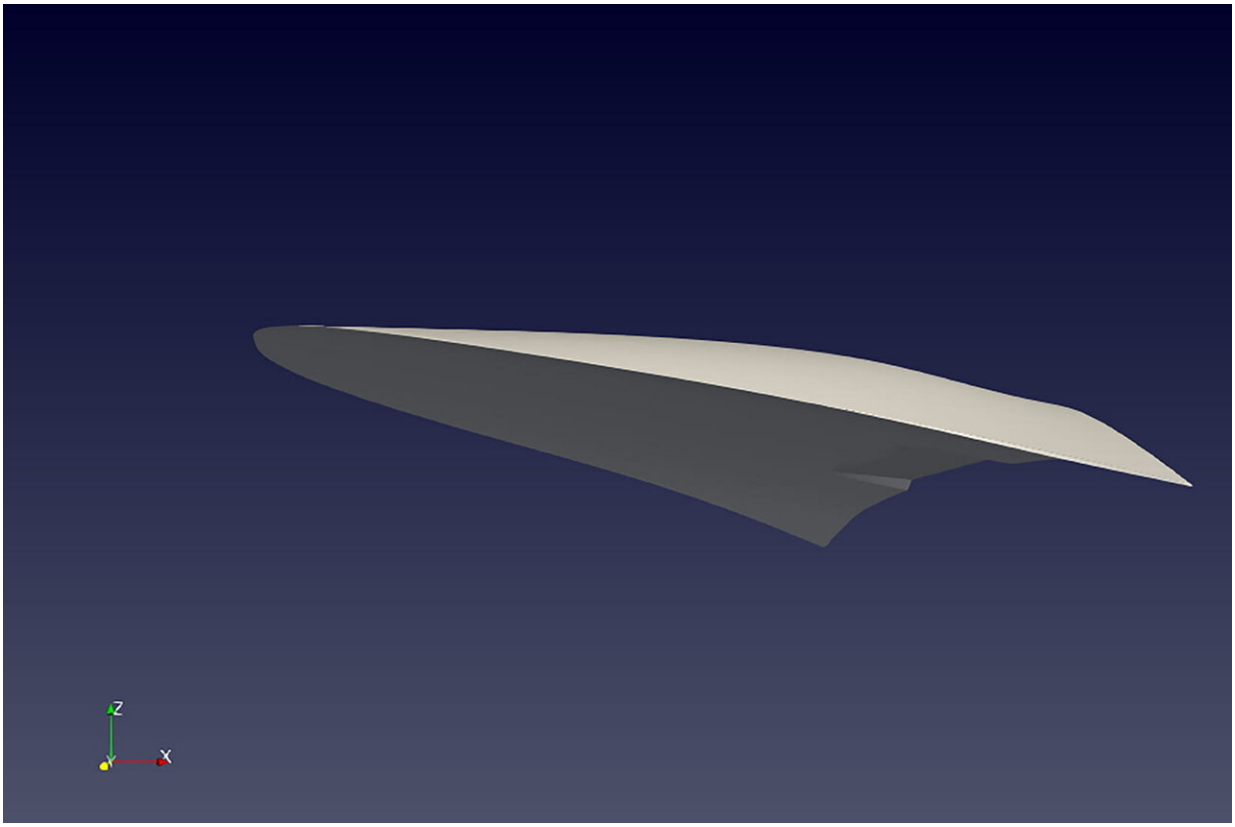
Spacecraft is designed to survive fire, surfs its own wave

April 13 2020, by Jeff Falk



An illustration of the capsule waverider in glide orientation. Credit: P. Rodi/Rice University

Patrick Rodi's new idea for surfing is far out, fast and white hot.

Rodi, a pioneering aerospace engineer who joined Rice University's Brown School of Engineering in 2018, has designed a high-flying vehicle called a "capsule waverider" that does more than catch a wave. It survives a fiery return from outer space before gliding like a surfer on its own shock wave.

The waverider is far from a typical airplane. While an airliner might fly about 600 miles an hour, the hypersonic waverider would be at least 10 times faster, and at such speeds the air flowing around an aircraft behaves in ways that are fundamentally different from how air flows around a conventional airplane.

"When you have hypersonic flow, you generate shockwaves," said Rodi, a professor in the practice of Rice's Department of Mechanical Engineering. "As a designer, you can choose the shape of that geometry such that the shock wave lies right along the vehicle's leading edge. So it's literally riding its own shock wave."

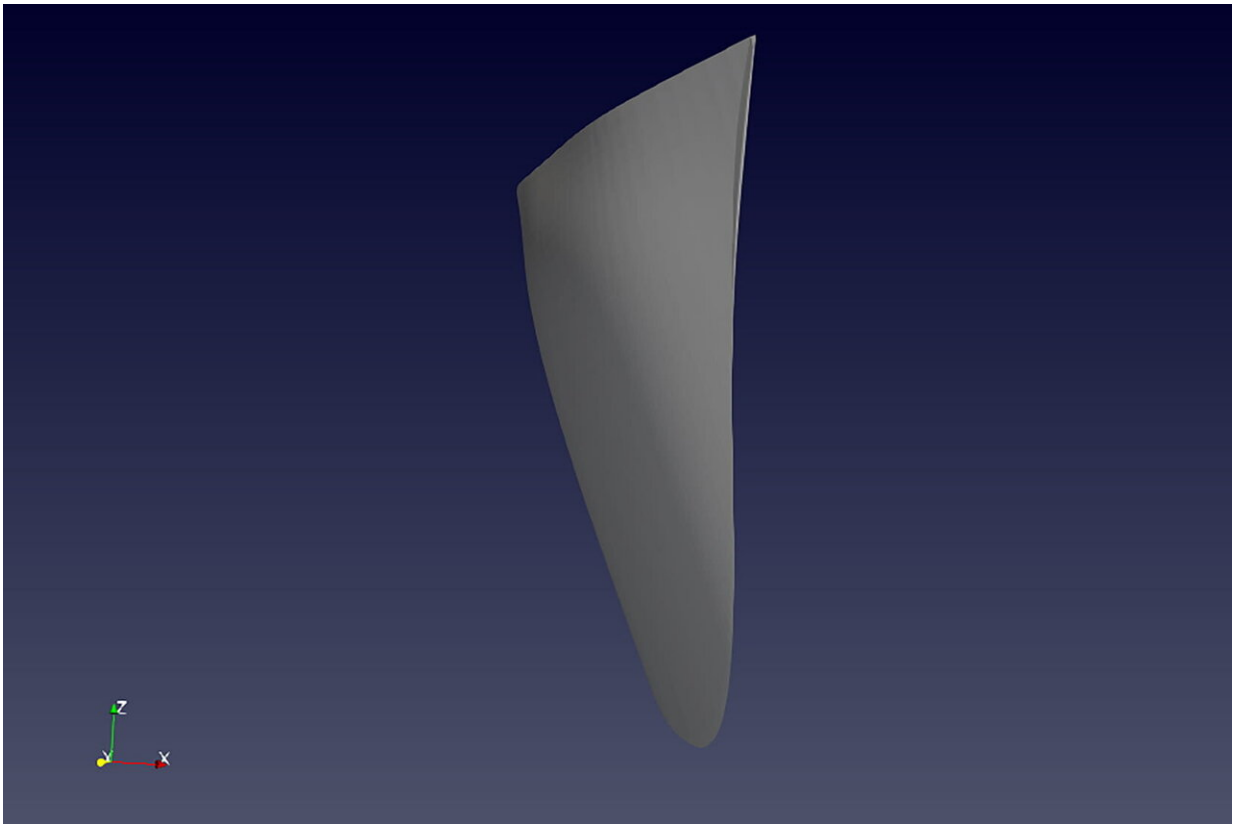
Rodi joined Rice after a 23-year career at Lockheed Martin, where he worked on many advanced programs at the famed Skunk Works in Palmdale, California, as well as on the Orion space capsule program in Houston. Waveriders have long been a passion for Rodi, who the Office of Naval Research has called "the most prolific waverider technology developer in the public record."

"Other vehicles have shock waves," he said. "But the shock waves are separated from the vehicle, and high-pressure leaks around that little gap between the shock wave and the body itself."

The waverider design stops the high-pressure air from leaking away.

"You're expending energy to compress the air, and now you're using that high-pressure air as efficiently as possible," he said. "You're not losing

that lift. You're capturing it by shaping the geometry, riding the wave. And it's very efficient. That's the big thing about waveriders. The lift-to-drag ratio is really high, which correlates linearly with gliding distance, or range, the metric you're looking for."



In its boost orientation, the capsule waverider has the blunt shape reminiscent of a traditional space capsule heat shields. Credit: P. Rodi/Rice University

Rodi was scheduled to present the capsule waverider design last month in Montreal at the American Institute of Aeronautics and Astronautics (AAIA) Space Planes and Hypersonic Systems and Technologies Conference, which was canceled due to the coronavirus.

"This is my sixth new class of waverider vehicles, and it's what is known as a boost-glide vehicle, which is a big deal in hypersonics these days," he said.

Boost-glide vehicles can be either long- or short-range and are often discussed as a new type of delivery system for weapons launched from ballistic missiles.

Like traditional warheads, boost-glide vehicles would be boosted into space on missiles. But traditional warheads do not maneuver, which means that it's possible to tell where they are headed just a few moments after they are launched. Boost-gliders can stymie defenders by changing direction and flying to unpredictable target locations.

"When it first enters the atmosphere, it punches pretty deep, and it gets really, really hot," Rodi said. "There's high-pressure loading, high heating. For re-entry you want something that can survive that high heating. Basically, you want a vehicle that kind of looks like a traditional space capsule. As a glider, you want something that's very efficient, with a high lift-to-drag ratio."

The capsule waverider class balances those demands, he said. On one side, it has the rounded, blunt shape reminiscent of a traditional space capsule heat shield. On the opposite side, it is a wing-shaped waverider glider.

Weapons weren't the inspiration for Rodi's boost-glide waverider. Rather, he envisions them as vehicles for landing people and supplies on Mars.

While the red planet's atmosphere is thin, spacecraft need heat shields to survive entry. This heating, the planet's rock-strewn surface and the communications lag between Earth and Mars combine to make landings

on Mars very difficult.

"That's a real problem for NASA," Rodi said. "This concept would allow you to come in as a capsule, flip over to a waverider, glide around, look things over, find your landing spot and then either drop off equipment with parachutes, glide in and skid across the Martian surface, or pitch up and land on the vehicle's tail. It gives you a lot of options."

Provided by Rice University