Reducing Unsteady Loads on a Piggyback Miniature Submarine

Simple, highly effective fixtures entail minimal modification.

Langley Research Center, Hampton, Virginia

A small, simple fixture has been found to be highly effective in reducing destructive unsteady hydrodynamic loads on a miniature submarine that is attached in piggyback fashion to the top of a larger, nuclear-powered, host submarine (see Figure 1). The fixture, denoted compact ramp, can be installed with minimal structural modification, and the use of it does not entail any change in submarine operations.

The miniature submarine is denoted as Advanced SEAL Delivery System [ASDS (wherein "SEAL" signifies the United States Navy's special-operations forces known as the Sea, Air and Land (SEAL) forces.] The ASDS is launched from the host submarine to clandestinely transport a SEAL team to a landing site, where the team performs an operation. Later, the ASDS is used to return the SEAL team to the host submarine.

During sea trials and subsequent computational analysis, large unsteady hydrodynamic loads were detected on the stern of the ASDS during piggyback transport. It was discovered that the unsteady hydrodynamic forces and moments were associated with unsteady separated flow that was caused by the combination of a strong adverse pressure gradient on the stern of the ASDS as well as blockage of flow by a mating trunk, pylon fairings, pylon cross struts, latches, and other fixtures used for mounting the ASDS on the host submarine. The unsteady loads acted on the rudders, stern planes, propeller, stators, and stern cone of the ASDS, causing fatigue and early failure of critical components.

An investigation of flow-control modifications to reduce the unsteady hydrodynamic loads was initiated. Of thirty modifications that were considered, the one judged to be most promising was the installation of a compact ramp on the host submarine hull between the rear ends of the aft pylon pair, near the stern of the ASDS. Unlike other flow-control modifications examined, this one is not based on the concept of confronting and reducing the flow separation directly; instead, it is based on the concept of mitigating the ad-

Figure 1. A **Miniature Submarine**, denoted an ASDS as explained in the text, rides piggyback on a submarine of the Los Angeles class.

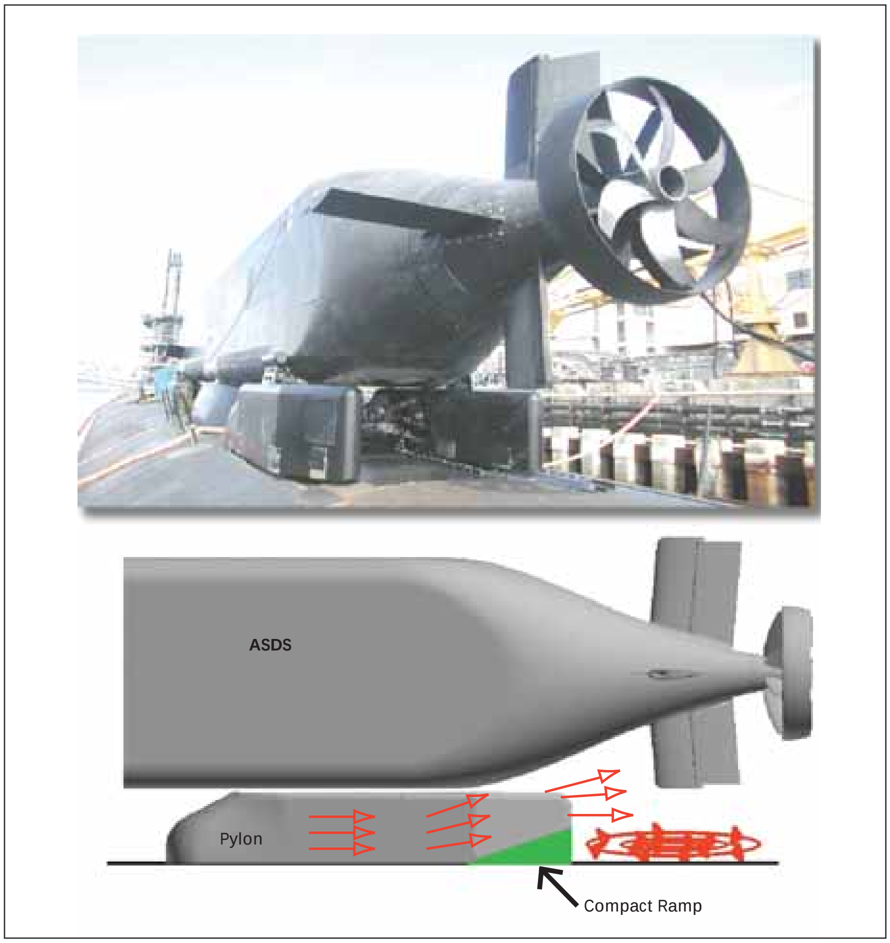


Figure 2. A **Compact Ramp** is mounted on the host submarine hull between the rear ends of the aft pylons to modify the flow to reduce unsteady hydrodynamic loads on the stern appendages of the ASDS.

verse pressure gradient and moving the flow separation away from the critical stern components of the ASDS and harmlessly onto the host hull downstream of the ramp, as depicted schematically in the lower part of Figure 2.

In water-tunnel tests on a scale model, the installation of the compact ramp was found to result in reductions of as much as 50 percent in unsteady hydrodynamic forces and moments on the stern appendages of the ASDS, leading to the selection of the compact ramp as sole candidate recommended for testing in full-scale sea trials. It has also been conjectured that structural components similar to the compact ramp could, potentially, confer flow-control and load-reduction benefits in applications that involve piggyback or other external attachments to aircraft.

This work was done by John Lin of Langley Research Center. Further information is contained in a TSP (see page 1). LAR-17364-1

Ultrasonic/Sonic Anchor

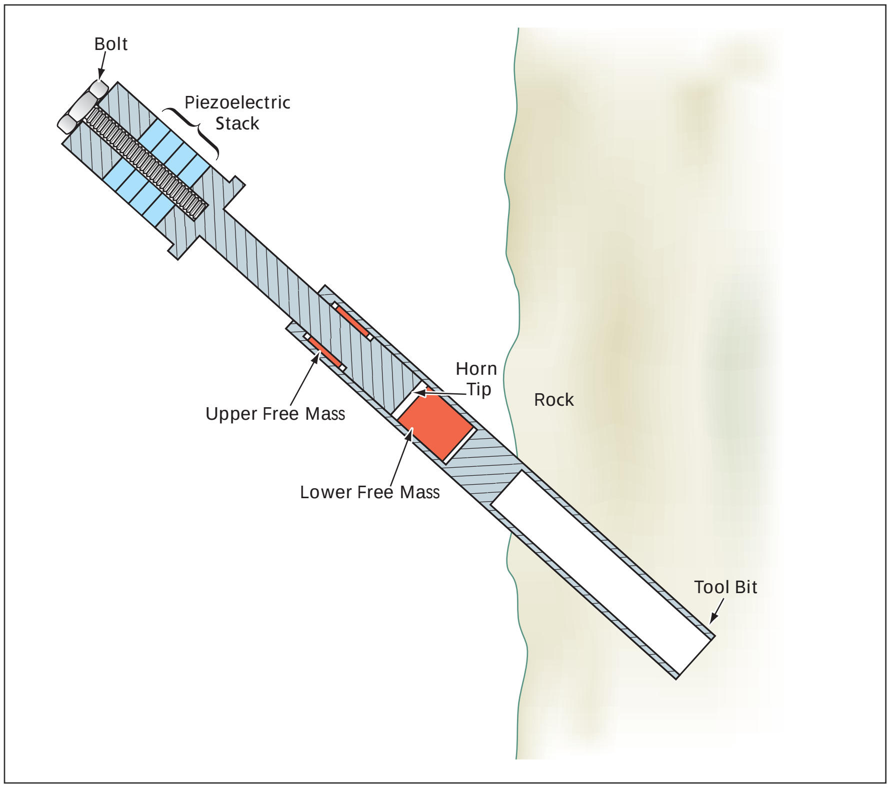
The anchor can be embedded or de-embedded with minimal axial force.

NASA's Jet Propulsion Laboratory, Pasadena, California

The ultrasonic/sonic anchor (U/S anchor) is an anchoring device that drills a hole for itself in rock, concrete, or other similar material. The U/S anchor is a recent addition to a series of related devices, the first of which were reported in "Ultrasonic/Sonic Drill/Corers With Integrated Sensors" (NPO-20856), *NASA Tech Briefs*, Vol. 25, No. 1 (January 2003), page 38. There are numerous potential uses for U/S anchors, especially in enabling walking robots and humans to climb steep rock faces for diverse purposes, including scientific exploration, recreational rock climbing, military maneuvers, and search and rescue.

Like the prior devices in this series, the U/S anchor drills a hole by means of hammering and chiseling actions of a tool bit excited with a combination of ultrasonic and sonic vibrations. The U/S anchor also contains an actuator that includes a piezoelectric stack at the upper end of a rodlike horn that serves to mechanically amplify the piezoelectric displacement. In addition, as in the previously related devices, the tool bit is mounted at the lower end of the horn. The piezoelectric stack is electrically driven at its resonance frequency (an ultrasonic frequency), and a bolt holds the stack in compression to prevent fracture during operation.

In a typical prior related device, the sonic vibrations are generated with the help of upper and lower mass that is denoted the free mass because it is free to move axially through a limited range within the actuator/tool-bit assembly. In the U/S anchor, there are two free masses: one above and one below the lower tip of the horn (see figure). Each free mass bounces between hard stops at the limits of its range of motion at a sonic frequency. The impacts of the free masses on the hard stops create stress pulses that propagate along the horn, to and through the tool bit, to the tool-bit/rock interface. The rock becomes fractured when its ultimate strain is exceeded.



The **Ultrasonic/Sonic Anchor** drills its own anchor hole in a rock face.

A major advantage of the U/S anchor (or of any device in this series) is that it is not necessary to apply a large axial force to make the tool bit advance into the drilled material. Similarly, during operation, only a small force suffices to extract the tool bit from the drilled hole. Hence, a human or robotic rock climber could easily insert and withdraw a U/S anchor at successive positions during traversal of a rock face.

This work was done by Yoseph Bar-Cohen and Stewart Sherrit of Caltech for NASA's Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1).

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, NASA Management Office–JPL. Refer to NPO-40827.