Aircraft Operating Environments Around High-Speed Ships

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Abstract

IN an effort to determine possible applications of hydrofoil ships to the overall mission of the U.S. Navy, the Navy is conducting an investigation into the feasibility of launching and recovering remotely piloted vehicles (RPV's) by landing or capturing them on hydrofoils during ship cruise conditions. Such a mission is desirable because of the high-speed capability of the hydrofoil ship and thus the capability of ship/RPV encounter at or near zero relative speed. The feasibility of such an operation has been studied in detail by M.L. Hill of Applied Physics Laboratory and is discussed thoroughly in Ref. 1.

As part of the program to determine the feasibility of RPV operations from hydrofoils, tests were run in the Virginia Tech 6 x 6 ft Stability Wind Tunnel to determine the flowfield around a typical hydrofoil ship in a foilborne position and to examine its effect on RPV operations. Tests were run using a 1/20 scale model of the hydrofoil ship Plainview (AGEH-1). Tests were run with the ship at yaw angles from 0 to 15 deg. Flow visualization tests using smoke and tufts, as well as velocity probe surveys with a five-hole pitot probe, were conducted. Tests were also conducted using a spring-mounted model of a large RPV to evaluate its reactions to the flow around the ship.

Contents

The primary results from the tests are shown in Figs. 1-4 as grids of velocity vectors showing the flow patterns of two critical planes across the ship's fantail area. Section AA is 5 ft forward of the full-scale ship's stern and section BB is about 35 ft forward of the stern. The dominant feature in the flow is seen to be a vortex from the forward deck edge of the ship, which causes a strong downdraft over the ship's fantail area in the zero-yaw case and which sweeps across the deck to cause a strong circulatory flow over the fantail in the yawed case. Pitot static tube surveys over the fantail deck showed a 12-ft-thick (full-scale) turbulent boundary layer over the deck.

Tests using the spring-mounted-model RPV on a traverse were filmed as the model was moved over several positions about the ship. As the tunnel was run, the RPV model was moved around the ship model to examine the effects of the flow on the RPV. The spring mounting of the RPV allowed it to react to pitch and yaw motions, and the model was free to swivel in yaw. Films were made of the RPV model as it was traversed over the ship. The resulting 18-min, 16-mm color film reveals much about the problems of flying an RPV in close proximity to the Plainview at ship angles of 0 and 15 deg. These tests revealed the strong tendency of the RPV model to roll, pitch, and yaw toward the deck as it reacted to the vortex near the deck edge. Near the forward deck edge the model was observed to go from an attitude of roll away from the ship to one of hard roll toward the ship as it moved over only a very slight distance inboard toward the deck, all the while pitching strongly in an nose down attitude. The only location in which the RPV did not show a strong pitch down tendency was between the pilot house and stacks above the ship.

On the basis of the study, the flow around the ship was found to have the form shown in Fig. 5. The flowfield appears to present a real hazard for RPV operations. An RPV approaching the AGEH-1 in the vicinity of the fantail under optimum conditions at zero yaw for the ship would experience

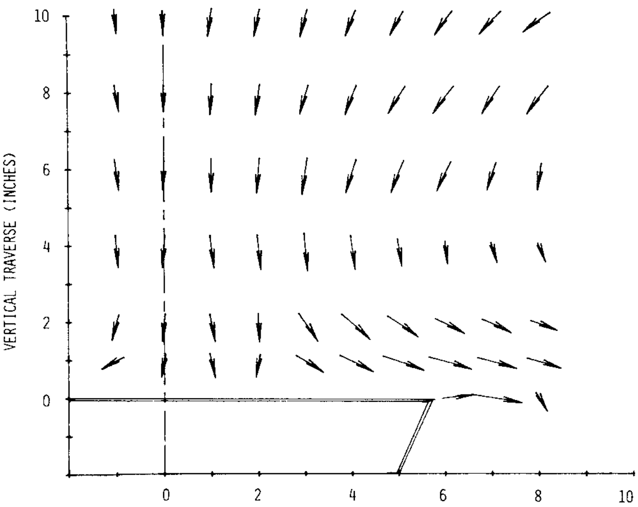

Fig. 1 Flow pattern near stern at 0 deg yaw.

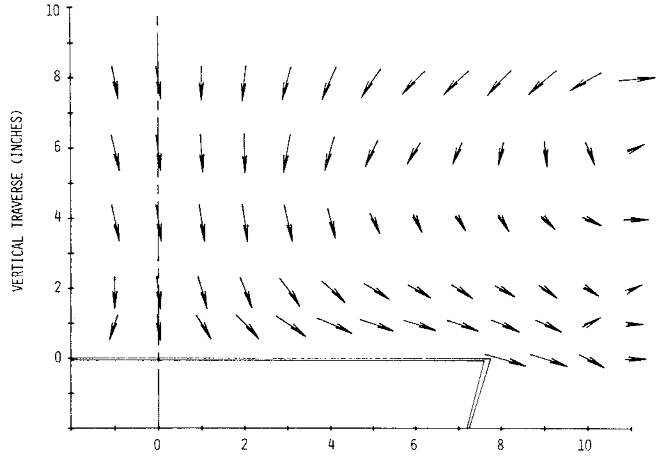

Fig. 2 Flow pattern near stern at 15 deg yaw.

Received July 7, 1978; presented as Paper 78-1184 at the AIAA 11th Fluid and Plasma Dynamics Conference, Seattle, Wash., July 10-12, 1978; synoptic received Oct. 16, 1978. Full paper available from AIAA Library, 750 Third Avenue, New York, N.Y., 10017. Price: Microfiche, $2.00; hard copy, $5.00. **Order must be accompanied by remittance.**

Index categories: Military Missions; Aerodynamics; Marine Vessel Systems, Submerged and Surface.

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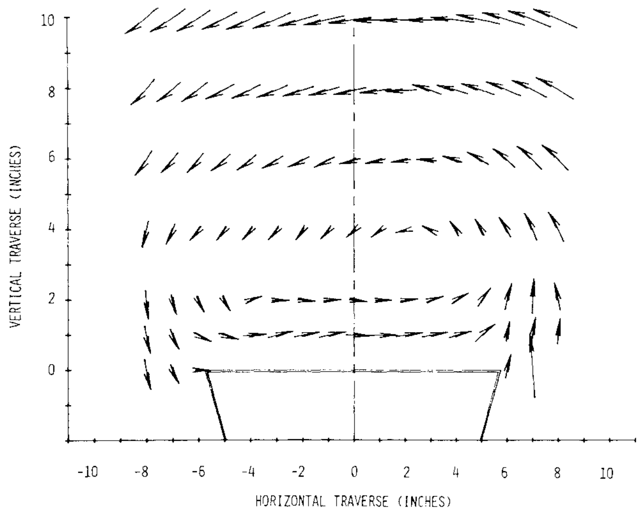

Fig. 3 Flow pattern at section BB, 0 deg yaw.

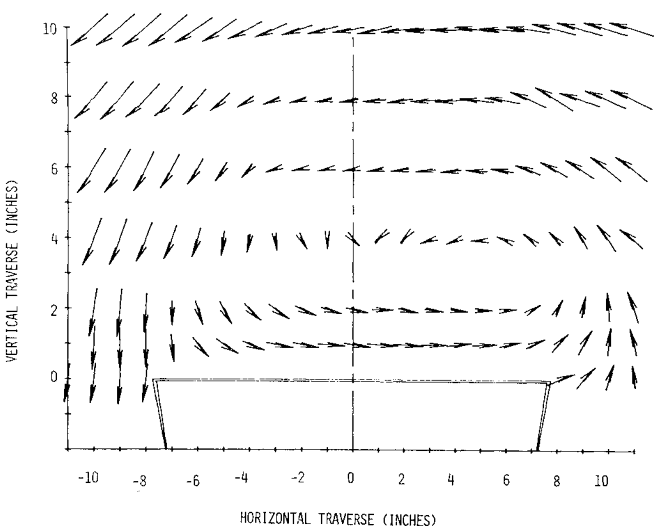

Fig. 4 Flow pattern at section BB, 15 deg yaw.

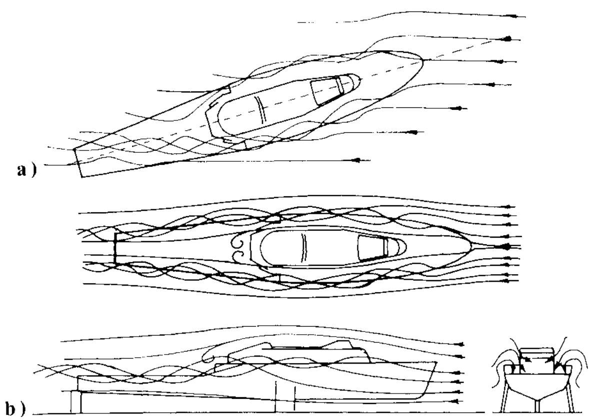

Fig. 5 General flow patterns around ships: a) 15-deg yaw flow; b) 0-deg yaw flow.

moderate to severe downdrafts near the center of fantail and would feel strong updrafts if the approach were made from either side of the deck. The deck edge vortex appears most intense in the vicinity of the pilot house, making operations difficult in this area.

In order to capture an RPV over the fantail area of the ship, a net would have to be placed approximately 20 ft or more above the deck in order to minimize the effect of the ship's flowfield on the RPV. Since the deck edge vortex near the front of the ship is fairly tight, its field of influence off to the side of the ship is not yet very extensive. It may, therefore, be possible to place a capturing device several feet to the side of the deck and fly an RPV to that point with relative safety.

The same general problems exist for the yawed flow case as for the nonyawed situation. However, the problems are more intense in crosswinds because of the intense turbulence created over the ship by the vortices being swept over the ship. This, coupled with the normal problems of crosswind control of the RPV, makes RPV capture in a crosswind most difficult. Fortunately the ship should normally be able to assume an into-the-wind attitude to allow capture under the more ideal zero-yaw circumstance.

References

[1] Hill, M.L. "Operation of Remotely Piloted Vehicle Systems from Multi Mission Hydrofoil Ships," Johns Hopkins University Applied Physics Lab., Aeronautics Division Rept. BAF-660-3, June 1977.