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WATER-TUNNEL TESTS OF SUBMERSIBLE VEHICLES WITH FORWARD CONTROL--ETC(U)
AUG 82 F K GOODWIN, R E REED N61331-78-C-0032
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This report describes an investigation of the effects of the test medium on pitching-moment, normal-force, and rolling-moment coefficients of a submersible vehicle with forward and aft control surfaces. The model was tested in both air and water in a water/wind facility. No significant effects of the test medium were found. Results of moment and force coefficients versus angle of attack varying from -3 to +15 degrees are given.

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NOMENCLATURE

C_ℓ	rolling-moment coefficient; rolling moment/$qS_{ref}D$, positive clockwise viewed from the rear
C_m	pitching-moment coefficient; pitching moment/$qS_{ref}D$, positive nose up
C_N	normal-force coefficient; normal force/qS_{ref}
D	reference length taken as body diameter, 2 in. (5.08 cm)
q	free-stream dynamic pressure
S_{ref}	reference area taken as body frontal area, 3.142 in^2 (20.271 cm^2)

INTRODUCTION

Nielsen Engineering & Research, Inc. (NEAR) under contract to the Naval Coastal Systems Center (NCSC) has been developing methods for predicting the hydrodynamic characteristics of submersible vehicles[1,2]. They are based upon data generated using specially constructed models which were tested in the 12-foot Pressure Wind Tunnel (PWT) at NASA/Ames Research Center, Moffett Field, California. The models and tests are also described in References 1 and 2.

Prior to testing in the 12-foot PWT, tests were conducted in the NEAR Water/Wind Tunnel[3,4] to determine the effect of the test medium on the hydrodynamic characteristics. In Reference 3, a 7-caliber body with a conical base, and with and without tail fins was tested. The tests described in Reference 4 used a 10-caliber body with and without tail fins. Two different bases were tested, a conical base and a tangent-ogive base. Both of these tests showed negligible effects of the test medium on the hydrodynamic characteristics.

In the tests described in Reference 2, bodies with sails were tested. Prior to performing these tests, the model for the NEAR Water/Wind Tunnel was modified so that control surfaces could be added to the forward portion of the model. Tests were then run in both water and air to determine the effect of the test medium on the hydrodynamic characteristics of this more complicated model.

This report describes this test program and presents the results.

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(1) Fidler, J. E. and Smith, C. A.: Methods for Predicting Submersible Hydrodynamic Characteristics. NCSC TM 238-78, July 1978.

(2) Nielsen, J. N., Goodwin, F. K., and Smith, C. A.: Methods for Predicting Tail Control Effects on Conical Afterbodies of Submersibles. NCSC TM 347-82, 1981.

(3) Fidler, J. E.: Water Tunnel Tests of Submersible Models. NEAR Informal Rept., July 1977.

(4) Fidler, J. E. and Reed, R. E.: Submersible Model Tests. NEAR TR 214, Dec. 1980.

MODEL

The model used in the test program is shown in Figure 1. The body consists of 1-caliber elliptic nose, a 7-caliber cylindrical centerbody, and a 2-caliber conical base, one of the bodies tested in Reference 4. Cruciform fins with a NACA 0018 airfoil section were attached to the conical base as shown. The fin dimensions are shown in Figure 2. A pair of horizontal fins could be mounted on the forward portion of the body as shown in Figure 1. These fins have the same planform as shown in Figure 2 for the airfoil shaped fin but are flat plates 0.15 in. (0.38 cm) thick with rounded leading edges.

TEST PROGRAM

The tests of the model were run in the NEAR Water/Wind Tunnel. This is a very flexible facility in which models can be tested in two media. The basic test section, 14 by 20 by 72 inches long (35.6 × 50.8 × 182.9 cm), is all plexiglass for 100 percent visibility. The nozzle, test section, and diffuser can be rotated as a unit, making the test section either 14 or 20 in. high. The latter was used in the tests. Flow speed ranges were 0 to 20 ft/sec (6.1 m/sec) in water and 0 to 200 ft/sec (61 m/sec) in air. The nozzle has a contraction ratio of 8:1 and there are four turbulence-damping screens in the settling chamber. Flow angularity in the test section was ±0.2 degrees and the maximum velocity deviation was ±0.2 percent.

The cylindrical center section of the model accommodated the NEAR 5-component strain-gauge balance. Measurements were taken of normal and side forces plus pitching, yawing, and rolling moments. Axial force was not measured. The location of the moment center about which the pitching and yawing moments were taken is shown in Figure 1.

Two models were tested. One was the model as shown in Figure 1 and the other was identical except that the forward right fin was removed. Pitch angle, α, was varied from -3 degrees to +15 degrees. The model roll angle was 0 degrees, tail fins horizontal and vertical. The tunnel free-stream test conditions were:

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(4) ibid.

In water: velocity = 17 ft/sec (5.2 m/sec)
dynamic pressure = 1.944 psi
Reynolds number (based on body length) = 2.5×10^6

In air: velocity = 180 ft/sec (54.9 m/sec)
dynamic pressure = 0.259 psi
Reynolds number (based on body length) = 1.8×10^6

RESULTS

The normal-force coefficients versus angle-of-attack for the two configurations are shown in Figure 3. Curves for data obtained in water and air are shown. It can be seen that the test medium had little affect on either configuration. Similar results are shown in Figure 4 for the pitching-moment coefficient.

The configuration with one forward fin is asymmetric so that it will produce a rolling moment. These results are shown in Figure 5. Again, there is only a small effect of the test medium seen in the data.

CONCLUSIONS

These tests have shown the following:

- The effect of test medium on the normal force and pitching moment was negligible for the configurations tested.
- The effect of test medium on the rolling moment for the one asymmetric configuration tested was also negligible.
- Additional checks should be made for more complicated configurations such as body-wing-sail-tail combinations.

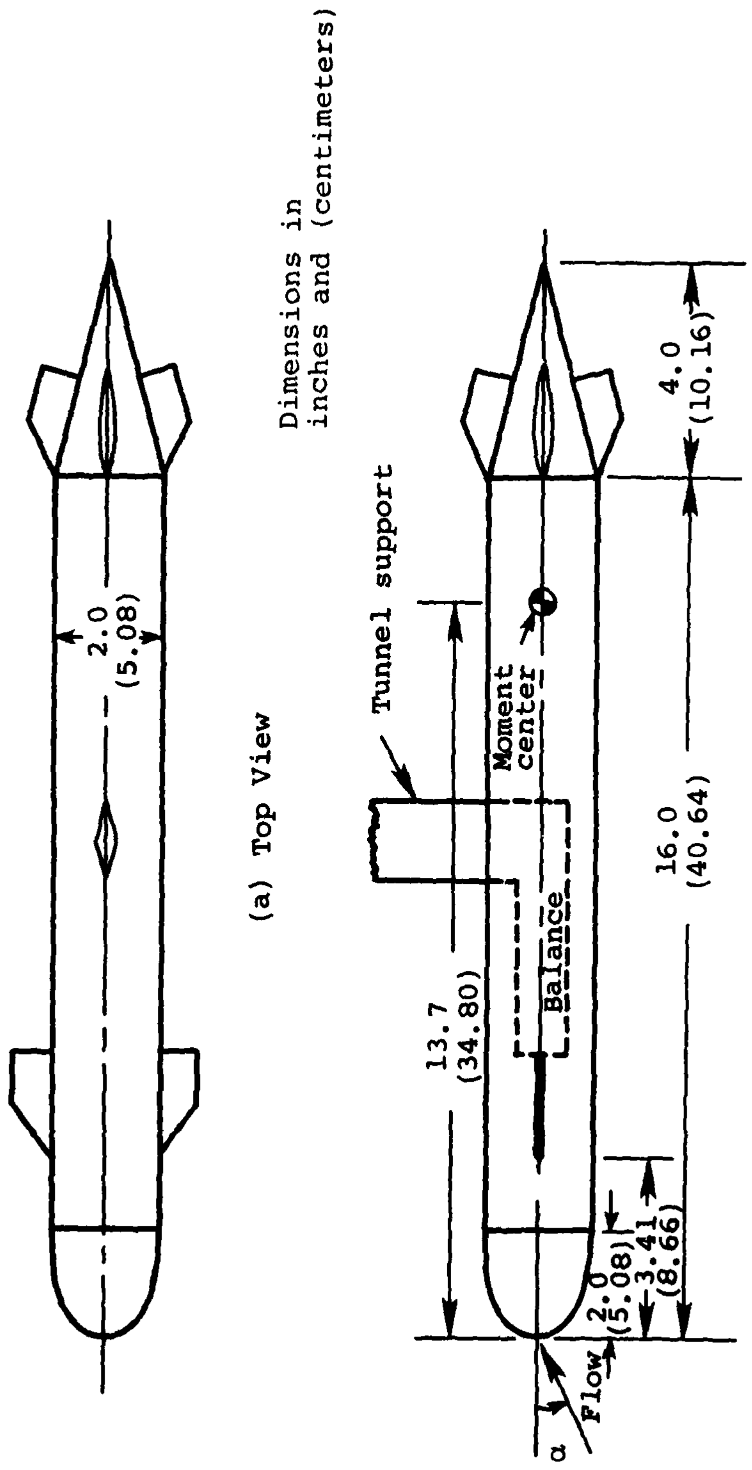

FIGURE 1. MODEL USED FOR TESTS IN NEAR WATER/WIND TUNNEL

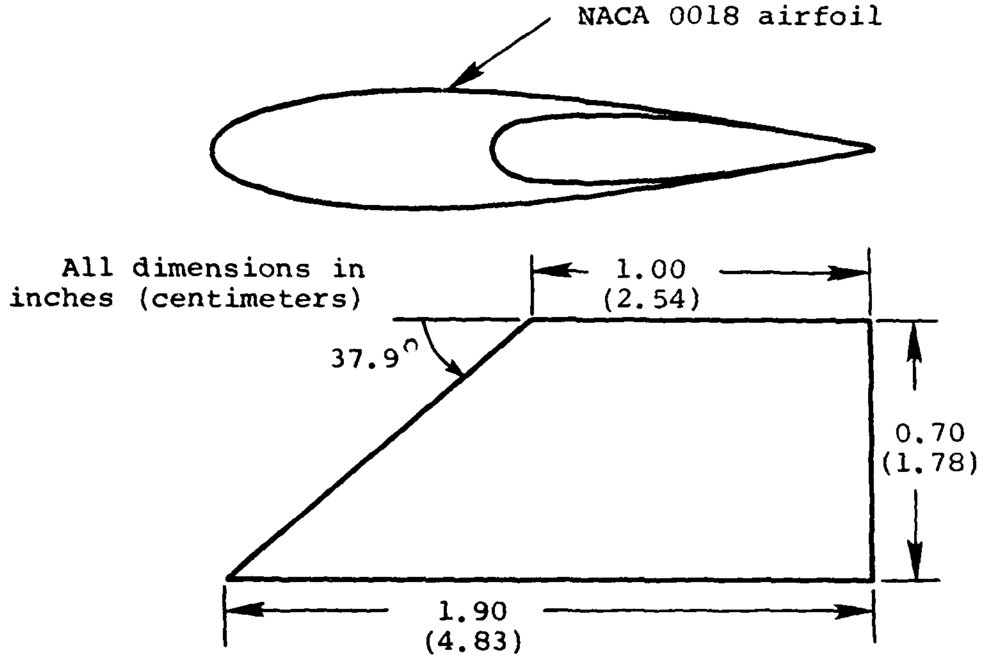

FIGURE 2. AIRFOIL SHAPED FIN

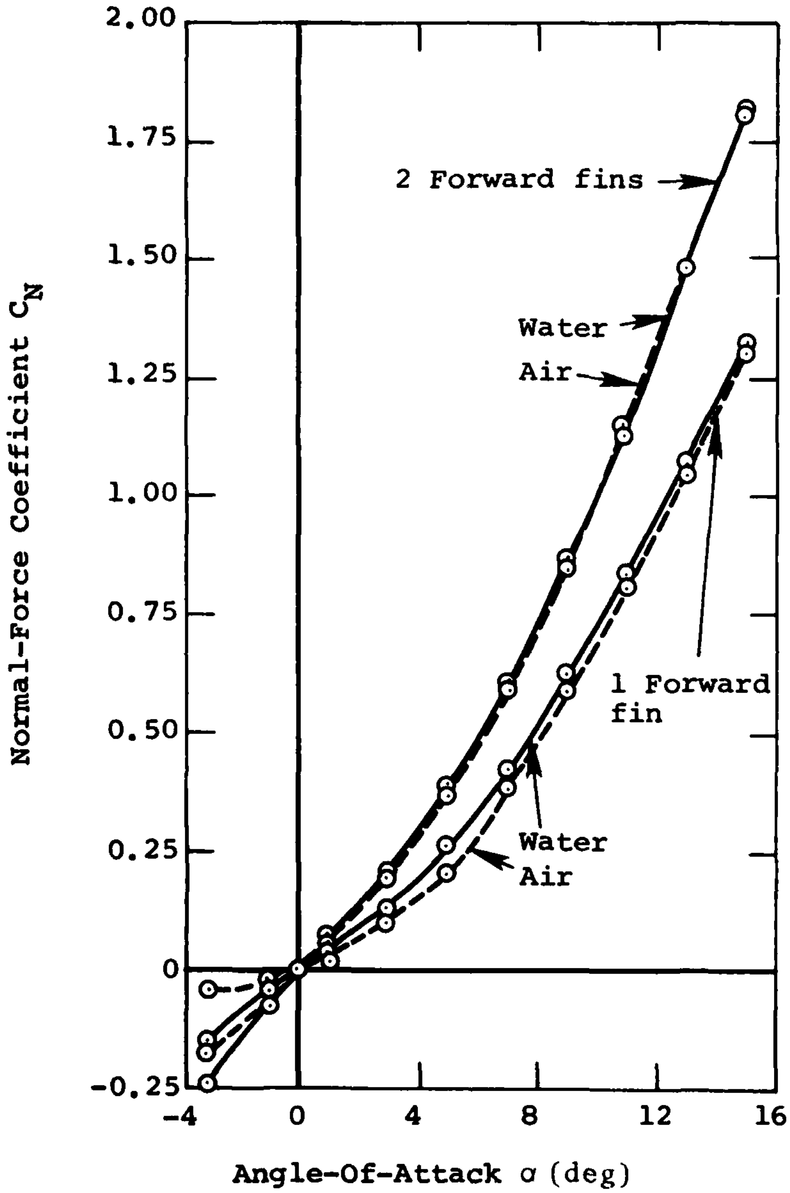

FIGURE 3. NORMAL-FORCE COEFFICIENT WITH FORWARD FINS

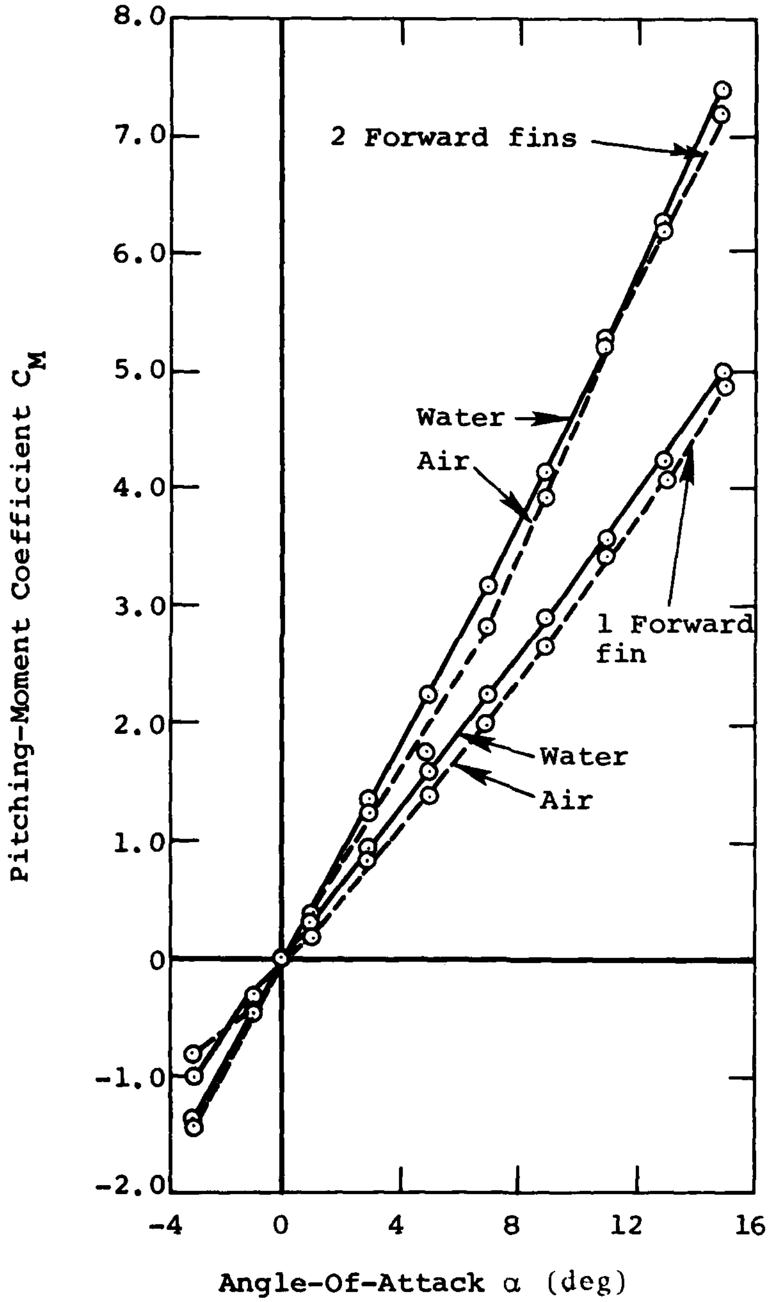

FIGURE 4. PITCHING-MOMENT COEFFICIENT WITH FORWARD FINS

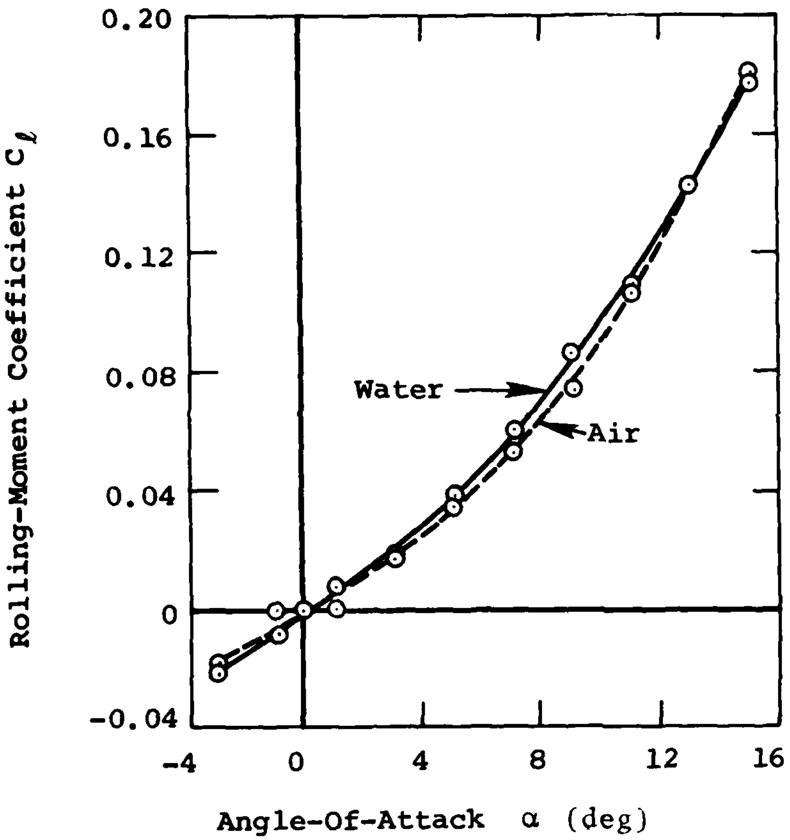

FIGURE 5. ROLLING-MOMENT COEFFICIENT WITH SINGLE FORWARD FIN

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