FROM: SEA 50151, T. Cannon

TO: DTNSRDC 1153, J. Meyer

SUBJ: Hydrofoil Small Waterplane - Area Ship (HYSWAS) Assessment
Forwarded to 05R, February, 1984

1. Enclosed is the copy of the report I sent to Capt Duff, February 1, 1984. Sorry for the delay in forwarding to you the final copy.

2. I think you should find most of your suggested modifications included in this draft. One change that did not get included in the original draft forwarded to Captain Duff was the modification to the EPH speed-power curve. This was later forwarded to him.

3. I would like to thank you for your help in preparing the HYSWAS assessment. I have all of your information in a file in my desk ready to return to you once I am reasonably sure the topic has left my desk. I would think another month should do it. As far as I know, Captain Duff has received the document,but has not commented on it.

4. Once again, thanks for the help. Let me know if there is anything I can do to return the favor. I look forward to working with you again.

Tom Cannon

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FROM: SEA 50151

TO: SEA 05RB, CAPT Duff

SUBJ: Hydrofoil Small Waterplane - Area Ship (HYSWAS) Assessment

1. The Hydrofoil Small Waterplane - Area Ship (HYSWAS) is a hybrid ship concept that combines the buoyant lift of a single submerged hull with the dynamic lift of a fully-submerged foil system to support an upper hull above the water surface. At low speeds, buoyancy is provided by the submerged hull, the strut, and portions of the upper hull. With increased speed, the dynamic lift provided by the foil system raises the upper hull above the water, thereby decreasing the waterplane area to that of the strut alone. Transition can occur gradually beginning at speeds below 20 knots.

2. The HYSWAS concept grew out of a series of studies performed by the David Taylor Naval Ship Research and Development Center as part of the Hybrid Marine Interface Vehicle Program initiated in 1973. The studies were an attempt to optimize ship performance by combining various lift modes (buoyant, dynamic, and powered static) into single platforms. A variety of platforms were conceived, and the HYSWAS configuration resulted in generally favorable characteristics.

The HYSWAS combines a SWATH - like buoyant force with a hydrofoil - like dynamic force. At full speed, the HYSWAS depends on between twenty and forty percent dynamic lift. This combination of buoyant and dynamic lift allows the HYSWAS a gradual transition thus alleviating the hump in the power curve found in most high performance/advanced ships. As a result, the HYSWAS is able to operate efficiently at both low and high speeds. The other HYSWAS advantage is the platform's ability to use the foil system to control its draft between minimum and maximum levels. This enables the HYSWAS to optimize performance depending on speed, sea state, and stability requirements.

3. The studies conducted under the Hybrid Interface Vehicle Program resulted in a comprehensive CONFORM level 2000 ton HYSWAS design (Ref. 1). The design report considered area/volume utilization, ship and machinery arrangements, weight, and intact stability. The report also discussed a number of detailed studies made in support of the HYSWAS program including performance estimates

(Ref. 2), resistance prediction based on model tests (Ref. 3), roll controllability (Ref. 4), structural design (Ref. 6), and optimum foil size and location (Ref. 5). Risk items used in the design included an all aluminum structure, and a planetary reduction gear. The resulting HYSWAS design demonstrated some favorable performance characteristics. With 50,000 SHP installed, the HYSWAS is projected to reach speeds greater than 40 knots with no real degradation in higher sea states (through sea state 5). There is potential for seakeeping that is superior to similar sized monohulls. Results from the seakeeping study (Ref. 4) showed that pitch and heave motions in head seas are projected to be less than those for a monohull.

The major HYSWAS advantage is its ability to operate relatively efficiently over a large speed range. This results from the HYSWAS's ability to operate partially foilborne at below off-design speeds by decreasing foil loading. This, in turn, provides higher ship lift-to-drag ratios. The only penalty paid for this type of operation is increased strut immersion which has little effect on total ship resistance. It is the smooth resistance curve, which results from the capability to slowly transit from a hullborne to a foilborne mode, that allows HYSWAS to maintain good range characteristics throughout its speed regime.

4. A comparison of the 2000 ton HYSWAS speed power characteristics with platforms of similar displacement was made and is shown in Figure 1. The figure demonstrates HYSWAS' smooth speed-power curve, but shows that in direct comparison with the other platform configurations (monohull, SWATH, Hydrofoil, and Extended Performance Hydrofoil) it holds no real performance advantage. Through 22 knots, the SWATH ship operates more efficiently than the HYSWAS. Through 35 knots, the monohull requires less power, and at higher speeds (above 35 knots) the foilborne hydrofoil has superior powering characteristics. The HYSWAS tracks fairly closely with the extended performance hydrofoil, which is expected because they have similar configurations.

5. In conclusion, the HYSWAS concept appears to be a feasible platform. Its main advantage is good powering efficiency over a wide speed range. Its disadvantages are at the low and high ends of the speed power curve. At low speeds, the HYSWAS requires more power than SWATHs or Monohulls, and at high speeds, HYSWAS has trouble competing with Hydrofoils. The HYSWAS is projected to have better seakeeping characteristics than an equivalent monohull in large head seas, but is not expected to match SWATH's excellent seakeeping

capability. The HYSWAS also has the disadvangtage common to all advanced concepts, i.e. technical risk. Many HYSWAS performance predictions have been made based on projected SWATH and large hydrofoil performance. It is difficult to assess the advantages a combination of these two platforms would have while neither platform currently exists. The method of analysis used in assessing many of the HYSWAS performance characteristics was derived from SWATH and small hydrofoil analyses, and then added together and scaled up to the 2000 ton size. Model tests done on HYSWAS and EPH have confirmed some of this analysis, but questions remain as to the nature of interference effects that could occur on a full scale prototype.

It is worth noting that the work that the HYSWAS studies are based on is now nearly 8 years old. There have been significant improvements made, particularly in SWATH design, that HYSWAS may be able to exploit. Contoured hulls for improved drag characteristics could be utilized, as well as advanced transmission systems. It is conceivable that an updated HYSWAS design could be more competitive than the notional 2000 ton concept studied. The Advanced Hydrofoil Office (Code 1150) at DTNSRDC has submitted a proposal to the Coast Guard for a conceptual design study on the application of a HYSWAS conversion on an existing U.S. Coast Guard WPB Cape Class cutter. A study of this kind could offer an update on HYSWAS state of development taking into account current SWATH and large Hydrofoil technology.

References

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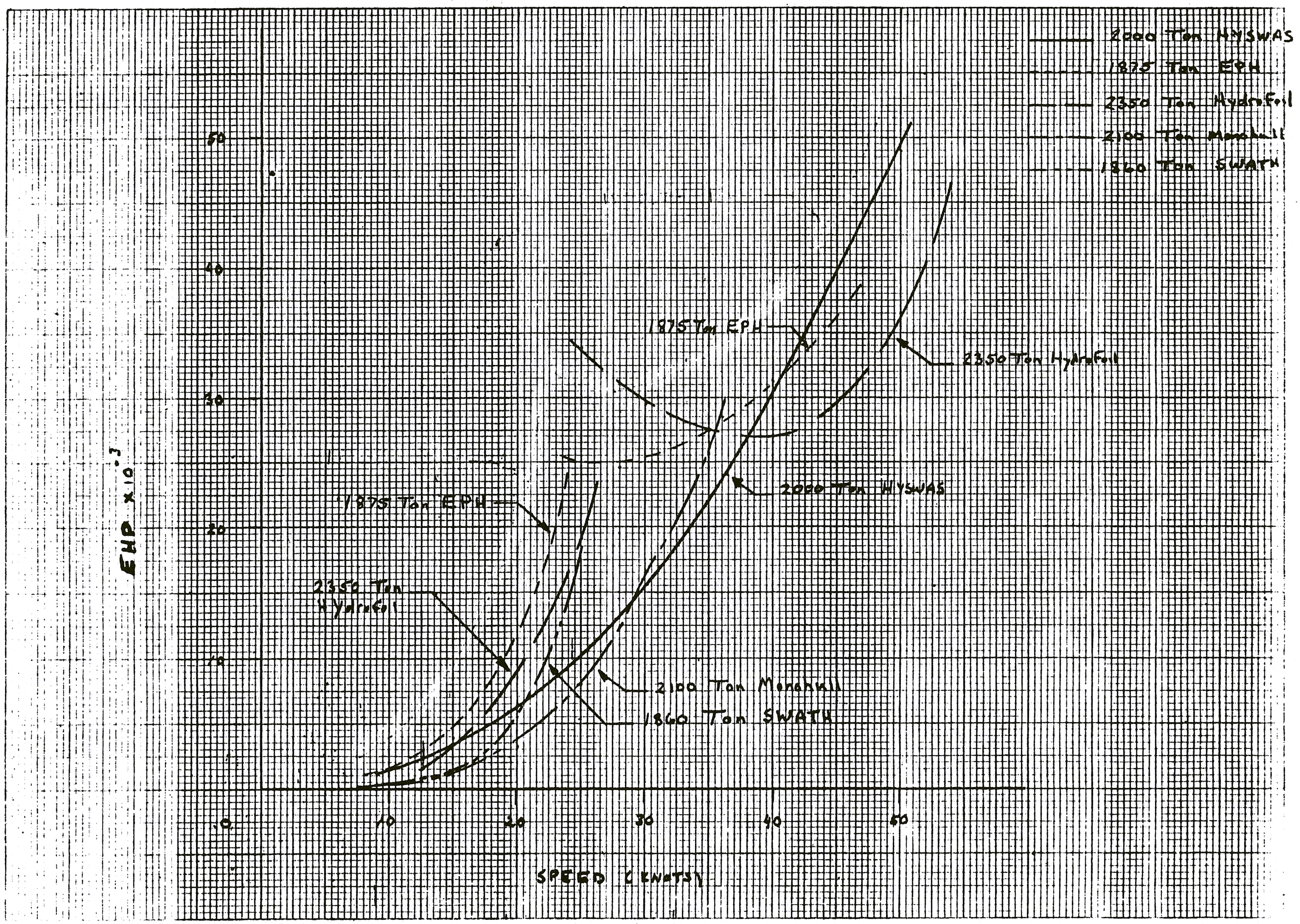
5. Lee, C.M., "Determination of Size and Location of Foils for 2000 Ton Hydrofoil Small Waterplane Area Ship (HYSWAS) for Vertical-Plane Stability," David Taylor Naval Ship R&D Center, Report No. SPD-648-01, November 1975.

6. Nappi, N.S. and F.M. Lev, "Structural Design of a 2000 Ton Hydrofoil Small Waterplane Area Ship (HYSWAS)," David Taylor Naval Ship R&D Center, Technical Note N-303 (June 1975).


2000 Ton HYSWAS
1875 Ton EPH
2350 Ton HydroFoil
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1860 Ton SWATH
1875 Ton EPH
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2000 Ton HYSWAS
1875 Ton EPH
2350 Ton Hydrofoil
2100 Ton Monohull
1860 Ton SWATH
EHP x10⁻³
SPEED (KNOTS)
50
40
30
20
10
0
10
20
30
40
50