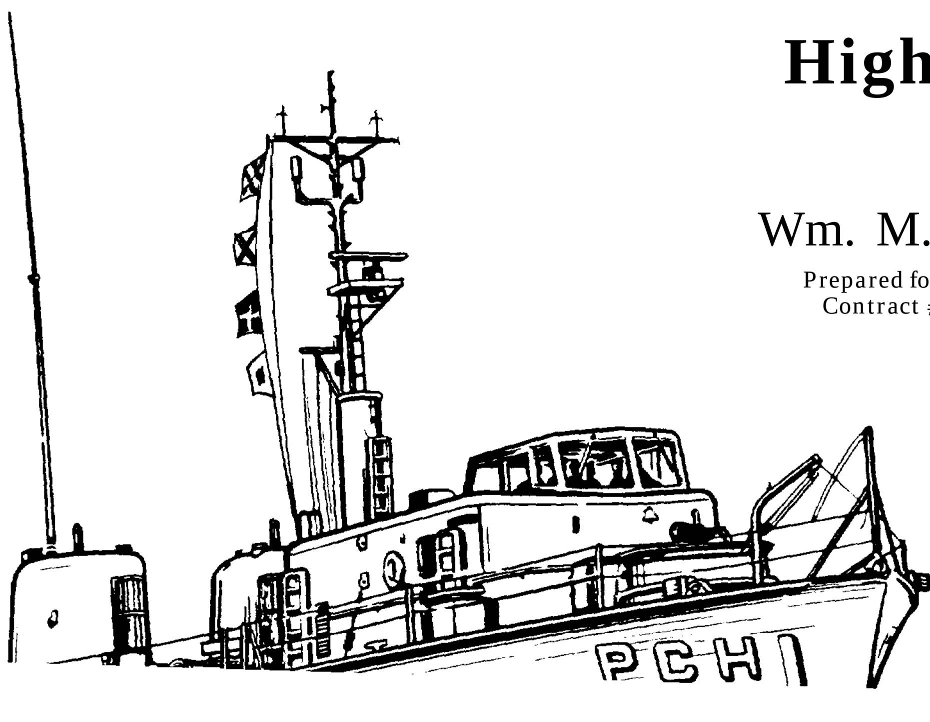
TWENTY FOILBORNE YEARS

THE U.S. NAVY HYDROFOIL

High Point PCH- 1



Wm. M. Ellsworth

Prepared for DTNSRDC under
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FD 36 and FD 40

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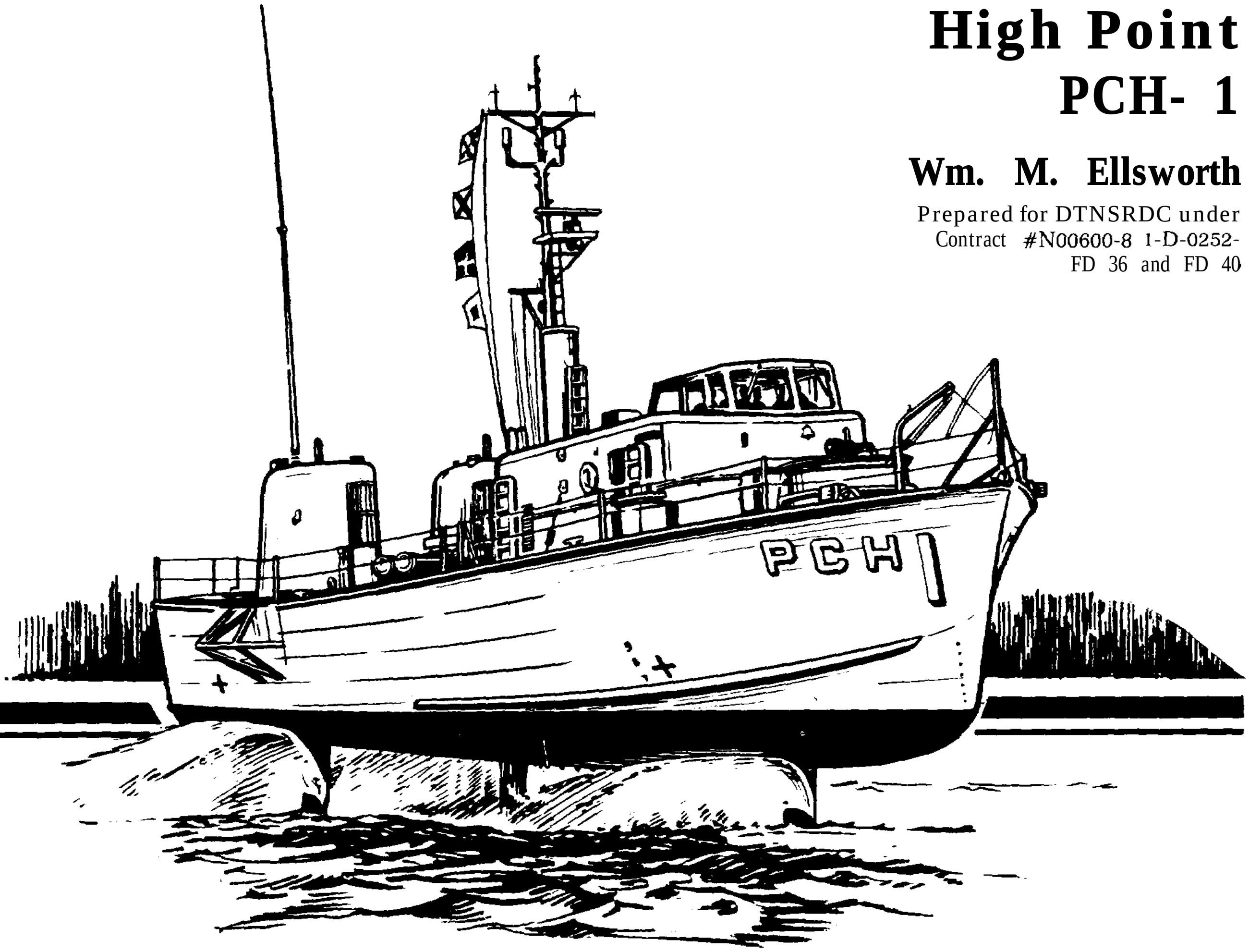

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Abstract

Early developments of hydrofoil craft in North America and Europe from the turn of the century to the Second World War are reviewed briefly. This establishes a foundation and places in context a more detailed examination of events leading up to the concept of the U.S. Navy's first operational hydrofoil, the HIGH POINT (PCH- 1). The conceptual design by the Navy's Bureau of Ships, Code 420; the contract design by BuShips Code 440; the acquisition by the Type Desk, BuShips Code 526; and the detailed design and construction by The Boeing Company and their principal subcontractor, the Martinac Shipbuilding Company, which was overseen by the Supervisor of Shipbuilding in Seattle, are discussed at some length. This is followed by a description of early trials and tribulations leading to a decision by the Chief of Naval Operations not to deploy the HIGH POINT to the Fleet but to utilize it as an R&D ship to further refine the criteria for design and explore the mission utility of hydrofoils. The formation of the Naval Ship R&D Center Hydrofoil Special Trials Unit (HYSTU) as a tenant activity of the Puget Sound Naval Shipyard and the many trials and ship modifications that took place over the years that followed are described, with emphasis on the lessons learned. This is the story of a unique ship and the more than twenty years of its utilization as an R&D vehicle which laid the foundation for the Navy's currently operational squadron (PHMRONTWO) of six Patrol Hydrofoil Missile (PHM) ships. It is also the story of many dedicated people; the officers and crews of the HIGH POINT, the civilian and military members of the Navy Engineering and R&D community, and the contractors. They were the backbone of the U.S. Navy's hydrofoil R&D program.

Preface

This is the story of the U.S. Navy's first operational hydrofoil ship, HIGH POINT (PCH-1); her conception, design, acquisition, trials (and tribulations), and her maturation. It is also the story of the people who played a role in the development of the hydrofoil concept; the naval officers and enlisted personnel; the navy civilians in the research, development, design, and acquisition communities; and the contractors who were an integral and necessary part of the development team. The fact that the story actually spans a period of some seventy years demonstrates that the hydrofoil ship was not a new concept. However, it took a very long time to bring it to a level of maturity adequate to convince the U.S. Navy of its utility as a new fleet asset. Change comes hard and requires dogged persistence on the part of those who seek to advance new and unconventional ideas.

The telling of the HIGH POINT story was the inspiration of my long time good friend and colleague James Lee Schuler. He was, for many years, the R&D Program Manager for Advanced Ships and Craft in what was once the Bureau of Ships and is now the Naval Sea Systems Command. A short time prior to his retirement from federal service, he was visiting the PCH at the David Taylor Naval Ship R&D Center (DTNSRDC) Hydrofoil Special Trials Unit (HYSTIJ) in Bremerton, Washington. He was accompanied by CDR Dave Patch, USN, Project Officer for advanced ships in OPNAV (OP-32). As they looked at the ship. which had never been in better condition. he was struck by the realization of how difficult it would be to convey adequately to someone new to the program, the true scope of the endeavors that had gone into the process of introducing hydrofoil ships into the Fleet. Upon his return to Washington, Jim Schuler contacted me and proposed that I undertake the task of writing a chronicle that would provide a detailed record of the people and events associated with the conception, design, construction, and employment of this very special ship. Having just retired from federal service, and having spent a good portion of my professional career involved with the development of advanced ships and craft, how could I do other than enthusiastically accept the challenge. In retrospect, I must admit to a substantial underestimate of the magnitude of the task. Having been intimately involved with pertinent events during most of those years, I found it most difficult to restrain my urge to add more and more material to the story. As a result. it has taken more than a year longer than originally planned. It has. however, been a labor of love, and I only hope that my emotional attachment has not resulted in too much detail of little interest to most readers.

In the course of writing the history of PCH, I found the DTNSRDC computerized Advanced Ship Data Bank, which was created during my watch. to be an invaluable source of information. As of this writing. it is understood that difficulty is being experienced in finding the funds required to maintain this unique reference source. Many of the references cited herein are likely to be found only in this Data Bank. It is essential that it be maintained and remain accessible to the R&D community as an irreplaceable data and information repository. I strongly urge its preservation. It has been my experience that the existence of valuable historical information is quite fleeting. It is most difficult to find material much beyond about 20 years or a technical generation after its creation, unless a serious and studied attempt is made to preserve it for posterity. Further, we must remember the old admonition that ***those who ignore history are doomed to repeat it.***

In tracing the course of HIGH POINT history. I found it helpful to create a chronology of key events in order to sort out the many occurrences that had some significance to the story. This chronology has been included as Appendix A with the expectation that it also will be of value to others who may have a need to recall the dates of such events as organizational changes and individual tours of duty during this period, In a similar vein. I found it necessary to reconstruct. in part, the PCH Operational Log which is reproduced in Appendix B. It provides a record of the time the ship actually spent on the foils. The limited number of foilborne hours, which are summarized in Appendix C, may come as some surprise. It is, of course, due to the early unreliability of the ship and its employment as an R&D craft. On the other hand, even those hydrofoils now in the Fleet may be expected to spend more than half of their peacetime operating life in the hullborne mode.

In gathering material for the PCH story, I interviewed a large number of individuals who have played, and in many cases continue to play. an important role in the development of hydrofoil ships. Most of these interviews were taped. They included several with former Officers-in-Charge of PCH, all of whom are listed in Appendix D; present and former civilians and military personnel in the Naval Sea Systems Command; members, past and present, of the DTNSRDC Hydrofoil Development Program Office and Special Trials Unit; and past and present employees of Boeing Marine Systems. It is they and the many others in this team effort who really wrote the story of HIGH POINT. Their high level of integrity, dedication, motivation, competence, and perserverance has always been an inspiration and I hope that this history does them justice.

Wm. M. Ellsworth

Rockville, MD
September 1986

CHAPTER 1

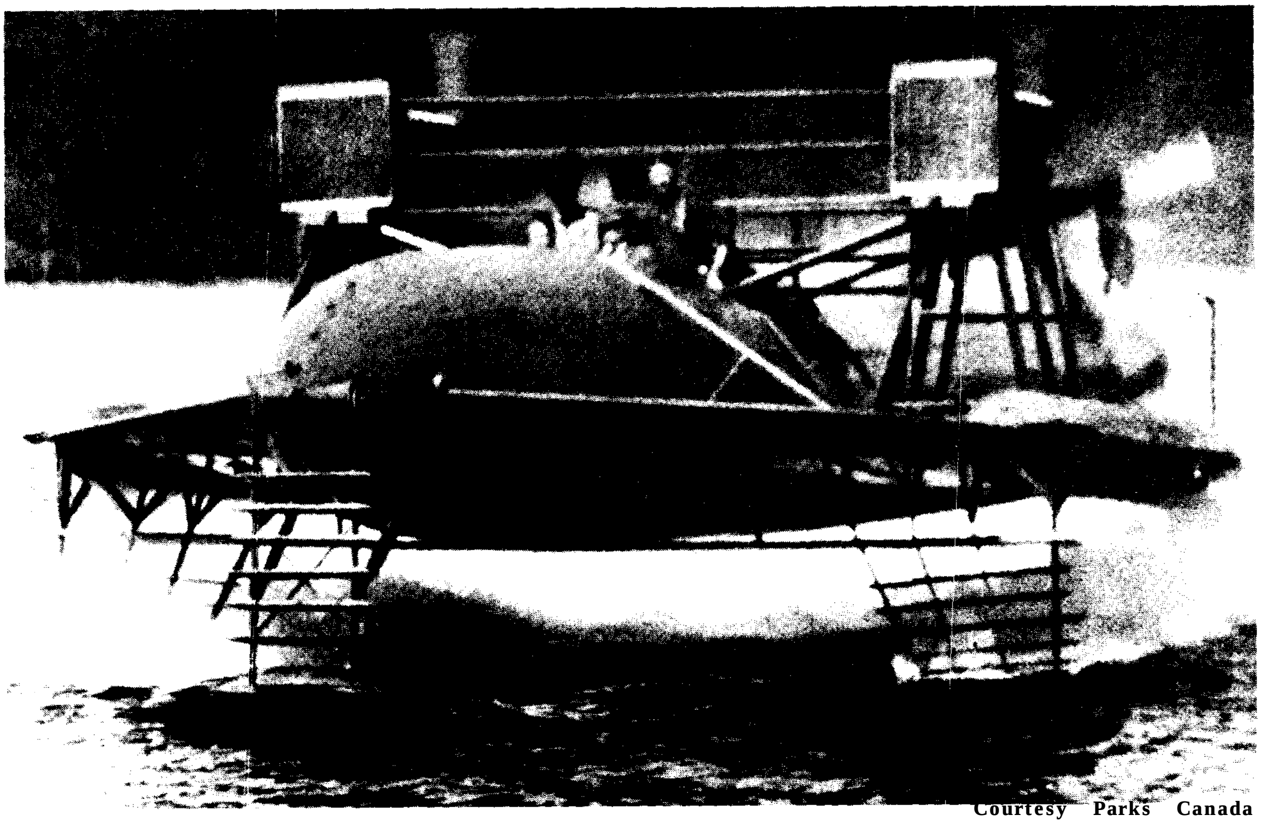
Hydrofoil Evolution

EARLY TEST CRAFT

In setting the stage for conception of the U.S. Navy's first operational hydrofoil ship, HIGH POINT (PCH-l), it is appropriate to review some of the key historical events in the earlier evolution of hydrofoil craft.

During the early 1900's there were a number of experimenters in North America who evidenced interest in hydrofoil concepts. In 1907 Wilbur and Orville Wright experimented with a hydrofoil catamaran on the Ohio river near Dayton, Ohio. Unfortunately, these tests were stopped by low water in the river and, to the later benefit of the aviation industry, they turned their attention elsewhere. Certainly the most spectacular experiments of the time were those of Alexander Graham Bell and his associate Frederick W. (Casey) Baldwin, References 1, 2, & 3. Bell, a U.S. inventor, found escape from the summer heat of Washington, D.C. in Baddeck, Nova Scotia, where he set up laboratories and workshops to conduct his research. After visiting Signor Enrico Forlanini in 1911 and witnessing tests of his 1.6-ton hydrofoil boat on Lake Maggiori, Italy, Bell is understood to have bought some of Forlanini's patents. Back in Baddeck he began a series of model tests of hydrofoil craft which he called *Hydrodomes*. These culminated in the HD-4 which set a world speed record of 70.85 miles per hour in 1919.

The HD-4, Figure (1), weighed about 11,000 pounds and was 60 feet long. The main torpedo-shaped hull, which was about six feet in diameter, was constructed of 1/2-inch wood planking reinforced with wire and covered with canvas. The two rectangular pontoon floats were 14 feet 9 inches long and were attached on 20-foot centers. The craft was powered by two 12-cylinder, 350 H.P., water-cooled, Liberty aircraft engines. These drove airscrews to produce a combined total thrust of 3400 pounds. The most significant design feature was what came to be called the Bell-Baldwin ***ladder*** foil system. There



Courtesy Parks Canada

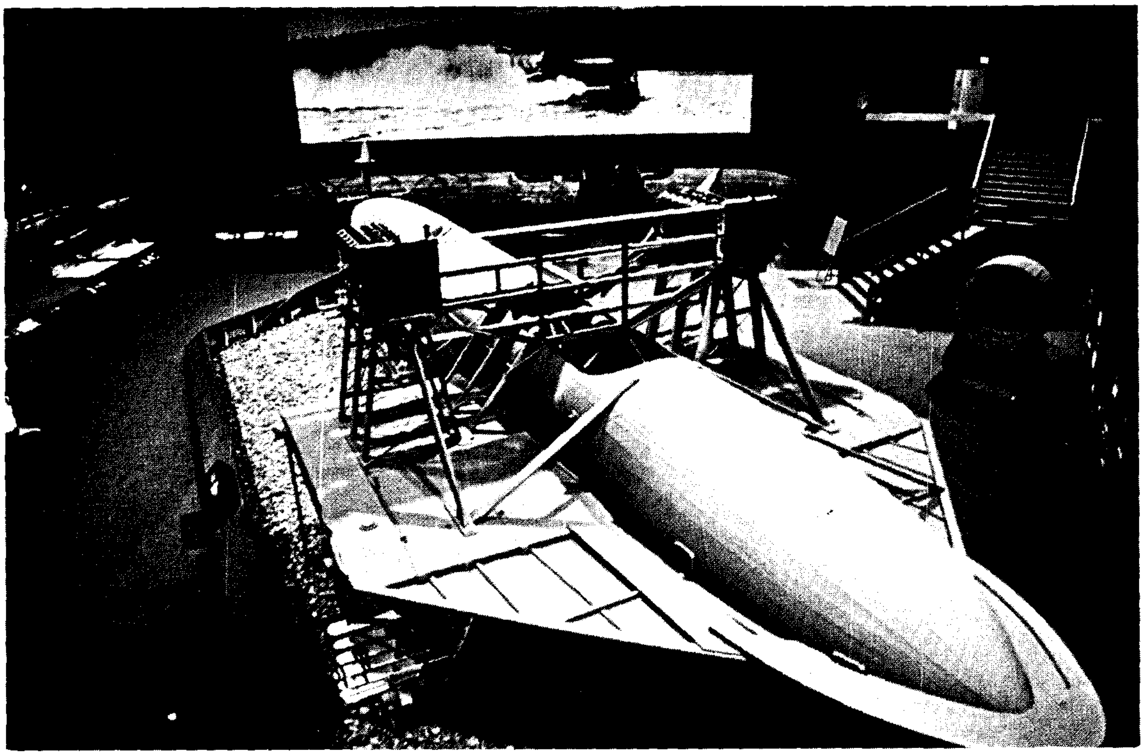
Figure 1. Bell-Baldwin Hydrofoil HD-4

were three main sets of foil ladders which produced lift; two forward under the sponsons and one aft under the hull. Foil sections were developed empirically by Baldwin and Phillip L. Rhodes, a New York naval architect who had joined their project. It was claimed that these foils produced a lift/drag ratio of eight. The aft foil ladder was steerable and acted as a rudder. In addition. there was another ladder foil placed at the nose of the craft. This so-called *preventer* foil, which came clear of the water at high speed, was designed to avoid *plough-in*, particularly during takeoff. **It may also be noted that** there were three sets of wooden airfoils attached above the hull, as originally proposed by Forlanini, to give added damping in choppy water.

The HD-4 represented a remarkable accomplishment even by modern standards. Between 1918 and 1939 Baldwin and Rhodes continually sought to interest the U.S. Navy in the military applications of hydrofoil craft. In this they were unsuccessful. Some say it was because of a tendency of the Bell-Baldwin craft to porpoise. During this same period, about a dozen small hydrofoil pleasure craft, up to 35 feet in length, were designed under the direction of Phillip Rhodes. These were reported to have been quite successful, Alex Barbour and J. Birette, of the Parks Canada Bell Museum in Baddeck, Nova Scotia, completed in 1979 a full-scale replica of the HD-4, Reference 4, which is now on display in the museum. Figure (2).

EUROPEAN DEVELOPMENT

Perhaps the most significant new thrust in development of the hydrofoil concept did not come until 1927. It was during that year that Baron Hanns von Schertel began to experiment with hydrofoil craft



Courtesy Parks Canada

Figure 2. Full-Scale Reconstruction of HD-4

in Germany, a year after he began studies at the Technical University in Rerlin-Charlottenburg. In Reference j, he describes some of his experiences as follows:

> The first trial runs in Berlin on Lake Wannsee with a boat powered by a very obsolete air-cooled aircraft engine and propelled by an air screw, finished catastrophically. The old engine did not give enough power for taking off. When I noticed that the steering control was nearly ineffective I cut off the ignition, but the motor was already so much overheated that it went on running perfectly by self-ignition. The boat approached more and rnore the numerous, frantically escaping boats which had gathered around me and I had to count myself very lucky that 1 did not hit one of the fleeing boats with the propeller. The adventure finished with me crashing into an island on the lake. I abandoned the fully-submerged foil system for the seventh test boat built in 1935, in which all acquired experiences had been incorporated. The craft was provided with a V-shaped front and aft foil with trapezoid outer portions. She performed fully satisfactorily under all weather conditions on the Rhine River. With only 50 hp she carried seven persons at a speed of nearly 30 knots. This craft proved for the first time that a hydrofoil is a fast and economical means of transportation and that its seaworthiness could no longer be doubted. This attracted representatives of the German Navy, Air Force, Ministry of Transportation and Finance and finally brought about the partnership of Gotthard Sachsenberg, with his shipbuilding organization.

In 1937, after a demonstration trip from Mainz to Cologne on the Rhine river, the Cologne-Dusseldorf Steamship Co. placed, with Gebruder Sachsenberg A.G. at Dessau, the world's first order for a com-*mercial* hydrofoil boat, To be on the safe side, the Schertel-Sachsenberg syndicate decided to build

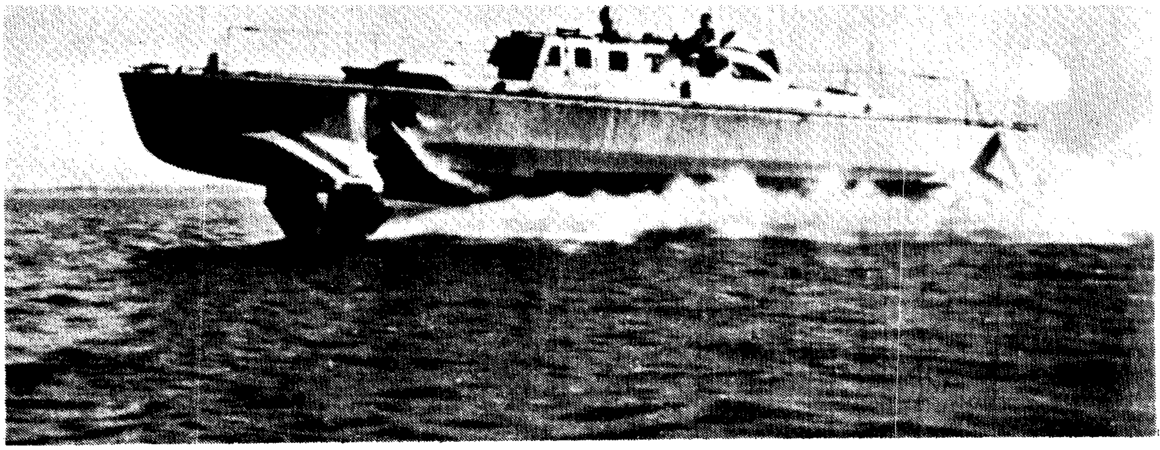


Figure 3. Schertel-Sachsenberg Hydrofoil VS-6

a larger test boat. It was completed at the outbreak of WWII and was later demonstrated to the German Navy. The war, however, prevented the fulfillment of the original order.

During WWII, von Schertel and the shipbuilder Sachsenberg collaborated in the construction of a number of hydrofoil boats for the German Navy, Reference 6. Research and design was under the direction of Prof. Georg Weinblum. (It may be noted that after WWII Prof. Weinblum, along with other German scientists, came to the David Taylor Model Basin when German scientists and engineers were recruited by the U.S. Navy under OPERATION PAPERCLIP.) In 1941, they launched the 17-ton VS-6, Figure (3), a mine-layer hydrofoil. It was 52.5 feet in length and was capable of speeds up to 47 knots. It was powered by two Hispano-Suiza gasoline engines of 1560 HP. In 1943 the 80-ton VS-8, Figure (4), was launched. It was 150 feet long and was designed to carry tanks and supplies to support Rommel's North African campaign. The VS-8, although originally designed for a top speed of 45 knots, was actually limited to 37 knots. This was because the only engine that could be made available at the time was a Mercedes-Benz diesel with 1800 HP. The underpowered craft was stable in head seas but came off the foils in some tests in following seas. Further, in 1944 it suffered a casualty due to sabotage and was eventually beached. At this point it was decided to concentrate on further improvements to the VS-6. Meanwhile, another 17-ton craft, VS-7, Figure (5), designed by Dr. Otto Tietjens, was built in Schleswig at the Vertens Yacht Yard. Tietjens had begun his earlier experiments in Philadelphia, PA in 1930 before returning to Germany and continuing his work in parallel with von Schertel.

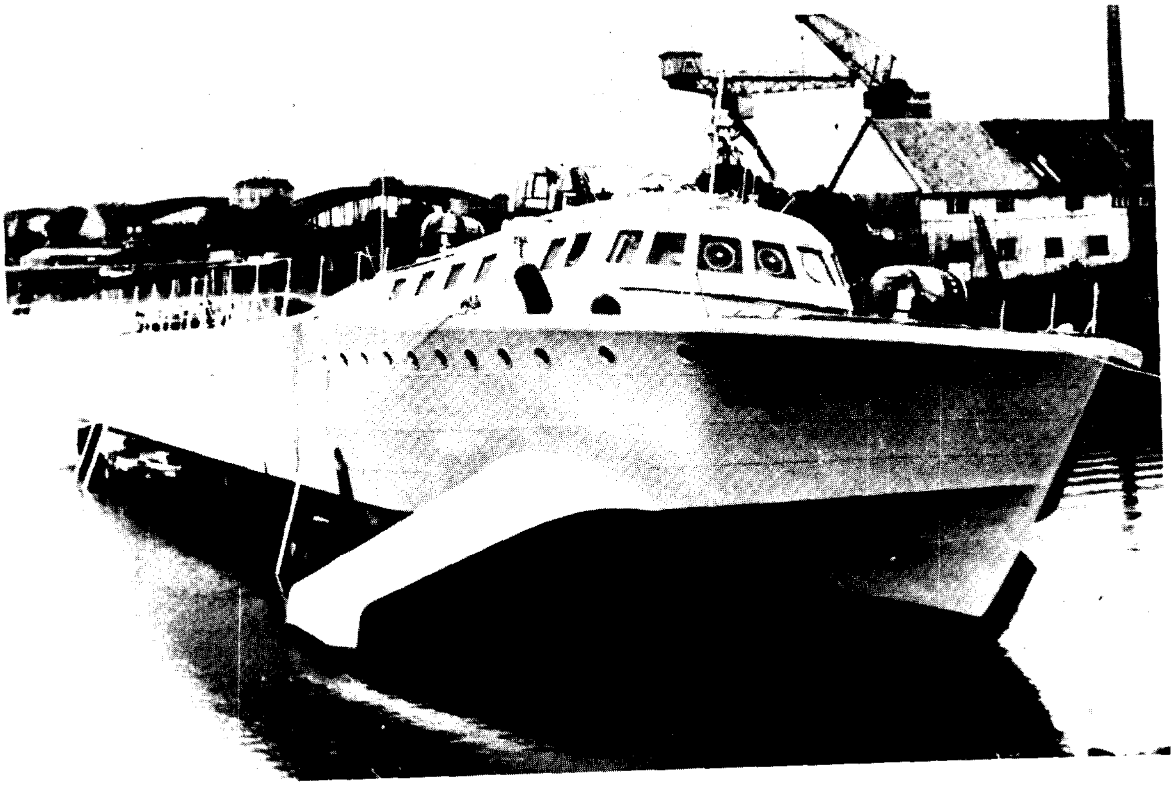


Figure 4. Schertel-Sachsenberg Hydrofoil VS-8

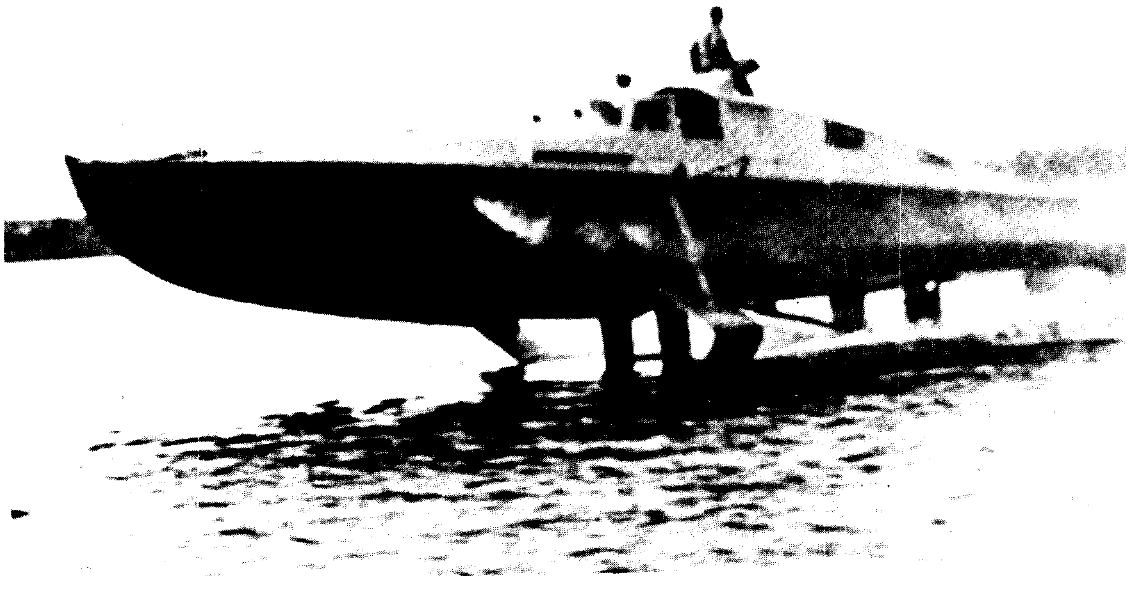


Figure 5. Tietjens Hydrofoil VS-7

Figure 6. Supramar Hydrofoil PT-10, FRECCIA D'ORO

Comparison tests of the VS-6 and VS-7 were run and the latter proved to be much faster, attaining speeds up to 55 knots. However, the VS-7 demonstrated much poorer stability and maneuverability than that of the von Schertel boat.

The final hydrofoil craft in this series was the 46-ton VS-10. It was 92 feet long and was designed as a torpedo boat capable of speeds up to 60 knots. Unfortunately, the day before its launching, it was completely destroyed in an air raid.

The last hydrofoils constructed by Schertel-Sachsenberg before the end of WWII were two small, single seat torpedo boats. They were designed to launch a torpedo over the stern and escape at 50 knots. Tests of these boats were interrupted by the war's ending.

After WWII. it was forbidden in Germany to build boats with speeds in excess of 12 knots. This led von Schertel and his partner Sachsenberg to move to Switzerland. There, in 1952, at a small shipyard in Stansstad, they completed the PT-10, Freccia d'Oro, (Golden Arrow). Figure (6). This 7-ton craft had 32 seats and was capable of speeds up to 35 knots. On 29 May 1952, the Konsortiun of Schertel and Sachsenberg joined with the Kredit and Verwaltungs-Bank, Zug, to form Supramar, A.G. based in Lucerne. That same year the Freccia d'Oro began the world's first hydrofoil passenger service on Lake Maggiore. In 1954 Supramar gave their first license to build craft of their design to the Leopoldo Rodriquez Shipyard in Messina, Italy. (It is with much sadness that the author notes the death of Baron von Schertel on 18 April 1985, in Stansstad, Switzerland, shortly after celebrating his 83rd birthday. He was a true pioneer and a major contributor to the development and application of hydrofoil craft.)

In 1955 Rodriquez started production of the 32-ton PT-20, a 72-passenger hydrofoil with a cruise speed of 35 knots, Figure (7). The first of the series was named Freccia del Sole. It was built to satisfy

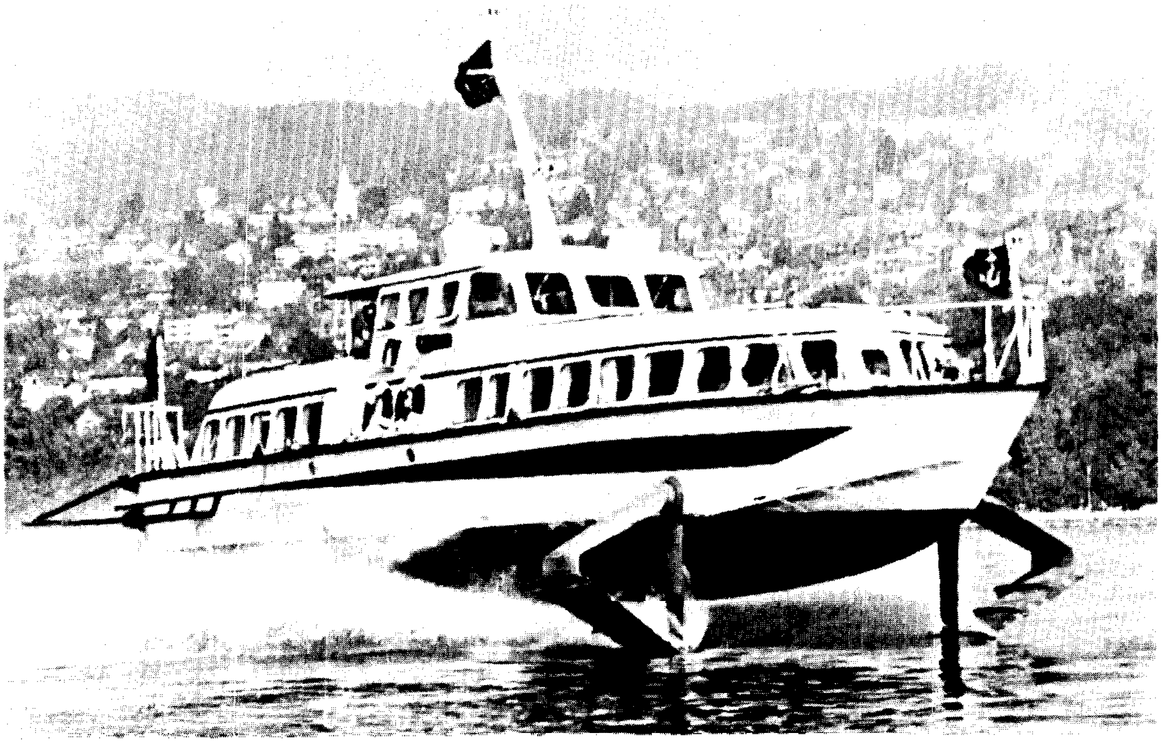


Figure 7. Supramar/Rodriquez Hydrofoil PT-20

maritime regulations and became the first passenger hydrofoil to receive class certification. As of this writing more than 150 hydrofoils have been built under license to Supramar of which by far the largest number were built by Rodriguez up until 1971, Reference 7. Then Rodriquez undertook production of their own craft which were designated the RHS series (Rodriquez Hydrofoil Ship). Figure (8) shows the RI-IS-160 passenger hydrofoil which is configured to carry about 160 passengers. (The latest commercial hydrofoil in this series is the 200-passenger SUPER JUMBO RHS-200.)

EARLY U. S. NAVY DEVELOPMENTS

In the United States at the end of WWII, the work of such pioneers as von Schertel and Tietjens did not go unnoticed by the U.S. Navy. The Office of Naval Research, and the Navy's Bureau of Ships, with some support from the Bureau of Aeronautics, initiated in about 1947, a research program to further develop the hydrofoil craft concept, Reference 8. The objective was to establish a technology base adequate for the generation of criteria for design of operational craft to meet projected military requirements. A variety of analytical and experimental projects were undertaken by industrial contractors as well as private, university, and government laboratories. The Bureau of Ships' David Taylor Model Basin was one of the leading laboratories in this program. Studies were focused on design of optimum foil sections, cavitation and ventilation phenomena, hydroelastic instability, structures and materials, hull form, propulsion, control, and many other technological problem areas. References 9, 10, 11, 12, 13, & 14 provide an overview of hydrofoil development during this period.

At an appropriate point in this expansion of the technology base, test craft. designs were undertaken. In 1952 three craft were constructed to investigate some of the basic design issues. The first of these

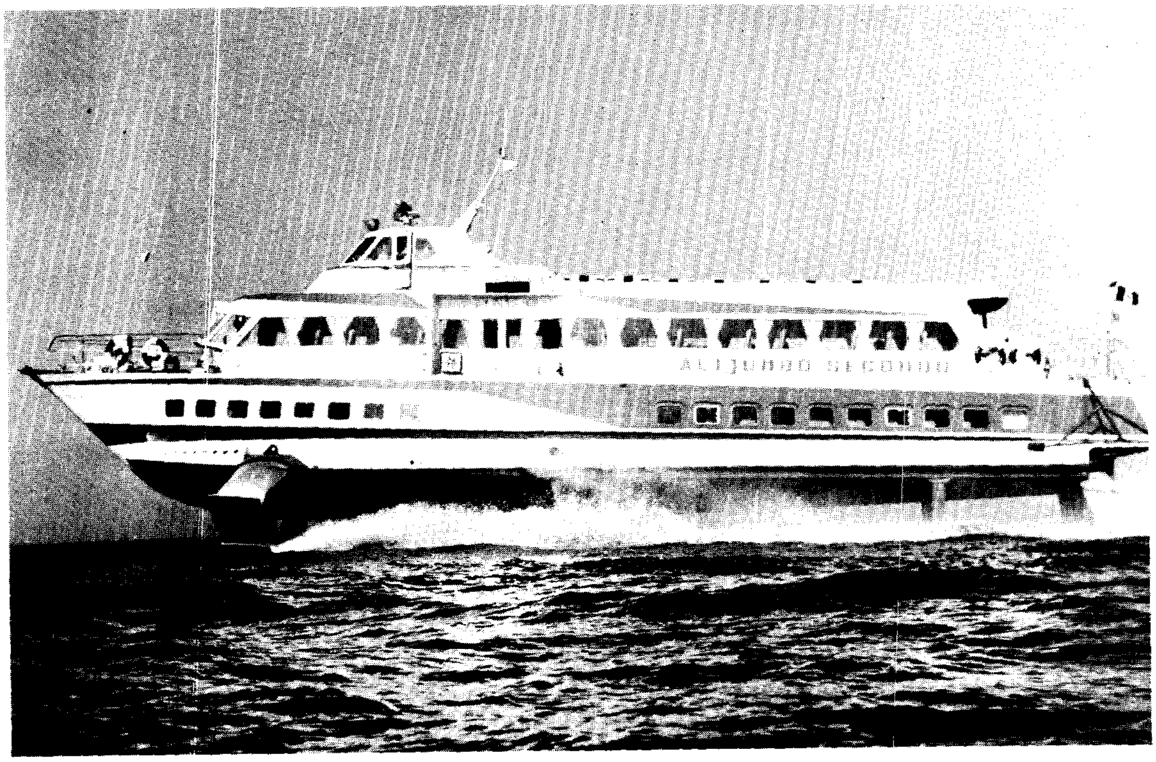


Figure 8. Rodriquez Hydrofoil RHS-160

to be completed was the HC-4, LANTERN. Figure (9), developed by Dr. Vannevar Bush and his company, the Hydrofoil Corporation of America, located in Annapolis, MD. The HC-4 was 36 feet long, 22 feet in beam and displaced 22,200 pounds fully loaded. It was one of the first to employ fully-submerged foils and was controlled in flying height and pitch by a sensor which measured the height above the water.

In the same time frame, a second test craft, designated the XCH-4 (Experimental Carl Hydrofoil No. 4), Figure (10). was completed by John H. Carl and Sons in Long Island, New York, Reference 15. This craft, known as the "Carl Boat" after the principal designer, William P. Carl, was 54 feet long, 19 feet in beam, and displaced 16,500 pounds. A system of ladder foils on two struts forward and a single strut aft supported the seaplane-like hull. Two 450 HP Pratt & Whitney R-985 Wasp Jr. air-cooled engines with air propellers were mounted on the top of the hull to power the craft. The ladders were comprised of V-foils which permitted smooth transition from the hullborne to the foilborne mode. In 1954 this craft attained a speed of about 78 knots in smooth water, exceeding Bell's record set in 1919. Because of the XCH-4's appearance, a story is told of a farmer along Chesapeake Bay who called the Coast Guard during XCH-4 trials to report that a seaplane had been trying unsuccessfully to take off for several days and undoubtedly needed assistance.

Shortly after final tests of the XCH-4, Bill Carl left J. H. Carl and Sons to form his own company, Dynamic Developments, Inc. His partner in this venture was Bob Gilruth, another hydrofoil enthusiast. They initially developed and produced a hydrofoil kit for conversion of small runabouts. Grumman Aircraft Engineering Corp. purchased an interest in the company as a base for their entry into the hydrofoil market. Eventually they acquired the company.

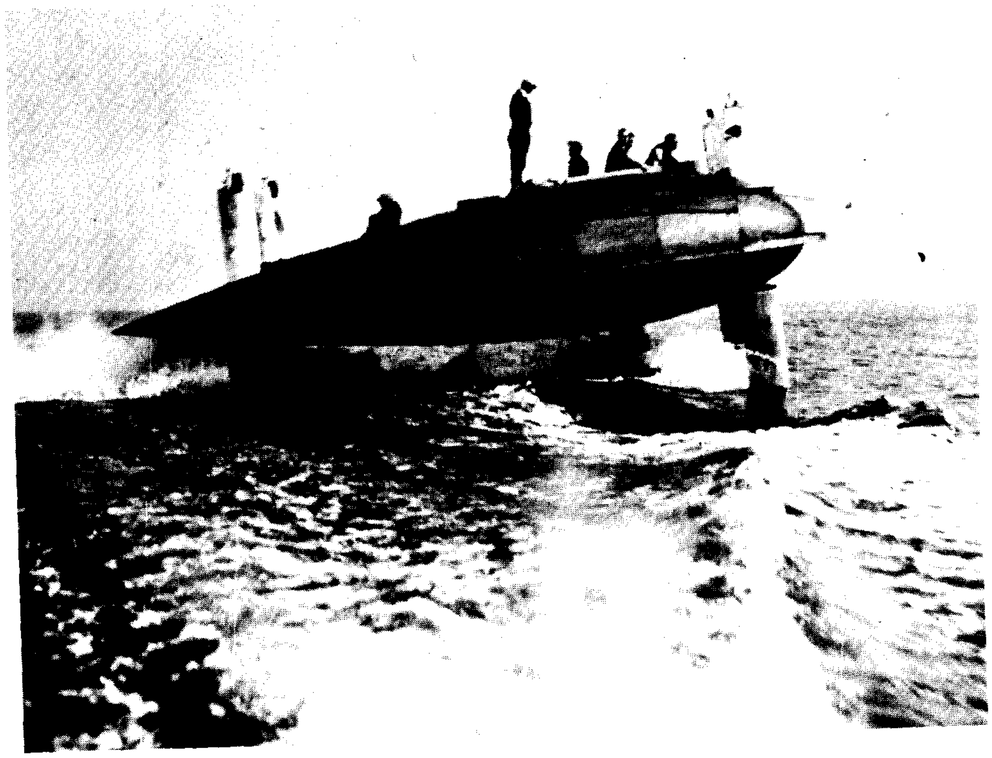


Figure 9. Hydrofoil Corporation LANTERN, HC-4

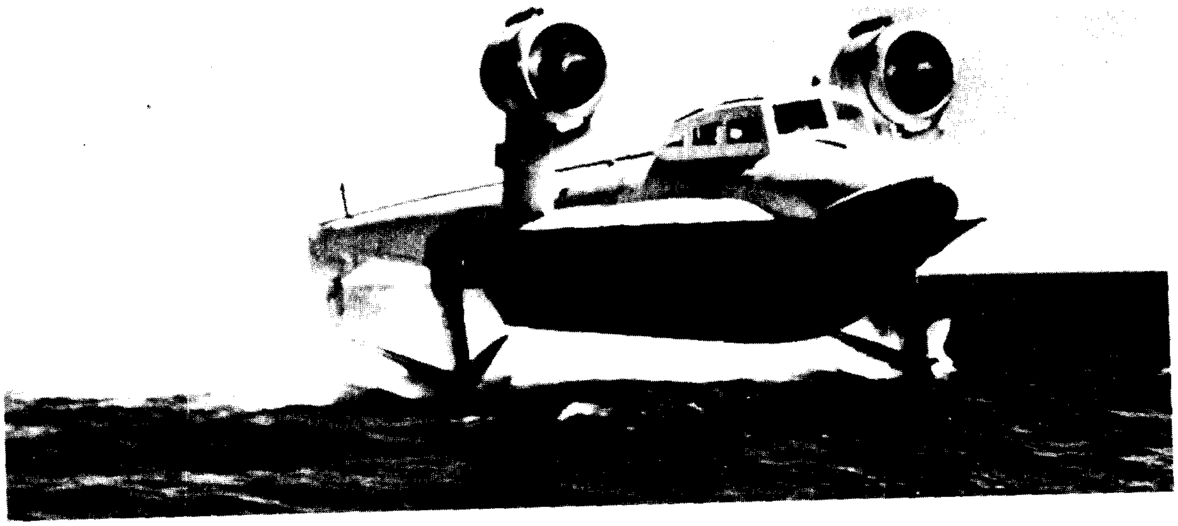


Figure 10. Experimental Carl Hydrofoil XCH-4

Figure 11. Baker Hydrofoil, HIGH POCKETS

The third test craft, named HIGH POCKETS, Figure (11), was built by Baker Manufacturing Co., Evansville, IN, References 16, 17, & 18. The hull, of conventional form, was constructed of fiberglass-reinforced plastic. It was **24** feet long overall with an extreme beam of about 15 feet including the V-foils on each corner. The maximum design displacement was 6000 pounds. The foils were solid extrusions of 24S-T4 aluminum of NACA 16-510 uniform section shape. T'he craft was powered by a Chrysler Crown Special gasoline engine, rated at 125 BHP, connected to a single propeller through a V-drive. The 45-degree V-foils proved significantly better in a seaway than the von Schertel *hoop* design. The craft operated in 5 to 6-foot waves off Pensacola, FL, attaining speeds up to about 35 knots.

HIGH POCKETS was used extensively to demonstrate the capabilities of hydrofoil craft including the first flight by a CNO when ADM Carney was given a demonstration in the summer of 1953.

THE LANDING CRAFT DIVERSION

In 1953 the Navy's focus shifted to the applicability of hydrofoils for landing craft. It is understood that this was motivated by the availability of funds to develop and purchase a large number of new LCVPs. It was proposed by hydrofoil enthusiasts to divert some of these funds to procurement of hydrofoil landing craft which offered the promise of a substantial increase in craft speed when assaulting a beach.

As a result of this interest, construction of several additional test craft was initiated to explore more fully this new application of the hydrofoil principle. The first of these was built by Baker Mfgr. Co. It was called HIGH TAIL, Figure (12), and was 20 feet long with a 5.5-foot beam and a displacement of 2,600 pounds. The craft had three retractable V-foils one forward and two aft. Mechanical sensors

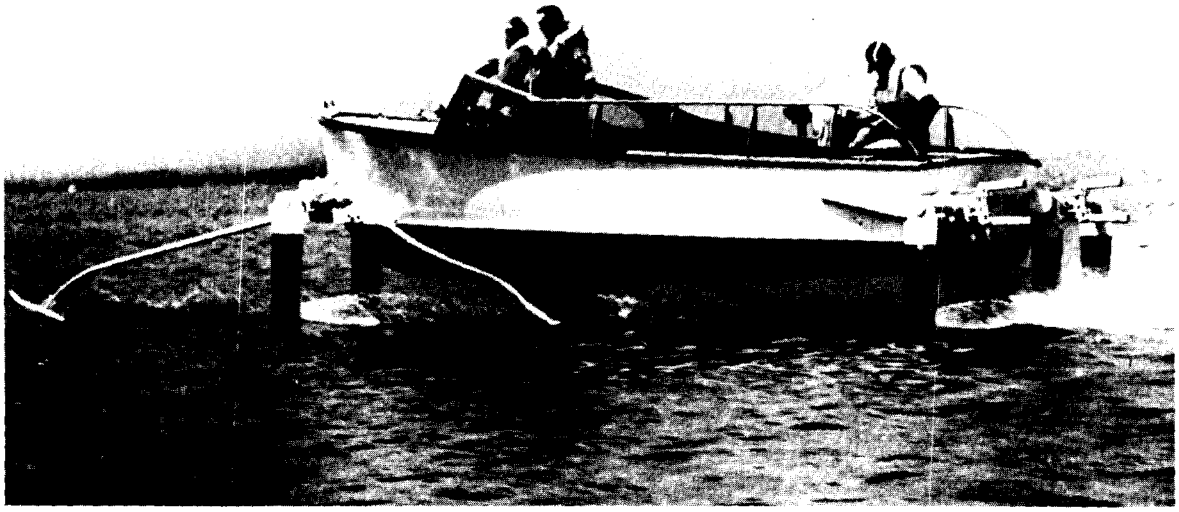


Figure 12. Baker Hydrofoil, HIGH TAIL

touched the water ahead of each foil and provided inputs to a mechanical control system. The forward foil was mounted on a vertical axis and provided foilborne steering. This craft attained a speed of 23 knots.

During the following two years design and construction of two larger landing craft for vehicles and personnel, designated LCVP(H), was undertaken. One was the HALOBATES, Figure (13), which was designed and constructed by Miami Shipbuilding Corporation. The President of this company was Robert J. Johnston a former Engineering Duty (ED) Commander in the Bureau of Ships. He had been transferred to the Office of Naval Research in 1952, relieving CDR Patrick Leehey, as Hydrofoil Program Officer. Bob Johnston served in this capacity until 1954 when he left the Navy. His relief in ONR was LCDR Robert Apple.

HALOBATES, completed in 1957, employed mechanical "feeler" arms riding on floats projecting ahead of the craft to provide inputs to a mechanical foil control system. This principle was advanced by Christopher Hook, a hydrofoil designer from England who collaborated with Miami Ship in this venture. HALOBATES was actually a modified LCVP with the addition of a transverse bulkhead to make it a two-compartment configuration. It was 35.5 feet long with a 11.7-foot beam and a full load displacement of 31,000 pounds. Power was provided by a 630-HP Hall-Scott gasoline engine. The foil and propulsion system design was complicated by the requirement for retraction which was provided by ball-screw actuators.

In flight tests HALOBATES successfully demonstrated speeds up to 34 knots in j-foot waves but, the use of mechanical feelers was not satisfactory to the Navy. As a result, a change was made to put a stepped resistance along the leading edge of the forward struts to provide a height signal based on the wetted length. At the same time, it was decided to replace the gasoline engine with an AVCO T-53 gas turbine. The craft then successfully completed its test program equipped with the Navy's first hydrofoil electronic autopilot and gas turbine power plant.

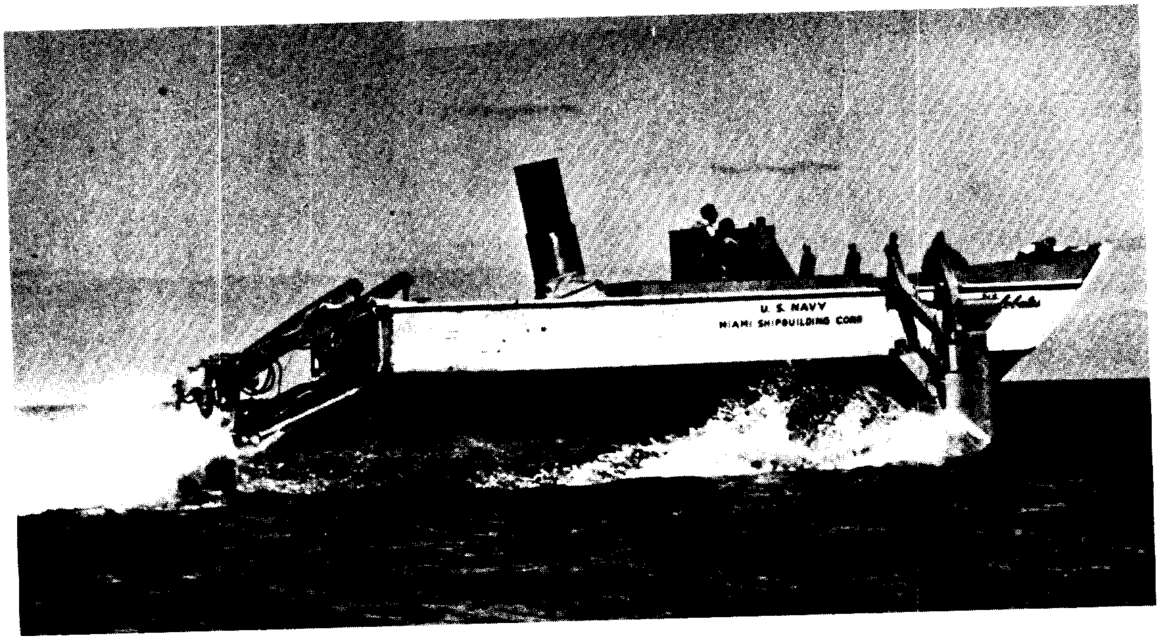


Figure 13. Miami Shipbuilding Hydrofoil, HALOBATES, LCVP(H)

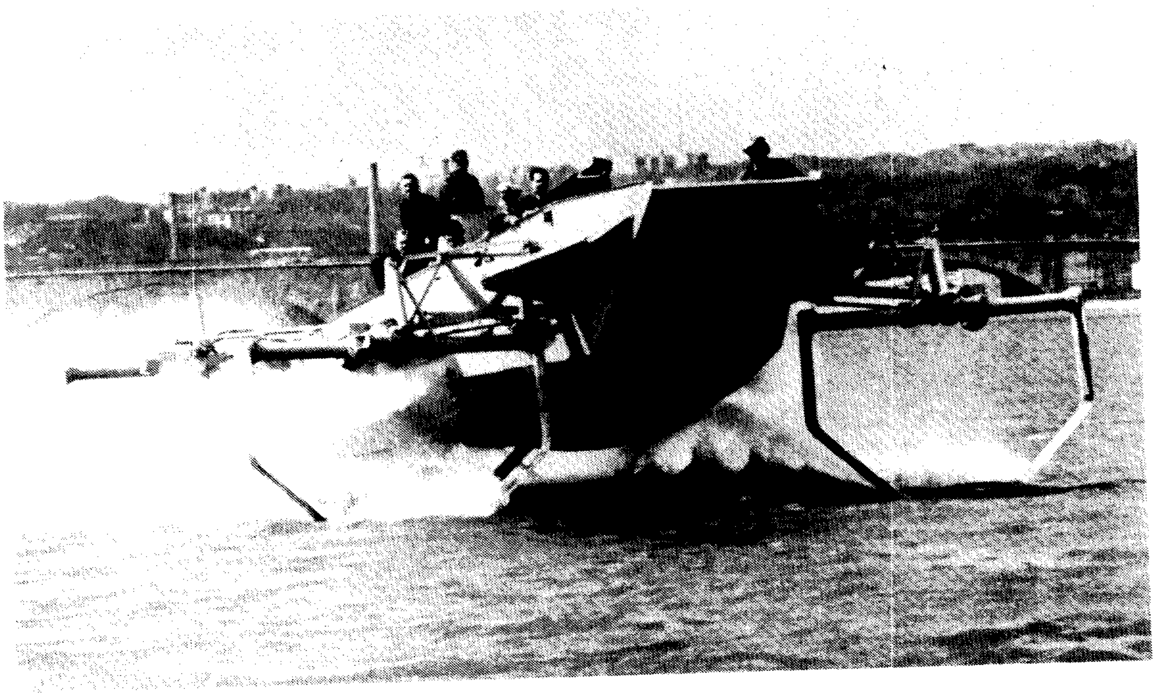


Figure 14. Baker Hydrofoil, HIGHLANDER, LCVP(H)

The second LCVP(H) was built by Baker Mfgr. Co. in the early 1960's and was named HIGHLANDER, Figure (14). It had four surface-piercing V-foils which were retractable and it could carry a payload of 8,000 pounds to the beach at 40 knots. It too was a modified LCVP much the same as HIGH POCKETS. It weighed about 10 tons in the light condition.

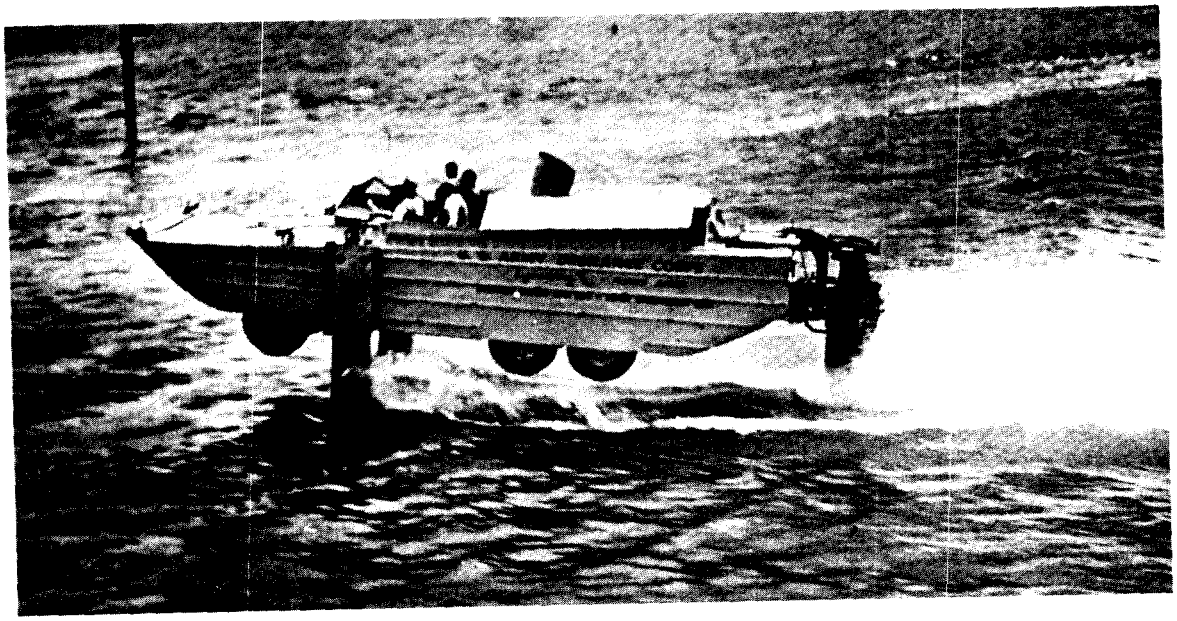


Figure 15. Miami Shipbuilding Flying DUKW

Figure 16. Avco Lycoming Hydrofoil Amphibian LVHX-1

During this period the U.S. Army also became interested in the potential of foils to increase the speed of their amphibious DUKW. Miami Ship, working with Avco-Lycoming, was given a contract in 1957 to demonstrate a "flying" DUKW. An Avco T-53 gas turbine engine was installed along with an elec-

Figure 17a. Foilborne

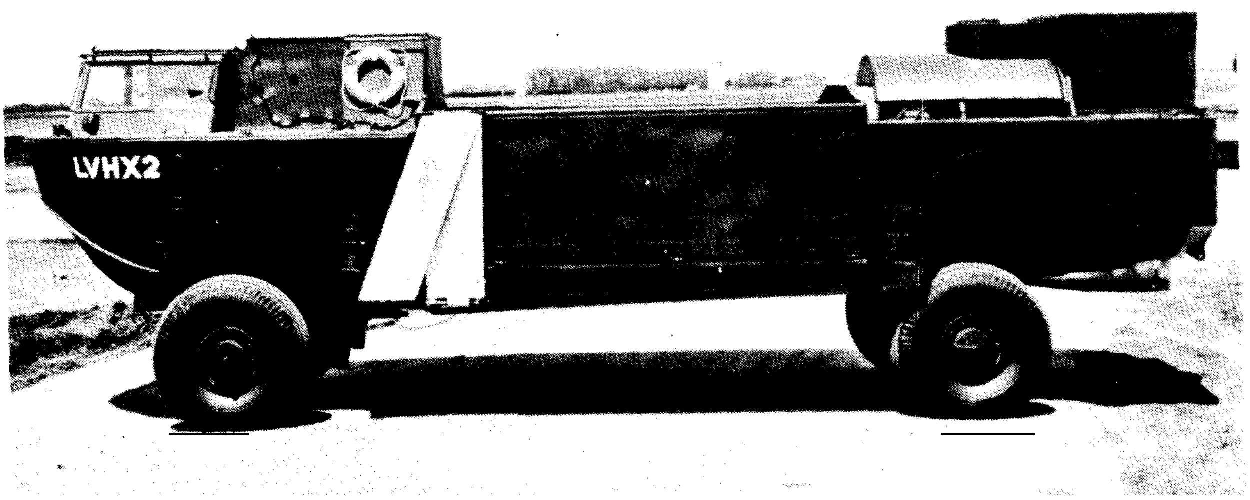


Figure 17b. On Wheels

Figure 17. FMC Hydrofoil Amphibian **LVHX-2**

tronic autopilot like that in HALOBATES. Retractable submerged foils were attached to complete the modification, Trials were run near Miami, Florida during which a speed of about 30 knots was achieved in calm water compared to the DUKW's normal water speed of around 5 knots.

In spite of the mechanical complexity of the Flying DUKW, Figure (15), as well as other disadvantages, the U.S. Marine Corps continued to have interest in the use of hydrofoils on wheeled amphibians. This led to their award of contracts for two competing designs of an LVHX. The LVHX-1, Figure (16), was built by Avco-Lycoming, and the LVHX-2, Figure (17), by FMC. Both were designed to meet the same requirement with aluminum hulls 38 feet long and a capability of carrying a 5-ton payload at a speed of 35 knots. LVHX-1 had a submerged-foil system and LVHX-2 employed surface-piercing foils forward with a single submerged foil aft.

During the trials program that followed it finally became clear that the complexities and costs of such features as foil retraction and high speed gas turbine propulsion presented too great a penalty to pay for the increased water speed. As a result, further pursuit of hydrofoil landing craft was terminated.

THE CANADIAN CONNECTION

After WWII, in Canada there was also a rekindled interest in hydrofoils. In 1948 Duncan Hodgson, a former Canadian naval officer, commissioned Bell and Baldwin's associate, Phillip Rhodes, to design a hydrofoil craft capable of setting a new world water speed record. Hodgson was subsequently persuaded to divert his craft to a demonstration of the military potential of the hydrofoil. In 1951 a project for this purpose was initiated at the Naval Research Establishment, Dartmouth, Nova Scotia. Michael C. Eames, a naval architect at NRE, was charged with the responsibility for this project. (He remains today as Canada's leading authority on hydrofoils and other advanced naval craft.) The hydrofoil designed by Rhodes was 45 feet long with a displacement of 5 tons. It was officially designated R-100 and unofficially named MASSAWIPPI in recognition of its having been built on Lake Massawippi in Quebec. The initial ladder foil configuration clearly reflects Rhodes' earlier association with the Bell-Baldwin team. In trials conducted by NRE this first design was found to be unsatisfactory. As a result, a complete redesign was made, Figure (18). The new foil system permitted an increase in displacement to 7.5 tons. Further trials in 1956 demonstrated good performance and speeds up to 45 knots were achieved in 6-foot waves.

An important joint IJ.S.-Canadian effort was included in the R-100 trials. The U.S. provided a three-bladed supercavitating propeller, designed according to Marshall Tulin of DTMB. for evaluation on the Canadian craft. After an initial structural failure of the blades, a strengthened version was successfully demonstrated. This led to later use of this type of propeller on both U.S. and Canadian hydrofoils.

With encouragement from the United Kingdom along with successful trials of R- 100, Canada decided to fund another test craft which was built in England by Saunders-Roe. This 17-ton craft, designated R- 103. Figure (19), was initially named BRAS D'OR, and later renamed BADDECK. It had several design features of special note. Although the foil configuration was similar to that of the modified R-100, the foils and struts, instead of being solid, were built up of aluminum sheet riveted over aluminum ribs and stringers. The hull was also aluminum instead of wood as used in R-100. Of particular note is the use of a center strut which housed a right-angle bevel gear transmission driving propellers on each end of the propulsion pod. This represented a significant departure from the long inclined shaft used in R-100 Power was supplied by two I-cylinder Rolls Royce Griffon gasoline engines rated 1,500 HP at 3,000 RPM.

The trials of R-103, which began in 1958, proved to be somewhat of a disappointment. There was, however, one particularly important result that strongly influenced hydrofoil design philosophy, It

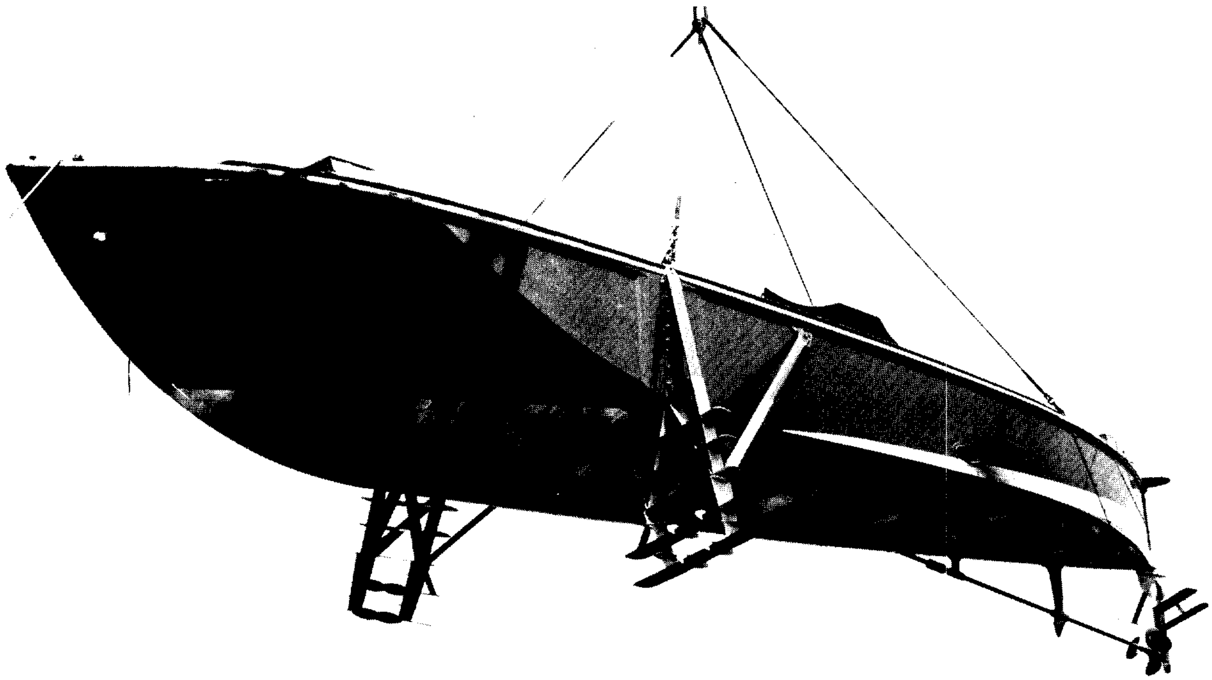


Figure 18a. Original Foils

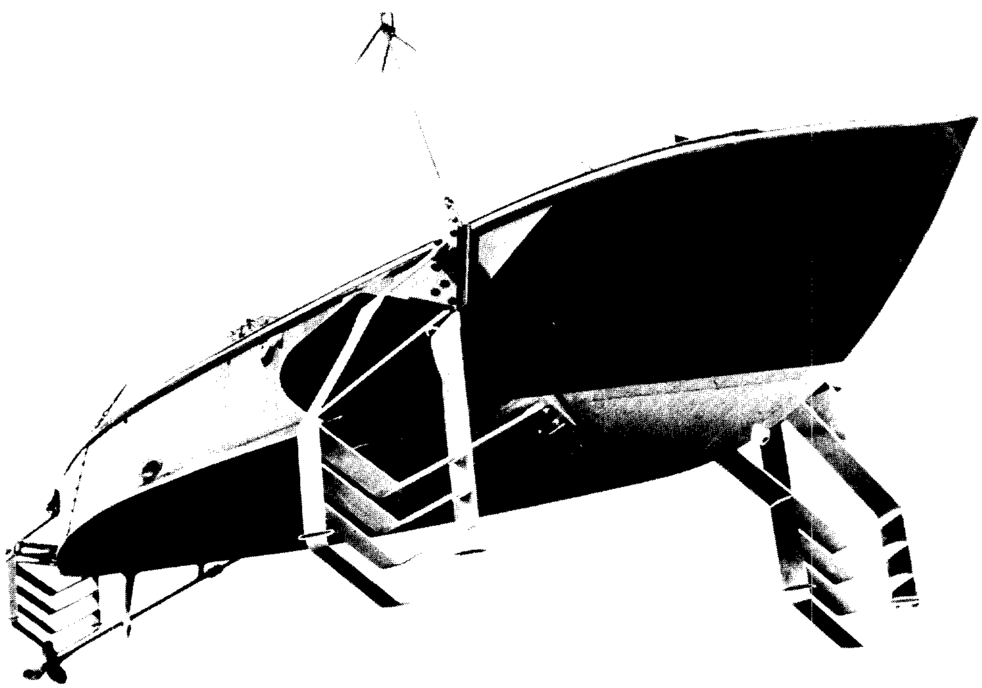


Figure 18b. Modified Foils

Figure 18. Canadian Hydrofoil, MASSAWIPPI, R-100

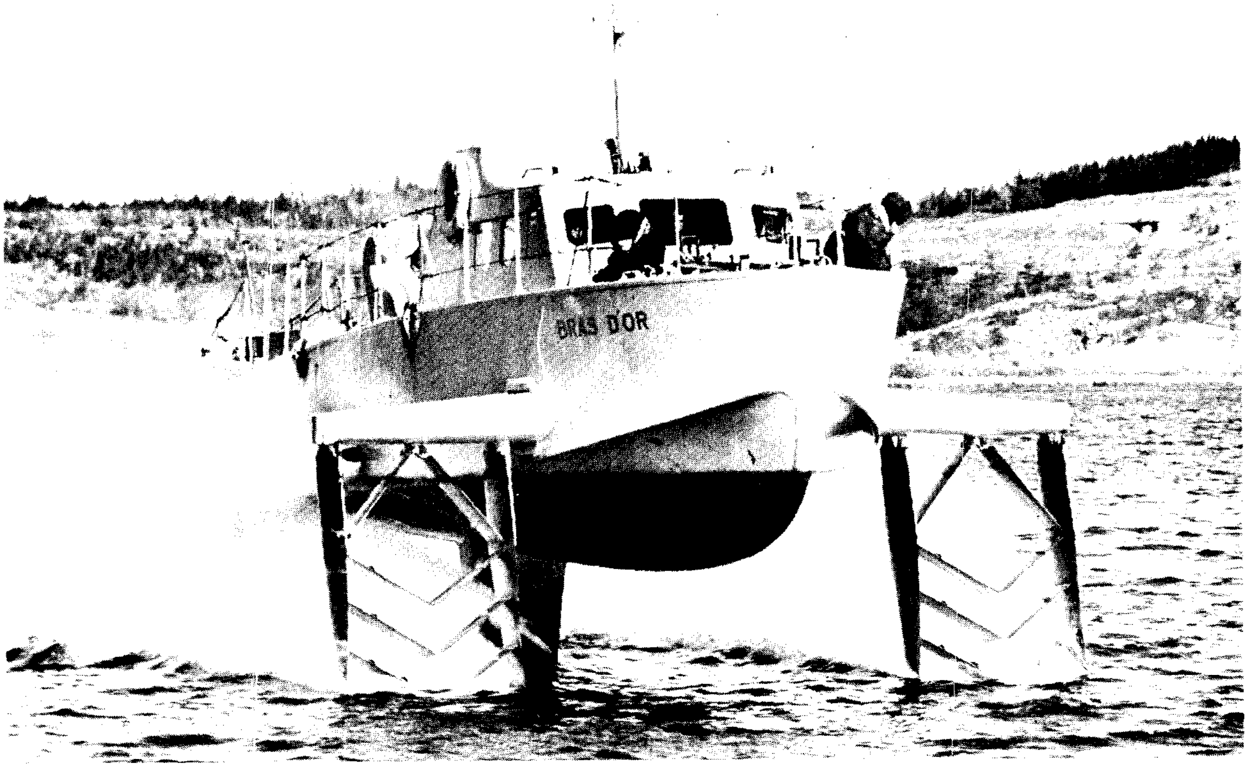


Figure 19. Canadian Hydrofoil R-103, Built by Saunders-Roe

was concluded that the Bell-Baldwin airplane configuration was not the best approach to design of a surface-piercing hydrofoil for operation in rough seas. To the contrary, it was decided that the forward foil should be relatively insensitive to angle of attack and act as a trimming device allowing the main stern foil to respond in advance of an incoming wave. The forward foil should, therefore, be small relative to the main lifting surfaces. Thus, it was concluded that a canard arrangement was essential for good seakeeping with surface-piercing foils.

In 1959, with continued confidence in the value of hydrofoils for the Canadian Navy, NRE undertook a study of design requirements for a nominal 200-ton ASW hydrofoil ship designated R-200. The design concept that resulted was reviewed in January 1960 by experts from the U.S., U.K., and Canada with the conclusion that the concept was sound. By this time the U.S. was well underway with their program to construct a 120-ton ASW hydrofoil with a fully-submerged foil system and autopilot control. It was agreed that the U.S. and Canadian approaches would be complementary in expanding the data base and providing the opportunity for comparison of two quite different designs.

In August 1960 a contract was awarded to DeHavilland Aircraft of Canada to carry out engineering studies and to determine the technical feasibility of the R-200 design. Based on the positive conclusions that resulted, a second contract was awarded to develop a preliminary design. Other work was also supported to carry out model tests and an in-depth examination of some of the more critical system details. In May 1963 this led to award of a three-phase contract to DeHavilland which called for preparation of contract plans and specifications, detailed design and construction, and the conduct of performance trials. DeHavilland, in turn, subcontracted fabrication of the hull and installation of ship systems to Marine Industries Ltd. in Sorel, Quebec. During construction on 5 November 1966, there was a disastrous fire in the main machinery space which almost caused termination of the program. In spite of the delays and cost increase, however, the ship, designated FHE-400 and named BRAS D'OR, was completed. It arrived in its slave dock in Halifax N.S., on 17 July 1968 to begin a long series of trials. Figures (20) & (2 1) show various views of FHE-400 which, although no longer operational, remains

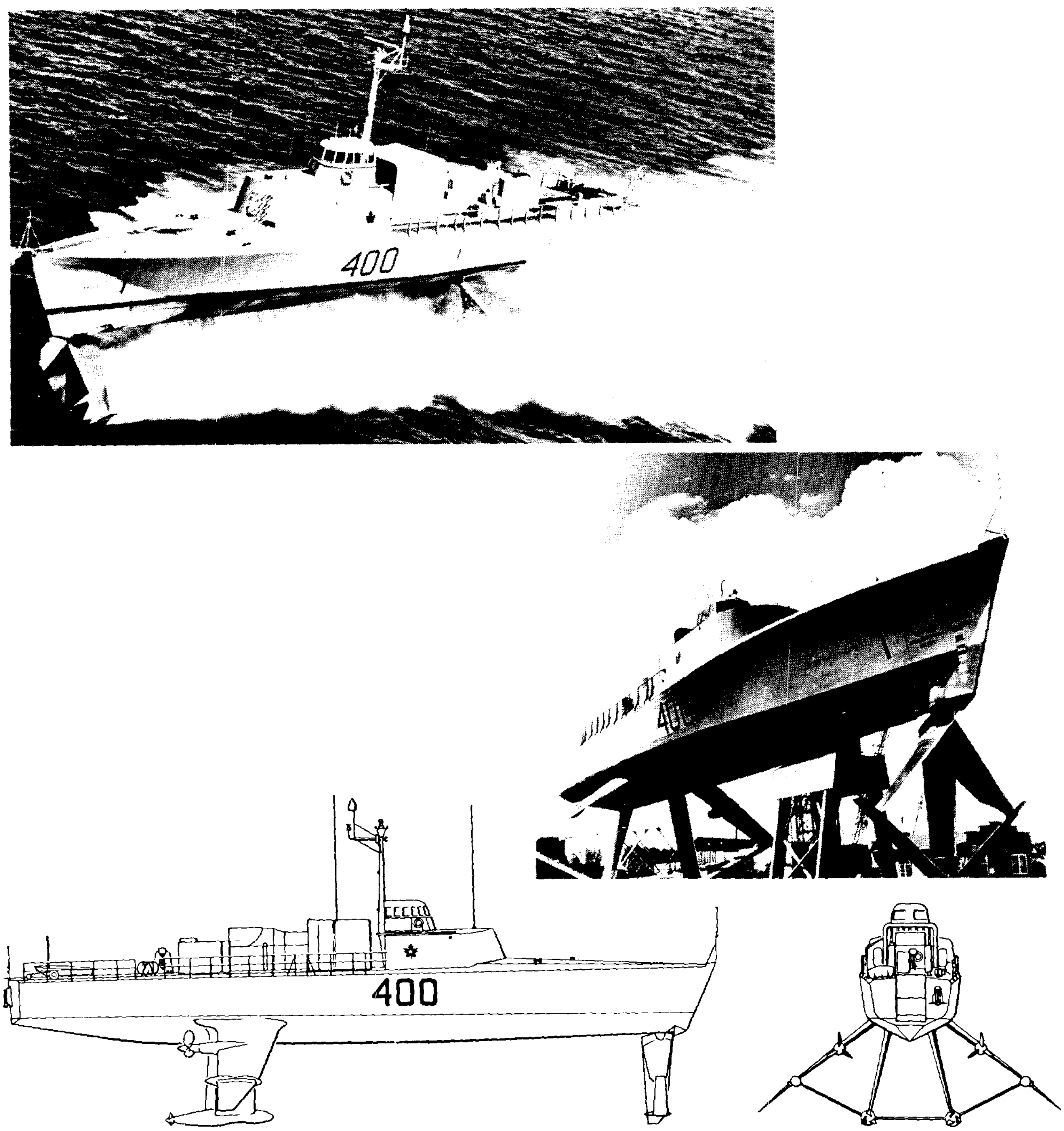


Figure 20. Views of Canadian Navy Hydrofoil, BRAS D'OR, FHE-400

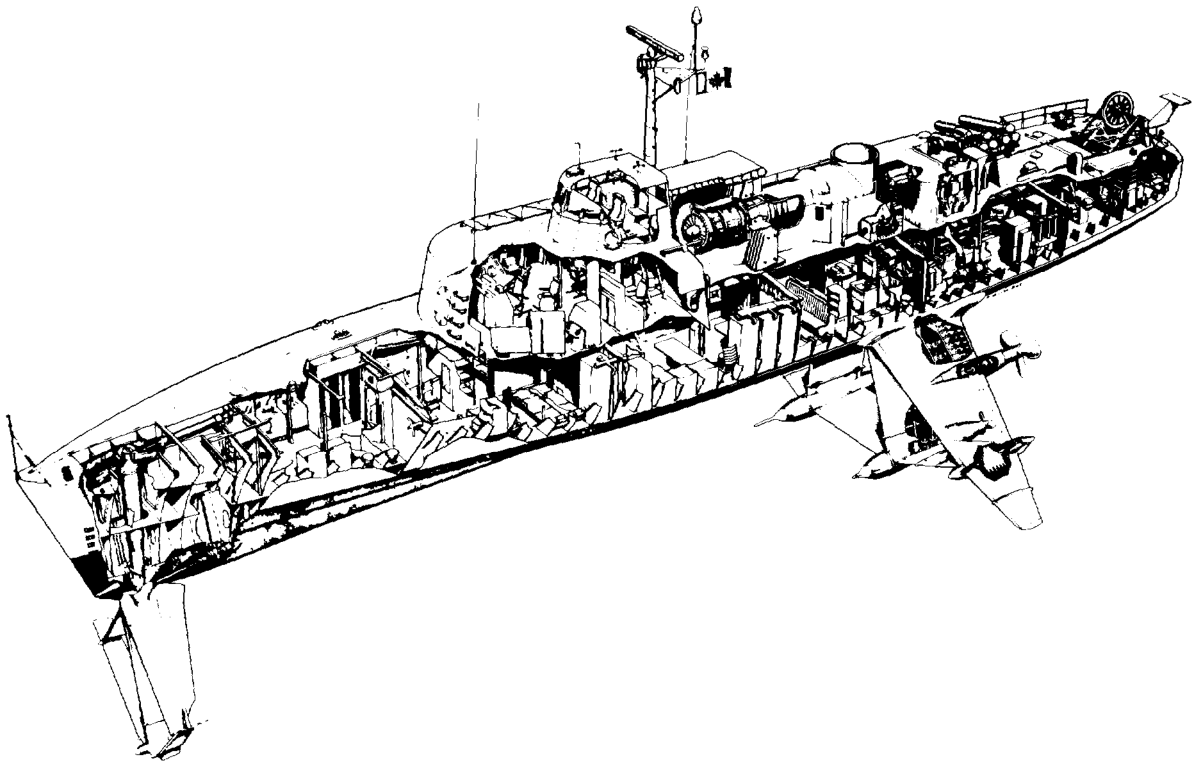


Figure 21. Cutaway View of HMCS BRAS D'OR, FHE-400

even today the most sophisticated and advanced design of a surface-piercing hydrofoil. Its design and extensive trials program contributed significantly to the technical data base and this was invaluable in complementing the U.S. development program. References 19, 20, 21, 22, 23, & 24, provide excellent background reading on Canadian hydrofoil development and the design and operation of FHE-400.

DEVELOPMENT OF SEA LEGS

In parallel with efforts to develop a hydrofoil landing craft, the U.S. Navy was pursuing another line of endeavor which was to have a much more far-reaching impact on the future of hydrofoil craft. During the early 1950's, with Navy support, the Gibbs and Cox firm of naval architects designed a versatile testcraft which was built by Bath Iron Works. This craft, Figure (22), was aptly named the BIW. It was configured to test a variety of different foil arrangements and types as well as different control schemes. It was 20 feet long with a j-foot beam and displaced about 1,800 pounds. It was powered by a 22-HP outboard motor. In carrying out this program, Gibbs and Cox assembled an excellent technical team under the direction of Tom Buermann which included Dr. John Breslin, Dr. S. F. Hoerner. L. E. Sutton, and Richard Browne among others. It was on BIW that the sonic height sensor was developed, Reference 25.

With the knowledge gained from this test craft, in 1954, Sutton and Browne undertook the modification of a Chris-Craft hull, adding fully-submerged foils in a canard arrangement and an electronic autopilot stabilization system developed by the Draper Laboratory of MIT. This new test craft was named SEA LEGS, Figure (23). The hull was 28.5 feet long with a 9-foot beam. As modified, it displaced about 5 tons. It was powered by a 235-H.P. Chrysler marine gasoline engine connected to a 19-inch propeller

Figure 22. Gibbs and Cox/Bath Iron Works Hydrofoil BIW

thru a V-drive and angled shaft, Figure (23). The foils were of aluminum with a German "Walchner" section shape, 12% thick. Forward foil area was 4.6 square feet and the aft foil area was 11.7 square feet. The electronic autopilot contained 160 vacuum tubes. Signal input to control flying height was obtained from a bow-mounted sonic height sensor similar to that developed on BIW.

SEA LEGS made its first flight in 1957 and demonstrated excellent seakeeping performance in rough seas at speeds up to 27 knots. During the latter part of 1957 and early 1958, the craft continued to provide demonstrations for Navy military and civilian visitors. In June 1958, at the urging of CDR R. W. (Randy) King of BuShips (now a retired Rear Admiral) the Chief of Naval Operations, ADM Arleigh Burke, approved a demonstration trip to the Washington, D.C. area. With hasty preparations for the trip underway, LCDR Ken Wilson (now also a retired Rear Admiral) who was then liaison officer in the Preliminary Design Branch of BuShips, made arrangements for SEA LEGS to be escorted by a Navy torpedo boat, the PT-812.

After a false start and return to the Gibbs and Cox pier in New York due to failure of a foil control attachment, the craft finally got underway for Cape May on 15 July. CDR Wm. Mac Nicholson was aboard as official Navy observer.(Now retired as a Captain, he was another of the key ED's in BuShips who believed strongly in the future of Navy hydrofoils). At that time, he was the Project Officer responsible for all small craft design in BuShips Code 440.

On the afternoon of 16 July 1958, SEA LEGS arrived at the Navy's small boat facility on the Severn River in Annapolis, Maryland and was lifted from the water by a Navy floating crane. During the

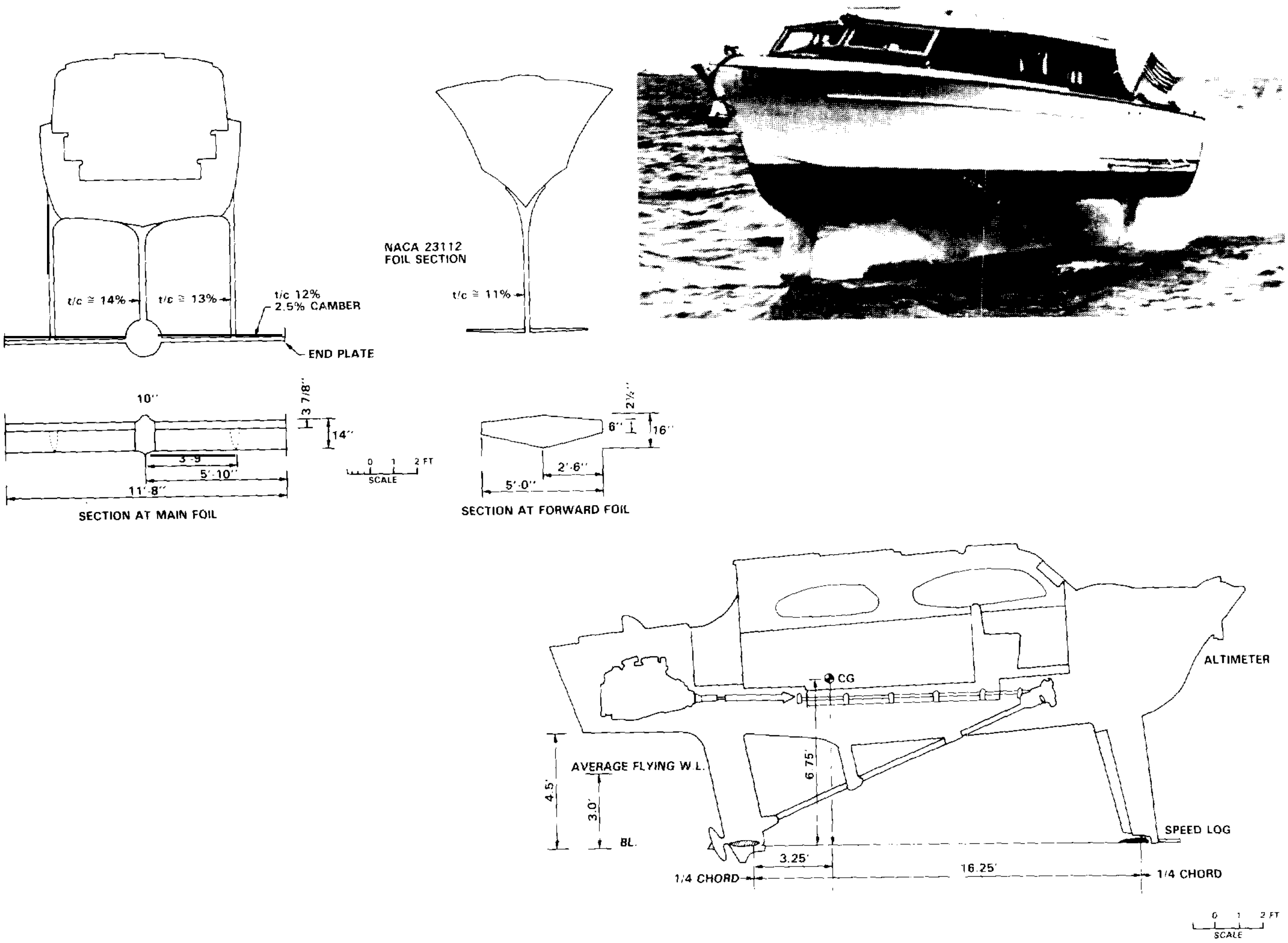


Figure 23. Gibbs and Cox Hydrofoil Test Craft, SEA LEGS

sometimes eventful voyage it had averaged 23 knots in seas up to 4 to 5 feet and clearly demonstrated its superior seakeeping performance compared to that of the PT boat, outrunning the larger boat all the way.

After a week of successful demonstrations in the Annapolis area, on 26 July SEA LEGS undertook the 170-mile run to Washington. LCDR Ken Wilson was aboard as the Navy's representative. They arrived at the Naval Gun Factory pier at 1540 hours after a relatively uneventful trip down Chesapeake Bay and up the Potomac River. The following day, Sunday, 27 July, they took aboard the CNO, ADM Arleigh Burke; the VCNO, ADM James Russell; the Chief of BuShips, RADM Albert Mumma; and CAPT Robert Madden, Director of Ship Design Division. (CAPT Mac Nicholson recalls that, 15 or 20 minutes before the CNO party was due to arrive, they "blew a tube" on the warm-up run and crash landed. Dick Browne managed to fix her in the nick of time just before the Admiral arrived.) This was undoubtedly one of SEA LEGS most important demonstrations. After 1 hour and 15 minutes, during which all VIP's took a turn at the helm on a trip to Mt. Vernon and back, the demonstrations were completed to everyone's satisfaction.

During the days that followed, SEA LEGS continued to show her unique capabilities to a wide spectrum of visitors. These included many other Navy officers of flag rank; congressional representatives, including Senator Saltonstall of Mass.; and numerous members of the press. radio, and television. The craft got underway for the return to New York on 19 August accompanied by John Bader. a hydrofoil designer from BuShips, as observer, On the last leg of the trip he was relieved by Robert Henry, another naval architect from BuShips. SEA LEGS arrived back in New York at 1800 hours on 20 August after covering 18 51 miles of which 1751 were on foils. The total flight time was 56 hours 12 minutes. The visitor box score for her successful demonstrations included 3 Congressmen, 17 Admirals, 3 Marine Corps Generals, 3 Assistant Secretaries. and numerous other important civilian and military visitors for a total of 375. This was a truely impressive accomplishment and one that had significant impact on the Navy's future course of action. In Reference 26, Dick Browne gives a running account of this voyage of SEA LEGS.

THE MARITIME CONNECTION

In 1955, as a result of the commercial application of hydrofoils in Europe and the research being sponsored by the U.S. Navy, a growing interest in this promising new type of waterborne transportation developed within the Maritime Administration. The Honorable Clarence Morse, Maritime Administrator at that time, became a most outspoken advocate for hydrofoil craft. The Coordinator of Research, Charles R. Denison, was also enthusiastic about the future commercial potential of the hydrofoil and in 1958 sponsored an extensive parametric study carried out by Grumman Aircraft Engineering Corporation and its affiliate Dynamic Developments, Inc., Reference 27. The purpose of the study was ***to determine the type of hydrofoil craft best suited to future express-cargo and passenger applications and establish design criteria for such craft.*** Speeds of 50 to 200 knots, displacements from 100 to 3,000 tons. and ranges from 400 to 3,600 nautical miles were considered. Foil sections shape and arrangement, appendages, weights, power plants and propulsors, hull form, and autopilots were covered including several preliminary designs for oceangoing vessels. Based on the favorable results of this study MARAD contracted with Grumman in 1959 for design studies of two test craft. One was to have conventional power and the other provision for a lightweight aircraft nuclear plant when such a system became available. This led to MARAD's award, on 18 January 1960, of a contract to Dynamic Developments to build an 80-ton experimental craft capable of speeds up to 60 knots powered by gas turbine engines. Provision was to be made for a second phase wherein the subcavitating foil system would be replaced by supercavitating foils. This was to permit the attainment of speeds up to 100 knots using the same power plant. Most unfortunately, Charles Denison, whose vision and enthusiasm was in great part responsible for this program, suffered an untimely death before the ship got beyond the early design stages. It was in his memory that the ship was later christened HS DENISON.

The DENISON program. References 28 & 29, followed the same tradition of joint sharing of costs which had characterized early MARAD studies and experiments. The contribution by MARAD to the costs of design and construction was $1.5M with Grumman and 73 other companies investing some $5 to 7M of their own funds.

Shortly after the death of Charles Denison, in light of a National Academy of Science study which recommended that MARAD focus and significantly increase their R & D program. a decision was made to consolidate MARAD efforts. At that time the most significant of these were the nuclear-powered merchant ship SAVANNAH and the DENISON program. James Higgins up to this point had been MARAD's naval architect coordinator for SAVANNAH. In that program emphasis was being shifted to installation of the reactor plant. With his role thus being considerably reduced, he was charged with taking over

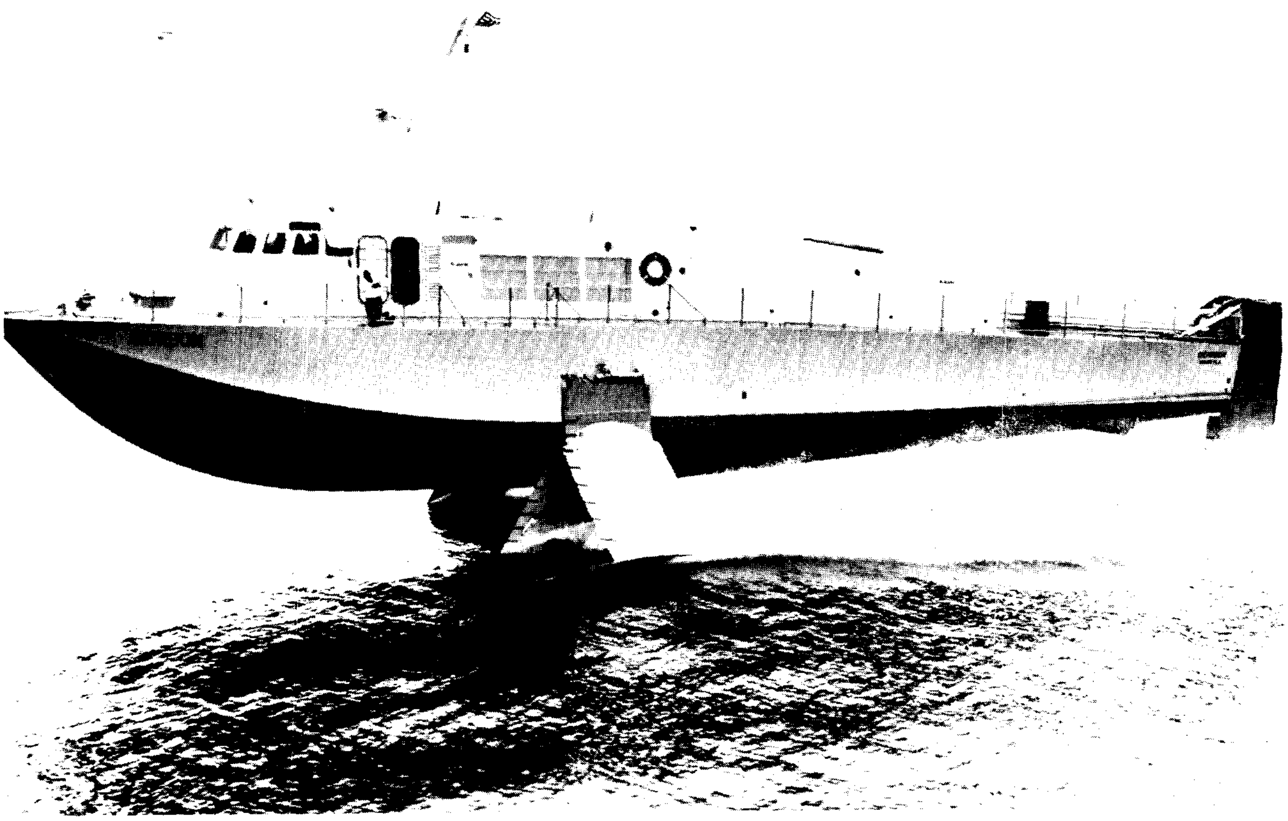


Figure 24. Grumman-Built MARAD Hydrofoil, HS DENISON

and pulling together the consolidated R & D program which included responsibility for continuation of hydrofoil development.

In January 1961 MARAD contracted with Stanford Research Institute for a study of the economic aspects of commercial hydrofoils and an evaluation of possible U.S. trade routes. At the same time efforts continued in construction of HS DENISON and the craft was launched on 5 June 1962 at Oyster Bay, Long Island. It began sea trials only four days later.

Figure (24) shows the 95-ton HS DENISON foilborne. The length overall was 104.6 feet, the maximum hull beam was 23 feet. and the maximum draft hullborne with foils extended was 15.4 feet. (It may be noted that the bridge provided no view aft. On one occasion this led to a grounding at speed due to the inability to run ranges in a restricted channel. This deficiency was noted by CDR Mac Nicholson when he was a observer during the trials. As a result, he later insisted that the PCH pilothouse have visibility aft.) The foil system consisted of two surface-piercing units forward which carried 85% of the load and a single fully-submerged foil aft carrying the remaining 15 %. Foils and struts were of 4130 steel and provision was made for full retraction as shown in Figure (25). The hull was of 5456 aluminum with both welded and mechanically-fastened structures. Main propulsion was provided by a single MS-240 General Electric gas turbine rated at 14,000 SHP. This was a marine version of GE's J-79 jet engine. MARAD obtained two J-79's from the Navy and baled them to GE who then provided the marine version

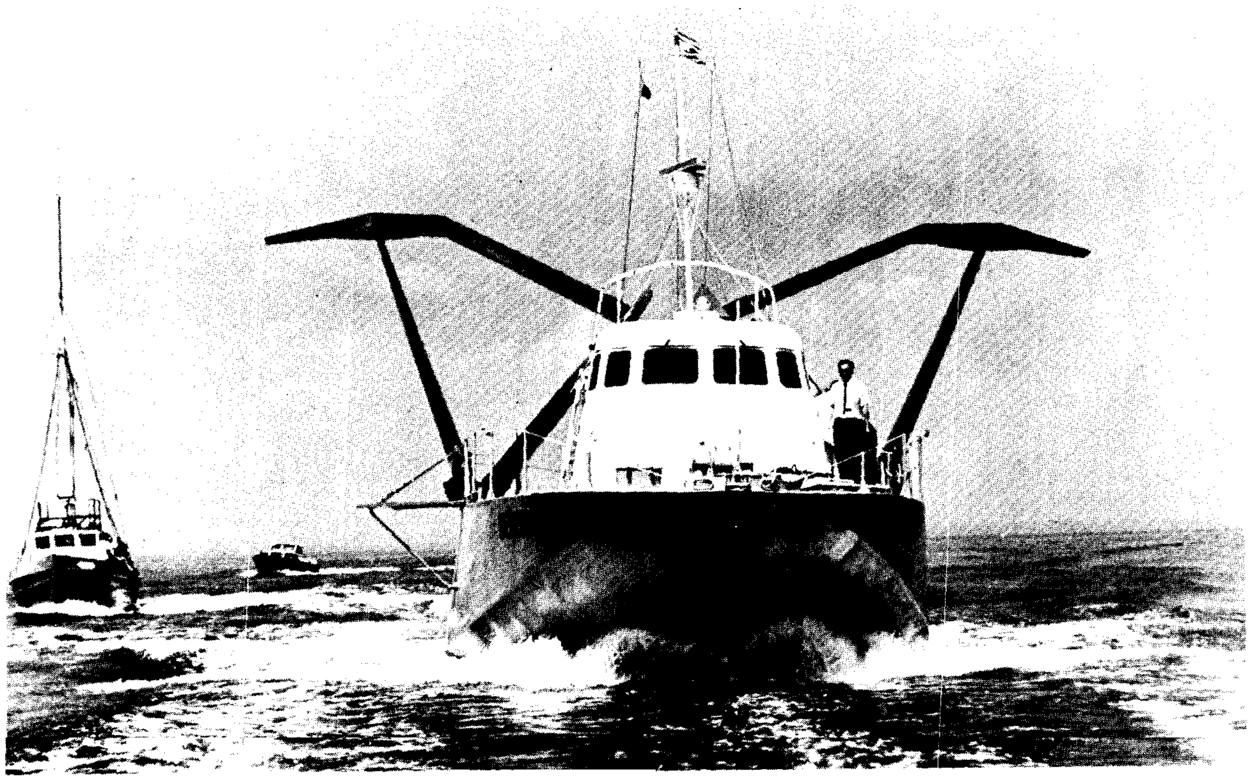


Figure 25. HS DENISON With Foils Retracted

by addition of a free power turbine. This was accomplished for the sum of one dollar. It may be noted, however, that this proved to be a good investment since it was the basis for GE's later LM series of marinized gas turbines which have been used extensively in Navy ships.

Power was transmitted through a right-angle bevel-gear drive to a supercavitating propeller, as shown in Figure (26). The propeller was designed by Marshall Tulin who, at that time, had just left DTMB to join with Phil Eisenberg in founding Hydronautics, Inc. The spiral bevel gears, 20 and 21 inches in diameter and turning at up to 4,000 RPM, were also built by GE and represented the most stringent requirement, by far, of any which previously had been manufactured.

In Reference 30, the tests and trials of DENISON are described. The first trials in rough water are of particular interest and a brief description of them is abstracted from the report and presented below.

> Operation in rough water was initiated in waves of three to four feet. Upwind and downwind runs were made over a buoyed five-mile course at speeds from 50 to 60 knots. The ship proved stable on all headings and during maneuvering with foilborne controls set in the manual mode and with automatic pitch control engaged. At fixed power settings, downwind speed was approximately two knots greater than upwind. Ship trim on a downwind course averaged one quarter degree less than on a reciprocal heading.
>
> Take-offs were made at normal power settings on upwind, downwind, and crosswind headings with no appreciable difference in craft behavior being, observed. Transitions to

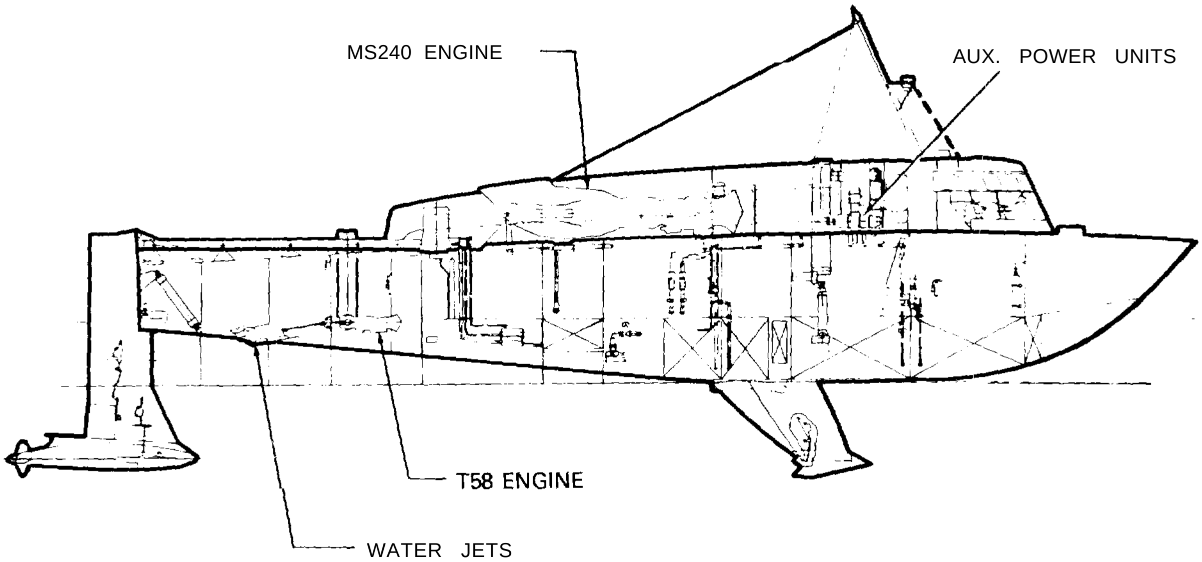


Figure 26. HS DENISON Machinery and Systems

foilborne attitude were rapid and smooth, requiring only the normal amount of control to establish steady-state foilborne operation.

During later voyages. operations continued in typical winter weather with winds of 30 to 45 knots and seas of 4 to 6 feet. The temperatures were below freezing on occasion, but no icing problems were encountered by DENISON during displacement or foilborne conditions. In comparison, the 30-foot escort boat was unable to proceed out of sheltered waters at these times due to heavy icing on the deck and superstructure.

Foilborne runs were made on all headings. One crosswind take-off was aborted following heavy spray ingestion through a cooling fan duct in the auxiliary power unit compartment but, otherwise, the ship proved stable and dry during runs both upwind and downwind. The transition to foilborne attitude was quick and clean when proceeding head to the wind and sea, but somewhat prolonged downwind, with attending touch-downs before reaching stable flight. Runs were made at speeds of 50 to 55 knots with the stability augmentation system in the manual mode. No hull impacting was monitored or felt by the operating crew.

Although, in 1962, the Navy was already well underway with acquisition of the PC(H) hydrofoil subchaser, the guidance design of the world's largest hydrofoil ship AGEH- 1, and the design and construction of the foil research craft FRESH-l, there was still criticism coming from the Department of Defense and the Congress over the Navy's failure to exert even more development effort. As a result of this criticism, CAPT James Stillwell, BuShips, came to Jim Higgins with the offer to cooperate with MARAD in the second, highspeed phase of the DENISON program. In discussions among Higgins, Stillwell, and Ralph Cooper of ONR. agreement was reached wherein the Office of Naval Research would put up $600K for design and BuShips would provide $2.5M to construct and install a supercavitating foil system on HS DENISON. MARAD agreed to act as contracting agent and operate the boat during test and trials. BuShips transferred the $2.5M to MARAD with a hold on spending pending further negotiations. As time went by all still seemed to be on track until the Navy, without alerting MARAD, changed course and decided to proceed with design and construction of their own high speed foil research craft, designated FRESH I. They subsequently withdrew the $2.5M for DENISON Phase II. This contributed significantly to an eventual decision by MARAD to terminate the DENISON program and any further efforts toward development of commercial hydrofoils.

It is clear that the MARAD program, and more particularly the HS DENSION, contributed in large measure to the growing technology base for design of hydrofoil craft, Many of DENISON's subsystems were at the leading edge of the state-of-the-art and knowledge gained thereby was invaluable in further developments by the U.S. Navy. It is unfortunate that it did not also fulfill the bright future originally forecast for the employment of commercial hydrofoils in U.S. service.

CHAPTER 2

PCH Design

PRELIMINARY DESIGN

With the growing momentum generated by the expanding technology base and the demonstrated attributes of hydrofoils for navy missions, in late 1957 the BuShips Preliminary Design Branch, (Code 420), began a design study of hydrofoils for anti-submarine warfare. In a letter of 24 January 1958, OPNAV 314D requested BuShips to do a study of the use of hydrofoils for harbor defense and coastal patrol. The work already underway was then focused on responding to this OPNAV request. A comparison was made of a notional hydrofoil ASW craft, PC(H), with the subchasers PC(S) and SC which were already in the projected FY 1960 shipbuilding program. It was concluded that a PC(H) would be capable of performing the mission and tasks of the PC(S) and SC in *a superior manner*. Estimates of comparative cost are shown in Table 1.

The results of this feasibility study by BuShips Code 420 were forwarded to OPNAV in a report dated 7 March 1958, Reference 3 1. Figure (27) is an artist rendering of the PC(H) concept which was included

TABLE 1

COST ESTIMATES

	PCH	PC(S)	SC
Lead Ship	$3.7M	$2.6M	$2.0M
Follow Ship	$2.8M	$2.0M	$1.5M

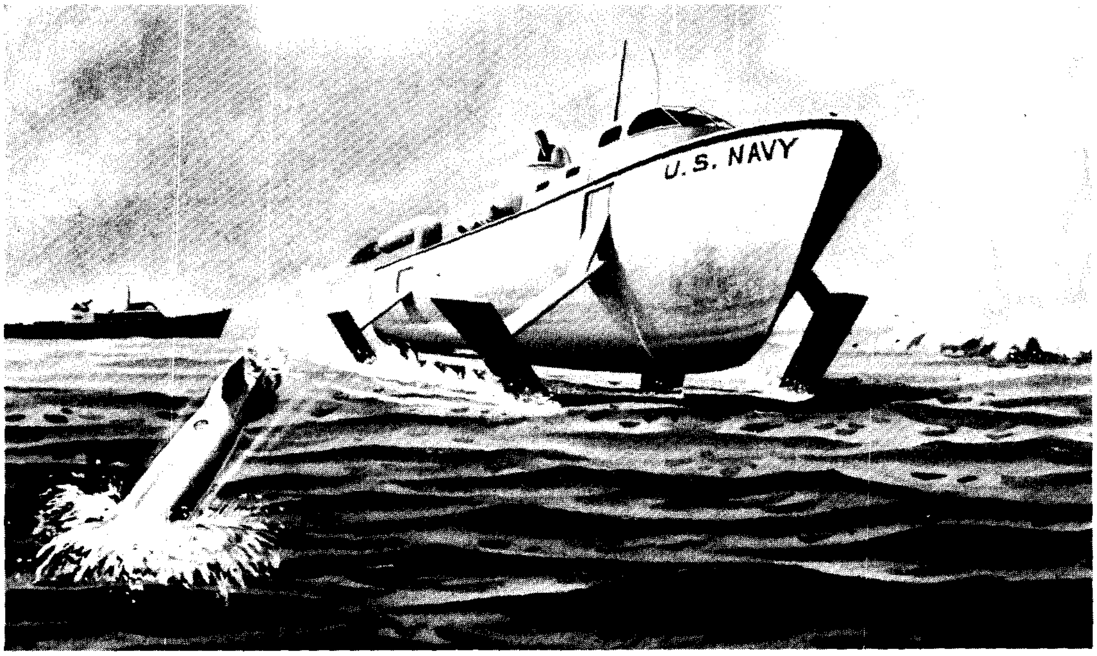


Figure 27. Early Concept of PC(H) with Surface-Piercing; Foils

in the report. It may be seen that it was proposed to use surface-piercing foils. Figure (28) is a sketch of this configuration which included a retractable strut-mounted sonar for submarine detection at low hullborne speeds. It is interesting to note that in February 1958, the Grumman Aircraft Engineering Corporation submitted to BuShips an unsolicited proposal for a 60-knot hydrofoil subchaser. They were told that such a craft was already under study and that the design would be accomplished by BuShips inhouse. This response is understood to have generated some concern in the Congress, particularly in the office of Senator Saltonstall, and a number of questions were put to the Navy regarding their past efforts and future plans. In a written reply the Navy reaffirmed their intent to do a design inhouse and noted that ***Grumman would be given every consideration in the event that outside design assistance were required.***

Shortly after submitting their design study to OPNAV, the hydrofoil PC(H) was substituted for the PC(S) and SC in the FY 1960 shipbuilding program. In June of 1958 the characteristics for this ship were approved by the Ship Characteristics Board, (SCB), and it was assigned SCB Project #202, Reference 32.

On 4 August 1958. LCDR Ken Wilson, Hydrofoil Project Officer in BuShips Preliminary Design, reviewed the charac-teristics of the PC(H) design concept in a meeting of the OPNAV Antisubmarine Plans and Policies Group (OP-312). He was accompanied by RADM Armand Morgan, Buships 400; CAPT Jack Obermeyer, BuShips 420; and CAPT Bob Madden, BuShips 410. The meeting was chaired by CAPT D. E. Willman, OP-3 12. Other OPNAV officers present included VADM Combs, RADM Knoll, RADM Weakley, RADM Johnson, and RADM Ramage.

LCDR Wilson's description of PC(H) attributes and its proposed use as an ASW Patrol Craft were favorably received. He noted the plan to employ a 3.5 KC strut-mounted sonar (SQS-20). Listening at low hullborne speed, upon receiving a contact, the ship would retract the sonar and go foilborne to close the target and deliver a weapon. This was referred to as the "grasshopper" technique. He reiterated the decision to use a surface-piercing foil system, or some modified version thereof, and

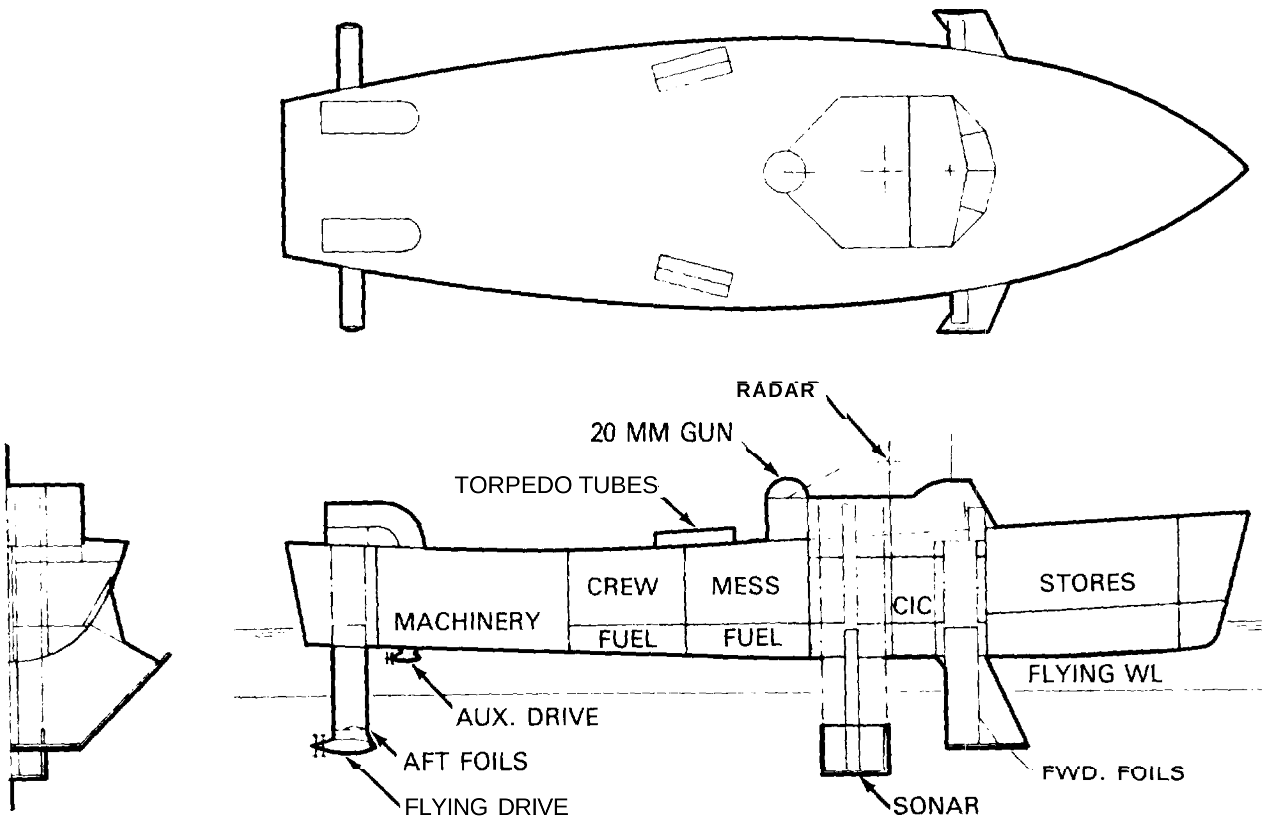


Figure 28. Drawing of Early PCH Configuration

noted that the estimate of $3.7M for the lead ship and $2.8M for follow ships was considered a modest cost for the increased capability provided.

With the blessing of OPNAV, the PC(H) preliminary design phase continued thru the remainder of 1958 and early 1959. There were a number of key players in Code 420. As noted previously. CAPT Obermeyer was head of the Preliminary Design Branch. His assistant was CAPT Stillwell who also later headed up the Advanced Studies Section, replacing CDR Larry V. Mowell. Other engineering duty officers who continued to play an important role in hydrofoil development included CDR Randy King, LCDR Ken Wilson, LCDR John Collins, and LCDR Perry Nelson. On the civilian side, the Technical Director of 420 was John Niedermair, the Navy's Chief Naval Architect, whose broad knowledge was reflected in innumerable naval ship designs. His two principal assistants were George Dankers and Ralph Lacey, both ship designers of considerable stature. Lacey, in particular, had significant influence in PC(H) design. Other naval architects and marine engineers in 420 who had roles in the PC(H) design included John Bader, Jim Dapper, Jim Mills, Ben Silverstein, and Ted Sarchin. Many significant aspects of the early design concept were attributed to John Bader in particular.

By March 1959, when the preliminary design of PC(H) was completed, the decision had been made to go with a fully-submerged, autopilot-controlled foil system in a canard configuration. This decision was greatly influenced by the experience with SEA LEGS and the foils on PC(H) were very similar to those on SEA LEGS.

It was thus that the many years of hydrofoil research and development finally bore fruit in the authorization to proceed with the design and acquisition of the U.S. Navy's first operational hydrofoil.

CONTRACT DESIGN

As was customary in the ship design process, upon completion of their work in preliminary design, on 5 March 1959 Code 420 turned over design control to the Hull Design Branch, Code 440. They became responsible for the preparation of the contract design, guidance plans, and specifications. Just prior to this turnover John Niedermair retired from federal service and was replaced as Technical Director of Preliminary Design by Owen Oakley who, at the time, was Head Naval Architect in Code 440. Oakley, in turn, was replaced by John Nachtsheim who had just returned from a year's assignment as Deputy Chief Design Engineer at the Puget Sound Naval Shipyard. During this same period a number of other significant changes occurred. CAPT. J. A. (Moose) Brown was relieved as Head of Code 440 by CAPT Nathan Sonenshein. (RADM Sonenshein served as Chief of BuShips from 3 1 July 1969 to 3 1 July 1972 when he retired.) Also, on 29 April 1959, RADM Albert G. Mumma and RADM L. V. (Mike) Honsinger were relieved as Chief and Deputy Chief of BuShips by RADM R. K. (Jimmy) James and RADM Robert L. Moore. Thus the key organizational elements of the Naval Ship Systems (Command and incumbents during the period of PC(H) contract design were as follows:

100	Chief (RADM R. K. James)
101	Deputy Chief (RADM R. L. Moore)
300	Asst. Chief for R & D (CAPT E. J. Fahy)
	Applied Science Division (CAPT T. B. Owen)
	Noise Reduction Branch (CDR P. Leehey)
	R & D Systems Division (CAPT H. C. Mason)
400	Ass't Chf., Des., Shpbldg. & Flt. Mnt. (RADM J. M. Farrin)
410	Dir. Ship Design Division (CAPT R. B. Madden)
420	Head Prelim. Design Branch (CAPT J. A. Obermeyer)
421	Tech. Dir. Prelim. Des. (0. H. Oakley)
	Asst. Tech. Dir. (R. Lace))
430	Head Machinery Design Branch (CAPT F. C. Jones)
	Asst. Head Mach. Des. (CAPT R. E. Foster)
	Tech. Dir. Mach. Des. (L. Wechsler)
440	Head Hull Design Branch (CAPT N. Sonenshein)
	Chief Naval Architect (J. Nachtsheim)
450	Head Electronics-Elec. Des. Branch (CAPT R.R. Bradley Jr.)
510	Director Ship Division (CAPT G. W. Bailey)
526	Head Mine, Service, and Patrol Craft Br. (CAPT R.T. Miller)
	Head Engineer (S. A. Peters)
	Asst. Engr. (M. Jewett)
	PC(H) Project Engineer (A. Koval)

In an interview on 25 April 1984, John Nachtsheim recalls some interesting aspects of the BuShips design philosophy and procedures that are pertinent to the PC(H) design.

> The PC(H) was different from the normal contract designs handled by 440. In this case, the technology was evolving and provided high speed on the surface which was extremely useful. The problem was that there wasn't a military mission crying out for this capability. There was a bit of groping about as to what it could be used for and what niche it would fit in. What evolved was ASW because of the threat of higher speed submarines. What you had here was a high speed sub chaser, too noisy to listen when on foils. but which could stop, drop its sonar and listen, get a fix, and continue to chase the submarine.

There was criticism over PC(H) being treated as a ship when, in fact, it was a boat. As such, it should have been assigned to the Small Boat Group which was under Bob Henry at that time. The point was made, however, that Hull Design had to learn how to handle these craft since PC(H) was a prototype and only small because it was the first one. It was expected that this was the wave of the future and hydrofoils eventually would become ships of destroyer size.

We in Contract Design had a different mentality from that of Preliminary Design. We were a lot less interested in new ship concepts than, say, getting better steels for deeper submergence of submarines, for example. We had sort of an incremental mentality compared to a full-blown start with a clean sheet of paper which was the mentality that Preliminary Design and the R & D community had. This was a way of life and hasn't changed. We took what we were given and stretched it or widened it but we did that in discrete steps from a given base line.

He also offered some excellent insight on the question of design feedback

We would take the design from 420 and do an independent analysis. Many times we found they were squeezing on margins and on some assumptions. We would not just buy that because we knew that in our phase there was always some growth and other things to consider. Even if they had conducted model tests on a certain configuration and we realized u-e weren't going to end up with that configuration, we would quickly order the Model Basin to change some dimensions or hold up until the matter was settled. We consulted Preliminary Design but it was our bag. There was actually a turnover - a cognizance switch - so they were really advisors but not potent advisors. When we finished the design we had a requirement to prepare a design history. One of its elements was to explain the deviations from the preliminary design. This would go back to them and if there were similar ships to follow, they would start with the design history and not repeat the same mistakes.

We turned over the contract plans and specifications to the Type Desk, which in this case. was Sid Peters in Code 526. They went out for competitive fixed-price bid for detailed design and construction. As for feedback from this phase, again it was a matter of exception. This was another clear delination of change in responsibility. The Type Desk now had control through non-deviation specifications and contract plans. There was no need for them to come back to us unless they got into difficulty. Otherwise, there was little liaison and we did not act as checkers to ensure they were following what we said.

It was intended that the Engineering Duty Officers would provide the feedback in the process. The civilians sat in one place and didn't have the flexibility as in case of the rotation of naval officers. The officers, who were bright people, went thru the process in SUPSHIPS, shipyards and back into design and this provided feedback in an ad hoc way.

It is noted that John Nachtsheim left BuShips in 1970 to become Head of R & D at the Maritime Administration. During the period 1959-1970 in BuShips he was responsible for the contract designs of more than 250 naval ships.

Reference 33 is the design history prepared for PC(H) which was issued on 19 February 1960 co-signed by CRD T. A. Efird and D. S. Wilson as Project Coordinators. (Terry Efird had relieved Mac Nicholson when he transferred to Puget Sound Naval Shipyard in late August 1959. Some time later Efird was also assigned to PSNS where he continued to play an important role in the PC(H) program.)

During contract design, as might be expected, a number of departures were made from the preliminary design. It is felt to be important to this PC(H) history to note some of these changes and other design considerations which illustrate the concepts and practices of that era. Accordingly, there follows an extract from the design history. This also illustrates some of the concerns which later experience with the completed ship proved to be well founded. (Underlining and italics are supplied by the author.)

Foil and Strut Design

The Code 420 foil design showed an all-welded HY-80 steel structure with a factor of safety of 1.0 based on yield strength. In the course of the contract design, two significant changes were made to that basic concept.

a. The connection between the forward foil and its strut is now bolted, and is to be the weak link in the structure. This reduces the chance of more serious damage (ripping the forward foil and strut assembly out of the hull) from hitting submerged objects while flying. The bolted connection also minimizes the problem of keeping the total assembly within tolerances for fairness and alignment.

b. The minimum factor of safety (F.S.) on yield is now specified as 1.25 and plating thickness has been increased accordingly. This increased F.S. or decreased working stress is being used to get greater fatigue life for the 80.000 psi yield HY-80. As with other high yield-strength steels, if we consider millions of loading applications, the allowable stress for HY-80 approaches that for H.T.S. and M.S. To further improve the fatigue strength, a note on the foil contract guidance plan calls for external welds to be ground flush with the contour. The fatigue question is of sufficient importance that (1) research testing is planned for the actual foil geometry and fabrication procedure prior to the completion of the PC(H) and (2) periodic inspection for fatigue crack inception is planned for the first few years of operation. Though fatigue is a problem, HY-80 steel for the foils and struts is considered to be the best material available today taking into account its high strength characteristics, knowledge and experience in its fabrication and welding properties, and its cost. The use of titanium foils was thoroughly investigated and looked very attractive from its high strength-to-weight ratio and excellent corrosion resistance. Titanium was not used since experience in its use is limited, no foils of the size required have been manufactured of this material, welding is required to be accomplished under highly controlled conditions. and it is very expensive. However, in order to obtain more information on titanium hydrofoils, a contract has been entered into with North American Aviation Corporation to design, build and test a 3/5-scale model of the forward foil on the PC(H). (This was done under the BuShips Materials R&D Program managed by George Sorkin. After the titanium forward foil model was completed, it was stored at BuShips' Norfolk Division and was never actually tested.)

Foil and Strut Loading

Loadings, estimated generally in accordance with the Code 420 concept, are shown in Section S22-1 of the Detail Specifications. Because the Bureau needs reliable data on loadings, we have specified that the builder install strain gauges inside the foils and calibrate them in the building yard. The most important loading factors that need further investigation for future design are for rough weather accelerations (similar to airplane gust loading) and rough weather turning (with some loss of lift on one side of the foils).

Foil Scantlings

The scantlings shown on the contract guidance plan are based on a strength analysis made by Dr. K. Hart of David Taylor Model Basin (DATMOBAS). Essentially, he made a rigid frame analysis, assuming 100% fixity, with appropriate unit loadings (e.g. one kip uniform vertical load on the outboard cantilevered portion of the after foil, and one kip uniform transverse load on the submerged portion of the strut). The assumed loadings are then applied and stresses determined by superposition. The scantlings are subject to development, and an independent stress analysis and static "proof test" are required of the builder.

Foil and Strut Vibration

The after foil and struts were also checked for vibration under an outside contract monitored by Dr. N. Jasper of DATMOBAS. This study showed that the natural frequency of the contract design structure is well out of the range of the natural frequency of the propulsion shafting within that structure. To assure that this desirable condition is maintained, the builder is required to make a similar study for the working plan installation.

Foil and Strut Fabrication Tolerances

The fabrication tolerances shown on the contract guidance plan are based on judgement as to what can be reasonably expected with a novel structure and good workmanship. The tolerances were deliberately kept out of the Detail Specifications, since that would require formal authorization for deviations. Some controversy between the builder and the Bureau over the hundredths or thousandths of an inch tolerances is anticipated. However, it is hoped that showing the design intent on a contract guidance plan, which is subject to development, will minimize any such controversy. The Detail Specifications do require a formal record of the actual dimensions as built. and the Bureau R-ill have to have check measurements made at routine dry dockings to see whether the structure is dimensionally stable.

Protection of Hydrofoils Against Corrosion and Fouling

Foil coatings must preserve a smooth, precise surface for high speed flow. The ideal coating should protect against corrosion, fouling, resist erosion and cavitation, and be reasonable in cost for application and maintenance. There is today (1960) no proven protective system that can provide all the desired characteristics.

There are no data available on the performance of antifouling coatings on hydrofoils at speeds up to 45 knots. However, it is believed adhesion of the coating and cavitation will definitely be problems. In addition, if any anti-fouling coating could be maintained without peeling or cavitation loss. the sloughing characteristics of the toxic elements in the coating that prevent fouling, would be accelerated and it is doubtful that film life will approach that expected on conventional underwater surfaces. Another minor problem is the roughness due to variations in coating application as well as the basic coating roughness.

The "Cox coating" process offers some hope for fulfilling many of the desired characteristics but is not yet at a state of development which will assure success. Briefly, the coating is formed on the foil surface by cathodically precipitating a calcium carbonate-magnesium hydroxide scale at current densities of 1 to 3 amps/sq.ft. The coating can be sloughed from the surface of the foil and thereby (it is hoped) remove fouling organisms. The coating offers a degree of corrosion protection. however, in the flying condition the coating is lost by sloughing and it is necessary to maintain a cathodic protection system. The feasibility of forming the coating and sloughing it off at various water velocities has been proven in the laboratory. At present work is underway to determine the sloughing characteristics of coatings containing various stages of marine fouling. Data from this work is expected to be available in 6 months. If the results of this work are satisfactory. the "Cox coating process" can be installed on the PC(H) for trial purposes on a full scale. Space, weight allocation, and electrical power requirements have been designed into the PC(H) for this purpose.

In view of the developmental status of the "Cox coating", it is not specified in the detailed specifications for the PC(H). A coating which provides resistance to corrosion is considered of more importance than one which offers only resistance to fouling. In the case of fouling it is felt that divers can remove the organisms at dockside at periodic intervals. Of the coatings available. the requirements for adhesion, toughness, smoothness and economy are best met by using an epoxy type coating. The specifications now require application of an "approved epoxy" coating.

Preservation of the Hull Against Corrosion and Fouling

The aluminum hull and the steel struts of the hydrofoil, as well as the non-aluminum alloys of the sonar assembly are to be electrically isolated by using dimensionally stable, glass fabric reinforced. thermosetting gasket materials. In addition a test method has been specified to check out the degree of isolation. Aluminum alloy "zincs" are provided in the vicinity of hydrofoil strut and sonar wells in the event the isolation system breaks down. Furthermore, should corrosion become a serious problem, an impressed current cathodic protection system can be applied to the hull.

The hull will be protected by an anti-fouling paint system

Hull Structural Material

Investigations were made of various types of construction and materials to determine the most economical method in regard to weight and cost. These investigations included studies of various aluminum extrusions and plastic designs using aluminum and plastic honeycombs with plastic and aluminum faces in varied combinations.

The assumed force of sea impact on the hull bottom is based upon test results on P.T. boats. The assumed loads due to sea slap are comparable to those used for submarine fairwater structures. In the interest of weight saving and on the basis that the assumed loads are conservative, all aluminum hull structure subject to sea impact forces is designed up to the yield of the material. Hull structure contributing to foil support is designed to a factor of safer) of 1.25 on yield. The design of the plastic superstructure includes a factor of safety of 1.5 on the ultimate strength. In most cases the plastic construction weighed more than the aluminum extrusions. The calculated plastic skins ranged in thickness from 0.1 to .16 inches to meet strength requirements. However, to design for impact or point loads. the skins would have to be considerably thicker. Consideration of special fastenings and additional solid cores in way of attachments would increase weight and cost of fabrication.

The studies indicated the use of aluminum extrusions afforded the best method of construction. Extrusions were designed for the superstructure, main deck, platform deck, transom. bulkheads, floors, hull sides and bottom in flat areas, strut trunks, transverse frames, gunwale angle and centerline keel.

The proposed extrusions were submitted to various aluminum companies for comment and price quotations. Collectively the reports stated that (1) the I-beam extrusions could be obtained; (2) the lightest proposed plate and stiffener extrusion could not be supplied and others only after modification; (3) the die cost per extrusion was high without large quantity orders. This made it necessary to reduce the number of extrusions to a minimum. The gunwale angle, centerline keel, and three plate and stiffener extrusions were eliminated, while the remaining plate and stiffener extrusion was modified for use in as many areas as possible. Where this extrusion could not be used, standard plate and shape designs were employed.

In the design of the plate and integral stiffener extrusion, to accomplish flange stabilization, it was necessary to use short webs and large fillet radii. For this extrusion, 6061-T6 aluminum alloy is used because of its extrudability. Welding is permitted only in the longitudinal seams where strength reduction due to welding is in the low stress plane. Transverse frames were designed with a uniform flange thickness to eliminate the need for tapered washers in fastening the integral plate stiffener flanges to the transverse frames.

Aluminum alloy 5456 is used where it is necessary because of the hull shape, to weld up the panels and then weld the stiffeners to the plate. It is used throughout the hull bottom, in hull sides forward of Frame 6, in the transom, in the forward strut trunk, in portions of the after strut trunk, and in areas adjacent to the strut trunks. Both alloys possess good corrosion properties in salt water.

Bulkhead Tightness

Where plating of bulkheads is removed in way of the deck or shell stiffeners (to avoid a transverse weld on the integral plating and stiffener extrusion) the required tightness is restored by the use of 10# density polyurethane foam blocks cemented in place with an epoxy resin adhesive. Foam blocks are also used to stabilize deck and shell longitudinals at web frames. Deck camber was kepr to a minimum to facilitate the alignment of bulkhead and deck stiffeners.

Strut Trunk

The strut trunk area was given special design attention to assure its withstanding loads from the foil struts. The deck plating and stiffeners and the lower portion of the after strut trunks are made of heavier plate and stiffeners than the extrusion to accomplish this. Also, additional floors are employed to transfer the load from the strut trunk to the shell, deck and longitudinal bulkheads.

Platform Deck

The platform deck was watertight in preliminary design. A check on the extent of flooding that would occur between any one of the watertight bulkheads indicated that the water would not rise higher than the floors except in the engine room and the large compartment amidships. The floor in way of the sonar trunk was made watertight along the skin of the craft to reduce the extent of flooding in the midship compartment. Due to the limited amount of flooding that would occur, the platform deck was made non-watertight. The platform deck design load was reduced to 250 psf in the forward area and the plate and stiffener extrusion was replaced by portable deck panels. These panels are of sandwich construction made up of aluminum skins with an end grain Balsa wood core. The panels are secured to the framing with CRES screws. These panels offer light weight construction plus ready access to the area under the platform deck.

Non-Structural Bulkheads

A weight study indicated that a special design of non-structural bulkheads and partitions could produce a weight saving over standard non-structural bulkhead designs. These bulkheads are made of 18 gauge (0.040-inch thick) rigidized aluminum panels with curtain plates of 10 gauge (0.1019-inch thick) aluminum.

Sonar Well

The sonar well design employs the integral stiffener extrusion with a bottom closure plate secured to the sonar transducer assembly. With the sonar housed. the closure plate fits flush into a recess and bears against the hull bottom around its outside periphery.

Foundations

All foundations were designed utilizing structural members of the hull, reinforced as necessary to carry the additional loads.

Superstructure

The superstructure design loads were reduced from 2000 psf to 1200 psf for the front. 1500 psf to 600 psf for the sides and 1000 psf to 600 psf for the top. These are arbitrary values based in part on our present design practice for submarine fairwaters and superstructure wherein sea slap loadings of 1000 psf are used. Some damage is expected if a large random wave were to crash down on the superstructure. However, it is not considered practicable, in a design such as this where weight is so critical. to design to some arbitrary high loading on the outside chance that it may someday be encountered. The design for the plastic super-structure includes a factor of safety of 1.5 based on the ultimate strength of the plastic.

Extensive cost and weight studies were made of the superstructure designed in plastic and aluminum to ascertain the optimum economical design. The plastic design offered the lightest structure and cost slightly less than the aluminum design. Reduction in the design loads resulted in a more significant weight reduction in the plastic design than in the aluminum. The use of the extruded aluminum plate and integral stiffener would result in about 600 pounds increase in weight. Since both the plastic and aluminum designs provided a sound superstructure at approximately the same weight and cost, the Detail Specifications state that the Bureau will consider a proposal to construct the superstructure, strut trunk housings, and sonar mast fairing of aluminum.

Longitudinal Strength

The longitudinal strength of the hull was checked during preliminary design assuming the craft to be supported by the foils and adding a dynamic factor of 0.7. The resulting stress of less than I 500 psi indicated an adequate margin for any hullborne condition. A moment of inertia check of the present design indicates little change from the preliminary design, thus, little change in longitudinal strength.

General Arrangements

In addition to the developments discussed previously, the following significant changes occurred during the contract design:

I. The auxiliary steering station was eliminated and the main engine controls were incorporated into the control panel in the new steering station.

2. The superstructure was made narrower to reduce weight. was moved forward one frame to improve the trim, and the forward end was rounded to improve the streamline flow.

3. The steering station was enlarged to provide space for the helmsman and the flight engineer. The steering station was also moved forward for improved trim and increased visibility. The center section of the steering station top opens hack thus permitting personnel to step out on top of the superstructure.

4. The torpedo tubes were moved forward to improve the trim and to avoid interference with the watertight hatch. leading to the crews quarters, when loading torpedoes into the tubes. The tubes were staggered to maintain the necessary structural clearance when torpedoes are fired.

5. The air intakes in the strut trunk housings were redesigned to meet the air intake requirements and to provide greater protection to the machinery room against the entrance of sea water.

6. Arrangement of the platform deck was changed in order to reduce weight and improve the trim forward. The collision bulkhead was shifted aft one frame (FR. 1 to 2) and a platform deck installed to provide space for an anchor windlass room. This permitted elimination of the portable anchor windlass on the main deck and installation of a fixed anchor windlass below deck.

7. The bulkhead at Fr. 3 was eliminated. Bulkheads at Frames 5 and 9 were shifted one frame forward and the bulkhead at Frame 12 was shifted one frame aft. This change eliminated the electronics workshop and repair parts stowage room and provided one general storeroom only between Frames 2 and 4. This was done on the basis that only minimum essential repair parts will be carried on board; all others will be short- based. This shifting of bulkheads also increased the area of the Officer's stateroom and the CPO living spaces.

8. Clips for safety belts are provided in the messroom and crew living space for the use of personnel in these areas during foilborne operations.

9. The fuel tank was enlarged to meet new fuel consumption requirements, and divided into two tanks for safety in case of damage to the hull. On the basis of foilborne stability data developed by DATMOBAS it was necessary to shift the fuel tanks two frames forward in order that the center of gravity of the craft remain forward of the neutral point during all conditions of loading. Shifting the fuel tanks forward also improved the trim forward.

10. The open signal station and flag bag were eliminated to reduce air resistance and weight. Signal flags are to be stowed in the deck gear locker.

11. Fueling at sea padeyes and transfer at sea padeyes are provided only on the starboard side of the strut trunk housing and the superstructure respectively in order to reduce weight. The locations on the starboard side were chosen because the helmsman is located on the starboard side of the steering station.

Habitability

Primarily as a result of weight considerations the following developments occurred during the contract design:

1. The officer and enlisted men's sanitary spaces were combined to save the weight of piping and fixtures, A lavatory is provided in the officer's stateroom and the CPO living space.

2. Doors to the officer's stateroom and CPO living spaces were replaced with fabric curtains.

3. Under-the-berth lockers are used for crew and CPO in lieu of stand-up type lockers.

4 Berths are located to make use of bulkheads or shell for support. Where other support is required, the upper berth is specified to be hung from the overhead and the lower berth to be supported from the deck under.

j Wherever practicable, furniture is either built-in or standard, modified to utilize joiner or structural bulkheads as backs or sides.

6. The combination freezer-refrigerator provides chilled water for the bubbler

7. The number of mess seats was reduced from 10 to 6. To have provided cooking equipment for feeding 10 men at one sitting would have increased the cooking equipment to larger, more power consuming units. The messing required for the crew is 30%, based on three shifts, excluding men on watch, galley detail, etc. With 2 CPO eating in the main mess room and 30% crew, 5 seats are required.

8. The extent of joiner bulkheads was reduced by careful attention to arrangement of spaces and lockers. The bulkhead separating the galley and mess room was eliminated. The dry provisions locker was eliminated: the dry provisions are stowed under a galley dresser.

TABLE 2

GROSS AREAS - SQUARE FEET/MAN			
	150-Foot Standard	Preliminary Design Plan	Contract Design Plan
Crew	16.5	20.0	28.0
CPO	26.3	47.5	49.4
CO	107.0	126.0	164.6

9. The use of plastic was investigated as a substitute for aluminum for crew and CPO lockers. There was no guarantee that weight could be saved; in fact, there was a possibility that plastic lockers would weigh more than the aluminum lockers. A weight saving was effected by using a lighter gauge CRES for the galley dresser top corresponding to that used in aircraft

10. The "Minimum Habitability Standards" do not include ships under 150 feet. However, the living space areas as shown on the contract plan exceed the area requirements for a ship over 150 feet in length. Table 2 compares the 150-foot standard and that achieved on the preliminary design plans with the contract plan areas.

Hull Specifications

The Detail Specifications for the PC(H) were prepared using a self-contained format, based on the General Specifications For Ships dated 1 May 1958 and including all amendments dated 1 April 1959 and earlier. Code 240's services were employed for typing and printing the specifications using the "Cardotype" process. The specifications were very critically reviewed to insure that only the lightest materials and equipments which would meet requirements were chosen. Broad use was made of commercial equipment, particularly for furniture and fixtures. The use of aircraft equipment was investigated and is specified for such applications as furniture, communication and hydraulic equipment.

Foil Retraction

The aft foil is raised and lowered by matched screw-type hoists driven by hydraulic motors. The two drives are linked through a coupling so that they cannot get out of synchronization and thus rack the strut and foil structure an excessive amount. The ball nut screw hoists in the preliminary design were eliminated and conventional type screw hoist:, installed for reasons of cost. possible corrosion problems. maintenance and availability.

The forward foil is provided with a hydraulic piston and cylinder-type hoist instead of a screw-type hoist because of its greater simplicity and because no significant weight saving was achieved in using a screw-type hoist. Both hoists are operated locally to reduce cost and weight.

Foil Foundation and Locks

The forces on the foils are transmitted into the ship structure via wedge-shaped, self-aligning lugs mounted on each strut, mating with lugs mounted in the ship structure. The mating lugs are forced together by spiral-cam. wedge-type locks, and when wedged together form solid, movement-free foundations for the cantilevered struts. The spiral-cam locks are hydraulically actuated and their control is incorporated in the foil raising and lowering control to simplify operation for retraction and extension of the foils.

Foil Actuation

The foil control flap actuator servo valves used are electro-hydraulic types for maximum response and are mounted as close to the actuators as practicable to minimize system sponginess.

The foil control flap hydraulic actuators are placed high in the struts to minimize saltwater contamination of the hydraulic system. The flap tillers are designed to fit and move in the restricted area of their respective nacelles.

Hydraulic Systems

The sensitivity and rapid response demand required of the control flaps necessitated use of servo valves which require extreme cleanliness in the hydraulic system. This need was met by using an independent system for this function thus keeping the foil control hydraulic system separate from the all-purpose. heavy-duty type hydraulic system used for general ship service.

Since the hydraulic demand for starting one propulsion gas turbine is equal to or greater than the hydraulic demand for raising the foils. and also since the gas turbine can be started only when the foils are lowered, the detnands preparatory to “take-off” do not include lowering the foils as part of the total combined demand specified in the Detail Specifications for sizing the ship service pump.

Pressure-compensated variable-volume pumps are used to keep pump control components and weight to a. minimum. In order to minimize weight, both ship service and foil-actuating hydraulic systems are designed in accordance with military aircraft standards.

Sonar Hoist

The rack and pinion type hoist designed by the Naval Research Laboratory during preliminary design was replaced by a simple cable and sheave type hoisting gear. This change resulted in a major reduction in weight, less complexity and reduced cost. The savings realized in this design permitted repackaging of the SQS-20 sonar with a large reduction in weight. power and space requirements.

Canopy for .50 Caliber Twin Mount

The preliminary design plans indicated a portable cover for the .50 caliber mount; the type of cover was not specified. Discussion in conference and statements made in various correspondence indicated that a bubble-type shield to streamline the mount was desired. However, the Bureau of Ordnance advised in their letter of 14 August 1959 that it did not have a plastic bubble for the .50 caliber twin mount Mk17. A removable canvas-type cover will be designed by the Bureau of Ordnance (now BUWEPS) after the final dimensions of the shield are furnished. The cover will be supplied in time to meet the completion date of the vessel.

Though the Bureau of Ordnance has agreed to furnish this cover, the Detail Specifications Section S73-1 is written in such a manner that this cover could be made a contractor-furnished item.

Anchor Handling and Stowage

The preliminary design called for two LWT anchors, one 75-pound and one 100-pound stowed on deck, a portable capstan which would be stowed below deck, and a single length of commercially cast aluminum chain.

In order to save weight. the design was modified to one 150-pound LWT anchor, two fathoms of 1/2-inch aluminum chain, and 75 fathoms of nylon line. The anchor windlass was installed permanently below deck in the anchor windlass room. To reduce wind drag the anchor and its handling equipment are stowed in the anchor windlass room.

With the aid of a small davit, several sheaves and two closed chocks, all anchor handling can be accomplished with the manually driven anchor windlass located in the anchor windlass room.

Weights

The PC(H) design is weight critical. This necessitated close control of the weights which was exercised, particularly in the latter stages of the design, to insure that the 1 10-ton full load displacement limit set for foilborne operation was not exceeded. Table 3 shows the variation in weight estimated during the contract design phase as well as the preliminary design estimate.

The major weight differences between the preliminary design estimate and the first complete contract design estimate were due primarily to the use of a different hull plating and stiffener extrusion than the one proposed by Preliminary Design, more detailed analysis of the propulsion units and equipment to be used, and changing the diesel electric generator from 60 KW to 75 KW.

From the weight estimate of 17 August 19 59, the full load condition continued to increase until it reached 113.91 tons. At this point a concerted effort was made to decrease the weight. This effort resulted in a craft with a full-load displacement of 108.74 tons. The major weight reductions were in the following areas:

1. A reduction in shell plating thickness where extrusions were not used.
2. Platform deck partially constructed of balsa wood and aluminum sandwich panels.
3. Superstructure changed from aluminum to plastic. This also eliminated the necessity of thermal insulation in the superstructure.

TABLE 3

WEIGHT ESTIMATES							
	LIGHT SHIP	FULL LOAD	DRAFT F.L.	TRIM F.L. BY STERN	GM F.L.	VCG F.L.	LCG F.L.
DATE	TONS	TONS	FT.	FT.	FT.	FT.	FT.
*12/--/58	83.61	107.56	3.65	2.44	9.94	7.36	9.40
08/17/59	86.75	110.84	3.74	2.55	9.48	7.84	9.62
09/22/59	88.66	112.58	3.78	2.49	9.34	7.86	9.41
09/28/59	87.38	113.91	--	--	--	--	--
10/23/59	85.25	110.14	3.72	2.46	9.36	7.94	9.41
11/17/59	83.49	108.47	3.70	2.43	9.59	7.71	9.33
01/15/60	83.29	108.17	3.85	2.49	8.89	7.86	9.36
01/18/60	83.29	108.74	3.86	1.99	8.94	7.76	7.[illegible]4

*Code 420 final values

NOTE: All of thr preceding estimates are with foils retracted and contain a +-ton margin located at the center of gravity for light ship. For an approximate vertical center of gravity for full load with foils extended subtract 0.8 ft. from the center of gravity; for light ship subtract 1 .0 ft.

4. Hydraulic starter specified for the auxiliary propulsion diesel instead of batteries and electrical starter.

5. Sonar and foil hoists were modified and the SQS-20 sonar repackaged.

6. Distilling plant was changed from the vapor compression type to the waste heat type This also reduced the weight of operating fluids.

7. Air conditioning was eliminated.

8. Carbon dioxide extinguishers were replaced with dry powder type extinguishers

9. Operating fluids were reduced by replacing the firemain with a centrally located fire pump and hose connections.

10. Rigidized aluminum panels were used for nonstructural bulkheads and curtains replaced non-structural doors.

11. The electronic shop was eliminated and all stores were combined into one storeroom.

12. Thermal insulation was reduced to a minimum.

13. The torpedo compressed air system was modified.

14. The diesel generator was reduced in size from 75 KW to 45 KW and the gas turbine generator reduced from 60 KW to 40 KW. This reduction in electrical requirements resulted in part from replacing the electrical heating system with an oil heating system.

Stability, Hullborne

Curves of form, with foils retracted, were developed from the contract lines plan and found to be in close agreement with the values calculated during preliminary design. Differences were due to taking into account the appendages which, for preliminary design, had been omitted. Cross curves of stability were also calculated with the foils retracted.

The spacing of the bulkheads was checked to see that an opening in the shell of 15% of the LHP would not open more than two adjacent compartments. The damaged stability after flooding the most critical group of compartments indicates that all criteria are met.

Limiting drafts for subdivision were calculated and found to be far in excess of what the foils could support. The hull could support say 140 tons, whereas the foils are designed for 110 tons.

No stability studies for foil extended conditions were made.

Stability, Foilborne

Foilborne stability and control studies of the PC(H) were conducted by DATMOBAS, Reference 34. The completed tests are:

1. Constrained model tests on a 1/8-scale powered model, Figure (29). These experiments gave the dependency of the forces and moments on the various parameters:

   a. Longitudinal stability: Angle of attack about the equilibrium incidence settings. pitch angular velocity. heave, depth. flap deflection. elevator deflection and speed of advance.

   b. Lateral stability: Sideslip angle. roll angular velocity, and rudder angle.

2. Forces and moments on the constrained model advancing into waves. However, head sea variations are limited by the tank length for the long waves and high speeds of advance.

3. Constrained tests on the forward foil by itself to determine elevator effectiveness. Knowing the performance of the forward foil alone permits a determination of the qualitative effects of downwash on the after foil.

The data collected and its interpretation is presented in a format that will be of maximum benefit to the autopilot manufacturer. The report includes:

1. Table of foil characteristics (geometry, size, etc.). This will include all pertinent physical characteristics for both model and prototype.

2. Tabulation of non-dimensionalized stability derivatives (including those estimated and those obtained experimentally). In addition, the experimental plots showing the data

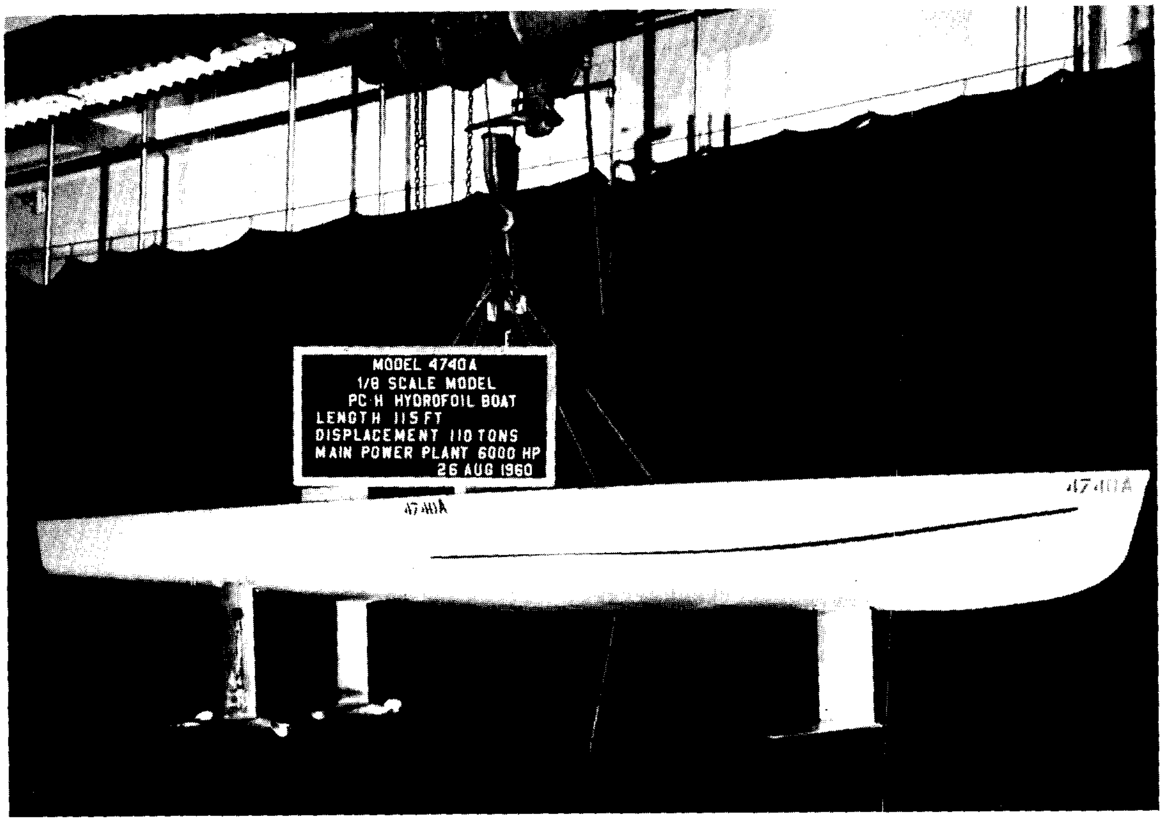


Figure 29. I/S-Scale DTMB Powered Model of PCH

points are provided. With these, the potential autopilot manufacturers can be better oriented to the degree of nonlinearity in the event a nonlinear treatment is preferable over that of a simple straight line approximation of the stability derivatives.

3. The open-loop transfer function for the longitudinal response has been calculated from the equations of motion using a linearized model. Nyquist plots showing stability and amplitude of motion are presented.

4. Analysis of the characteristic equations of motion for the stick-fixed (open-loop) dynamic stability show that the craft is longitudinally stable.

j. The stick-fixed neutral point has been calculated for two center of gravity locations. A third location is being calculated reflecting the location of the center of gravity (c.g.) of the PC,(H) at the time the contract plans were signed. The neutral point gives the most aft location at which the c.g. can be placed before making the craft unstable.

6. Analog computer studies to determine the effect of various flap rates are being conducted for 12, 24 and 48 degrees per second. The effects of these rates are being studied for a range of pertinent sensitivities in the autopilot loop for the 45 knot condition. A schematic diagram of a tentative autopilot loop is being furnished. Studies on the 12-degree flap rate have been completed and will be included in the report.

Further work has been ordered from DATMOBAS utilizing the rotating arm facility, to obtain the remaining lateral plane derivatives and turning characteristics of the PC(H). This information is expected to be obtained by the end of August 1960. provided the rotating arm facility is put in operation in May.

1/s-Scale Model Propulsion Tests

At the time the contract plans and specifications were signed, on 18 January 1960. confirmation of predicted propulsion characteristics for the contrarotating tandem arrangement of propellers had not yet been attained.

On the basis of the same cavitation index for model and prototype. 1/3-scale model pro pulsion tests indicate that the thrust required for take-off can be developed but with less than the 50% margin in thrust desired for rough water operation. In foilborne condition, the tests indicate that full speed can be attained but approximately 92% of the installed power is required instead of the desired 80%. Cavitation occurs in way of the intersection between the strut, nacelle and foil thus causing a very disturbed water flow condition to the aft propellers. On the after propeller the leading edge of one blade ruptured and the two other blades were bent during one of the high speed tests. This indicated that the after propeller was being overloaded and is attributed to the confused waterflow condition to this propeller. To correct this condition the Model Basin is now conducting tests in the 24" variable pressure propeller tunnel to determine the optimum location of the foil relative to the strut and nacelle, and optimizing the filleting in way of the strut. Model propulsion tests will be reconducted with a stronger after propeller designed by Code 644.

It is hoped that satisfactory propulsion data will be obtained with this modified contra-rotating tandem arrangement of propellers. However, alternative proposals are also being considered. They are a single propeller forward of each nacelle, and contra-rotating propellers forward of each nacelle.

If time permitted, it would have been desirable to have further delayed the signature of the contract plans and specifications on the PC(H) until reliable and satisfactory propulsion data were in hand. However, for funding purposes, it was considered essential that the contract for constructing the PC(H) be awarded prior to the end of Fiscal Year 1960, thus precluding any further delay.

Although rather lengthy, the foregoing extracts from the Design History illustrate the depth of detail in the information developed by BuShips and provided to the contractor. Justifiable variations were, of course, permitted during development of the detail design but, it is clear that the PC(H) design was almost entirely a product of BuShips designers. The design was supported by a number of model tests conducted by DTMB. These are reported in References 35, 36, 37, 38, and 39.

Figure (30) is a drawing of the PC(H) as it was envisaged upon completion of contract design. This drawing was enclosed with the "Letter of Promulgation" issued over RADM James signature on 15 March 1960.

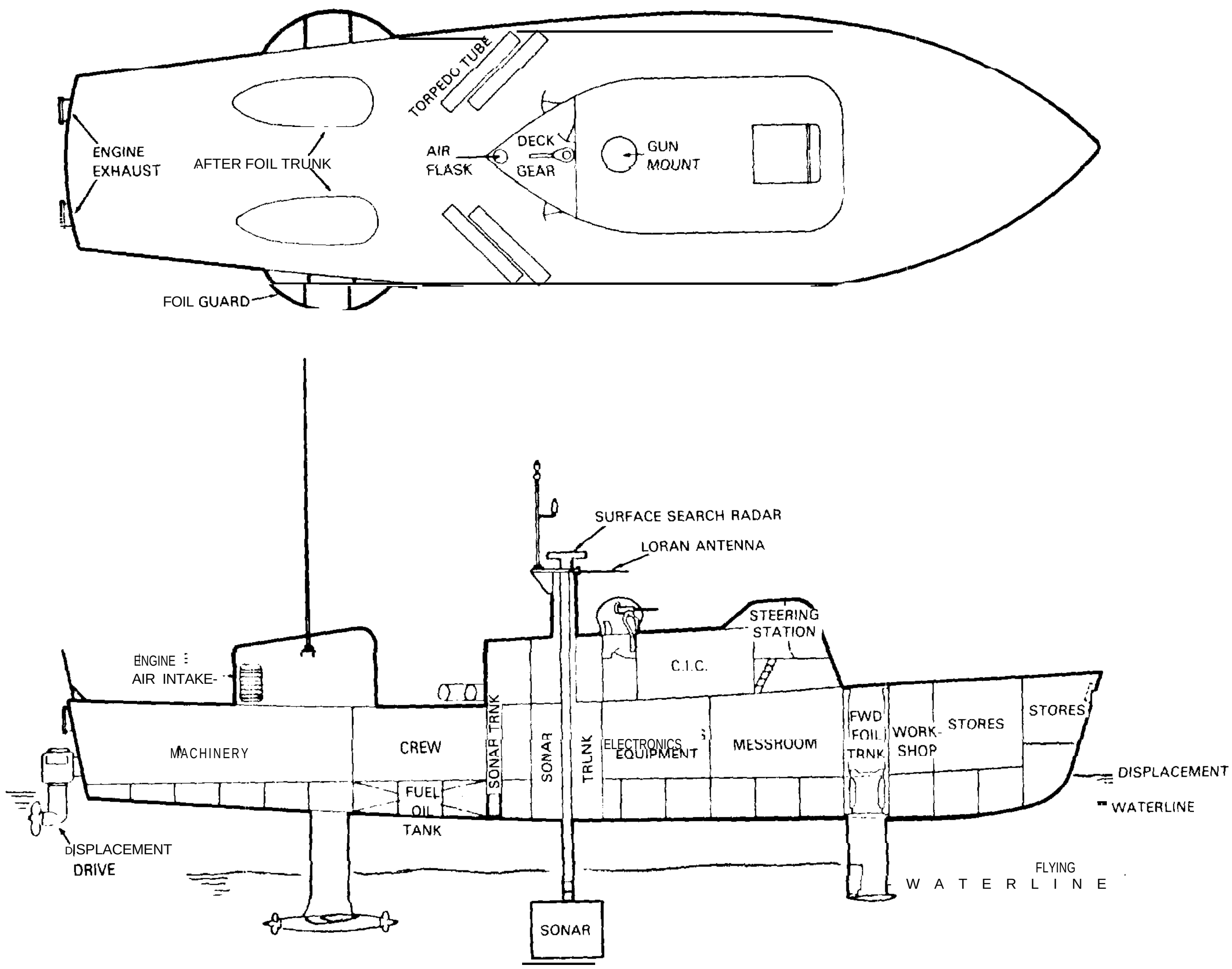


Figure 30. PCH Contract Design

CHAPTER 3
Acquisition

THE BID PACKAGE

The PC(H) bid package which contained the contract guidance drawings and the design specification, Reference 40, was prepared under the direction of the BuShips Mine. Service. and Patrol Craft Branch, otherwise known as the *Type Desk*. At the beginning of PC(H) acquisition. this branch was headed by CAPT Richards T. Miller. The Head Engineer was Sidney A. Peters who is credited with buying more of the Navy's small craft than any other individual. His deputy was Mark Jewett and the Project Engineer in charge of PC(H) acquisition was Al Koval.

As noted in the design history, the specifications were derived by using the General Specifications for Ships of the U.S. Navy and modifying them to account for the special features of a hydrofoil craft. As might be expected rhis did not fully **account** for all of the unique aspects of a hydrofoil, particularly the critical nature of system weight. This resulted in some interesting initial oversights. For example, the original specification called for explosion-proof solid brass light fixtures and an ammunition storage locker to meet battleship requirements. Sid Peters, who retired in May 1970 after more than 40 years in BuShips, recalled the problem with specifications in an interview on 27 February 1984.

> That was a custom which never fit any of the craft that 1 was involved with. The General Specifications didn't apply at all to wooden ships, (i.e. mine sweepers), but they would take out certain paragraphs and sections and insert them in this thin book of detail specs which did nothing but refer to the Gen *Spec*. That was always a problem because none of them seemed to fit since they were for destroyers and above or auxiliaries. They finally gave that up (later on) and said that each specification for each type of ship shall be self-contained, which was a Godsend.

Shortly after completion of the contract design, a bid package was prepared and bids were solicited from industry. In an interview on 23 April 1984. Bob Johnston, who in 1960 was still President of Miami Shipbuilding Corp., recalls that his company put in a fixed price bid of $4.5M. Grumman bid somewhere around $7M, the Martin Co. $4.1M, and Boeing $2.1M. These bids did not include the cost of government-furnished equipment (GFE) which was significant in magnitude.

CONTRACT AWARD

In June 1960, Boeing was awarded a contract, (NObs-4359), for $2.08M, fixed price. As an interesting sidelight, CAPT Mac Nicholson noted in an interview on 10 July 1984 that. prior to Boeing's interest in hydrofoils, he recalled having shown a movie of SEA LEGS trials to their management and expressing his enthusiasm and optimism about the future of hydrofoils. In his view this influenced Boeing in their decision to enter the competition for the PC(H). It may also be noted that, upon losing the PC(H) bid, Miami Ship's Board of Directors met and decided they should not be in the hydrofoil business. At that point, Bob Johnston resigned as President and joined Grumman's marine operation.

Boeing's research and entry into hydrofoil programs had begun in 1958 with inhouse R&D funding. A marine group was established under Robert E. Bateman in 1959 as part of the Boeing Aerospace Division. The PC(H) was their first contract award for a Navy ship. (This group was a part of the Aerospace Division of Boeing for some time before it became a separate corporate activity as Boeing Marine Systems. BMS recently celebrated its 25th anniversary once again under Bob Bateman who was reappointed General Manager in 1975.)

DETAIL DESIGN AND SUBSYSTEMS

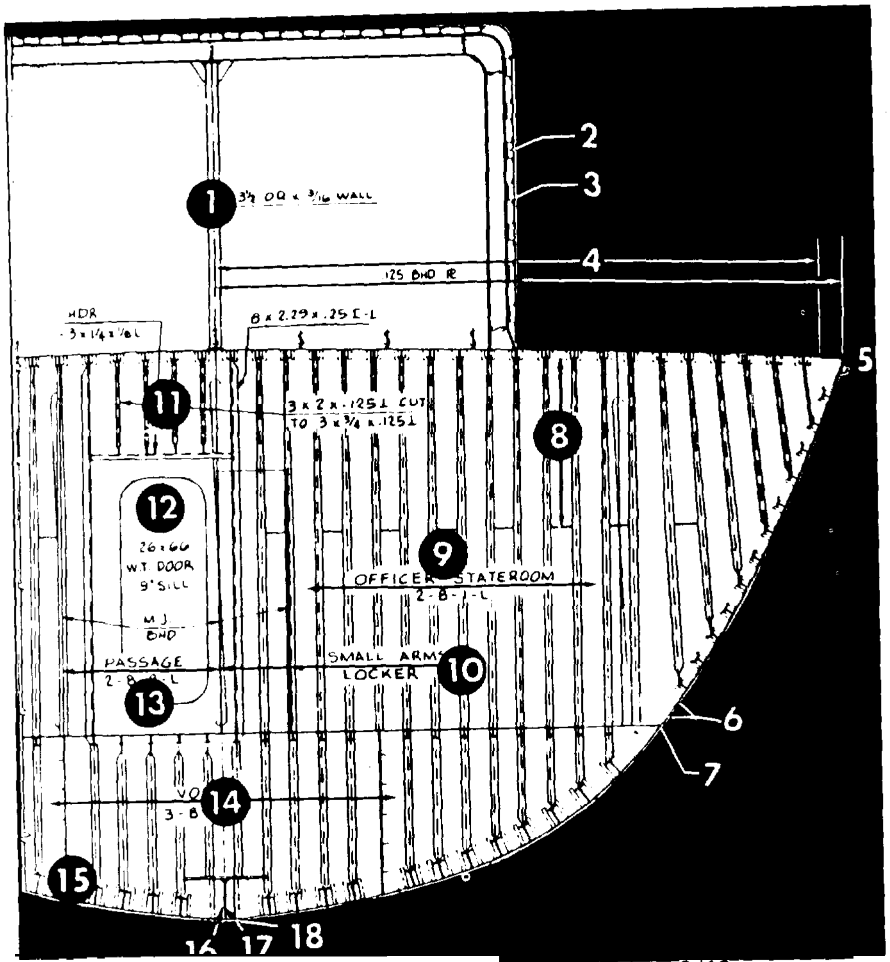
Boeing appointed E. Clyde Bovee as manager of the PC(H) program. He gave a paper. Reference 41, to a meeting in October 1963 of the Pacific Northwest Section of SNAME in which he described the PC(H) detail design and construction. Much of the material covering this phase has been extracted from that report.

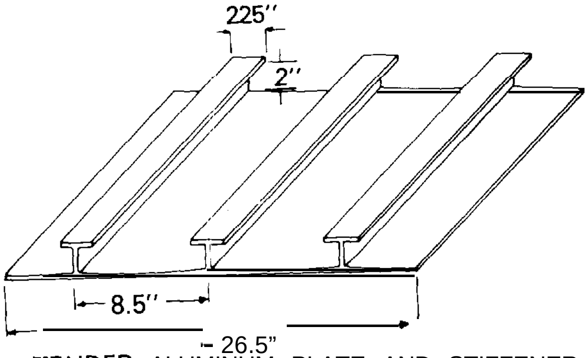
Bovee states that Boeing quickly realized that, although PC(H) had many features allied to aircraft, it was also much like a ship. As a result, they contracted the hull construction to J. M. Martinac Shipbuilding Corp. in Tacoma, Washington. Also, the naval architect firm of W. C. Nickum and Sons, in Seattle, was engaged to do the detailed design of the hull. Boeing undertook to do the design and construction of the transmissions, foils and struts, retraction mechanisms, autopilot, and hydraulic systems.

Hull Design

The original design specified that the hull would be of 6061 aluminum with both welded and riveted joints. This was changed to 5456 aluminum using all-welded construction. This alloy was chosen for its superior salt water corrosion resistance and good weldability. For deck beams, side frames, and keel, heavy extruded i-sections were used. For the main deck and side plating, integrally-stiffened extruded panels were used. Each panel was 26.5 inches wide with three T-bars extruded integrally with the plate on 8.5-inch centers, Figure (31). The extrusions had a maximum length of about 52 feet. Joints were designed for metallic inert arc welding.

Numerous openings in the hull were required other than normal hatches, manholes, etc. The hull sonar was mounted in the center of the ship suspended in the framework of a hole 8 feet in diameter running from the main deck thru the keel. Problems of structural design around this hole, in order





EXTRUDED ALUMINUM PLATE AND STIFFENER

1 3 1/2 O.D. x 3/16 WALL
2 ,051 SHT HAT STIFF
3 MN DK HSE. 064 SHT SKIN
4 MN DK PNL EXTR
5 MN DK 13'-2 3/8" ABV BL
6 SPRAY RAIL. 125 PL
7 PLATE DK. 125 PL 54 ABV BL
8 BHD STIFF FLGS TAPERED TO 3/4" AT MN DK LONG
9 OFFICER STATEROOM 2-8-l-L
10 SMALL ARMS LOCKER
11 HDR 3 x 1 1/4 x 1/8 L
12 26 x 66 W.T. DOOR 9" SILL
13 PASSAGE 2-8-2-L
14 VOID 3-8-O-V
15 LONG BHD .25 PL
16 COLLAR PL .125 PL
17 CVK 12 x 5 x 9.65# I
18 BL SHIP

Figure 31. PCH Extruded Aluminum Panels

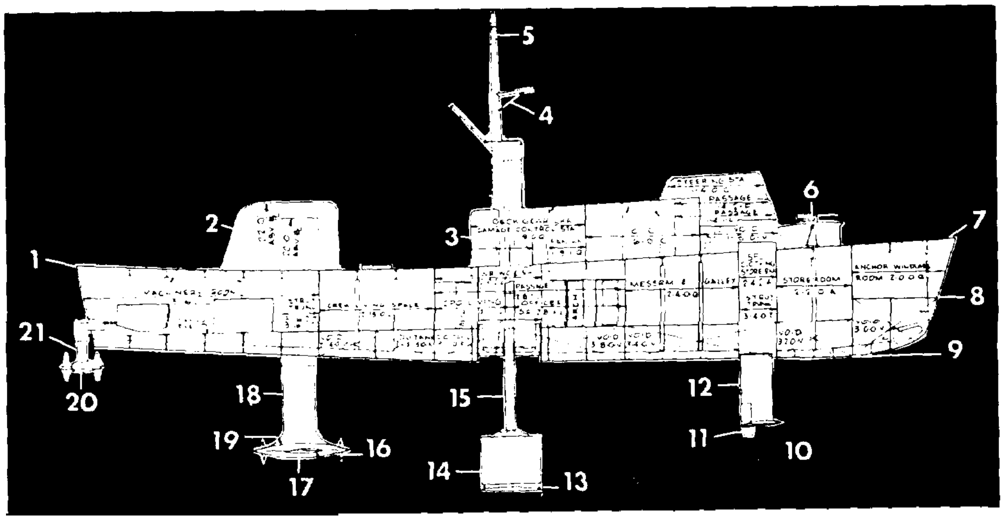
to distribute the loads, were formidable. Additional openings about three feet by five feet, one forward and two aft, were designed into the hull to house the struts when retracted. These strut trunks also extended from the hull bottom to the main deck. The stern side of each aft strut trunk was penetrated to accept a disconnect coupling between the propulsion turbine and the upper foilborne transmission gearbox. The close alignment of this shafting dictated a maximum deflection of the trunks of no more than .03 inches under all load conditions.

The deck house was originally specified to be of plastic sandwich construction with aluminum as an alternate. Boeing designers concluded that aluminum would be preferable. The thickness of aluminum selected. around .050-inch, was too thin for practical welding so the entire structure was put together with Huck lockbolt-type rivets. Alloy 6061 was selected as the material to be used.

Figure (32) is an elevation drawing and Figure (33) shows the arrangement of the platform deck. In order to keep the steering station and bridge controls as simple as practical, an engineer's station was provided just forward of the main machinery space, Figure (34). Thus all engine instruments, alarms, and starting controls were located below deck with only essential instruments and controls located in the pilot house, Figure (3 5). Even so, with the autopilot and other instruments, the steering station was still complex compared to a conventional displacement craft.

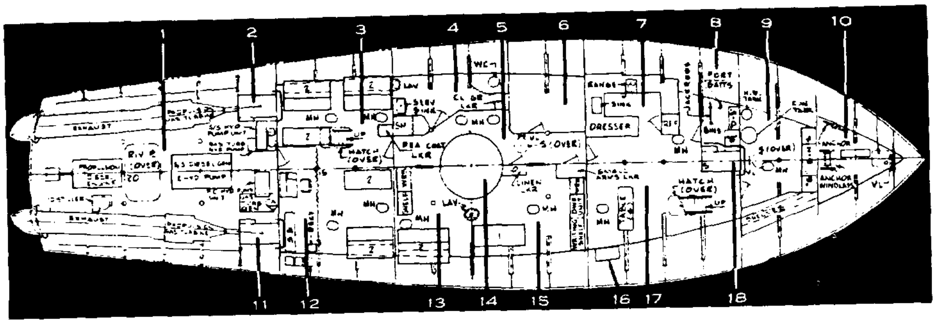
Foil and Strut Design

The foil and strut configuration was specified by the Navy based on NACA airfoil data verified by model tests. Foil loading was distributed approximately one-third forward and two-thirds aft. Each



1 MAIN DECK
13'-11" ABV B AT C
2 STRUT TRUNK
HOUSING P/S
3 SONAR MAST
FAIRING
4 SONAR MAST
FAIRING
5 RADAR ANT PLAT
6 SINGLE 50 CAL
MACH GUN
7 MAIN DECK
16'-0" ABV B AT C
8 PLATFORM
8'-0" ABV B
9 BASELINE
10 121.125 BEL B
EXTENDED
11 FWD HYDROFOIL
12 FWD STRUT
13 16'-9 1/2" BEL B
EXTENDED
14 AN/SQS-33 (SN-1)
SONAR
15 AN/SQS-33 SONAR
MAST 3-10-0-T
16 12'-2 3/16" EEL B
EXTENDED
17 AFT HYDROFOIL
18 AFT STRUT P/S
19 NACELLE P/S
20 HULL BORNE
PROPULSION UNIT
21 PLATFORM DK
54 ABV B

Figure 32. PCH Elevation Drawing Showing Arrangements



1 MACHINERY ROOM
3-16-O-C

2 STRUT TRUNK
3-16-2T

3 CREW LIVING SPACE
2-13-O-L
10 MEN
1 PEA COAT
LKR

4 WR, WC & SH
2-10-2-L
1 LAV
1 SHR
1 WC

5 PASSAGE
2-8-2-L

6 SONAR EQUIP
ROOM
2-8-2-C

7 GALLEY
240-O

8 SPL. CLOTHING
STOREROOM
2-4-2-A

9 STOREROOM
2-2-O-A

10 ANCHOR WINDLASS
ROOM
2-O-o-Q

11 STRUT TRUNK
3-4-0-T

12 ENGRS CONTROL
STA #5

13 CPO LIVING
SPACE
2-11-1L
2 MEN
1 LAV
1 WRB

14 SONAR TRUNK
AN/SQS-33
3-I 0-0-T

15 OFFICE
STATEROOM
2-8-I -L
1 LAV
1 WRB

16 STATIC CONV

17 MESSROOM
2-4-2-A

18 STRUT TRUNK
3-16-1T

Figure 33. PCH Platform Deck Arrangements

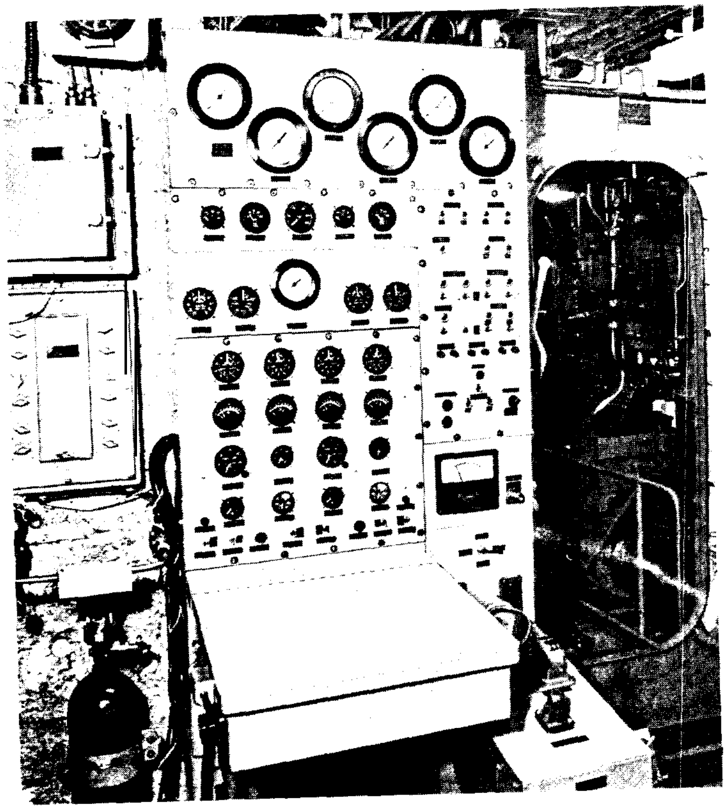


Figure 34. PCH Engineers Station

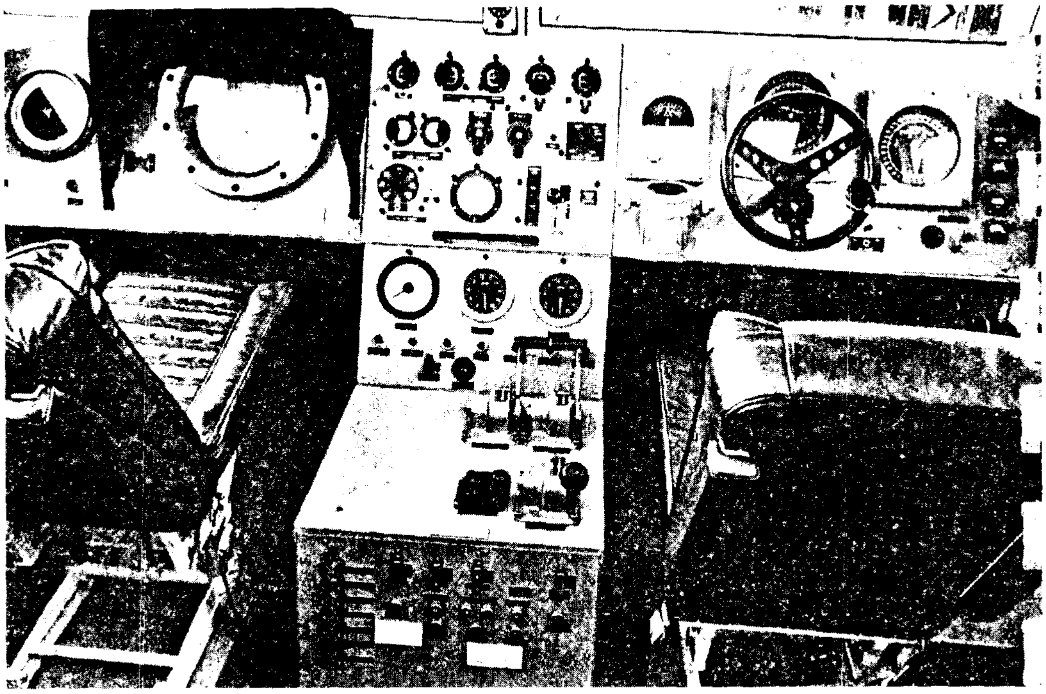


Figure 35. PCH Bridge Steering Station

strut was designed in two sections which were bolted together. The upper box section transferred foilborne loads into the hull and the lower faired section connected the strut base to the foil. The forward foil was designed as a single assembly bolted to the strut. The aft foil assembly consisted of two outboard sections, each welded to a nacelle containing the lower bevel gear transmission. Each nacelle, in turn, was bolted to the center foil span. The aft struts were bolted to a strut stub integral with each nacelle. Flaps for foilborne control were hinged after sections of the foils.

In the original configuration steering control was provided by two small rudders, one on the lower aft section of the forward strut and the other a spade rudder on the same shaft extending below the forward foil.

Strut and foil material was HY-80 low-alloy high-yield-strength (80 ksi) steel. This has excellent notch toughness having been developed primarily for navy submarines. It, however. is subject to salt water corrosion and has to be coated. This led to many of the early difficulties to be described later. The strut/foil structural design followed the general practice for aircraft wings. Spars were used for spanwise stiffening and ribs were used for chordwise structure with plate for the covering skin, Figure (36). Plate thickness varied from 3/16-inch on the outboard tip of the forward foil to over one inch on the nacelles. Because the propulsion transmission system and flap controls were within the strut/foil assembly, the most critical design consideration was stiffness. Deflections had to be held to the minimum acceptable levels to ensure proper operation of internal mechanisms under all loading conditions.

Main Machinery

The main foilborne propulsion engines were two Bristol Siddeley marine Proteus gas turbines. Figure (37). The characterstics of these turbines, also used in the British Royal Navy BRAVE class patrol boats, are given in Table 4.

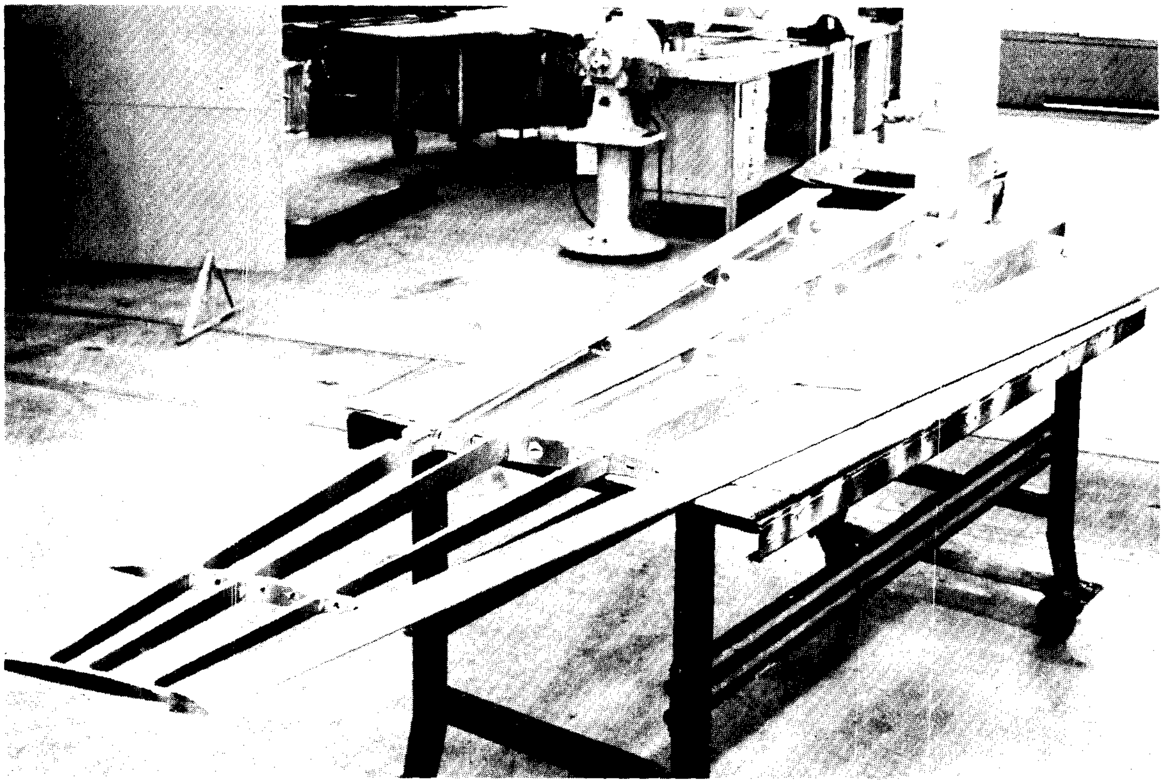


Figure 36. Steel Spars and Ribs in PCH Forward Foil

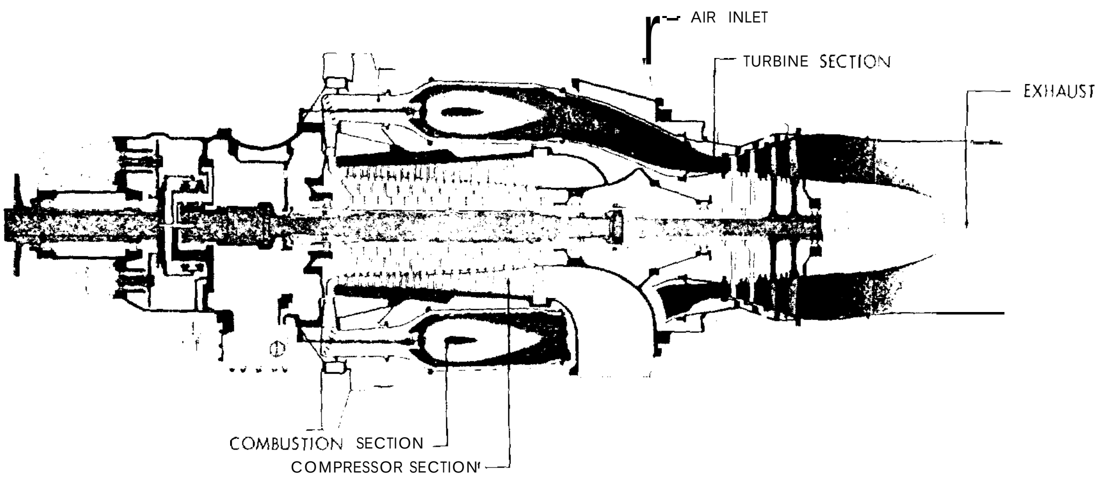


Figure 37. Bristol Siddeley Marine Proteus Gas Turbine

TABLE 4

PROTEUS TURBINE CHARACTERISTICS	
Specific Wt.	0.67 pounds/horsepower
Specific Fuel Consumption	0.60 pounds/horsepower-hour
Fuel	Diesel oil or aviation kerosene
Max. Cont. Power	3100 HP
Output Shaft Speed	5000 RPM
Air Mass Flow	0.68 pounds/minute/HP
Pressure Ratio	7.49
Compressor Speed	11,750 RPM max.
Power Turbine Speed	11,600 RPM max.
Combustion Temp.	3632 Deg.F
Exhaust Temp.	425 Deg.F
Exhaust Shroud Temp.	400 Deg.F

Power is transmitted through an upper right-angle spiral bevel gear bo-x mounted on top of each aft strut. These, in turn, are connected through a single vertical shaft in the center of the struts, to spiral bevel gears in the nacelles and stub spline shafts to tandem propellers fore and aft on each pod, Figure (38). Propellers were counter-rotating at a maximum speed of 1500 RPM. Specifications called for a full-power test of the transmission system prior to installation.

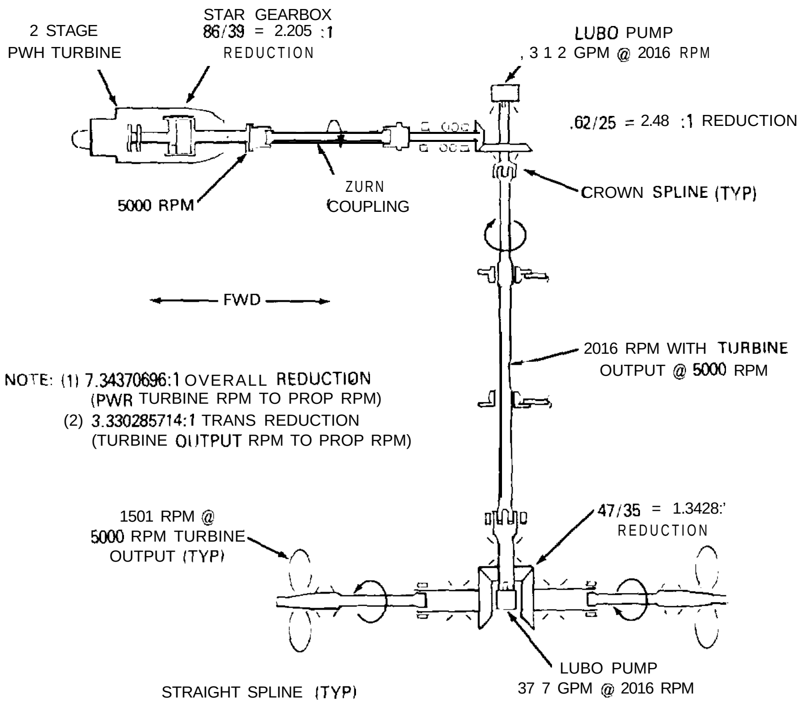


Figure 38. PCH Right-Angle Bevel Gear Drive

The design of the spiral bevel gear transmission in the lower gear boxes was the responsibility of Bill Hamilton. The upper gear boxes were the responsibility of Al Rand. Before coming to Boeing to work in the BOMARC program Rand had spent 10 years with Western Gear where he rose to the position of Asst. Chief Engineer. When George Henderson, who was Chief Engineer on the PC(H) project, sought a gear specialist from Boeing personnel. Al Rand was identified and hired as a member of the PC(H) engineering team and has remained with it ever since. The PC(H) gears were manufactured by Gleason and represented the state of the art for right angle spiral bevel gears. They were the largest that could be cut at that time. Figure (39) shows the lower gears and the nacelle gear boxes.

After being assembled, the foilborne transmission major subassemblies were installed in a large steel jig so that the input shafts to the upper transmission boxes were face to face, Figure (40). The four propeller shafts were connected through test gear boxes so that they could be ‘operated at the required propeller speed. The input shafts of the upper gear boxes were locked together through a Thomas coupling with an applied torque calculated to give the required loads on the gears and bearings. The cooling and lube oil systems were connected, as they would be on the ship, and both complete foilborne transmissions run as a closed loop using electric motors connected to the gathering boxes which were in turn connected at the propeller shafts.

Before running the 24-hour full-speed test called for in the specification, Boeing ran a no-load overspeed test, Some of the bearings froze up and popped the circuit breakers on the electric motor drive. It was found that this was due to the Timken roller bearings being set too tightly. George Henderson wanted to open up the end-play but Timken did not agree. Boeing went ahead anyway and the problem was eliminated. It is recalled by Al Rand that Bill Hamilton. the lead designer on the hullborne drive, was an advocate of Timken bearings whereas Rand was partial to SKF. This led to many friendly debates.

It is important to note that the nacelles themselves comprise the lower gear boxes. This led to later problems with saltwater contamination of the lube oil. The tandem propeller arrangement also later proved troublesome due to the effects of the forward propeller wake, as had been predicted.

For hullborne operation, a 600-HP Packard diesel engine was provided. This was connected through the transom to an inboard/outboard transmission unit, Figure (4 1). This unit was cantilevered off the engine subbase and penetrated the transom just above the waterline. As specified, it was retractable by rotation upward into a stowed position. When extended it was capable of turning 360 degrees to provide steering when operating on the hull.

Boeing did the machining of the hullborne propulsion unit at the Development Center. The housing of 3 56 aluminum was cast by Sunset in Renton, WA. This unit was originally supposed to be a “pusher” but, there was a later problem caused by ventilation at around 10 knots. Because of this and interference with the towed sonar projector it was changed later to a tractor drive with the propeller forward.

It is noted that the Packard diesel was supplied as GFE from the Navy’s repair facility. It was supposed to have been completely overhauled. It was soon determined, however, that it was inoperable and Martinac was requested to open it up and inspect. They found that the crankshaft bearings were shot and it became necessary for them to rebuild the engine including reboring the block.

The output shafts of the two main engines and the hullborne engine were connected to the transmissions thru Thomas flexible couplings. In the initial configuration, these were quick-disconnect couplings. (They were changed later to a bolted configuration designed by Enzo Marmentini. In that design

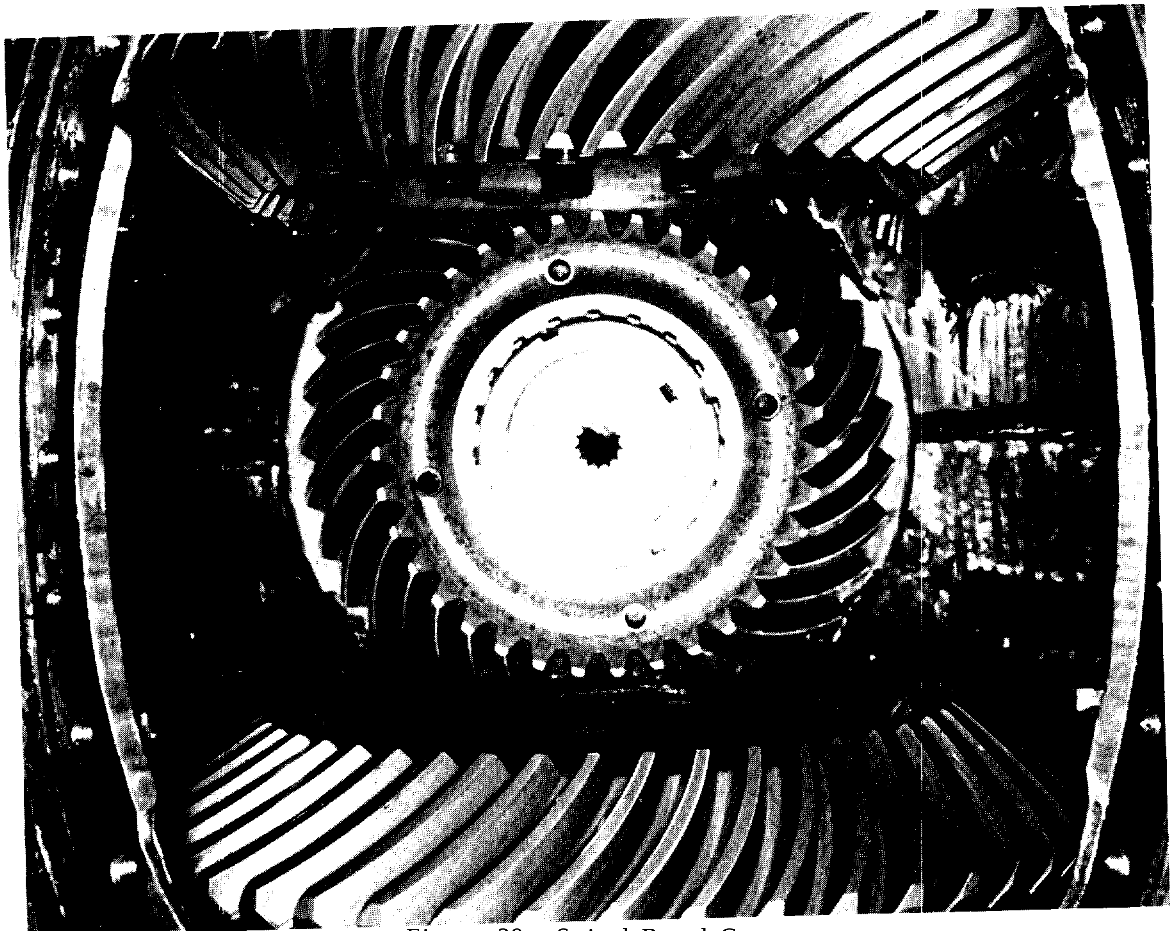


Figure 39a. Spiral Bevel Gears

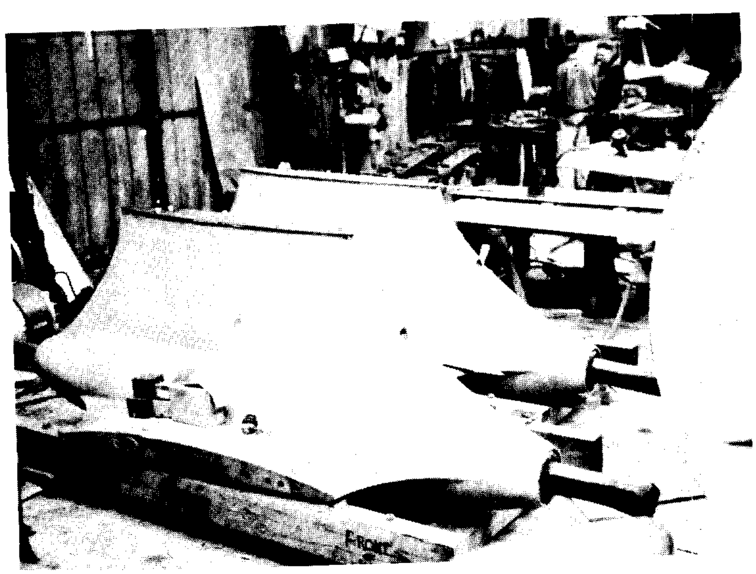


Figure **39b.** Lower Gear Boxes

Figure 39. **PCH** Lower Transmission.

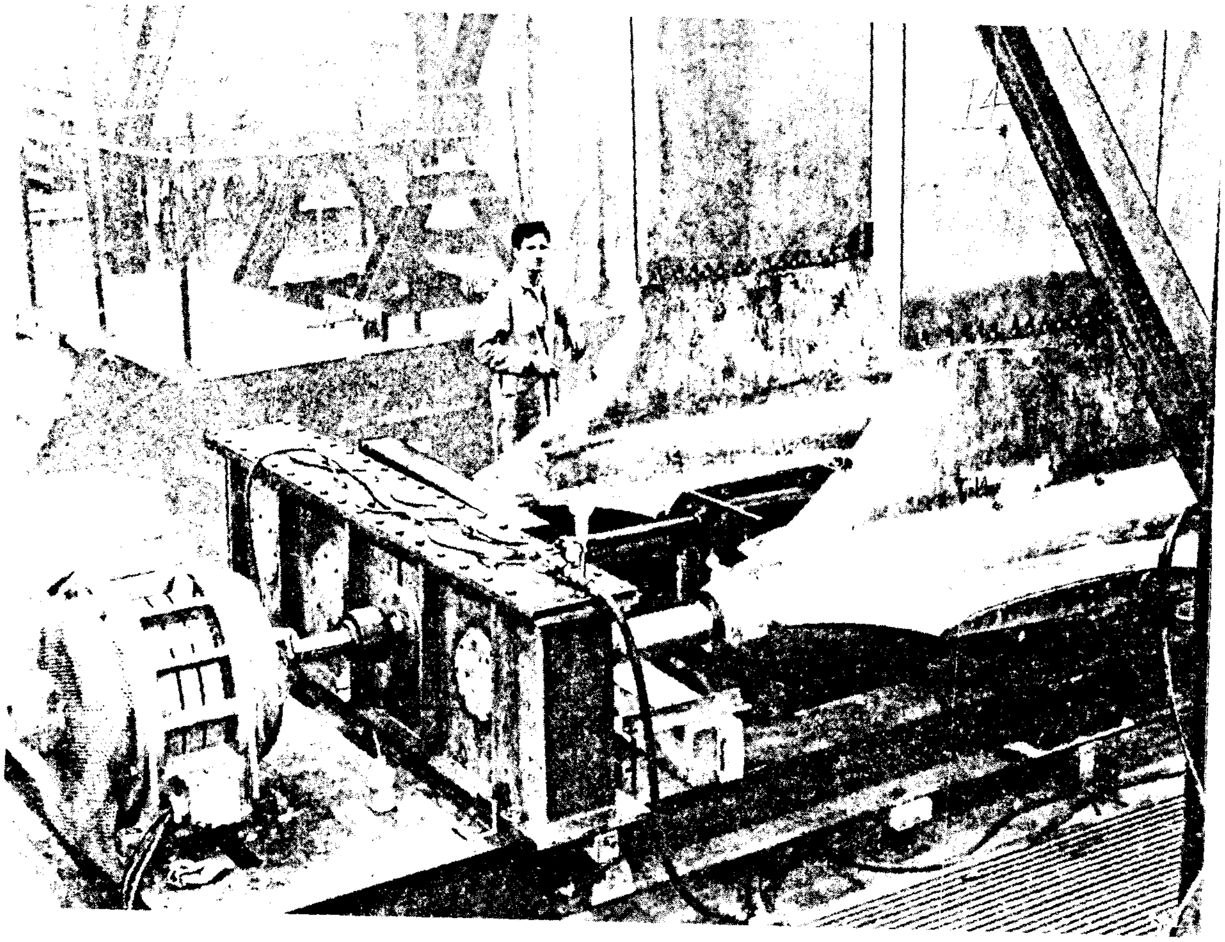


Figure 40. PCH Foilborne Transmission in Full Power Test Rig

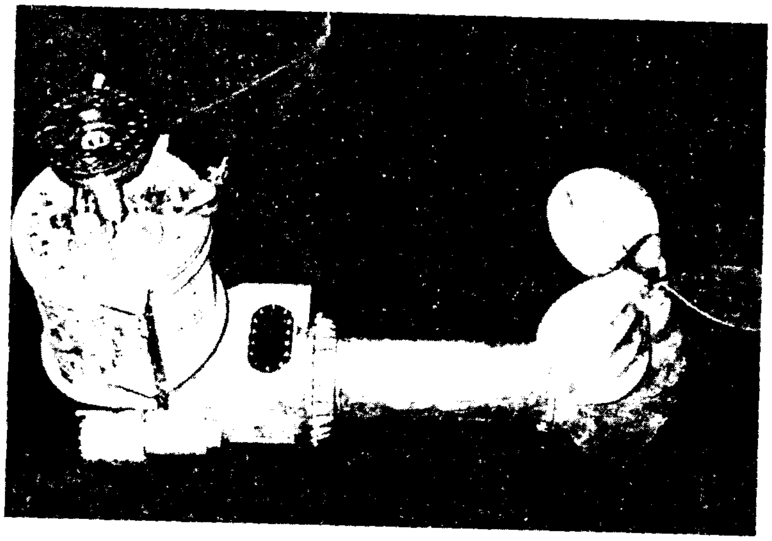


Figure 41. PCH Hullborne Transmission and Outdrive

it was necessary to manually unbolt the couplings in order to retract the main struts. This took an inordinate amount of time and a second modification was introduced.)

Foil Retraction

Provision was made to retract the struts vertically into housings on deck which also served as turbine air inlet ducts. Tbe retracted foils nested close under the keel. Hullborne draft was thus reduced from 17 feet to 6.5 feet. Retraction and extension was accomplished by hydraulically-driven leadscrews in each strut, Figure (42). Fully retracted, the top of each strut was pulled up tight against two large steel pin fittings and held there by a brake on the cross-shaft. In the extended position, the top strut base was lowered into position, over-torqued with the hydraulic motor, and held on four large steel pads by means of a brake on the drive mechanism. Provision was made later to provide a more positive means of locking.

The SQS-20 hull sonar provided in the original design (an EDO AN/SQS-33 XN1 was actually installed) was lowered and raised by a hydraulically-powered chain and sprocket drive. In the extended position it was 16 feet below the bottom of the ship. It was designed to be used only in the hullborne mode at speeds only high enough to provide steerage way. In the stowed position the bottom of the transducer fitted flush with the bull covering the opening.

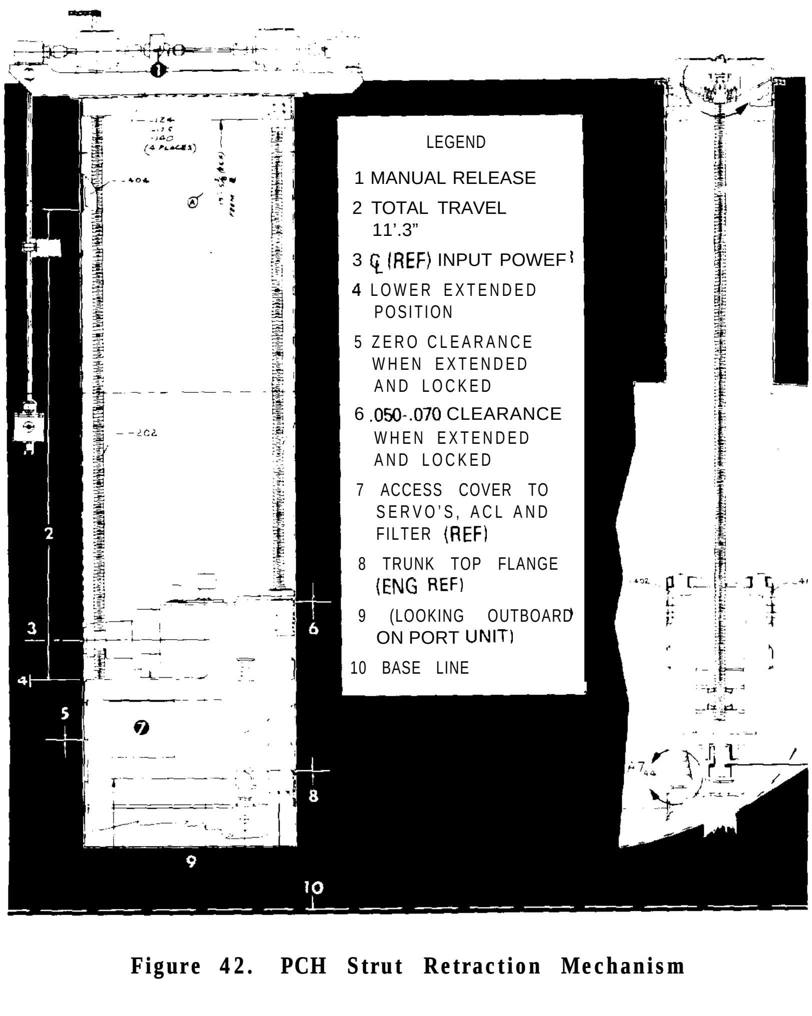


Figure 42. PCH Strut Retraction Mechanism

Auxiliary Machinery

Electrical and ships service hydraulic power was supplied by a General Morors 4071 diesel driving a 45 KW generator on one end and hydraulic pumps on the other. A standby electrical power source was furnished by a small Solar gas turbine with a 40 KW generator. Standby hydraulic power was provided by a Solar turbine driving a hydraulic pump. These systems were also later modified to correct problems that were experienced. The hydraulic system was a 3000 PSI aircraft-type which was not familiar to Martinac shipyard personnel. In order to impress those who worked on the system with the importance of cleanliness, it was necessary to enforce a tight discipline. Workers were issued white gloves and white coveralls which were changed every other day. It was also required that hands be washed frequently. This discipline paid off and the system went together and worked well. Vickers was a subcontractor on the hydraulic system and also provided a sophisticated hydraulic test stand which supplied 20 gal/min at 3000 PSI with flow meters and adapters to fit all hydraulic system components.

The hydraulic fluid chosen was SKYDROL, commonly used in aircraft systems. It had a very high flash point which minimized the danger of fire. However, it was difficult to deal with due to its corrosive nature, serving as an excellent paint remover and solvent for many other materials including shoe soles.

It is noted that there was also a requirement for sound isolation of the auxiliary machinery to reduce noise to a minimum during sonar operation. This required special foundations and an acoustic enclosure of the engine.

Autopilot

The Navy specifications set forth the following requirements for the autopilot:

> Stability and operating altitude of the ship during foilborne operations shall be automatically maintained by an autopilot system, The system shall include all necessary components to insure that the ship will perform below and at design speed in state 5 sea conditions (lo-foot waves) with 0.5 g. maximum vertical accelerations at Frame 4 and 0.2 g. maximum lateral accelerations at center of gravity (fullload) under all headings without manual assistance.
>
> Maximum use of standardized military aircraft-type autopilot components as may have been developed shall be made. Electronic equipment shall be solid state, rugged and reliable. Packaging shall be of modular construction to permit ease in servicing.

Boeing employed their extensive knowledge of aircraft autopilots to do their own development and design of the PC(H) autopilot. It was an analog system developed from studies using an analog computer. As shown in Figure (43), the autopilot controls ship attitude thru hydraulic actuators. The foru-ard foil flaps move together to control flying height with inputs obtained from a bow-mounted sonic height sensor. The two aft center flaps control trim and the two aft outboard f-laps (ailerons) control roll by differential operation.

Armament

Initial armament consisted of a 50-caliber single-mount machine gun in a gun tub on the main deck forward of the deckhouse and two twin-barrel MK-32 torpedo tube systems. one on each side. A MK-44 torpedo was to be stored in each tube.

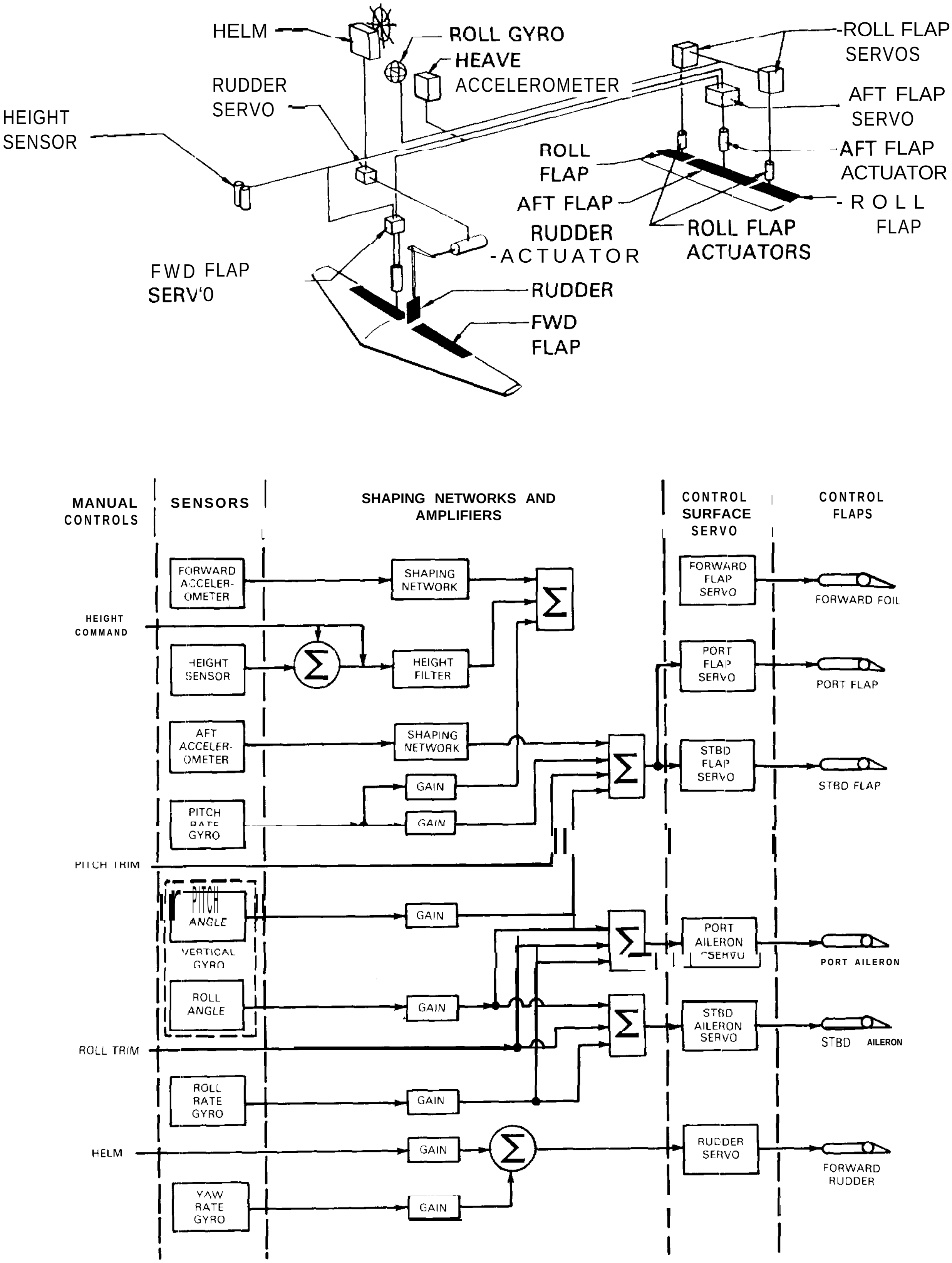


Figure 43. Schematic and Block Diagram of PCH Autopilot

The navigation and fire control system included a tactical true-motion display in CIC and a repeater at the steering station. The display was supposed to show the true position of the helmsman's own ship and either a sonar or radar target.

SHIP CONSTRUCTION

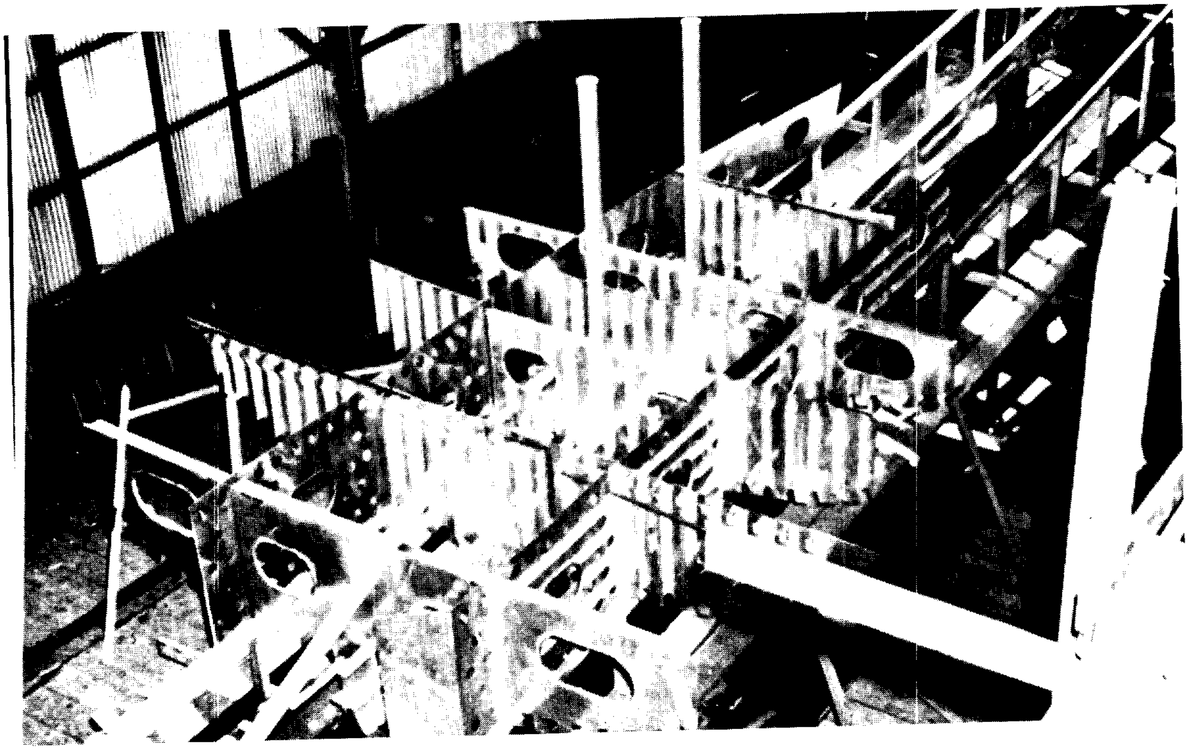
Hull lofting began in the fall of 1960 at the Martinac Shipyard in Tacoma. Plywood patterns were made from the loft lines as an inexpensive but acceptable method for building a single ship. The keel was layed on 27 February 1961. Bulkheads, frames, and floors were subassembled and then positioned on the ways. The platform deck plating was added, then the structure up to the main deck, the main deck plating, and finally the hull plating. Figure (44) shows some of the stages of hull construction.

Bovee states that the most difficult and critical part of the hull construction was the welding of aluminum. A considerable amount of time was spent in establishing welding procedures and qualifying welders. A man was selected at the shipyard, trained, and was assigned as welding inspector. He took daily weld samples from each welder which were fractured and examined for sound weld metal. He visually inspected all welds with a magnifying glass. As the hull reached completion a random spot check of critical welds was made by x-ray and repairs effected as required. Prior to pressure testing of the hull, hull joints were inspected by "dye-penetrant". The dye was applied to the welded joints from inside the hull and it was found that minor weld defects, otherwise not visible. would show up by the dye penetrating to the outside. These weld defects were ground out and repaired. (The success of the careful control of welding procedures is evidenced by the fact that no leaks were encountered in over a year after the ship was in the water.) Few **cracks** were encountered in the structural welding. The cracks that occurred were mostly crater cracks, occasionally a transverse crack. and a few cracks at weld joint intersections. Porosity was a more difficult problem. Carefully controlled weld machine settings and the use of an inert gas mixture of argon and helium helped minimize porosity.

The lines for the foils and struts were laid out on glass cloth and a photo template method of reproduction was used. The templates were full size and were cut up as metal patterns for the steel details. The steel details were rough sawed or flame cut to the patterns and were then assembled **in** steel welding jigs. The welding procedure developed for HY-80 followed the recommendations of the Navy which had wide experience in welding this steel. Metallic arc welding with coated electrodes was the method used. The heat input was carefully controlled so that the temperature of the steel adjacent to the weld was kept in the range of 70 to 150 degrees F. This kept cracking and the effect on mechanical properties of the steel to a minimum. A carefully detailed welding sequence was an important part of the controlled welding conditions and. as a result, little warpage was encountered.

All contouring of the foils and struts was accomplished by hand grinding using templates for checking in a manner very sirnilar to the finishing of propellers. Final machining of critical bores for shafting and the bolted joint surfaces, was accomplished by use of boring nulls. A major and different problem with this construction was the assembly of the foils and struts into the ship The foils and struts were completely assembled prior to installation in the ship, with the exception of the last bolted joint between the struts and foils. The forward strut was suspended above the ship and lowered into the strut trunk-the retraction screws being fed into the nuts on the strut base. After the strut was installed in the retracted position, the forward foil was positioned under the ship, lifted into place and bolted to the strut. A similar procedure was used for the aft foils and struts. The aft foil assembly was many times heavier to handle than the forward, weighing approximately 12 tons.

Coating of the foils and struts was required to protect the HY-80 steel from corrosion and erosion.



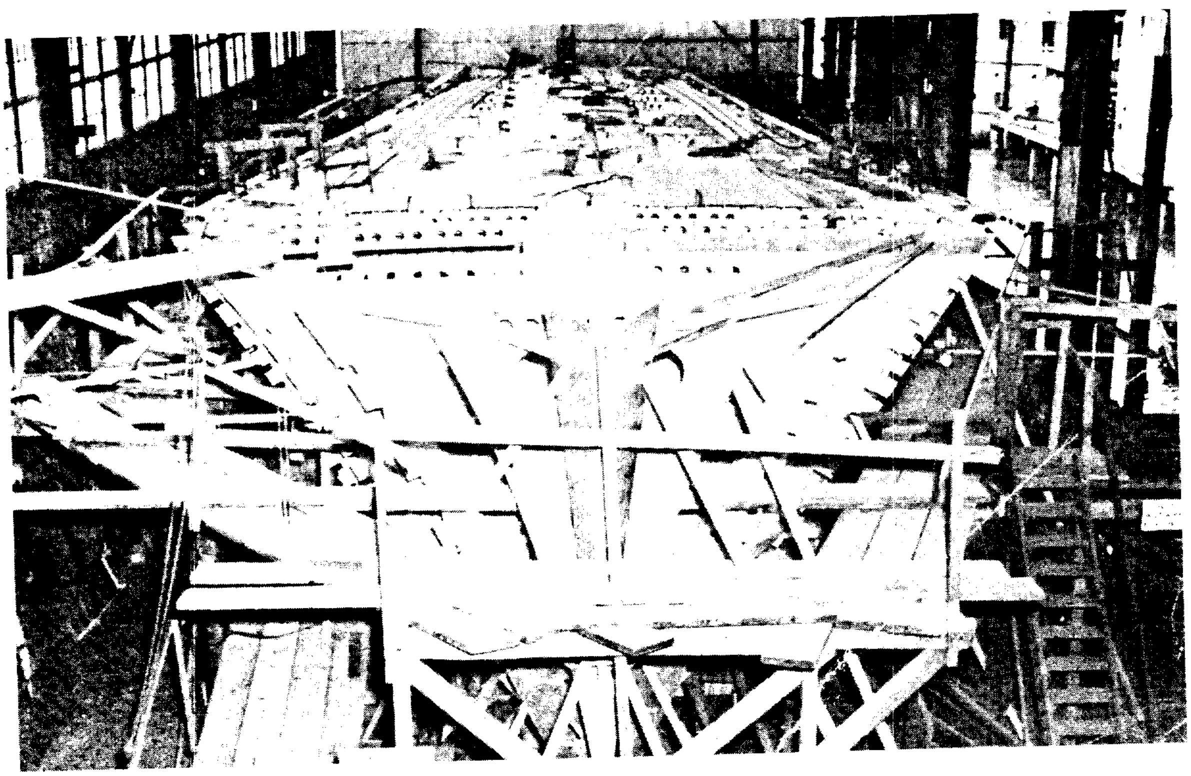


Figure 44. Photographs of PCH Hull Construction

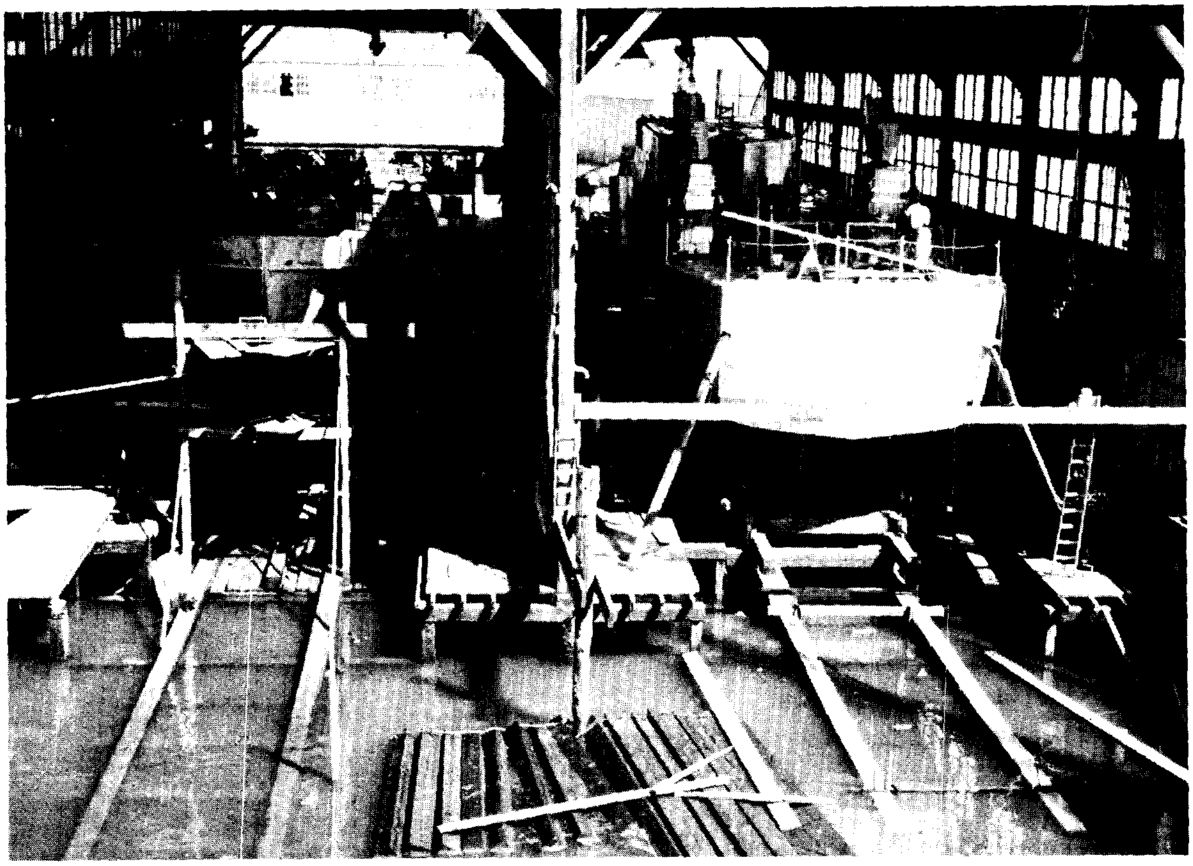


Figure 45. PGM on Building Ways Left of PCH

Originally a hot sprayed epoxy paint was specified. This was changed by the Navy to a special neoprene rubber coating which required construction of a housing for the struts and foils so that the proper conditions of temperature and humidity could be maintained. The coating procedure called for:

Grinding steel surface to 180 RMS
Degreasing with trichlorethylene
Brushing with a coat of wash primer
Brushing with a coat of neoprene primer
Successively applying 1. j mil neoprene coats to 35 mils thickness

In spite of this rather elaborate process, the maintenance of coatings proved to be one of the most troublesome problems in later operations.

Figure (45) shows PC(H) and a PGM on adjacent building ways at Martinac just prior to launch.

SUPERVISOR OF SHIPBUILDING

Construction of PC(H) was under the cognizance of the Navy Industrial Manager, CAPT J. B. Shirley, later renamed Supervisor of Shipbuilding ‘or the 1 3th Naval District. There were two SUPSHIP engineers and one inspector assigned to oversee the PC(H) project. Pete Sias was initially assigned as Project

Figure 46. PCH Sponsor Mrs. Allen with Other VIPs

Engineer. He was joined later by Sumiyasu Arima when he returned in 1959 from a years tour in BuShips, having been on loan from Puget Sound Naval Shipyard. At BuShips he had been assigned to review the design of the PC(H) electrical system. On his return to Seattle, he accepted a position at SUPSHIPS. (As will be noted later. he eventually became a member of the Hydrofoil Special Trials Unit formed by David Taylor Model Basin to support hydrofoil development.)

LAUNCHING

The ship was launched in conventional fashion in the early evening, of 17 August 1962. It was a gala affair attended by many dignitaries. The master of ceremonies was W. E. Beall, Senior Vice President of Boeing. The invocation was delivered by CAPT H. C. Albrecht, of the Navy Chaplain Corps. The principal speaker was VADM Homer N. Wallin, USN (ret) a strong advocate of hydrofoils. Those in attendance included:

J. S. Martinac. Pres., J. M. Martinac Shipbuilding Corp.
Wm. 31. Allen, Pres., the Boeing Co.
Robt. Bateman, Mgr., Boeing Advanced Marine Systems
E. Clyde Bovee, Boeing PC(H) Program Manager
RADM George Towner, USN, Commander., 1 3th Naval District
RADM Floyd B. Schultz, USN, Commander.. PSNS
RADM Peter V. Colmar, USCG, Commander.. 13th Coast Guard Dist.
CAPT J. B. Shirley, USN, SUPSHIP, 13th Naval District

The sponsor was Mrs. Wm. M. Allen. shown in Figure (46) with Mr. Martinac, Mr. Allen, Mrs. Wallin, and VADM Wallin In Figure (47) Mrs. Allen is shown wielding the traditional bottle of champagne as she christens the ship HIGH POINT. in honor of High Point, North Carolina.

Figure 47. Sponsor Mrs. Allen Christens Ship HIGH POINT

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CHAPTER 4

Early Trials

BUILDER'S TRIALS

Figure (48) shows the PC(H) in the water immediately after launch. After the hull was launched, outfitting continued for the remainder of 1962 and early 1963. Figure (49) is a photo of the machinery space taken on 25 October 1962. Looking aft to port it shows one of the Proteus gas turbines installed on its foundation. Figure (50) shows the ship alongside the Martinac pier on 4 December with plastic "houses" sheltering the work areas. From 14-24 December the ship was in drydock on high blocks as shown in Figure (51).

During a test run on 27 April 1963, the ship suffered a casualty due to failure of a hydraulic cylinder lock on the hullborne drive retraction system causing the unit to rotate upward into its stowed position since there was no positive lock. This allowed the propeller to shear a hole in the transom which resulted in flooding of the main machinery space. Disaster was averted by quick action of the Boeing crew who stuffed jackets into the hole and effected temporary repairs until permanent repairs could be made. (Later on a positive locking device was installed to ensure that such a casualty would not happen again.

On 7 May 1963, the ship was moved by tug into Commencement Bay to continue testing of the gas turbines. Difficulty was experienced in getting a successful start. In repeated tries the result was an out-pouring of flames and smoke from the turbine exhausts. This soon caused activation of the Tacoma fireboats and the Coast Guard who converged on PC(H) with sirens wailing on the assumption that the ship was afire.

The first lift run of the ship was made on 22 May, initially for 5 minutes with the hull still in contact with the water and then for 3 minutes with the keel clear. During Boeing trials, although Martinac

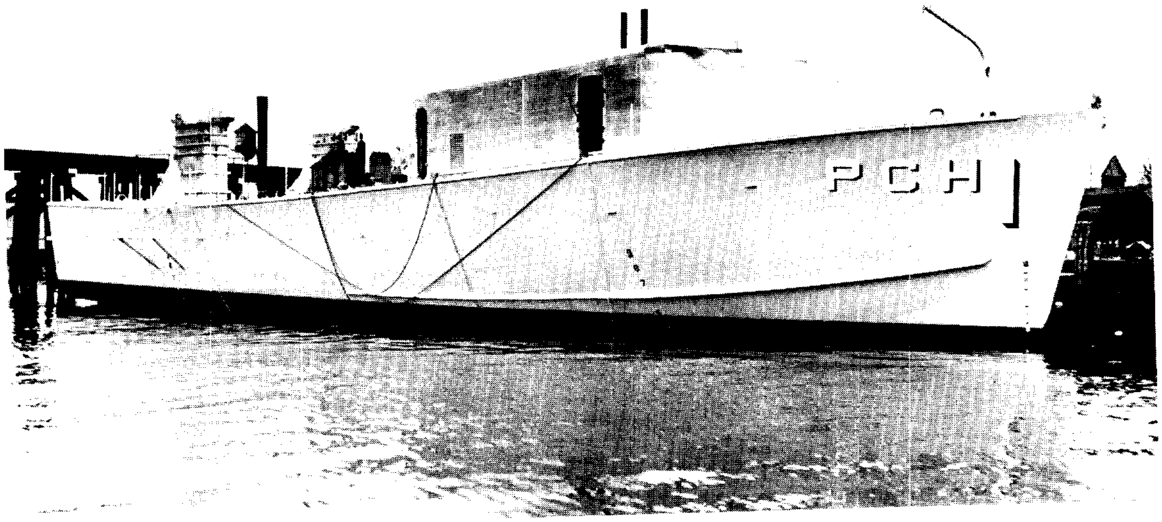


Figure 48. PCH in the Water After Launching

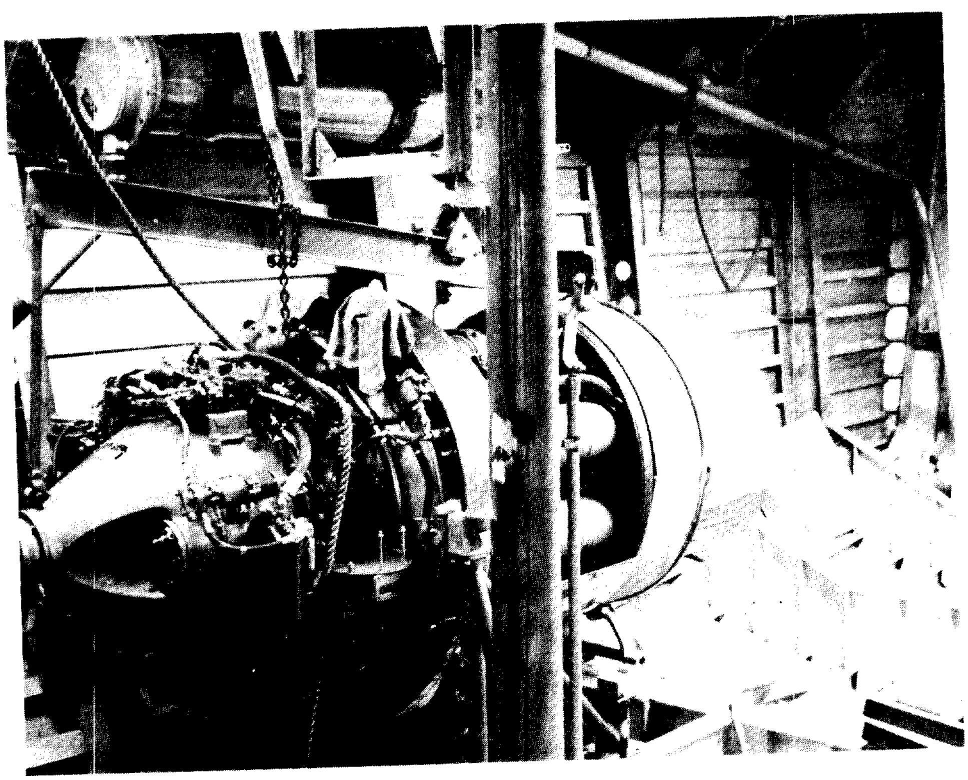


Figure 49. Proteus Gas Turbine Installed in PCH

Figure 50. PCH Dockside at Martinac Shipyard

Figure 5 1. PCH on High Blocks, December 1962

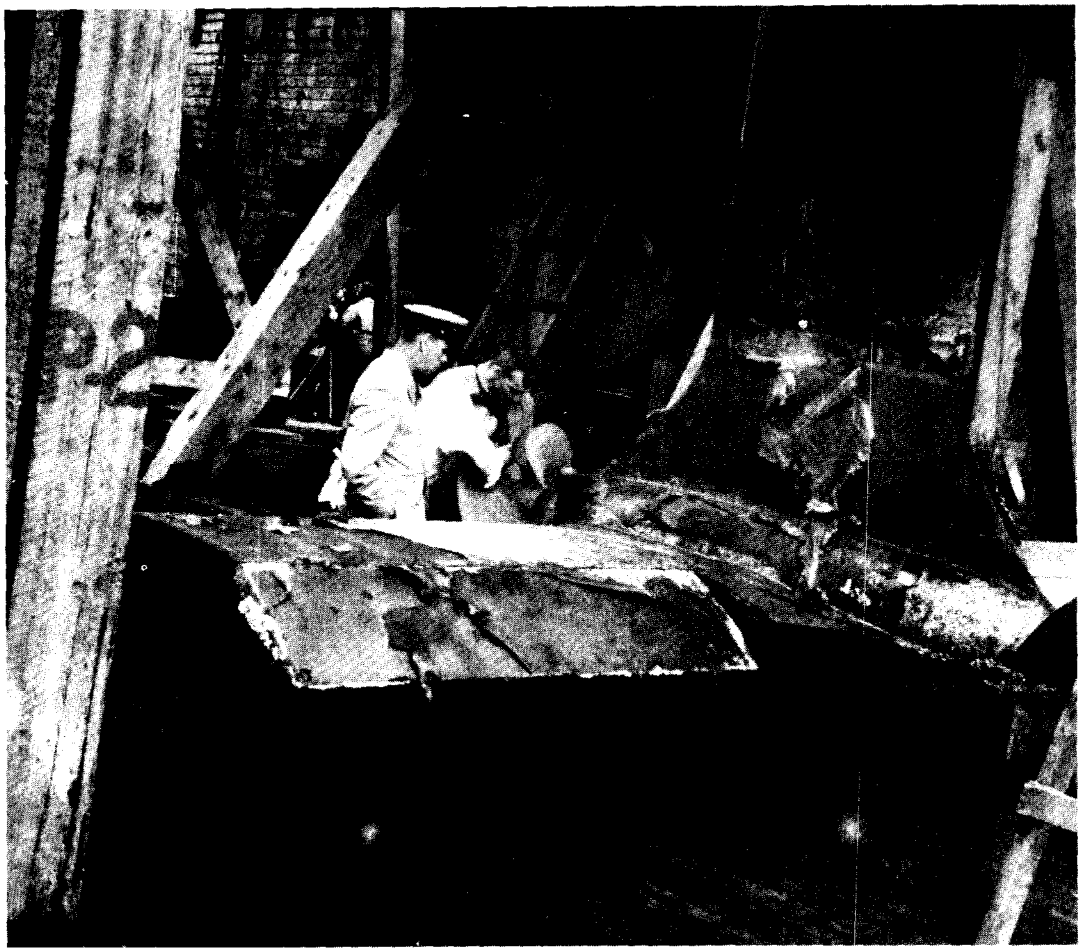


Figure 5 2. Neoprene Coating on PCH Struts **and Foils in Tatters**

had provided a licensed skipper/navigator who was aboard as required, it was Bill Hamilton of Boeing who took the helm. George Henderson, Boeing Chief Engineer on the PCH program, acted as Chief *of the boat.*

The first Builder's Trials, originally scheduled for April, actually occurred on 29 May 1963. They were not fully successful although the craft operated foilborne on three separate runs. The first run was for 5 minutes and the second was about 10 minutes. The final run 'was at full power for about 30 minutes but power had to be reduced due to an increase in the level of vibration. The required 1500 RPM was not maintained during the foilborne full power run. Also, the hullborne full power run was not completed due to the loss of diesel cooling water suction when the craft went into a rurn. Other required test sequences were also postponed and on 31 May 1963 the ship was again placed in drydock at Tacoma Boat. Upon later inspection it was found that the aft port propeller was slightly damaged from debris and both aft propellers showed severe cavitation erosion after no more than 2.5 hours running time. Also, the starboard aft propeller had a crack 1. 5 inches long at the root of one blade.

The neoprene coating on the foils was found to be peeling in patches and where it was still adhering it had accumulated substantial marine growth? Figure (52). The speed sensor was removed from the foward foil for repairs and about 10 gallons of salt water was drained from the forward foil assembly.

The coating, which had originally been applied by the Navy's Materials Laboratory, was removed up to the flying waterline and the surface was sand-blasted after special precautions were taken to prevent access of sand to bearing surfaces. DIMETCOTE #3 was then applied as a base and this was covered with standard Navy vinyl paint. The neoprene coating was retained above the flying waterline.

The ship was undocked on 14 June and the second Builder's Trial was conducted on 2 July with 35 minutes of foilborne time logged. The third and final Builder's Trial was completed on 9 July, adding another 32 minutes to the accumulated foilborne time. Finally, after having been rescheduled a number of times, Preliminary Acceptance Trials were run by the Navy's Board of Inspection and Survey on 11 and 12 July. This added 50 minutes of foilborne time. On 17 July, RADM Bill Brockett, Chief of BuShips, was given a 17-minute demonstration ride. A week later the ship was drydocked for a 3rd time for a period of eight days to prepare it for delivery. Upon undocking, Boeing made check runs including about 25 minutes foilborne which brought the total foilborne time to a little over five hours. On 1 j August 1963 PCH was delivered to the Navy at the Puget Sound Naval Shipyard. It was at this point the clock started running on warranty items. Figure (53) shows the principle dimensions and layout of the ship as delivered.

PRE-DELIVERY SHIP'S FORCE

In the original schedule it was planned that PC(H) would be placed "in service" sometime during the latter part of February 1963. In a letter from CINCPACFLT dated 1 3 November 1962, HIGH POINT was tentatively assigned to COMASWFORPAC for operations and COMINPAC for administration. The Prospective Officer-in-Charge (POIC), LT Henry G. Billerbeck. and members of the crew arrived in late 1962. Personnel assigned were divided into two distinct groups; the ship's complement and a support group. The ship's complement consisted of the POIC and twelve enlisted. The support group consisted of five enlisted and it was intended that they be assigned mobile support vans and remain ashore during operations. The ship's complement, as originally envisaged in the preliminary design. was to be made up as follows:

Officer in Charge	1-LT
Ship & Propulsion Control	1-BM2
Sonar Operation	1-SO1 & 1-SO3
CIC Officer	1-QMC
Surface Search Radar	1-RD2
Gun	1-CS3
Radio Communications	1-ET3
Phone Communications	1-ENSN
Machinery	1-ENC & 1-EN2
Electrical	1-EM2
Torpedoes	1-TMSN

In a letter to the CNO dated 6 February 196.3, LT Billerbeck raised questions about the classification of PC(H) as a "Combatant Patrol Ship", and the intent to place the ship "in service" which would give it an administrative workload of a regular commissioned ship. Some of the issues he raised are as follows:

> The detail specifications for the construction of HIGH POINT do not provide stowage facilities for cryptographic material, cryptographic equipment, registered publications and COMTAC publications. No provisions are made for office facilities aboard the craft. Adequate

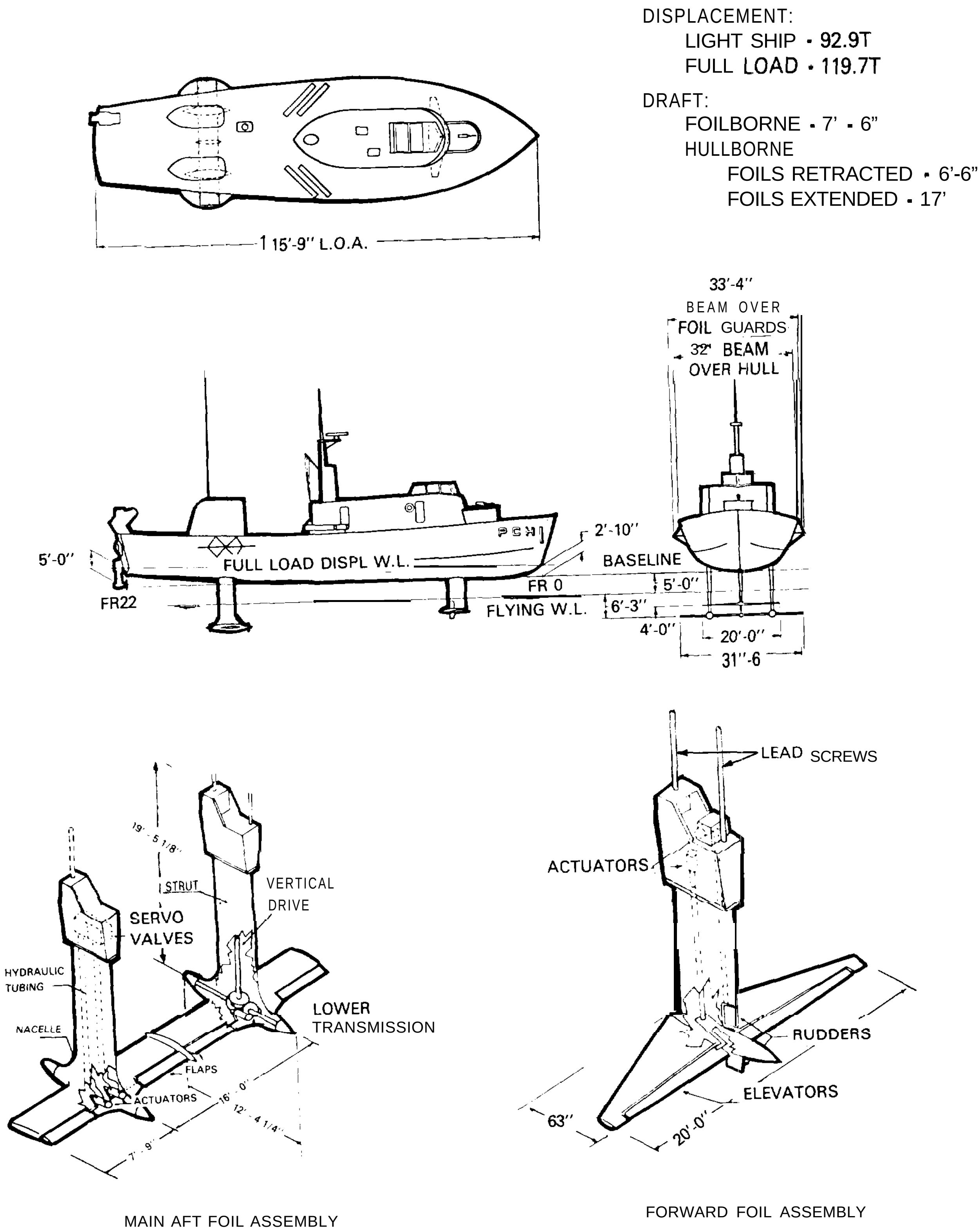


Figure 53. PCH Dimensions and Layout as Delivered

facilities for normal fleet communications are not provided. One AN/ARC 58 set and two AN/ARC 51 sets are being installed in HIGH POINT. These units in their present condition are not useable for CW transmissions. The ship has one commode for twelve enlisted men and one officer. No separate shower or commode has been provided for the Officer in Charge. The officer's stateroom is not private since only a partial bulkhead separates it from the Chief Petty Officer's quarters. Only limited cooking facilities have been provided. It will be extremely difficult to prepare a complete meal on the small unit provided. No separate eating facility has been provided for the Officer in Charge. The refrigeration unit provides only ten cubic feet of refrigeration space which is not considered enough to permit the prescribed ten days endurance for the thirteen men assigned to the craft.

The personnel presently assigned to the craft consist of the OIC, an onboard crew of twelve enlisted personnel. and a temporary support force consisting of one officer and six enlisted personnel. A radarman. a signalman, a yeoman and a hospital corpsman are not included in the assigned personnel. The Navy Officer Billet Classification assigned to the OIC is a 9273 rather than a 9222 classification.

In its present condition HIGH POINT is unable to carry the administrative load of an "in service" ship because of design features and the lack of essential general service ratings. It is the opinion of the Prospective Officer in Charge that HIGH POINT is being constructed as a service craft with an ASW capability and not as a combatant ship. If the craft is an "in service" service craft, the personnel allowance assigned at this time is satisfactory. If the craft is an "in service" ship to be operated in all respects as a full combatant, modifications and a revised personnel allowance will be necessary to adequately maintain required records and to operate, maintain, and administer the ship.

Since HIGH POINT is weight-critical and changes necessary to place it in the combatant ship category will add weight, the POIC will proceed, unless otherwise directed, with the assumption that HIGH POINT is an "in service" service craft to be provided complete administrative services by a parent activity. It is anticipated that HIGH POINT will operate on a day-to-day basis from the parent activity or operate for a defined period of time away from the parent activity. The mode of operation may be similar to an aircraft on a mission or an A.E.W. patrol craft flying the barrier.

In a communication to the CNO on 14 February, LT Billerbeck further stated:

In view of the type of operations expected by ships of the PC type and the special equipment on board HIGH POINT. it is believed that the permanent allowance of personnel assigned is inadequate. In order to properly maintain necessary records, to stand required in port and underway watches, to meet established communication standards, and to maintain and overhaul equipment, it is recommended that a permanent allowance of at least three officers and twenty enlisted men be established for HIGH POINT. The following breakdown of enlisted men is recommended for the operation of the ship as a fleet unit: BM2, QMC, SMSN, S01(0403), SOG2, FTG1 (11 12), FTG3, ET1, RM2 (2312), YN2 (2511), SK2, CS2(3012), ENC(4354), ENT(43 18). 2 EN2's, IG 1, EM3(4612), HM3, and TN.

By 18 April 1963 the personnel on board consisted of the following rates:

BH1	(0 163/0000)	ET1	(15 1 1/0000)	CS2	(30 12/3042)
QMCA	(0000/0000)	ETR2	(990 1/0000)	MMCM	(4354/0000)

SO1 (0471/0478)	SK2 (2815/0000)	MM1 (4272/0000)
SOG2 (0478/0412)	EN1 (5345/4294)	MM2 (4294/4272)
FTG1 (1128/1112)	EN2 (4318/0000)	FN (5345/4200)
FTG2 (1186/1112)	IC1 (4711/0000)	ENCM (4353/0000)

Questions regarding skill mix and numbers of ship's force were, of course, to be expected since no hydrofoil ship had, at this point, been deployed to the fleet. In retrospect, this was another reason to retain the ship in an R&D status.

It is interesting to note the following record of endorsements on the POIC's letter of 6 February requesting clarification of the ship's classification:

1st Endorsement by COMINPAC 7 March 1963
2nd Endorsement by COM-13 14 March 1963
3rd Endorsement by COMASWFORPAC 11 April 1963
4th Endorsement by CINCPACFLT 24 April 1963
5th Endorsement by CINCLANTFLT 7 May 1963

Final disposition of the issue of PCH's classification was not to come until many months later when it became clear that original plans for fleet deployment were not appropriate.

With regard to training, here again there was no real experience base upon which to lay out an adequate crew training program. Training was supplied intermittently during the construction and Builder's Trials period by Boeing and the various subcontractors for major subsystems.

As of 28 March 1963, the following crew training had been given:

Orientation Course	14 hrs.- 50 min.
Hydraulic Systems	27 hrs.- 25 min.
Static Converter	4 hrs.- 45 min.
Autopilot	10 hrs.
Sonar System	18 hrs.
True Motion Display	9 hrs.- 30 min.
MK16 Plotter	8 hrs.
MK264 Presetter	2 hrs.- 30 min.

During Builder's Trials, members of the crew were aboard as observers. However, operation of the ship was under the control of Boeing personnel.

SPECIAL PERFORMANCE TRIALS PLANNING

The desire to maintain close control of costs under the firm fixed price contract dictated that there be no "frills" in the PC(H) program. One result was that there was essentially no trials instrumentation installed beyond that which was a normal part of the ship's own instruments. The brief trials that were run gave only a limited indication of the troubles to follow Boeing's delivery to the Navy. Also, there was no contractual provision for continued support from the contractor, except to correct deficiencies under the warranty.

One of the reasons for the abbreviated trials before delivery was BuShips intent to conduct Special Performance Trials after the Navy took control of the ship. In a letter dated 17 January 1962 from BuShips to the CNO, availability of the ship for such trials was requested. It was proposed that most of these special trials be conducted between Preliminary and Final Acceptance Trials in the Puget Sound area. Here, it should be recalled that, at this point, PCH was still expected to be delivered to Commander, Mine Forces, Pacific. The delivery point was to be the U.S. Naval Station, San Diego, California.

In the BuShips letter to the CNO it was noted that PC(H) trials would differ in many respects from the usual "standardization" trials for standard ship types. It was proposed to conduct the following series:

Trials	Duration	Location
Acoustical & Vibration	3 weeks	Carr Inlet (PSNS)
Standardization	5 months	Puget Sound
Roughwater powering		
Stability & Control		
Handling		
Roughwater Motions		
Structures		
Sonar Equipment	3 months	San Diego

Trials of the sonar system were recommended to be conducted in San Diego since this was the location of the Naval Electronics Laboratory which was responsible for development of hydrofoil ASW systems.

The CNO responded to the BuShips request in a letter dated 23 January 1962 redesignating PSNS as the delivery point for PC(H). The ship was to be accepted by the Commandant of the 13th Naval District and assigned to BuShips for the period necessary to conduct Special Performance Trials. Accordingly, a change order (No. 50) specifying the new delivery point was sent to Boeing by CAPT H. J. O'Neill, BuShips Code 526 via SUPSHIPS, Seattle.

A further letter of 16 February 1962 from the CNO to COM- 13 and BuShips, gives more details regarding the fitting out and placing in service of PC(H). COM-13 was requested to place the ship in service when determined ready, about 19 November 1962. A fitting-out period of about 15 days was assigned with PSNS designated the fitting-out activity. A readiness-for-sea period of 17 days was assigned when PC(H) completed fitting out, about 4 December 1962. At this point, with t'he ship in all aspects ready for sea, the Special Performance Trials would begin. This miscalculation of readiness dates further illustrates the lack of appreciation of the still experimental nature of the ship and the failure to anticipate the many developmental problems yet to come.

On 29 August 1962, RADM Schultz, Commander of PSNS, wrote a personal letter to CAPT Jim Stillwell, in BuShips, in which he asked for clarification regarding the role to be played by PSNS in the trials to be conducted by the David Taylor Model Basin, (DTMB). In a phone conversation on 12 September, CAPT O'Neill, BuShips Code 526, read the proposed answer to the letter. It had been drafted by LCDR James R. Wilkins Jr. who had been assigned by BuShips Code 420 to coordinate Special Performance Trials of PC(H). The letter advised that no definitive agenda for the trials had yet been prepared, noting that it was being prepared by DTMB who were having difficulty in establishing that they could record outputs from the autopilot without jeapordizing the guarantee. The Model Basin had been further directed to outline the proposed trials in detail and indicate the purpose of each trial. This was to be completed by 1 October. A conference of all interested parties was to be called soon thereafter and a complete trials agenda was to be prepared by 30 October. It was also noted that Boeing had made an unsolicited proposal to conduct the full-scale evaluation and special trials instead of DTMB, but no decision on that had been made.

Status Report

In response to the growing concern over the lack of definitive plans, during 1 1- 12 October 1962. LCDR Wilkins paid a visit to Martinac and Boeing. He was accompanied by J. E. Grissom. BuShips Code 4 56; and Fred H. Imlay and Frank J. Welling from DTMB. The purpose of the visit was to inspect PC(H) and clarify plans for the special performance trials. In a meeting at Martinac on 1 I October, they were joined by CDR Terry Efird, LCDK Dave Hamlin, and Carl Neustrom of PSNS; Carl Peterson of the Carr Inlet Acoustic Range; LT Henry Billerbeck, POIC of PCH; and Pete Sias of SUPSHIP.

LCDR Wilkins issued a trip report of this meeting on 7 November 1962 and it provides an excellent insight into the concerns regarding the situation at the time. Some of the more pertinent comments are extracted as follows:

> Discussions about the Builders and Acceptance Trials indicated that Boeing. as is to be expected, intends to make as few runs as possible to demonstrate performance. Mr. Sias is definitely concerned that the Builders Specifications do not indicate in sufficient detail what tests are mandatory. He feels that the Specs will have to be strengthened in order to require the type of tests which SUPSHIP wants, As a specific example. Mr. Sias feels that the INSURV Board will want to investigate how the craft performs when electric power to the autopilot is lost while the craft is flying. However. no requirement for any failsafe features for this situation is included in the Specs. and no requirement to demonstrate satisfactory performance in this eventuality exists. It is considered that the approach Boeing is planning to use to obtain gain settings for the autopilot control system seems to be a *cut-and-try* method. Although computer simulations have been made and presumably will be used for guidance, there is no way to check the effectiveness of individual gain settings because the autopilot system is not instrumented. Thus, it may well be desirable to carry out a separate set of SP Trials to obtain a more complete checkout of the autopilot system, to establish what the optimum settings are, and to give a better understanding of the system. The latter knowledge will be invaluable when trouble shooting in case of less than optimum system performance at some later time in the life of the craft. This is a matter for Codes 450 and 632 to investigate.
>
> The O-in-C of PC(H)-1 has had no prior experience in hydrofoils and has never been able to get back to CNO or BuShips to learn more about the operational and design concepts which have led to PC(H)-1; i.e. he doesn't really know what he is expected to do with her. His actions to get back to Washington, D.C., should be vigorously supported by BUSHIPS and if he is successful he should be fully indoctrinated while here.
>
> The question of what to do about strain gauging of the after foil remains unsolved because of the question of the life of the Boeing installed gauges. If those gauges are still operational by the time Special Performance Trials begin, the structural tests should be run off first—even before the acoustics trials-in order to obtain as much information as possible from that installation. However, if these gauges are inoperable. several decisions are required. The first is whether new gauges will have any longer life than the original ones. The second is whether the information to be obtained from these trials is of sufficient value to justify the

expense of docking the ship and installing the new gauges. If so, then the location of the new gauges must be established. Finally, the number of times this routine will be repeated in the event of failure of the second, third, etc. set of gauges must be established. If the Boeing gauges do not stand up, regauging and running of structural trials should be done after all other SP trials are completed.

Drydocking of PC(H) would seemingly be unnecessary since it will be light enough to be capable of being lifted by the large cranes available at Puget Sound and other naval shipyards. A dolly into which the craft could be lowered, and by means of which it could be transported into a shop or other covered work space, should be built for convenience in taking PC(H) out of the water.

The design of the system by which data will be obtained from the sensors in the autopilot control system must commence immediately. In view of Boeing's offer to do this, a decision must be made whether they or DATMOBAS will get the job. It is the opinion of the reporting officer that this should be done by DATMOBAS, that they should deal directly with SUPSHIP Seattle in obtaining the necessary information about the sensor signals, and that any difficulty in obtaining data should be reported to Code 526. It is assumed that DATMOBAS would also manufacture the required fittings and circuits.

Speed and Powering Trials

Although planning for the Builders and Acceptance Trials had just begun, it was clear that the data obtained therein would not be sufficient to meet the needs of the Special Performance Trials. It is considered better to duplicate runs in the SP Trials and thus establish repeatability and a check on the B&A Trial results.

Mr. Welling stressed the paramount importance of accurately calibrating the E.M. log in order that the B&A Trials will be meaningful.

Means of measuring speed during powering runs were discussed, and it was established that it is not possible to install a transponder in the foils as would be necessary in order to track the craft by the 3-D acoustic range in Carr Inlet. However, the RAYDIST system, which yields a fix by tracking the position of a radio transmitter installed on the tracked vehicle, can be used and will suffice. In the event that scheduling problems interfere. it will be possible to use either of two measured mile ranges in the area.

It was reaffirmed that it is impossible to locate thrust or torque meters on the craft for obtaining direct powering data. Thus, power will have to be estimated by comparing air inlet and exhaust temperatures, etc., obtained from instruments on the engines with builders tests and data. SUPSHJP Seattle has the required data, but that for the diesels applies only to the type of engine, not the specific engines in PC(H), thus limiting accuracy of power prediction of diesels to about 5 % . The builder's data on the Proteus engines was obtained from tests run on the specific engines used in the craft.

Boeing is doubtful of the propeller performance, despite the existence of model data, because of the unusual operating conditions. It is considered by the reporting officer that, while there is no doubt that very little experience with propellers in this operating range exists, Boeing's attitude is mainly a means of laying a groundwork for blaming the propellers if there is difficulty in obtaining desired performance.

When discussing the extent of the hullborne powering trials, the method by which transition from hullborne to flying conditions is to be accomplished was considered. The Boeing personnel explained that the autopilot control system would be off as take-off power was applied. After the craft reaches a speed that will be established by trial and error during the Builders Trials. the master flying switch will be turned on, the flaps will deflect to maximum and takeoff will be accomplished. This is in effect the "jump" technique sometimes used on SEA LEGS. Mr. Henderson indicated that Boeing's philosophy on taking off is that it is important to take maximum advantage of the acceleration of the vehicle to get over the resistance hump. Thus, the autopilot is left off so that the flaps remain faired into the foils, minimizing resistance. until the optimum speed is reached. The energy of acceleration is then counted upon to overcome the additional drag of the extended flaps. (Boeing's Bill Ledray says this is not completely correct. One approach was to leave the master gain control at zero with the flaps at minimum drag.)

This philosophy, while logical, is open to question as yielding the optimal method for take-off in all conditions of sea state. Thus, it was decided to include tests in the SP Trials by which the hullborne resistance will be determined at various speeds in the take-off speed range in both conditions, i.e.. with the flying switch both on and off. In this way. the "static" or constant speed resistance curves will be known, and the significance of the "dynamic" effects which are implied in Boeing's philosophy can be established.

Discussion between CDR Efird of NAVSHIPYD BREM and Mr. Welling ended in an agreement that NAVSHIPYD BREM personnel would conduct and report on the Powering Trials. The agenda will be written by DATMOBAS.

Structural Trials

The major questions relating to the Structural Trials revolve about the life of the strain gauges which are externally mounted on the after foil. Mr. Bovee (explained that after the gauges and their leads were bonded to the foil and struts they were covered by a sheet of aluminum foil. The edges of the aluminum sheet were bonded to the foil and struts by a 1/2″ to 3/4″ strip of waterproof bonding cement on all sides. All this was then covered by the neoprene foil covering, which is known from MATLAB tests to absorb water to a small but not insignificant degree. Thus, Mr. Bovee is hopeful that the gauges will remain operable.

Model Basin personnel are fearful that the gauges will not be operable by the time the SP Trials begin. At Mr. Imlay's request, Mr. Bovee estimated the time required to remove strips of neoprene over the gauges, remove the old gauges, install new gauges and re-cover them to be two weeks in drydock.

The installation of pressure gauges in the hull was considered feasible by Boeing. However, they raised the question of how the holes would be closed after the tests were over and pressure transducers removed, noting that welding up the holes would not be practicable because of the difficult)- of welding this type of aluminum. It was agreed that it would be possible to attach some type of flanged fitting which could be closed with a cover plate. It was agreed that the Model Basin would provide a design for such fittings. since they know the details of the transducers, and submit the design to SUPSHIP and Boeing for comment and revision as necessary.

Mr. Bovee noted that a drydocking is presently scheduled for the week of 4 December and observed that it would be possible to accomplish the installation of pressure taps at that time if it is desired. CDR Efird questioned the lack of strain gauging of the hull for the strength tests. He stated that knowledge of stress levels in the hull near the foils during flying conditions would seem to be of interest, particularly since the installation of strain gauges for this purpose would not be difficult.

Stability and Control Trials

A discussion of the type of information needed for the SP Trials led to consideration of the means proposed by the Navy and by Boeing for obtaining the data. The results of these discussions were an admission by Mr. Henderson of Boeing that, based on the needs of the proposed trials as they had been described at the meeting, the data needed for these trials would come from the autopilot control system, He further admitted the technical feasibility of the methods proposed by the Navy for obtaining the data from the autopilot system. However, both he and Mr. Bovee noted that the position of the Boeing Co. on this matter must be that any modification to the designed autopilot system introduces a possibility of malfunction which would not otherwise exist, Thus the Boeing Co. will not accept any responsibility for malfunctions of the autopilot system which occur because of modifications made to allow readout of data from the system. LCDR Wilkins accepted this statement and stated that the Bureau of Ships recognizes that such restriction on Boeing's guarantee is reasonable, but that, since the methods of isolation of recording instruments were well known and had been successfully used many times in the past by the same people who would be instrumenting these trials; since the autopilot control system on SEA LEGS, upon which that of the PC(H)-1 is based, had operated perfectly for years though completely instrumented; since we feel that no other means of obtaining data will provide us with adequate information; and since no technical objections to the USN proposal had been raised at this meeting, planning would proceed on the basis that data would be obtained from the autopilot system.

Any remaining question on the technical feasibility of the USN proposed system of taking data from the autopilot system was then completely eliminated by the offer of Mr. Henderson to design and construct the necessary circuitry. Asked if Boeing would then accept the responsibility for the operation of the modified autopilot system, Mr. Bovee unequivocably refused.

It was established that the strength of the PC(H)-1 main deck is adequate to support the water tanks which were proposed by DATMOBAS for the static stability trials. It was also established that the pumps installed in PC(H)-1 for engine cooling water would be adequate to pump water between tanks between runs. Much of the “piping” of the cooling system is actually plastic hose. Thus, it is inexpensive to manufacture sections with leads to the the tanks which can then be removed after the trials and replaced by the normal system.

Seaworthiness Trials

The type and scope of the Seaworthiness Trials was described to the assembled group by Mr. Imlay. However, since the decisions relating to measuring motions had been made during discussion of the Stability and Control Trials, nothing significant arose from this portion of the meeting.

General

The effort Boeing is putting into hydrofoil design is truly impressive. With two test craft of their own, one of which is waterjet propelled, and a third craft in planning stages, they are making a strong bid to become the lead class of hydrofoil designers. Their effort certainly dwarfs that of the Bureau of Ships, at least in so far as the number of people who are actively engaged full time on hydrofoil design and research.

Later, on 19 November 1962, another conference was held which dealt with another aspect of the Special Performance Trials. This meeting, at Boeing, was attended by LCDR Dave Hamlin, PSNS; Larry Harvey, Chuck Miller, Dave Washburn, and Fred Parker of NEL, San Diego; and George Henderson and Roy Malm, of Boeing. BuShips had assigned NEL the tasks of evaluating the suitability of hydrofoil craft for anti-submarine warfare and defining the characteristics of a sonar system for that purpose. They were interested in collecting data on PC(H) performance, particularly in rough water; operation of the sonar and navigation systems; and the craft underwater noise characteristics. At this meeting NEL was requested to present a proposal for their participation in PC(H) trials as soon as possible.

Meetings, phone conversations, and exchange of corrospondence regarding Special Performance Trials continued between DTMB. BuShips, NEL, PSNS, and Boeing during the first half of 1963, with growing concern as schedule dates were shifted to accomodate delays in delivery of the ship. The situation during this period is illustrated by a 5 June 1963 letter sent to BuShips Code 442 by DTMB. The letter was prepared by Lou Becker of the Structural Mechanics Laboratory and signed by E.E. Johnson. In it the following comments were made:

BuShips' letter of 14 July 1960 requested DTMB to conduct various tests on PC(H). Numerous planning conferences resulted in the test agenda outlined in our letter of 30 November 1962. Two alternative plans. both based on a late February delivery date. were included. The first was based on the premise that the strain gauges installed by the builder would be operable, and the second was to be followed if the builder's gauges were not operable.

As a result of several delays in delivery by the contractor. roughwater structural trials have been delayed from April 1963 to early August or November. The probability of getting sufficient rough water in early August in the test areas is only 4 percent. A drydocking will be required to install pressure gauge inserts regardless of the plan followed. In a phoncon of 4 June 1963 between LCDR Hamlin and our Mr. Becker ir was reported that all of the builders gauges on the rear foil system have failed and will not be replaced at this time. Accordingly. it is assumed that the first plan is to be disregarded.

CHAPTER 5

Post Delivery Tribulations

After delivery, on 15 August 1963, HIGH POINT was drydocked at PSNS on 4 September. A lift was made using the 250-ton hammerhead crane with a strongback and four slings, as shown in Figure (54), and the ship was placed in cribbing on the dock. Inspection revealed the following:

1. One blade of the aft starboard foilborne propeller was broken with about one-third of the blade missing.

2. All three blades of the aft port foilborne propeller were cracked at the forward root section.

3. Cavitation erosion was evident on the suction face of both aft foilborne propellers. Figure (55).

4. The ship's bottom and the struts appeared in good condition.

5. Numerous bubbles were apparent in the coatings on the foils and nacelles.

6. Erosion and/or corrosion was significant at saltwater inlets and most areas around flap hinge points.

Also, at this point, work was continued to accomplish both contractor and government-responsible items identified in the Preliminary Acceptance Trials. Table j indicates the status.

The problems identified upon drydocking the ship were communicated to BuShips Code 526 by PSNS. As a result, on 10 and 11 September 1963, LCDR N.O. Larson, BuShips 440; R. Beatty, BuShips 644 (Propeller Branch); and Al Koval, BuShips 526. visited PSNS to investigate the failure and general

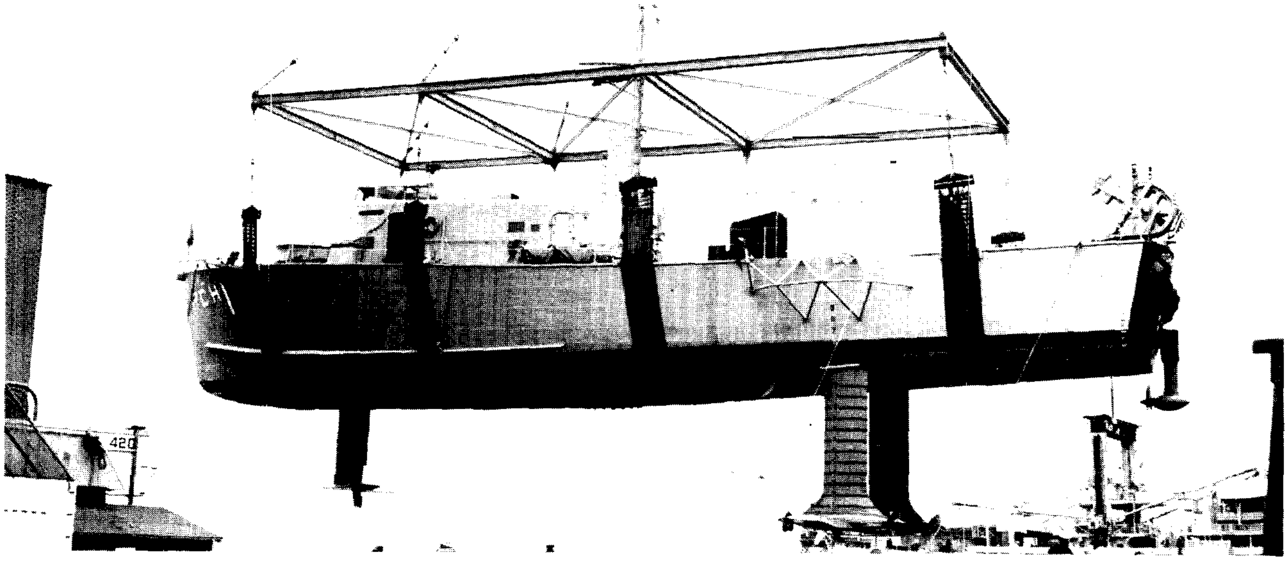


Figure 54. PCH Lifted by Hammerhead Crane at PSNS

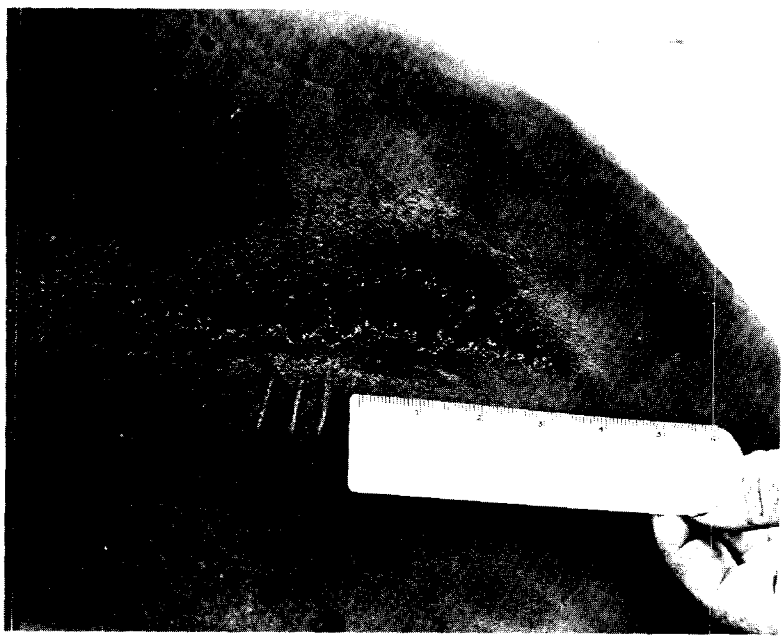


Figure 55. PCH Propeller Cavitation Erosion Damage

TABLE 5

STATUS OF PAT ITEMS (5 Sept. 1963)		
Section	No. of Trial Items	No. Completed
Main Propulsion	60	30
Auxiliaries	9	2
Electrical	40	18
Damage Control	45	28
Habitability	16	8
Weapons	24	10
Navigation	17	10
Operations	64	13
Deck	15	8
Medical	2	0
Supply	21	4

deterioration of the propellers and foil coatings, to determine the cause, and develop the necessary corrective action.

FINAL ACCEPTANCE TRIALS

In spite of the numerous problems which remained unresolved, final acceptance trials were conducted on 27 and 28 January 1964. In a letter dated 4 February, the senior member of the INSURV Trials team wrote the following to RADM John D. Bulkeley, President of the INSURV Board:

a. HIGH POINT (PCH-1) is constructed in accordance with contract specifications except for deficiencies covered in the work list.

b. Material deficiencies exist in the ship that substantially reduce her fitness for Naval Service, but are not of such magnitude as to warrant rejection of the ship. They can be corrected by accomplishment of Part I items on the work list. The Board recommends conditional acceptance of the ship for restricted service, pending correction of deficiencies in Part I work items, and final acceptance for unrestricted service when all Part I work items have been completed.

c. The ship is in an unsatisfactory material condition of readiness for war in as much as the following deficiencies prevent her from reasonably carrying out her mission for a period of 90 days without a tender, base, or shipyard availability:

1. Craft unable to operate foilborne into head winds of 20 knots and above (because of steering problems).
2. TACNAV system inoperative.

3. Binding in hullborne steering.
4. Hydraulic pump for hoist-lower hullborne sonar inoperative.
5. MK 16 plotter inoperative.
6. Foilborne steering control not sufficiently demonstrated.

The report of the INSURV Board was endorsed by the CNO on 13 February with the recommendation that 28 January be established as the date of conditional acceptance of HIGH POINT for restricted service with final acceptance to be obtained when it was determined that the ship was ready for unrestricted operations. This was approved on 18 February by Kenneth E. Belieu, Assistant Secretary of the Navy for Installation and Logistics.

BACK IN WASHINGTON

At this point, it is noteworthy to revisit the Washington scene and catch up on other developments of significance in the PCH-1 story.

In parallel with the PCH-I design, acquisition, and trials, another part of the Navy's hydrofoil development program was unfolding. During 1761 James L. Schuler had accepted a new assignment in the BuShips Research Directorate, Code 300. He was made Program Manager for Hydrofoil R&D along with responsibilities for several other programs and projects. His involvement was to have a profound impact on the future of hydrofoil development in the years to come. Schuler had graduated as a Naval Architect from Webb Institute of Naval Architecture in 1947 and had joined the Preliminary Design Branch of BuShips in August 1950. From there he later migrated through several positions in BuShips, picking up a law degree from George Washington University night school along the way. When he arrived in Code 300, FY60 emergency funds of $11.436M had already been allocated for hydrofoil Exploratory Development under a general project entitled “Hydrodynamics”. Some 40 different tasks had already been started and were underway at university and government laboratories as well as a number of industrial contractors. This program was designated the Buships Hydrofoil Accelerated Research Program (HARP), and had been initiated under the cognizance of Ralph Lacey in Code 420. Even though no additional funds were allocated in FY61 and FY62, the large infusion of FY60 funds generated a substantial momentum and involvement of the technical community in the more fundamental aspects of hydrofoil R&D.

During 1963-4 a number of other personnel changes of significance in the hydrofoil program took place on the Washington scene. In March. 1963, Dr. Alfred H. Keil, former head of the Structural Mechanics Laboratory at DTMB, became the Model Basin's first civilian Technical Director. He was made responsible to the Commanding Officer and Director, CAPT Jack Obermeyer, for executive direction of the Model Basin's four laboratories; Hydromechanics, Aerodynamics, Structural Mechanics, and Applied Mathematics. On 3 1 May 1963, Dr. Karl E. Schoenherr retired as Head of the Hydromechanics Laboratory, and was replaced by Dr. Wm. E. Cummins, a long time senior member of the Laboratory technical staff.

On 29 April 1963, RADM R. K. James, Chief of BuShips, was relieved by RADM W. A. (Bill) Brockett who, as a Captain, had been Model Basin Industrial Officer. On 14 June 1963, CAPT Obermeyer was relieved as DTMB CO&D by CAPT J. M. (Monty) Ballinger. (CAPT Ballinger's tour as CO&D was a short one and on 30 September 1964, he was relieved by CAPT Dennett K. (Deke) Ela.)

DTMB Hydrofoil Program Coordinator

Since inception of the Navy's hydrofoil R & D Program, the Model Basin had been a key participant. Further, they had come under considerable pressure to support the PCH Special Performance Trials and to provide additional technical help in solving PCH problems. As a result, the decision was made to hire Wm. M. Ellsworth as Hydrofoil Program Coordinator in the Hydromechanics Laboratory. He formerly had been an employee of the Laboratory, returning to this newly created position on 3 March 1964, after spending six years in industry. At this point, it is interesting to recall the proposal of RADM Schultz that someone be given the job of overall hydrofoil program coordinator. (At the outset it was nor realized that the new Hydrofoil Program Coordinator at DTMB would do other than coordinate related activities of the Hydromechanics Laboratory. Later, however, this position was to encompass much broader responsibilities for the technical management of the Navy's Hydrofoil R&D Program.)

FRESH-I & AGEH-1

Although PCH-1 had been designed as a state-of-the-art fifty-knot hydrofoil submarine chaser, intended for fleet deployment, the Navy's ultimate objective was a hydrofoil capable of speeds up to ninety knots, This led to two other acquisitions. First, was the project to design and acquire a high speed foil research craft. This project, which was managed by Don Stevens, Reference **42,** in BuShips Preliminary Design (Code 420). was a part of the BuShips Hydrofoil Accelerated Research Program. In June 1961, the Navy had awarded another contract (NObs-4472) to Boeing for $ 1.46M in R&D funds to produce such a craft which was designated FRESH-I. The 15-ton craft was to be highly instrumented and capable of testing various foil systems in either a canard or airplane configuration. It was to be powered by an aircraft jet engine to eliminate interaction of the strut/foil system with the propulsion system. Another contract (NObs-86826) was awarded to the Crumman Aircraft Engineering Corporation in 1962 for the design and construction of a "transit" foil system for installation and evaluation on FRESH-I, This was a foil design which was expected to provide a smooth transition from a subcavitating to a fully-cavitating flow regime and thus permit attainment of speeds up to 100 knots.

In a second project, FY62 SCN funds had been appropriated to construct an. experimental hydrofoil, AGEH-1. It was to be 320 tons, making it the world's largest hydrofoil ship. Also, it was to be capable of later modification to achieve speeds up to 90 knots. A contract (NObs-4492) for the AGEH-I was awarded to Grumman in 1062. Phase one was to cover the guidance design and Phase two was for detailed design and construction. The guidance design was completed in May 1963 and the Navy exercised its option to go out for competitive bids for Phase two. The low bid was submitted by Puget Sound Bridge and Drydock Company, Seattle. WA. A short time earlier. they had been acquired by Lockheed and became the Lockheed Shipbuilding and Construction Company (LSCC). They were awarded a contract in June 1963 and construction began in January 1964. More details on the AGEH- 1 are given in Appendix G.

Figure (56) is a drawing of the FRESH-I and Figure (57) is a photograph of the craft foilborne. The catamaran configuration provided great flexibility for exploring various strut/foil arrangements.

Acceptance trials for FRESH-I were scheduled for 10 and 18 July 1963 with the intervening week to allow changing from an airplane to a canard foil configuration Tests run on the afternoon of 10 July were quite successful. The Trial Board who witnessed the tests consisted of Pete Sias and Sumi Arima of SUPSHIPS- 13 and Joe Grissom and Don Stevens of BuShips. Foilborne runs were made at speeds of 50 to 80 knots and included flat and banked turns. All operations were in calm water. Following

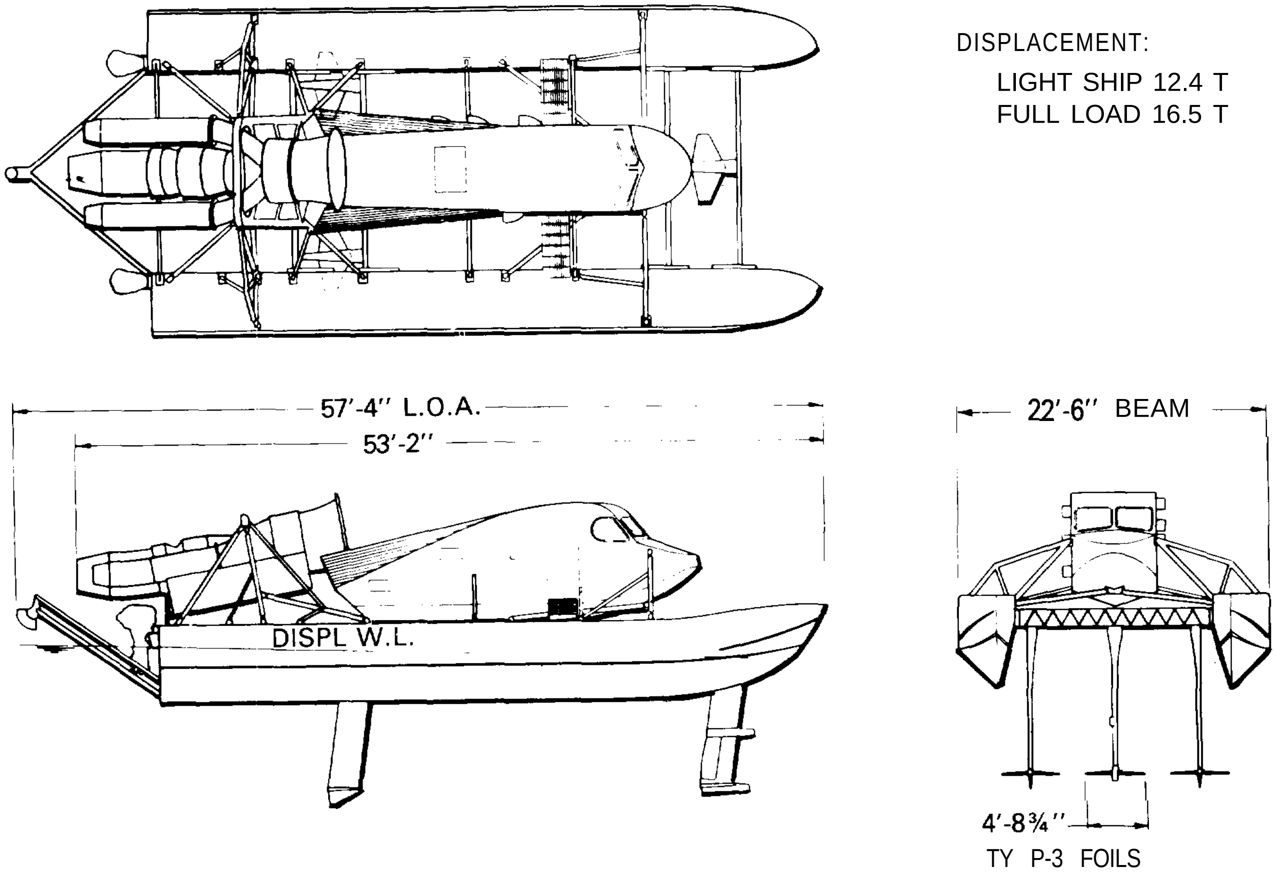


Figure 56. FRESH-I Principal Dimensions, Canard Configuration

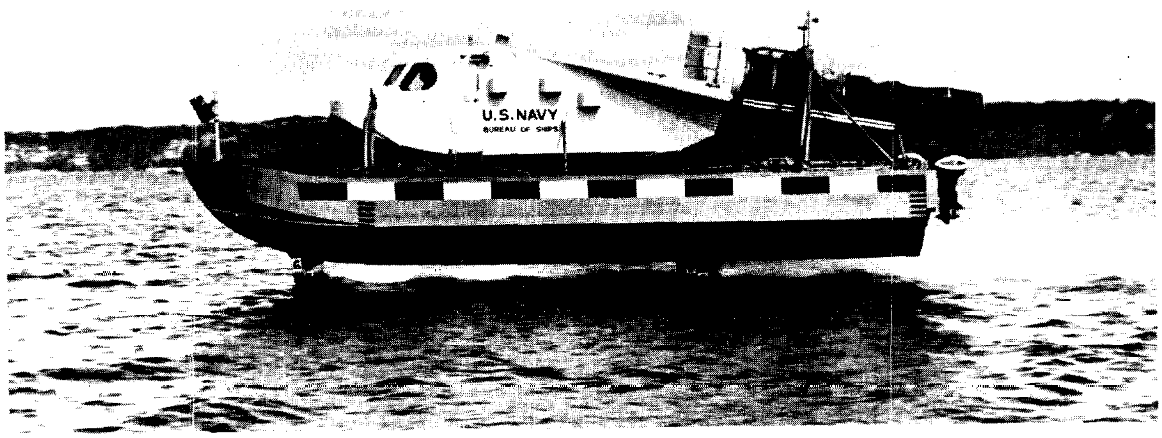


Figure 57. FRESH-I Foilborne

the trial runs, CAPT H. J. O'Neill and Mark Jewett, of BuShips Code 526, and Joe Grissom, BuShips Code **456,** were given demonstration rides.

On 18 July, Acceptance Trials with the craft in a canard configuration were scheduled. Pete Sias was aboard and occupied the co-pilot seat. Vern Salisbury, Boeing test pilot, as usual occupied the left seat at the controls. Salisbury, a Colonel in the Marine Corps Air Reserve, had been recruited from the Boeing flight line where he had been a test pilot for several years. In the rear seat Bob Hubbard, manager of the Boeing autopilot development team, manned the instrument station. Data from the extensive instrumentation suite was recorded and also telemetered to a shore station where it was continually monitored by Boeing engineers during trials.

The trial on that afternoon was ill-fated. During the high speed run the craft completely capsized. In a taped interview of Vern Salisbury on 22 February **1984,** he recalled events during the accident.

> We came down **the** Duamish river from the Boeing Missile Production Center into Elliott Bay and started the main engine. We proceeded hullborne to the test area where the chase boats and the Coast Guard patrol boats and helicopter had positioned themselves along the six-mile course. We traversed the measured mile off Vashon Island which the Navy accepted as valid for determining speed. Pete Sias was in the co-pilot seat which was normally occupied by a Boeing test engineer or member of the control system development group. They were usually jockeying the flaps to maintain proper foil depth. Their control input was more than I had ever recognized and consequentially I did not take into account the fact that Pete was not performing the same functions as the regular co-pilot. I had recognized all along that some adjustments were continually being made during previous R&D trials but I didn't realize they were as significant as they later turned out to be. As we got down to the end of the test course and were turning around to come back and complete the exercise, I noticed that we were flying a little high. Hubbard agreed that we were a bit high. and I said I thought we were too high. He suggested pushing the controls over to bring her back to the right height. Neither of us recognized that by pushing the nose down we would induce a directional instability by not having "enough feathers in our arrow" back aft. This **was because** the aft end was too high without enough strut in the water. So, I pushed the nose down just slightly and it seemed like it was starting to correct, but it leveled off so I pushed it down a little more. Then it took off to the right. I immediately put the wheel over to the left-full over— thinking this would correct it. I did throttle back a little bit but I didn't want to pull the throttle completely because this was a record run and I didn't want to abort it in the middle. The craft continued to yaw and then started to roll and I pulled the throttle back further. She continued to roll and I thought she was going to catch on the port catamaran hull but it didn't. It had enough momentum to gradually roll completely over. When it hit it was upside down and at a speed of about 70 knots. We had been going 80 knots down the course so I had killed off about IO knots before we hit. The window in front of me carried away but it didn't hit me in the face; it hit Pete Sias and cut his chin pretty deeply. When I saw the glass carry away I reached 'back and tried to unlatch my door but turned the handle in the wrong way since we were upside down. I unlatched Pete's seat belt and tried to get him turned around. By this time the water had nearly filled the cabin and I was just about out of breath. I had grabbed a deep breath when I saw the window carry away. With Pete blocking the way to the bubble of air that remained in the cabin, I went out the window. I almost cut my hand off on the ragged edge of glass that remained. In the meantime, Bob had seen the bubble of air so he unlatched himself and got Pete turned around and got his head in the bubble. Then he managed to get his door open and both got out of the cabin. I hatd taken another breath

at the surface and went back only to find both of them gone. Back on shore, Boeing had been advised of the situation by the marine telephone link and tugs and a barge crane were already underway to the scene. The chase boats picked us up out of the water and took us to the Fauntleroy ferry dock where an ambulance was waiting to take us to the hospital.

All of the prior planning which had been done caused everything to work like clockwork. Furthermore, the instrumentation records permitted us to completely reconstruct the whole sequence of events which provided solutions to go forward with the next generation of hydrofoils. With all the procedures, controls, and safety features we had built into the program I don't think there was ever a possibility of losing someone.

I have only one regret about the accident and that is it influenced the Navy's decision to not continue attempts to go 100 knots. I believe that in R&D you have to stay way out in advance and I don't think it was a good decision to cut off our ability to go on up in speed.

After the accident, the craft was refurbished, successfully completed all trials, and was accepted by the Navy. At this point, however, the focus of the R&D program was concentrated on the achievement of reliable 50-knot operations and pursuit of 100-knot hydrofoils was suspended. FRESH I was then put into mothballs at Boeing and never ran again. Also, even though they were completed by Grumman and delivered to the Navy, the transit foil system was never tested. Figure (58) shows members of the HIGH POINT crew with Boeing and other Navy personnel during an inspection of the craft a short time after it was put in mothballs. Even though the FRESH-I tests were terminated, there was a positive result for the PCH. The instrumentation system from the craft was eventually installed on HIGH POINT and served the Navy's hydrofoil R&D program well during later trials.

SPECIAL PERFORMANCE TRIALS

Several attempts were made during the 63-64 period to conduct Special Performance Trials on PCH but the problems that continued to plague the ship made trials scheduling difficult. These trials were under the cognizance of DTMB and a number of Model Basin personnel were involved. They included Fred N. Saxton, who was responsible for instrumentation, Peter C. Clawson, who was concerned principally with stability and control, and Fred Imlay, who was overall coordinator. Hullborne acoustic trials had been run at Carr Inlet, Figure (59), from 1-19 October 1963. From 25 January to 3 February 1964, some of the stability and control trials had also been completed.

Sometime in early February 1964, RADM Schultz, Commander of PSNS, had brought the apparent lack of interest on the part of Boeing in the fate of PCH-1 to the attention of Boeing Aerospace Vice President Lyle Wood. About that same time C. Thomas Ray, Chief of Marine Technology in Boeing's Marine Systems Group, had also alerted his management to the deteriorating situation. He was chartered to look into the matter and make recommendations for action. This might be considered the turning point and beginning of a new cooperative relationship in the hydrofoil program that was to endure for the many years to follow. On 17 February Kenneth W. Brown, who was then Manager of Boeing Advanced Marine Systems, met with CDR Hamlin and LCDR Billerbeck and proposed that Boeing conduct an investigation of HIGH POINT's problems to be followed by a proposal for their solution. This led to a meeting at PSNS on 19 February attended by CDR Hamlin and LCDR Billerbeck and several members of the Boeing staff including Tom Ray, Roy Malm, Fred Watson, Dave Petrie, and George Henderson. A plan of action was developed wherein members of a small group from Tom Ray's technical staff would contact ship's force and others in PSNS to identify problems which needed to be addressed forthwith. It was agreed that Boeing would provide recommendations for a course of action before

Top Row Left to Right:

Chief Boatswain Mate Hohson
Unidentified Crewman
Yeoman 2/c Vcesbicki
Radarman Elkins
Seaman Hyde
Unidentified Crewman
Gene Parsons, Boeing

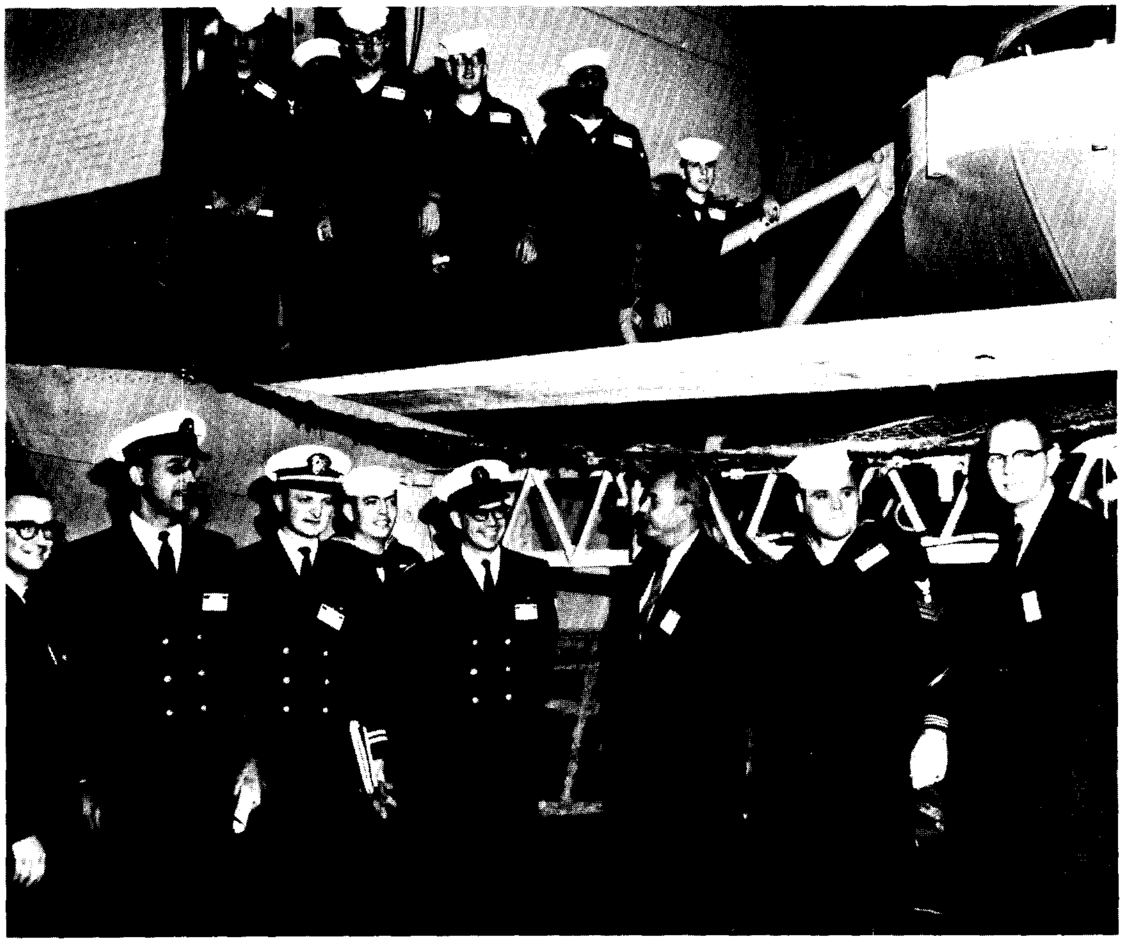
Bottom Row Left to Right:

Vern Salisbury, Boeing
Unidentified Crewman
Storekeeper 1/C Primo
Chief Boatswain Mate Snider
Chief Enginemate Pondelick
LT Mike Terry, SUPSHIPS
Unidentified Crewman
OIC LT Steve McGanka
LCDR Don Stuart PSNS
Dick Merritt, Boeing

Figure 58a. PCH Crew Visits FRESH-I at Boeing

CDR Hamlin's attendance at a BuShips conference on PCH-1 to be held on 27 February. Immediately following the meeting at PSNS, Ken Brown wrote a personal letter to RADM Schultz assuring him of Boeing's continued interest in seeing that PCH-1 met the Navy's goals and requirements.

As promised, in a letter of 24 February to CDR Hamlin, Tom Ray presented the results of Boeing's initial technical audit of PCH-1 problems and made recommendations for action to be taken. He also proposed that Boeing's technical staff be permitted to participate in future ship operations.



Top Row Left to Right

Electrician Ennis
Engineman Rhodes
Firecontrol Tech Jay
Radarman Anderson
Ship Cook Vernon
Sonarman Yost

Bottom Row Left to Right:

Dick Merritt , Boeing
Chief Quartermaster Beresford
OIC LT Steve McGanka
Sonarman Walker
Chief Firecontrolman Thomas
Vern Salisbury, Boeing
Engineman Wheeler
Ken Soderman. Boeing

Figure 58b. PCH Crew Visits FRESH-I.

In a lengthy letter to BuShips, DTMB, and SUPSHIPS, dated 4 March, prepared by CDR Hamlin and signed by RADM Schultz, PSNS reiterated their concerns with unsatisfactory material status of PCH-1 and the recommendations that they had expressed earlier at the BuShips conference. They strongly recommended that the ship be officially recognized as experimental and that funds and repair efforts be concentrated on the more important problems. It was also pointed out that an extension of the Special Performance Trial period was essential. A nine-month extension was officially requested by PSNS in a follow-up letter to BuShips dated 13 March, 1964.

Wm. Ellsworth, the DTMB Hydrofoil Coordinator, accompanied by Fred Imlay, got his first real exposure to the PCH-1 situation in a meeting held at BuShips on 3 April 1964. Other attendees included

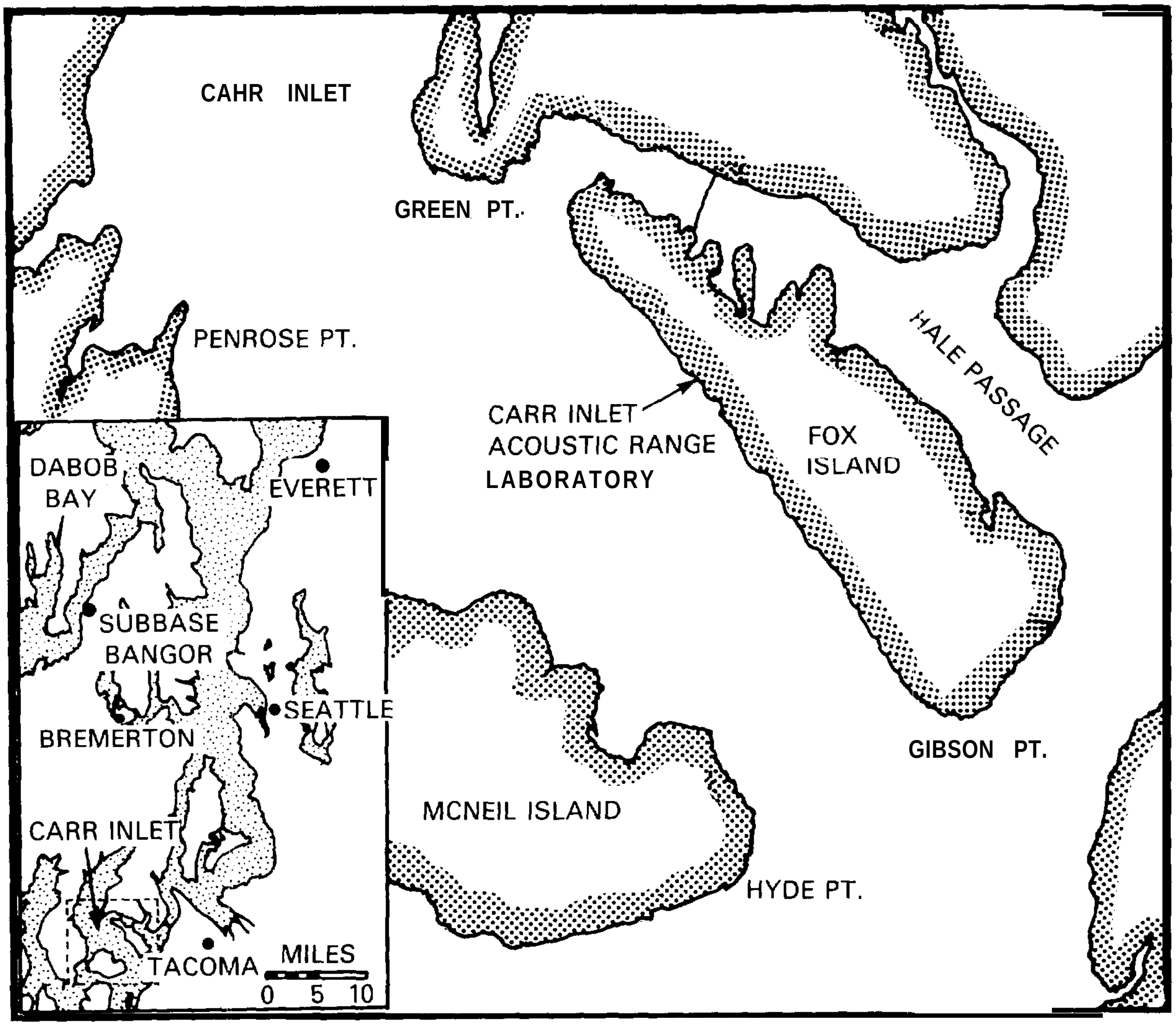


Figure 59. Carr Inlet Acoustics Range

Owen Oakley, Technical Director of BuShips Code 420; Don Stevens and LCDR Bob Umberger, also from 420; CDR W. J. Dixon, Mark Jewett. and Al Koval from BuShips 526; and Tom Ray from Boeing. Ray reviewed past operating difficulties and the status of PCH- 1. He also presented a proposal for Boeing to supply engineering services needed to make the craft fully operational. The detailed discussion that ensued resulted in the following conclusions:

a. Achievement of fully-operational status for PCH- 1 would require a well-coordinated team approach. Team leadership should remain with PSNS with technical support to be supplied by Boeing, BuShips, and DTMB.

b. The objective should be to achieve the best performance with the existing configuration by systematic improvement of various components. The critical nature of the program precluded major design changes at this stage.

c. A distinction had to be made between trials that were an integral part of steps required to make the craft fully operational, and the special performance trials that were subsequently conducted to verify performance and collect data for use by DTMB.

d. Trials instrumentation already on board would be left intact for Boeing's use during operational testing.

e. Where feasible, DTMB would supply instrumentation assistance during operational tests and would endeavor to have an observer aboard.

f. DTMB would submit a design for new forward propellers in an attempt to reduce the effects of wake and tip vortex cavitation on foils and aft propellers.

g. Analysis of data obtained by DTMB in the wake survey of a 1/3-scale PCH propulsion model would be expedited.

h. DTMB would investigate means to reduce cavitation in local areas of the foils and struts and make recommendations to Boeing and PSNS.

On 15 April 1964, Ellsworth made the first of many trips to Seattle spending the next day inspecting PCH-1 and talking to PSNS representatives. The following day discussions were held at Boeing and the strong relationship with Tom Ray continued to grow. At that time, all hands were preparing for a visit of James H. Wakelin, Navy Assistant Secretary (R & D). He was given a briefing on hydrofoils by Boeing and also rode PCH-1 on 25 April for 41 minutes foilborne. This followed on the heels of an abortive attempt the day before to determine the source of erratic steering which had for some time been a problem with the ship. In this instance, a 1/4″ pitot tube line was attached to the leading edge of the forward strut. The purpose was to measure the flow angularity at the foil. A fence was also put on the forward strut in an attempt to prevent air ventilation from the water surface. This experiment only aggravated the erratic steering problem and the pitot tube and fence were removed. However, at the points where the tube had been welded to the leading edge of the strut, the coating was damaged and these irregularities continued to generate flow disturbances and attendant steering anomalies, particularly at high foilborne speeds. Nevertheless, the demonstration for Mr. Wakelin was accomplished successfully without mishap.

On 2 1 April 1964, RADM Schultz had dictated a personal letter to RADM Brockett, Chief of BuShips, expressing his increasing concern over PCH-1 and the future of the Navy's hydrofoil program. After mulling it over for several days he decided not to send it but rather enclosed it with another personal letter dated 28 April, to RADM "Moose" Brown, BuShips Code 400. The following is a quotation from that letter (underlines supplied by the author):

> I spent a good deal of time with Commander Hamlin last Saturday discussing all of the problems with PCH just to insure that I wasn't going off the deep end in writing to you. After this discussion I can confirm that from where we sit the program appears to lack direction. As you know, we have in the Puget Sound area a good share of the hydrofoil development program with the special performance trials on HIGH POINT, the building of AGEH-1 and the Boeing work on FRESH-l. The David Taylor Model Basin is involved in the hydrofoil program and I presume a number of other activities. We have, after some fumbling around, gotten on to a working basis with Boeing, but this came slowly at first. I think I can say that we now get 100% cooperation from them although, at the present, the contract covering

their services has not yet been negotiated. They are working and we are working on the assumption that it will be. We have no knowledge that any of the troubles we have experienced on PCH-1 are being ground into AGEH-1 even though it is being built right here in the area. Of course, we could obtain information in this regard from SIJPSHIP. Seattle, but we'have not been given any status in any work other than PCH- 1 work. Incidentally, this letter is not intended to be a pitch for our inclusion in the program because I am not sure that the Puget Sound Naval Shipyard will have a long range part in hydrofoil development and, therefore, it may not be wise to invest in us as an overall program coordinator. What I am trying to say, though. is that there must be an overall program coordinator more deeply involved in the developmental aspects than is the Type Desk. Unless the Type Desks are quite different from what they have-been in the past they are capable of handling routine problems and are not geared for this program.

My recommendation is that either you or Red give someone the job as a hydrofoil program coordinator and that he be responsible for following all the work, getting answers on technical problems and grinding this into the future direction of the program. He will have to work through the Type Desk. of course, on contractual and administrative problems, but he should be in fact a technical director and incidentally I would think that he would spend a fair share of his time in this area keeping abreast of the program.

If you do not have the personnel or the competence to accomplish the above, I will risk raising the hackles on the back of your neck by suggesting that you hire some agency such as Boeing or Gibbs & Cox to manage the program for you. I have a high regard for Boeing's competence and interest in this program. and while it will cost money I feel they will do a job.

As to the detailed troubles with PCH- 1, I think the Type Desk is fully cognizant. We do not have many answers yet, though, and I am fearful that if this program flounders along too long hydrofoils will acquire a bad odor.

The PSNS request for extension of PCH-1 Special Performance Trials was favorably endorsed by BuShips and CINCPACFLT and forwarded to the CNO who, on 7 May, approved the extension. In a separate action, the CNO acknowledged the experimental status of the ship. In a letter to CINCPACFLT. dated 22 May 1964, the following statement was made (underlines supplied by the author):

The Chief of Naval Operations granted a nine-month extension of performance trials conducted and planned for HIGH POINT. In view of the nature of these trials and the new hydrofoil data being developed as a result of these trials, HIGH POINT must be considered as being in an experimental status until satisfactory completion of all trials. This trial period need not be limited to that planned for the Puget Sound area, but may well be extended to include sonar and other appropriate operational tests. Redesignation of HIGH POINT to (EPCH-1) is considered unnecessary.

RADM Brown responded to RADM Schultz in a personal letter also dated 22 May 1964. Part of his reply is quoted as follows:

I appreciate your recent letter and share in your frustration on the problem of HIGH POINT. I concur that we cannot allow the program to continue to flounder. While the recent cooperation from Boeing and the better coordination at TMB are encouraging, I am convinced that little real progress has been made towards arriving at a fully operational PCH-1.

> In pursuing the idea of letting a private firm handle the program for PCH-1, I have concluded that the best approach is to let a contract with Boeing to determine what needs to be done to make PCH fully operational and to accomplish the necessary work. The contract which we are in the process of negotiating with Boeing relates primarily to trials and by no means covers the determination and accomplishment of corrective action. A natural question arises as to administration of a contract for corrective effort. If Boeing prefers for good reason to berth PCH at its Seattle or Renton plants during such a period, then it would appear preferable to administer the contract through AIM Seattle (Area Industrial Manager). If, on the other hand, there is good reason or necessity for retaining the craft in Bremerton, then it would be desirable for the shipyard to administer the contract as we previously discussed. In either event, we would want to give Boeing a fairly free hand, with major design decisions referred to the Bureau. Such an arrangement will require effective liaison and communication arrangements.
>
> The lessons so painfully learned on PCH-1 will be ground into the AGEH situation, and, hopefully, adequate arrangements will be set up prior to completion of the ship. Certainly the Bureau's early confidence in the operability of PCH- I as contrasted with actual experience should provide a good background to demonstrate the need for improved arrangements for AGEH.

RADM Schultz quickly replied in another personal letter to RADM Brown, dated 27 May. It is of considerable significance in setting the stage for what was to follow and therefore the text is reproduced below in its entirety:

> After reading your letter of 22 May, which Don Stevens delivered to me on Monday, I must agree that the lessons so painfully learned on PCH-1 should be ground into the AGEH situation. I feel that the only really effective way to assure that these lessons will be ground into AGEH and other hydrofoil craft projects and studies is to assign a BuShips Hydrofoil Development Director who will report to you. He should be intimately aware of the progress and problems of each project. He should get answers to technical, design or material problems, assure that the mistakes made and problems encountered on one program are not repeated in a later program, assure that developmental testing and engineering effort is directed toward promising and profitable goals, that duplication of effort is avoided, and that problems or studies are assigned to the persons or organizations best able to handle them. To enable him to carry out these duties, he should be authorized to travel and encouraged to visit his program sites frequently. HIGH POINT's place among these programs should be to furnish information so that her problems may be avoided on AGEH and other hydrofoil craft. Toward this end, HIGH POINT must be tested, "debugged", and finally proven in rough water. The contract which you are negotiating with Boeing covers the testing and study needed to determine HIGH POINT's problems. The action to correct these problems will necessarily evolve as testing progresses. We have asked you to include in this contract an allowance of five hundred man hours of engineering service which can be used in specifying the corrective action determined necessary as a result of testing. If the corrective action requires drydocking and structural modifications, this work will most easily be accomplished here in Bremerton. If the action requires changes to HIGH POINT's automatic control system or sensors, this work may be more easily handled by Boeing. In general, it appears best that this yard provide the industrial support and the on site control of the test program, and that Boeing does the testing and makes recommendations for whatever corrective action is found to be needed in the course of the test program. Bremerton appears to be the best location of berthing HIGH

POINT during the test program because most of the industrial and logistic support is located here. Furthermore, the crew are living with their families in the Bremerton area and extended berthing in Seattle: would adversely affect their morale.

I feel that with the pending Boeing test contract we will have the basis of a sound program for making HIGH POINT operational; or, if this should prove to be infeasible, for determining her limitations so that future hydrofoil craft may profit from the analysis of these limitations.

Up to this point, Boeing had been working to identify and correct PCH-1 problems without additional contract coverage. Eventually, however, they were covered in an engineering services contract, NObs-4788, with BuShips.

A severe loss occurred in June 1964 with the transfer of CDR Dave Hamlin, Asst. Chief Design Engineer, PSNS, and one of the key players in the PCH-I story. Much of his active role was eventually taken over by Verne Whitehead who shared an office with CAPT Terry Efird, Design Superintendant. CDR Don Stuart, Ship Superintendant, also continued his active role.

ROUGH WATER TRIALS

On 19 June 1964, the ship was undocked after cleanup and refurbishment of the coating on the forward strut. Calm water dynamic response tests were conducted to provide data for a Boeing computer simulation in preparation for the first rough water trial. It is noted that, at this point, the craft was capable of both flat and banked (coordinated) turns. The degree of coordination could also be varied.

On 29 June, HIGH POINT transited to Neah Bay near the entrance from the Pacific Ocean into the Strait of Juan de Fuca, Figure (60). Most of the trip was made in the hullborne mode. The following day, 30 June, they proceeded to the test area, some 2 to 12 miles north of the coast of Washington, between Cape Flattery and Neah Bay. Sea conditions were found to vary with time and consisted mainly of swells with an average distance between crests of about 175 feet. The average wave height. determined later by analysis of the data, was 3.5 to 5 feet with an occasional wave exceeding the 8.7-foot length of the forward strut.

Initially, hullborne tests at speeds up to 10 knots were made at various headings around a sea rose with foils first retracted and then extended. The purpose was to determine the damping effect of the struts and foils in a seaway. Although little qualitative difference was experienced between the extended and retracted modes, it must be remembered that HIGH POINT has a "wet" retraction system that does not permit full removal of the foils from the water. Accelerations due to hullborne slamming were, however, found to be much more severe than those resulting from wave "furrowing" while foilborne. Average peak accelerations at the steering station were 14.2 ft/sec^2 while hullborne at 8 knots. This is to be compared with average peak accelerations of 2.9 ft/sec^2 at 43 knots in a foilborne run made in the same seaway immediately following the hullborne test.

Initial attempts to take off and maintain foilborne operations were not successful in that the forward foil emerged from the decending face of waves in a characteristically difficult following sea with the hull subsequently plowing deep into the ascending face of the next wave. Throttles were cut immediately pending assessment of the problem. It was quickly determined that a large part of the difficulty, was due to a resonant anti-contouring characteristic of the heave/pitch control loop that was known to exist at this particular frequency of wave encounter. An adjustment to the pitch control loop was made and subsequent takeoffs were successful. It was also found that bullish persistence with the

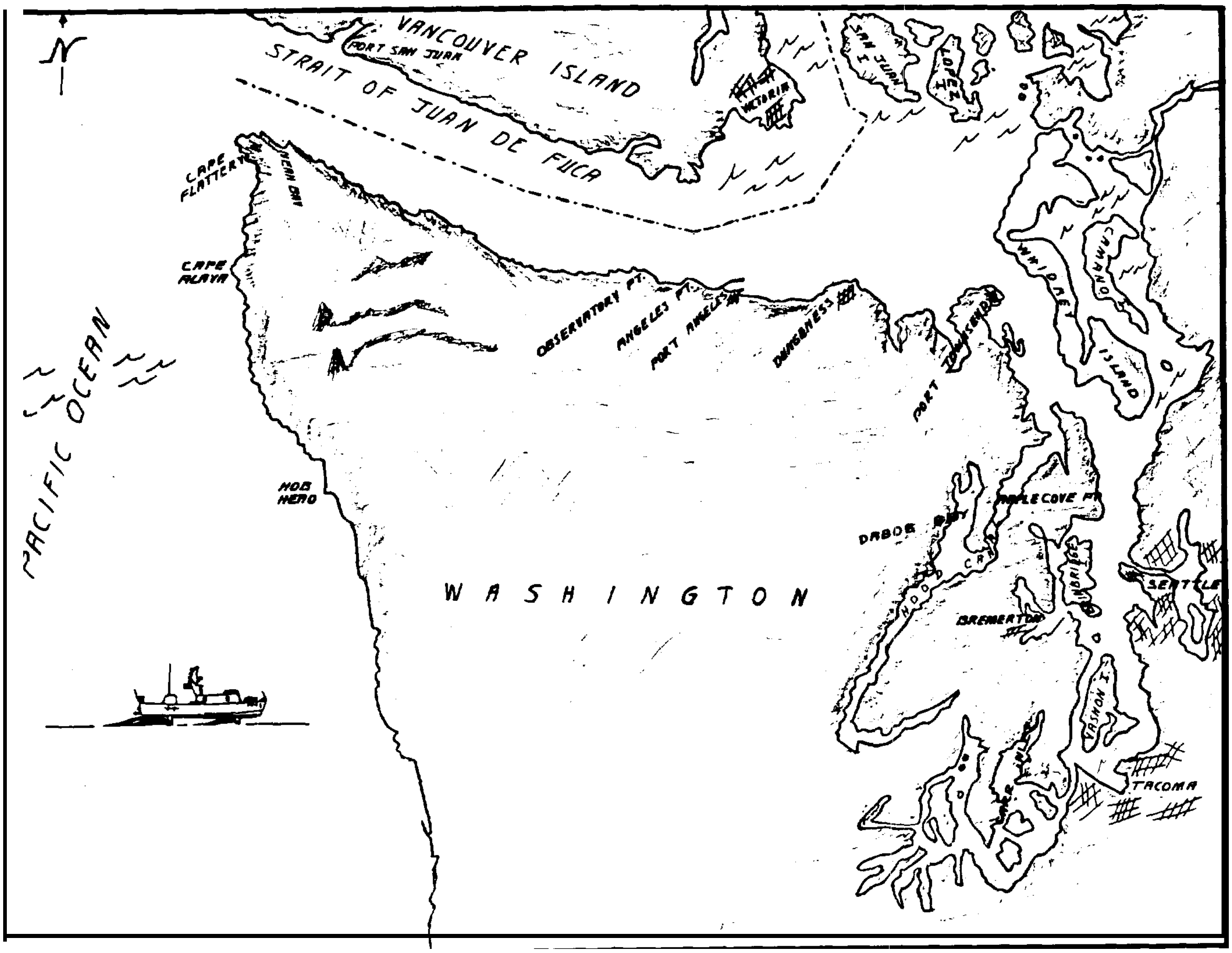


Figure 60. PCH Pacific Northwest, Operating Area

throttles allowed the craft to speed up to where the foil lift coefficient decreased to an operating region that made foil lift less susceptible to the effects of ventilation that resulted when the forward foil came near to the surface.

Dave Petrie. who along with other Boeing engineers Bill Ledray, Don Stark, and Jim Vogt, were involved in these tests, tells an anecdote regarding the first experience in getting foilborne in a seaway. LCDR Hank Billerbeck, OIC of HIGH POINT, was quite apprehensive of increasing the throttles while impacting the waves. Petrie finally convinced him to shove them to the firewall at just the right moment and they finally got up on the foils and the ride smoothed out beautifully.

Foilborne tests for the remainder of the first day consisted of take-offs and lengthy runs under conditions of head, bow, beam, quartering, and following seas. These tests were followed by 360-degree turns through a sea rose. A complete set of these tests were made at 36 and 43 knots.

During the many port turns that were made, there were three instances where the stern began a divergent slide outward (maximum yaw rate of 11 deg./sec) along the radius of the turns. Throttles were cut and height set was brought down to the hullborne mode within five seconds after the onset of the skid-out. Even so. there were roll angles outward up to 1 7 degrees. Initial hull **contact** occurred on the starboard quarter with considerable wash being taken over the starboard quarterdeck. The hull impacts (acceleration peaks of 18 ft/sec/E2/E) were likened to landing on a pillow and the accompanying roll was not precipitous. This maneuver was the same as that experienced once during the calm water tests on 19 June, but entirely different from the erratic turning during runs made 2-i April-6 May which was caused by the frayed neoprene coating on the leading edge of the forward strut.

The previously observed inability to make high speed turns sharper than 2 deg/sec in calm water was again observed in rough water. One difference was noted. The wave phasing action on the forward and aft struts while going through bow or quartering seas was strong enough to alternately reverse the turning rate and then increase it momentarily. A modification to the control system was made the evening of 30 June to increase the amount of banking in turns from 65% to 100%; that is, sway acceleration was reduced from 35 % of radial acceleration to 0%. The purpose of this change was to reduce the side-slip velocity for a given turn rate and thus relieve the rudder of its requirement to oppose the yaw static stability of the boat.

Thirteen take-offs and landings were made that first day with the total foilborne time being 1 hour and 39 minutes. A review of the data during that evening confirmed an observation that the boat had not been platforming as well as it should have and pitch motions averaged 1 .6 to 1.9 degrees in a following sea. There was also evidence that at least **some** of the difficulty experienced with forward foil ventilation followed by hull plowing into the larger waves was due ***to*** this control characteristic. The plan for the next day therefore included further adjustments to the heave/pitch control loop.

On 1 July, most of the day was spent hullborne waiting for a dense fog to lift. Water conditions were similar to those of the day before. In the late afternoon, foilborne tests were conducted during a clearing period with a 17 to 22-knot westerly wind. The wind generated 1 to 3-foot waves with white caps which were superposed on the swells. Tests this day had two objectives relative to control adjustments made the previous night; (1) test the effectiveness of the increased turn coordination as a means to improve turn rate, and (2) check the platforming characteristics with the revised heave/pitch gains. Results of the increased turn coordination were favorable and turning, rate was clearly improved. However, even with this improvement, turn rate was still poor, particularly at the higher speeds of 42-45 knots. The strong winds during the turning tests once again demonstrated the strong effect of hull aerodynamic forces on turn capability.

Gain changes made to improve platforming were such as to tighten control in all loops. Results of these changes were not wholly satisfactory in that the control system over-responded to the seaway, in particular to the shorter period wave disturbances. A subsequent reduction in height sensor authority, in concert with the higher gains in the other control loops, resulted in a reduction in craft pitching from average peaks of 0.87 deg down to 0.3 deg when operating in following seas.

The anticipated problem of ingestion of water into the exhaust ducts of the main turbines in a following sea did not materialize. A test had been devised by covering the stack covers with a water-soluble paint. Results were not conclusive since the seastate was not as high as the foilborne design limit under which the turbine exhausts might open.

One difficulty, not specifically related to the test program, occurred during the second day of the trials. In mid-afternoon the engine room bilge was found flooded to within 3 inches of the floor grates

(3 feet deep at frame 16). By use of a portable pump, the water was pumped out and testing was resumed. The problem was found to be due *to* a 3-inch salt water line coming loose from the starboard distillate pump. It was estimated that between 10 and 15 tons of water were being carried during foilborne operations just prior to discovery of the flooding condition.

The return transit to PSNS was made on 2 July, with the major portion again being in the hullborne mode and only about one hour foilborne.

In the latter part of July, further acoustic and vibration trials were completed at Carr Inlet and, in early August, hullborne portions of speed and powering trials were accomplished. Foilborne speed and powering trials in calm water were conducted in mid September as well as spiral tests to determine the effectiveness of a larger spade rudder which had been installed by Boeing. On 2 1 September, HIGH POINT again transited to Neah Bay to run a second rough water trial. This time the transit was made foilborne and took a little over two and one-half hours. Trials began the following day. but were terminated after about one and one-half hours of foilborne time when an excessive amount of salt water was found in the main transmission lube oil. The ship made the transit back to PSNS in the hullborne mode and, on 25 September was drydocked for inspection and repair.

GROWING CONCERN

The concern over the problems of PCH-1 had continued to grow during summer of 196-i. Correspondence between Seattle and Washington, both formal and informal continued to emphasize the need for better coordinated action. A proposal had been made by Boeing in late summer to take over the PCH-1 and operate it out of Pier 91, in Seattle. This created quite a stir at PSNS and SUPSHIPS, Seattle, as well as a strong rebuttal from the OIC of PCH-I. LCDR Billerbeck. As a result, a conference was called at BuShips on 9 September to discuss the issues raised by PSNS and OIC HIGH POINT.

Attendees included:

BuShips	Code
RADM J. A. Brown	400
CAPT H. C. Field	4 10 (actg.)
George Main	406
Owen H. Oakley	420
LCDR R. C. Umberger	420
Don L. Stevens	421
CAPT E. T. Steigelman	5 10
CAPT W. Gundlach	526
Sid Peters	526
Al A. Koval	526
L. C. Ellis	526
OPNAV	
CDR D. Rogers	OP725
SUPSHIPS, Seattle	
LT (jg.) M. R. Terry	
PSNS	
CAPT T. A. Efird	200
OIC PCH-1	
LCDR H. G. Billerbeck	

After introductory remarks by KADM Brown, in which he reviewed the past history of PCH-1, a lively discussion ensued. CAPT Field stated that the Bureau was undermanned and, although the need for a full-time hydrofoil project manager was recognized, the only way they could see to get this capability was to enter into a contract with a private contractor with hydrofoil experience. Boeing was felt to be the obvious choice in view of their familiarity with the ship. He also commented that with PCH being in PSNS it was felt it would not receive the prompt attention required because of the many other larger ships with higher priority. In rebuttal, PSNS stated that they could be just as responsive as Boeing once a decision had been made on corrective action to be taken. It was also pointed out that the Bureau could improve the response time by providing adequate funds to the Shipyard so that it could proceed with repairs without having to go back to the Bureau on each repair item. After more discussion, the following agreements were reached:

(a) PCH would remain at PSNS.

(b) PCH would remain "in service".

(c) PSNS would furnish industrial support to PCH in way of dockside services and changes or equipment installations.

(d) PSNS **would** continue to schedule and coordinate Special Performance Trials to be conducted by DTMB.

(e) The Bureau would enter into a new contract with Boeing covering the following items:

(1) Manage, coordinate and provide. under Bureau of Ships technical direction, the engineering effort to make PCH- 1 operationally reliable.

(2) Make the necessary tests. trials and investigations to determine if the ship can be reliably operated foilborne in rough water, both platforming and contouring, up to and including sea state 5. If deficiencies are discovered. recommend solution to the Bureau.

(3) Determine causes and propose corrective action for known deficiencies

(4) Incorporate corrective measures in the ship as approved by the Bureau with installation work aboard the ship to be provided by PSNS. Minor manufacturing of hardware items costing up to $5,000 may be accomplished by Boeing.

(5) Evaluate adequacies of remedies after incorporation in the ship.

(6) Revise "as-constructed" drawings to show changes made.

(7) Make weekly reports to the Bureau by telephone or message as to what has occurred in the past week and what is planned for the coming week.

(8) Summarize reports in writing once each month and include status of money spent.

It was further stated that the changes proposed by Boeing would be reviewed and approved by the Bureau. If work aboard PCH was required, the Bureau would request PSNS to accomplish. However, during the course of tests being conducted by Boeing there may be some minor work to be accomplished on PCH. In these instances, Boeing would make the request to PSNS (Verne Whitehead, Code 247.1) to have these items accomplished. Whitehead would request issuance of a job by P&E and follow up on work to be accomplished by Production. The Bureau emphasized the need for prompt response to requests of this nature.

The Bureau also noted that it was not expected that the new Boeing contract would be negotiated until sometime in December. In the meantime, Boeing would continue to operate under NObs-4788 which would run until 26 December 1964.

LCDR Billerbeck raised the question about getting an extension of time from CNO to continue this experimental work on PCH in order to come up with permanent fixes on the various deficiencies. The test period had been scheduled through calendar pear 1964. The Bureau advised that getting another extension of time would not be a problem and that they would make the necessary arrangements with CNO.

It is clear that 1964 was a year of painful reassessment for all concerned. At the onset, relationships between the Navy and Boeing were strained, particularly regarding the fixing of responsibility for correction of deficiencies and provisions to cover the costs thereof. This situation was complicated by the Navy's having done a major portion of the design inhouse and the contractor's position that contract commitments had been met in accordance with the Navy's direction. As time went on, however, with Boeing's willingness to work with the Navy in dealing with PCH- 1 problems. a close relationship developed that was to persist over the many years to follow this early period of coming to terms with the realities of R&D.

CHAPTER 6

Regrouping

MOD-O REPAIR

The drydocking on 24 September 1964 to repair leaks of salt water in the starboard transmission was the 13th time HIGH POINT had been lifted from the water. A total of 264 days had been spent in drydock since the launching in August 1962. In 260 flights only about 5-i hours of foilborne time had been accumulated since the first flight in May 1963.

It was initially estimated that repairs would take about 4 weeks. However, during early October concern mounted over the prospect that the ship would continue to be plagued with recurring problems. As a result, on 22 October, the decision was made to make more extensive modifications and repairs. These included replacement of all carbon steel piping in the struts; and inspection, with repair or replacement as necessary, of wiring, shafting, bearings, and gears. As it turned out this, and the correction of other problems that were discovered. was to take a total of 529 days to accomplish.

On 30 December 1964. RADM Schultz issued a PSNS notice stating the methods by which work on HIGH POINT would be expedited. He noted that BuShips had placed a contract with Boeing to provide engineering support. Industrial support was to be supplied by PSNS. He also noted that the time involved in normal shipyard overhaul and repair procedures would not meet the urgent time demands for HIGH POINT. As a result, other procedures for expediting the work would be invoked. This included designation of a Shipyard Trial Coordinator and a Boeing Coordinator to aid in expediting work. More specifically, the following actions were directed:

(a) In the Planning Department all plans, memoranda, and job orders were to be hand carried during routing and teletyped to Production Shops. It was expected that not more than one day would be required between issue of a plan or memo from Design and start of work in Production.

(b) All HIGH POINT work in Production was to be expedited and inter-shop delays avoided. There was to be liaison between personnel in Planning and Estimating,, Design, and Production.

(c) All requisitions concerning HIGH POINT were to be closely progressed and every effort made to shorten delivery times.

(d) Verne Whitehead was designated Hydrofoil Coordinator in PSNS Code 247.1. He was made responsible for taking appropriate direct action with departments, divisions, and shops to ensure rapid issuance of plans, memoranda, and job orders and to avoid delay of shop work due to a lack of information.

These unprecedented actions by the Shipyard were further evidence of RADM Schultz's special concern for the Hydrofoil Program. The long delay involved in the MOD-O repair and refurbishment was not attributable to any lack of support by PSNS. Rather, it was due primarily to the unanticipated extent of problems that required correction **and** the lack of adequate and timely funding to support the work incurred. Of course, funds had not been originally budgeted for this purpose and this created a serious drain on OPTAR funds available to MINEPAC, the Type Commander.

Boeing assigned Dick Merritt, a structural engineer from Tom Ray's technical team, as Project Director for the refurbishment. Art Anderson was assigned as the Boeing Coordinator in the Shipyard. (It may be noted that some time later Art formed his own Company, Art Anderson Associates, and he continued to support the Navy's Hydrofoil Program for many more years.)

As the refurbishment of PCH continued to progress slowly, it became more and more apparent that major modifications would ultimately be necessary in order to achieve acceptable reliability and the desired performance levels. The struts and foils were removed from the ship and put in the PSNS shop where they were disassembled. Upon inspection of the transmissions in the lower gear boxes, it was found that the continual leakage of salt water had caused extensive bearing and gear corrosion. This recurring leakage had been taking place at propeller shaft seals and through cracks and holes in the nacelles. As a result, it was necessary to replace the entire lower transmission system. This was a major contributor to extending the time of the overhaul.

During the refurbishment, a positive-pressure oil seal system was installed on each propeller shaft, ensuring that any leakage past the outer seals would be oil leaking out rather than salt water leaking in and contaminating the lube oil. This later proved to be a successful solution to this problem, although it was recognized that future designs should provide for separate watertight gearboxes inside the nacelles.

On 8 June **1966** HIGH POINT finally completed its MOD-O refurbishment and overhaul and was undocked to begin the Boeing verification test program called for under contract NObs-4838.

RESTRUCTURING THE PROGRAM

In December 1964, mounting concern over the problems of PCH had caused the Pentagon to freeze $1.8M of FY66 funds for hydrofoil R&D pending a reassessment of the program. In a letter dated 14 December, Dr. Robert Morse, ASN (R&D), directed BuShips to review the program and make recommendations for action to be taken. In response to this direction, RADM Brockett, Chief of BuShips, in a letter of 31 December, requested DTMB to undertake a review covering the current state of the art, major technical problems still to be resolved, approaches to solve these problems, and a proposed R&D program with estimates of funding needed to reach reasonable goals. The Model Basin accepted this assignment and on IO February 1965, advised Dr. Morse that a panel of experts had been formed under the chairmanship of Mm. M. Ellsworth and that they would be prepared to report the results of their findings by the end of the month. The briefing for Dr. Morse actually took place on 22 March 1965. Several recommendations were made including the need for a project organization to manage the Hydrofoil Program. It was further noted that, although technical problems could be resolved with proper attention, assignment of HIGH POINT to the Fleet was premature.

The briefing to Dr. Morse set a number of actions in motion. On 2 June 1965, a revision of the Advanced Development Objective (S46-06 XR1) was issued by OPNAV, Reference 43. This refocused the program to concentrate on the development of hydrofoils capable of speeds up to 50 knots as opposed to the original objective of 90 knots. Appendix E is a copy of the revised ADO which was confidential when issued but is no longer classified.

Issuance of the revised ADO was followed by a letter from the CNO to BuShips, dated 6 July, which requested revision of the Hydrofoil Technical Development Plan (TDP) with the long range view of providing an in-house Navy capability for test and evaluation of various advanced surface craft including hydrofoils and air cushion vehicles. A day later, ASN (R&D) sent another letter to the Deputy Chief of Naval Material for Development requesting recommendations for improvements in the Hydrofoil Program management organization. This was passed to BuShips for action. The Bureau responded by sending a letter, dated 20 July, to DTMB requesting that the Hydrofoil Coordinator, Wm. M. Ellsworth. be detailed to BuShips Code 34 1 for a period of six months during which he would act as Hydrofoil Program Manager. The Model Basin was agreeable to this assignment and Ellsworth reported the following week and was assigned to Code 3-i 1-H. There was some concern, however. on the part of the Model Basin management regarding TMB's future role in the program. This was reflected in a memorandum written for the record on 2 1 July by CAPT Deke Ela, Model Basin Commanding Officer. Comments in this memorandum are reproduced below.

> The BuShips letter of 20 July 1965 has been discussed at length with CAPTS Bennett and Meyer. CAPT Bennett has confirmed with RADM Fee that our suggestion of using DTMB ceiling points to give the Program Manager a full-time staff can be done (apparently without further authority). Furthermore, I have been assured that the initial effort has been made with the Type Desk to designate individuals to assist as required.
>
> Some points which I stated to Bennett, Meyer, and CDR Donaldson should be kept in mind:
>
> a. Staffing notwithstanding, the lines of fiscal responsibility are not clear. Without question. the Project Manager should establish the levels of funding in order of technical importance within the budget, even though other desks, such as the Type Desk, actually authorize expenditures. As long as uncoordinated spending can occur, regardless of whether it be R&D or SCN, chaos will continue to prevail.
>
> b. Similarly. contract administrative authority. as for example in change orders, is not clearly defined.
>
> c. First priority is placed on documentation of a new TDP. The objective is to obtain release of S 1.8M which is withheld pending an approved program. I take issue with this, believing

that the first priority lies in intense technical review of AGEH and PCH planning with the objective of getting timely changes out *to* prevent further failures in the full scale test program. Exhibition of a thorough going technical effort and a good set of test plans will do more to release funding than any other thing. Furthermore, such action provides all the ammunition necessary to quickly generate a TDP in pretty hard terms. Failure to recognize the urgency of cranking immediate changes into the AGEH almost certainly builds another black-eye into the program when that ship attempts trials.

d. It is not clear that Codes 400 and 600 have the same feeling of urgency to avoid another series of failures that is felt in the 300 Codes. Authoritative coordination by the Program Manager is not possible unless these Codes attach the same significance to the program as Code 300.

e. I continue to feel that the proper ultimate place for the Hydrofoil Program Manager is at DTMB in line with Dr. Keil's original comment. I think another attempt to do this, however, must be the result of a conversion of the entire program into an R&D effort versus a divided R&D-SCN funded effort as it is at present.

Regardless of the above, there is much to be done right now in the administrative line. An Office must be established and above all some positions described and advertised in order to create help. Staffing may be an acute problem at the levels of technical competence desired in the face of the GS-14 freeze. From budgeting to parking there is much to be done administrativelp to get this thing rolling and it is well for Bill Ellsworth to get started.

In a draft BuShips Notice, dated 1 August 1965, it was proposed to set up a Hydrofoil System Program Management Section (Code 341-H) under the Ships Research Branch (Code 341) of the Applied Research Division (Code 340). In this plan it was proposed that W. M. Ellsworth would be the Program Manager, and that he would have three Project Engineers reporting to him. One would be responsible for tests and modifications of hydrofoil R&D craft; another would be responsible for mission analysis and mission equipment development; and the third would be responsible for performance evaluation and design/development support. This draft BuShips Notice was enclosed in a memorandum of 12 August from BuShips to the Deputy Chief of NAVMAT for Development. In it the following statements were made :

The ASN (R&D) has requested that the DCNM (D) present recommendations for improvements in the management organization and experimental testing provisions of the hydrofoil and other advanced surface craft projects. The purpose of this memorandum is to provide a summary of the various actions either taken or contemplated by BuShips to enable DCNM (D) to respond to the Secretary by 15 August as requested.

Concerning managerial organization for the overall field of advanced surface craft. the establishment of a designated project office for all such craft would be premature at this time. although events may ultimately favor formal projectization. The BuShips Hydrofoil Program Manager will be vested with stronger more clearly defined lines of authority. This arrangement derives from the principles discussed in paragraph (4c) of NAVMAT INST 5000.5, and gives the Program Manager sufficient authority and support to permit him to carry out his responsibilities without simultaneously involving the Bureau in the many administrative embellishments required to support a formally designated Project Manager. Further, it provides for the assignment of a full-time management team devoted exclusively to the management of the Hydrofoil Program. It is prudent to permit this arrangement to operate undisturbed for six months after which it will be re-examined to determine its effectiveness.

A similar technique will be applied to the initial management of the proposed research and development plan now being formulated in the area of surface effect ships, another constituent of advanced surface craft. The effectiveness of this program management organization will also be examined at the end of six months and, if it appears that even stronger central managerial authority is desirable, then the establishment of a Chief-of-Bureau designated project for advanced surface craft, to include hydrofoil and surface effect ship programs, will be considered.

Addressing the other specific items enumerated in the Secretary's letter, copies of BuShips documents which have recently been prepared to update the hydrofoil. Technical Development Plan (TDP) and to improve the program management are enclosed.

The new hydrofoil Advanced Development Objective (ADO) and the TDP now under preparation will align the program toward the realization of maximum technical and operational return from effort spent to date. A team to review the design of AGEH-I has been established. The David Taylor Model Basin has been formally assigned the responsibility, under the BuShips Program Manager, for the test and evaluation of AGEH- 1 and PCH- 1, including preparation of detailed plans and conduct of all trials.

The above action, which will be formally presented in the revised TDP, comprises positive response to all the issues, referring to the deferral of $1.8M of FY66 funds, raised by DDR&E and reflected in the ASN letter. Release of these deferred funds will be pursued actively.

As noted in this memorandum, in a letter of the same date, BuShips formally assigned DTMB the responsibility for T&E of PCH. and of AGEH when delivered.

By mid-September, a draft revision of the TDP was completed and informally submitted to Howard Peterson. in the Office Of the DDR&E where the deferral of FY66 funds had originated. In Section 5 of the draft TDP. it was proposed to establish a Hydrofoil Craft Special Trials Group instead of an Advanced Surface Craft Trials Activity which had been considered earlier. This draft of the TDP was approved shortly thereafter and FY66 funds were released on 1 October 1965.

On 3 1 January 1966. RADM Brockett was relieved as Chief of BuShips by RADM Edward J. Fahy. The original proposal to establish an adequately-staffed Hydrofoil Program Office in BuShips was not approved and early in 1966 the six-month detail of Wm. M. Ellsworth was concluded. As a final action, he and Jim Schuler drafted a letter to DTMB, which was finally signed out on 28 March 1966, in which it was requested that the Model Basin assume responsibilities as BuShips' Technical Agent for the Hydrofoil Program. They were to be responsible to the BuShips Hydrofoil R&D Program Manager, a position reassigned to Jim Schuler along with his many other program responsibilities. DTMB did not immediately respond to this request. But, on 19 April 1966, they did establish a Hydrofoil Development Office. Code 050. This was headed up by W. M. Ellsworth, reporting directly to the Technical Director, Then, in a letter dated 26 April 1966, the assignment was accepted conditional upon being given the authority to provide the necessary staffing. This was prompted by the personnel ceiling and freeze on high grades (GS-13 and above) that was in force at that time.

LOCATION OF THE TRIALS UNIT

During October and November of 1965, there had been a lengthy exchange of personal letters between RADM Schultz at PSNS and CAPT Deke Ela, Commanding Officer of DTMB. This exchange was precipitated by RADM Schultz having been apprised of a proposal to locate the hydrofoils trials activity at Pier 91 in Seattle rather than at PSNS. This alternative was, in fact, under consideration. One reason was the desire for easier accessibility to Boeing's engineering support. The main reason. however, was concern that the next Shipyard Commander might not continue to accord the hydrofoil craft the high priority given to them by RADM Schultz. After all, by comparision to the capital ships, such as aircraft carriers, that overshadowed it, the PCH might well get lost in the noise. Furthermore, the fact that an alternate location was being considered enhanced the Model Basin's expectation of receiving more favorable concessions as a tenant of PSNS.

In a letter, dated 3 December, RADM Schultz expressed his concerns to the Chief of BuShips, RADM Brockett as follows:

> It is understood that the Bureau may propose to physically relocate the HIGH POINT to the Naval Supply Depot, Pier 91, Seattle, for the test, evaluation, and deficiency correction program. Although the Shipyard does not know the details of plans for the HIGH POINT when presently authorized work is completed, or all of the factors which might influence those plans, the following advantages of basing the craft and accomplishing industrial work in the Shipyard are furnished for consideration.
>
> a. The time-consuming process of contracting commercially for industrial work would be eliminated.
>
> b. The uneconomical aspects of contracting commercially for industrial work would be eliminated.
>
> c. Industrial work would be done by mechanics who have accumulated over two years experience and know-how on HIGH POINT.
>
> d. The crew of the HIGH POINT, presently living in Bremerton with some in leased houses, would not be forced to move or commute to Seattle.
>
> The following comments are also considered pertinent:
>
> a. Although a debugging period is to be expected on such a developmental project. there were and probably still are many unsatisfactory engineering and construction details which have resulted in an excessively long debugging period to date. The HIGH POINT may continue to spend more time under repair than in the water in the near future.
>
> b. Based on discussions with Boeing personnel, the current program under NObs-4838 anticipates only 25 hours of foilborne operation before additional checks and possible repair or modification of the foils and propulsion system will be required.
>
> c. Although design services might have to be furnished at "long distance" by a design agent. overall time in getting the work done would be minimized if Shipyard manpower and facilities are used. From past experience, the prime consideration should be to insure a masimum availability of corrective effort when needed.
>
> d. Early in the HIGH POINT test program it was apparent to Puget Sound Naval Shipyard that a test and deficiency correction Program Manager in BuShips was required. This was

proposed by the Shipyard Commander in unofficial correspondence dated 27 May 1964 and 7 August 1964. Now that the Bureau has set up a Program Manager, it is believed that the test and deficiency correction phase can be accomplished in minimum time and for a minimum cost using Shipyard industrial support.

It is recommended that the Bureau make an analysis of the advantages, disadvantages, and estimated costs before deciding to relocate the HIGH POINT. Such a review should include the Shipyard's views on, and experiences with, the HIGH POINT.

It is requested that the Shipyard be given the opportunity to comment on any proposed program before it is finalized.

In spite of RADM Schultz's arguments, on 16 December 1965, RADM Harry Mason, Assistant Chief of BuShips for R&D, signed out the following letter to the CNO via the CNM, addressing the plan for test and evaluation of PCH and AGEH:

In BuShips letter of 31 March 1965 a proposed plan was outlined for post-delivery trials of the hydrofoil research ship AGEH- 1. The plan envisioned approximately six months of operation by a contractor followed by assignment of the ship to a type commander for conduct of such operations as considered necessary for the long range phase of the program.

In his letter of 6 July 1965 the CNO requested reconsideration and revision of the proposed plan with the long-range view of providing an in-house Navy capability for test and evaluation of advanced surface craft. CNM's endorsement of 23 July concurred in the need for a more effective instrument for accomplishing tests on advanced surface craft.

The Bureau of Ships has now completed revision of the TDP for Hydrofoil Craft in response to changes made in Advanced Development Objective (S46-06X). Section 5 of the revised TDP sets forth a plan for establishment of a Hydrofoil Craft Special Trials Group predicated upon the following considerations:

a. Trials of PCH-I will resume early in 1966 and Navy Special Trials of AGEH- 1 are expected to commence in the summer of 1966. This does not permit adequate lead time to establish a broader scope Advanced Surface Craft Special Trials Activity.

b. Both PCH-1 and AGEH-1 should remain in the Seattle area in close proximity to the builders, at least for a period of one or two years, in order to facilitate correction of design deficiencies.

c. Maximum utilization of trials personnel and contractor support dictates the need to operate both PCH-1 and AGEH-1 in the same area. i.e. Seattle.

In light of the foregoing, the following actions are proposed:

a. Formation of a Hydrofoil Special Trials Group comprised of the present crew of PCH-1, selected military personnel assigned to AGEH- 1, and technical trials personnel from rhe David Taylor Model Basin augmented by contractor support.

b. Assignment of responsibility for the special trials program to the David Taylor Model Basin

c. Establishment of an interim operating base for PCH-1 and AGIEH-1 at the Navy Supply Depot, Pier 9 1. Seattle.

Cognizant activities including DTMB; Navy Supply Depot, Pier 91, Seattle; and COM- 13, have all been apprised of this plan and have informally expressed concurrence. Facilities of the Navy Supply Depot are, furthermore, felt to be well suited to support the envisaged test and evaluation operation.

In order to implement the proposed special trials plan the following actions are requested:

a. Transfer of command and primary support of PCH-1 from Commander Mine Force, Pacific Fleet, to Commanding Officer and Director, David Taylor Model Basin, and provision for area coordination by COM- 13.

b. Retention of PCH-1 in an "in-service. not in-commission" status.

c. Change of home port for PCH-1 from Bremerton, Washington to Seattle, Washington upon completion of current repairs at Puget Sound Naval Shipyard and operational checkout; the exact date of such change to be established.

d. Similar assignment and designation of AGEH-1 upon delivery of the ship to the Navy.

This plan is felt to represent the most realistic interim solution to the satisfaction of immediate needs to conduct extensive special trials of Navy hydrofoil craft. Action must be taken without further delay so that firm plans may be completed on a time schedule consistent with anticipated craft availability. The Bureau will continue to explore the needs and means for establishment of a more extensive special trials group to encompass all advanced surface craft.

Needless to say, when RADM Schultz read the BuShips letter proposing Pier 91 as the site for the trials activity, he reacted strongly. Verne Whitehead. the PSNS Hydrofoil Coordinator, was charged with immediate preparation of a reclama, which was signed out on 30 December 1965. In this letter the following comments were made:

This Shipyard concurs with the basic concept of the proposed Hydrofoil Test and Evaluation Unit. However, for the reasons spelled out in our letter of 3 December 1965, the proposed T&E Unit would prove more effective if based at PSNS. The following proposal for basing the crafts and accomplishing the industrial work in the Shipyard is furnished for consideration.

a. As already stated. the T&E Unit would be assigned to DTMB for command and primary support with area coordination provided by COM- 13.

b. The crafts would use Pier 3C in the Shipyard which is fully equipped with steam. water. electrical power, and crane service.

c. T&E Unit personnel would use Building 580 as office space and space for storage of test equipment.

d. There are single barracks and messing facilities within the Shipyard to take care of Navy test personnel.

This berthing and office space assignment places the T&E Unit at the edge of the industrial complex yet close enough to have industrial and logistic support readily available.

The Shipyard's organization for industrial support of the T&E Unit will remain much the same as it is and has been in the past for PCH. The Shipyard has assigned a Program Manager, Project Engineer. and a nucleus of shop employees that are experienced with PCH and its necessary repair procedures. Work requirements for the Shipyard are introduced at the Project Engineer level and are handled on a walk-through basis. Staffed in this manner. repairs can be made expeditiously and close liaison can be maintained with cognizant activities. Industrial support for the crafts would be handled in the following manner:

a. The DTMB Trials Director would advise the PSNS Project Engineer of work required in whatever form is desired by BuShips and DTMB (verbally. handwritten. typed work request, etc.).

b. The PSNS Project Engineer will have prepared a formal item description for further processing and for record purposes.

c. Those items within the scope of work authorized by BuShips for PSNS accomplishment will be immediately undertaken and a copy of the job order furnished to BuShips for information and review.

d. Those items requiring Bureau approval will be referred to the Bureau for decision by telephone. PSNS will recommend shipbuilding accomplishment of any design work which the shipbuilder is better suited to accomplish. PSNS will undertake any work as soon as it is authorized by BuShips and forward a copy of the job order. BuShips will contract for any design desired from the shipbuilder.

e. An allotment will be furnished to the Shipyard to fund accomplishment of authorized work.

Consideration must be given to the following in the assignment of location of the Test and Evaluation Unit base:

a. Location at the Shipyard eliminates the time consuming and uneconomical aspects of contracting commercially for industrial work on a non-competitive basis.

b. The test. evaluation, and correction of defects phase undoubtedly will result in many unexpected and unusual demands for services. material, trade skills, etc., to which the Shipyard will be immediately supportive. No other activity in the area has the comparable physical and trade skill resources and no other is geared to the same enthusiastic response to such needs.

c. The U. S. Navy should maintain an in-house capability, knowledge, and experience in this field. If it does not, we will be continually at the mercy of the private contractors and will never get the in-house capability, desired by the Chief of Naval Operations.

In view of the above, it is again strongly recommended that the Test and Evaluation Unit be based at the Shipyard.

On 24 May, the CNO sent a message to all concerned commands advising of the intent to establish a Hydrofoil Special Trials Group and reassign PCH and AGEH as R&D craft. In message replies, COMINPAC, CINCLANTFLT, and NAVSHIPYD BREM concurred in the proposed action except that PSNS reiterated their objections to the use of Pier-91 as the base of operations. Finally, in a message to the CNO, dated 11 July, BuShips accepted RADM Schultz's proposal. The message was as follows:

> ANALYSIS OF HYDROFOIL CRAFT SPECIAL TRIALS ACTIVITY REQUIREMENTS INDICATES DESIRABILITY BASING SPECIAL TRIAL GROUPS AT NAVSHIPYD BREM, BREMERTON, WASH. AMEND REF (A) TO INDICATE HOME PORTING OF PCH-1 AND AGEH- 1 AT BREMERTON. WASH.
>
> REQ IMPLEMENTATION REF (B) BY ASSIGNMENT OF PCH-1 AND AGEH-1 TO COM-13 FOR OPERATIONAL CONTROL AND CO&D DATMOBAS FOR TECHNICAL CONTROL.

As will be noted later, it was some time before CNO actually approved the recommendations that had been made. Anyone familiar with the inner workings of a bureaucracy, can perhaps appreciate that this account of the process of getting PCH-I redesignated as an R&D craft and assigned to the Commanding Officer of a laboratory as Type Commander leaves out a myriad of details. During this period, there were several stalwart and persistent supporters of hydrofoils who worked tirelessly to keep things on track. First there was Jim Schuler, BuShips R&D Program Manager, whose grasp of the "system" was and still is extraordinary. In the Pentagon, CAPT Bob VonGerichten. one of the rare Aeronautical Engineering Duty Officers, worked the problems in OP-07 under the DCNO for R&D. In the Office of the ASN (R&D), the support and enthusiasm of CAPT Bob Schniedwind and, indeed that of Dr. Frosch himself, was invaluable. Finally, there was Howard Peterson, a long standing hydrofoil enthusiast in the Office of the DDR&E. It was always his contention that PCH should make an uassisted deployment to Hawaii in order to attract more attention.

Perhaps the most interesting commentary on the process of achieving this milestone was the notation by CAPT VonGerichten that the proposal actually had to be "chopped" by 21 Admirals before it was finally approved.

MOD-I STUDY

On 3 and 4 August 1965, a conference had been held to discuss a HIGH POINT Technical Performance Improvement Program. At that meeting, Wm. M. Ellsworth was introduced by Jim Schuler as the Acting BuShips' Hydrofoil R&D Program Manager, Code 34 1H. Other attendees at the two day session included:

Al Kennedy	Boeing PCH Program Manager
Dick Merritt	Boeing PCH Project Engineer
CAPT Bill Gundlach	Head. BuShips Code 526
Sid Peters	Chief Engineer. BuShips Code 526
Al Koval	PCH Project Engineer. BuShips Code 526
LCDR Bob Umberger	Project Officer. BuShips Code 420
Verne Whitehead	PSNS Code 247. 1
LT Steve McGanka	OIC PCH
Dave Washburn	Manager Hydrofoil Mission Subsystems. NELC

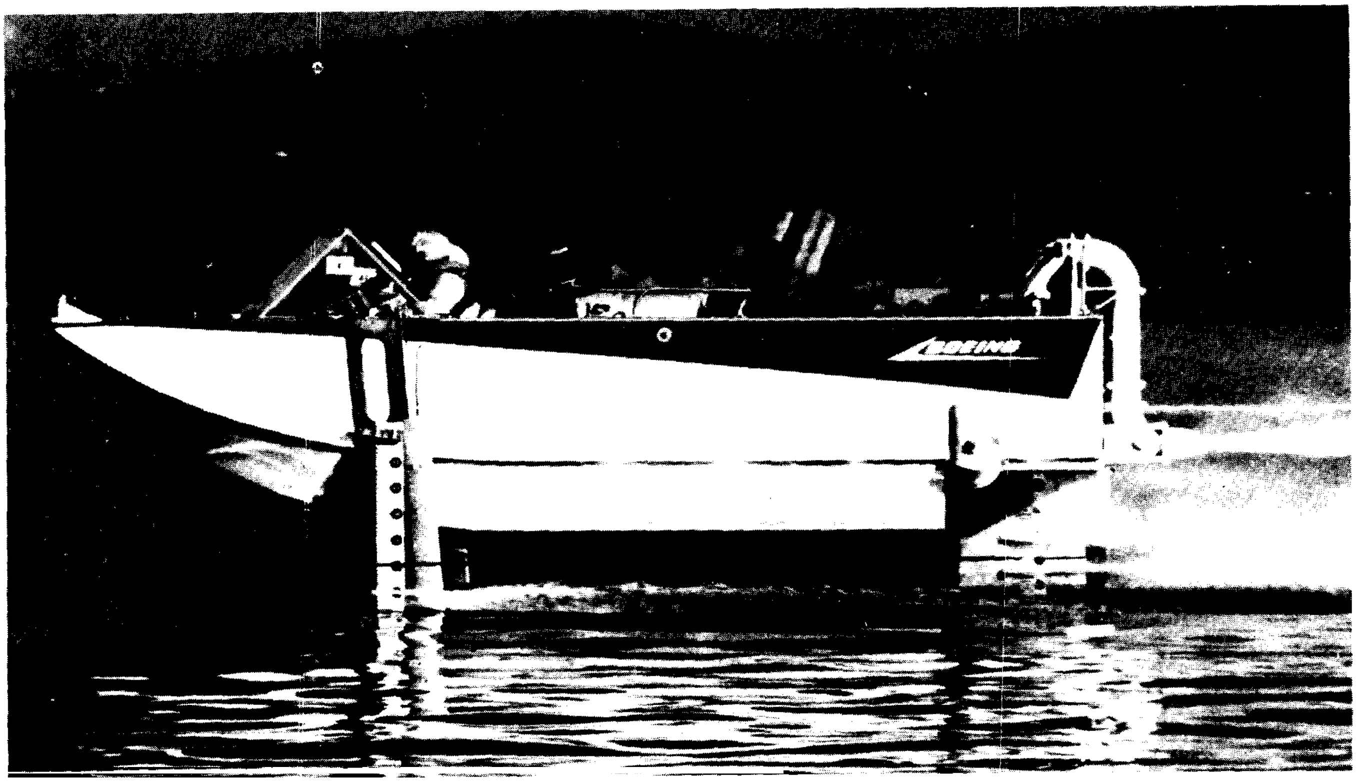


Figure 61. Boeing Waterjet Test Craft, LITTLE SQUIRT

During the meeting, the Boeing representatives discussed HIGH POINT's deficiencies and proposed to undertake a study and develop recommendations for improvements. This led to agreement on a revised program plan consisting of two major phases. Phase-I would comprise a preliminary design study, a detailed design of approved modifications, construction and installation of MOD-I design changes, and a test and evaluation program to validate changes and establish a new performance baseline. Phase-II would expand knowledge of performance boundaries and explore various mission applications.

Following the conference, in a letter dated 23 November 1965, BuShips requested a proposal from Boeing to perform a preliminary design study of MOD-I PCH. Boeing responded in December with a proposal to examine a number of alternatives for the strut/foil configuration, propulsion, automatic control, materials, and structure. Based on their successful experience with the 57-ton hydrofoil gunboat, TUCUMCARI (PGH-2), they strongly recommended the inclusion of a waterjet propulsion system as one of the options in the study.

Boeing's proposal was accepted and the study, which was to extend over some period of time, was initiated. It included extensive analyses and computer studies, model tests, and tests on Boeing's waterjet craft LITTLE SQUIRT, Figure (61).

BOEING VERIFICATION TRIALS

After HIGH POINT was undocked upon completion of the 529-day MOD-O refurbishment, preparations were made to begin Boeing verification trials called for under contract NObs-4838. The contract called for Boeing to:

(a) Conduct a test program and provide analysis required to demonstrate the operational reliability of HIGH POINT.

(b) Direct and report on additional trials, tests, and investigations to demonstrate the capability of HIGH POINT to operate reliably in rough water with:

Adequate turning and steering.
Minimized broaching of the forward foil.
Significant reduction of cavitation and ventilation.
Adequate protection against cavitation erosion damage.

It was further specified that the trials program would include 25 hours of foilborne operations.

Boeing produced a Master Test Plan supported by detailed test agenda and instructions. The Master Plan called for three test phases. Phase I was to provide for crew training in hullborne operations and safety procedures. Phase II included practice in takeoff and landing procedures and foilborne operations in calm water. Phase III called for a final series of tests in rough water. Upon completion of the test program the ship was to be drydocked for a detailed inspection and evaluation of previous fixes.

Hullborne trials were begun on 22 June 1966 but were interrupted on 12 July when salt water was once more discovered in the lube oil of the port transmission. This caused the ship to be drydocked again for a period of 45 days. Hullborne trials were resumed on 29 August and on the following day HIGH POINT went foilborne for a brief two-minute run. On 31 August, after about one hour of foilborne operation, there was a structural failure of a titanium propeller which had been produced by DTMB for evaluation. The failure was attributed to hydrogen embrittlement of the 6Al-4V titanium material. The propeller was replaced and trials continued with brief interruptions to give demonstrations to VIP visitors. One such demonstration was given for RADM Ed Fahy, Commander of NAVSHIPS, on 16 September. Figure (62) shows him being welcomed aboard by (left to right) Verne Whitehead of PSNS; Al Kennedy of Boeing; H. W. McCurdy, President of Puget Sound Bridge & Drydock (later became Lockheed Shipbuilding & Construction Company); RADM Fahy; Bill Shultz of Boeing; and LT Steve McGanka, OIC of HIGH POINT. In a communication dated 4 March 1985, Al Kennedy, who is now Chief Project Engineer in Boeing Marine Systems, recalls a somewhat traumatic event of that day.

> During the trials we did in the local area, the crew had the option to select operational modes. I remember, particularly, in those days they could elect to make either flat or coordinated (banked) turns. The relationship of the management and direction of the program was sort of a three-pronged activity, and we had not yet determined whether the hardware or the operational mode should preclude flat turns. It had become increasingly obvious that they were dangerous, particularly when the forward strut ventilated, resulting in a left turn when a right turn was called for.
>
> The management aspect came into very clear focus during the demonstration for RADM Fahy. LT McGanka, in demonstrating the vessel, was approaching Blake Island in the vicinity of the Bremerton channel and elected to make a turn in the flat-turn mode. When we realized his maneuver, we held our breath and waited to see in which direction the ship would turn. As luck would have it that day, it turned in the direction commanded. I don't think either RADM Fahy or Mr. McCurdy ever realized the hazard of that maneuver.

Figure 62. RADM Ed Fahy, COMNAVSHIPS, Visits PCH

After post-trial meetings, I recall we developed an unsigned, unreleased memo of understanding between Boeing and LT McGanka which, in effect, allowed him to recognize our authority on technical issues of this nature while preserving his authority and responsibility for the safety of the ship. The later formation of the Hydrofoil Special Trials Unit went a long way in preventing that kind of dual authority from causing problems in the test program.

Upon completion of calm water tests, which included about 23 hours of' foilborne operations, on 19 October 1966, HIGH POINT made a non-stop 3 hour and 19 minute foilborne transit from PSNS to Neah Bay, WA. Swells were encountered which averaged 6 feet with the highest recorded being 10 feet.

Rough water trials were successfully conducted off Cape Flattery from 19-2 1 October and 2 j-27 October, Reference 44. The trials on 25 October were temporarily interrupted by an unexpected occurrance. A Russian trawler appeared in the area and anchored outside the breakwater at Neah Bay. They advised the Coast Guard Station that they had suffered a propeller casualty and needed to make underwater repairs. Permission was granted, but this presented a problem for HIGH POINT due to the classified nature of its design and performance capabilities. Needless to say. the level of message traffic between the ship and Washington, DC quickly increased. HIGH POINT was ordered not to demonstrate its foilborne capability within the view of the intruder and had to remain on the hull until they were in a position where the trawler could not make visual or electronic observations of foilborne operations.

The highest sea state was encountered on 26 October at a location about 15 miles West of UMATILLA lightship. Conditions were characterized by a well-developed state 5 sea with a significant wave height of 9.0 feet. The largest wave recorded was 14.0 feet. Wind velocity was about 25 knots during the 2 hours and 12 minutes of the test. At times there was green water over the superstructure. On one occasion, salt water entered the engine room through the separators in the turbine air intakes.

High structural loads were measured on the aft foil tips during these tests. There were thirteen occasions when the loads exceeded the normal smooth water loads by a factor of three. However, underwater inspections and measurements of the foil geometry did not indicate any deformation or cracking of the foils.

Maneuvering and turning characteristics at all headings in winds up to 30 knots were entirely satisfactory. Takeoffs and landings could be made at all headings. No abnormal attitude or directional control problems were noted during the total of 11 hours and 3 1 minutes of foilborne time that were logged during these rough water tests. The foilborne disconnect couplings, which had been a source of continual problems before the refurbishment, operated satisfactorily during the trials. However, on 28 October. after takeoff for the return transit to PSNS, a vibration was detected in the couplings. This led to the decision to make the return transit on the hull. (Later examination of the couplings revealed a component failure and misalignment sufficient to require complete refurbishment.)

During these trials, foilborne comfort was reflected in the relative absence of sea sickness when on the foils. Only four cases of mild sea sickness were acknowledged while foilborne throughout the entire trials period. In contrast, during periods of hullborne operation in a seaway, up to 40% of those on board suffered from mal de mer. It is also interesting to note that, after the uneventful 3-hour foilborne transit to Neah Bay, only 3 minutes elapsed after landing before the first man became ill.

In his report to the CNO on these trials. the OIC of HIGH POINT, LT Steve McGanka, made the following statement:

> The rough water trials have demonstrated dramatically the military potential of the ocean-going hydrofoil craft. In particular, HIGH POINT has achieved sufficient foilborne capability to make the exploration of this potential feasible. <u>Accordingly. an appropriate shift in the concentration of effort and resources should now be made toward mission evaluation.</u>

An important innovation that came out of these roughwater trials was a new device to measure the wave height conditions being experienced by the ship. This was developed by Don Stark, one of Boeing's key engineers in the hydrofoil program. In an interview on 22 February 1984, he made the following comments:

> One of the problems of running trials in rough water was that we didn't know what the sea state was. In 1966, I developed an onboard wave height measuring instrument which we could use to define the sea state from a moving hydrofoil. I tied the sonic height sensor into an accelerometer located at the bow on a stable table. The output of the accelerometer was doubly integrated to get height and from this I subtracted the ship height. What remained was the wave height. I had discovered in writing out the equations and 'doing computer simulations that, if you combined the accelerometer and the height sensor output in a certain way, and if you duplicated the filters so that the height sensor filter and accelerometer filter are complementary, then all ship motion down to zero frequency is subtracted out. The sensor itself couldn't go to zero frequency because in the process we took out the low frequency portion of the signal. I was trying for a lo-second time constant, but 1 couldn't get enough capacitors to achieve this. The leakage in the capacitors was causing drift, so I settled for a 'i-second time constant. As a result, even today it doesn't do a good enough job in a quartering sea. This could be corrected with an inertial platform, but at much greater cost than this little 5 to 10 thousand dollar instrument. This is my claim to fame in the hydrofoil program.

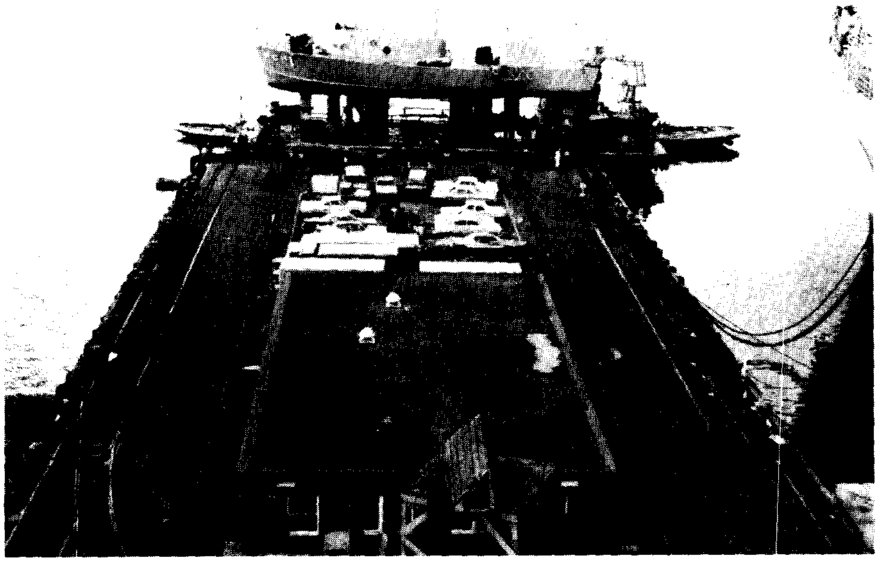


Figure 63. Building 580, Pier 3 PSNS, with PCH on Barge

THE TRIALS UNIT IS ESTABLISHED

In September 1966, a draft of a Host-Tenant Activity Agreement was prepared by DTMB and submitted to PSNS for review and comment. The Shipyard returned the draft with their comments in a letter dated 7 October 1966. The Model Basin concurred in the changes that were proposed and returned a signed copy of the revised Agreement on 2 November. Finally, on 10 November 1966, the DTMB Hydrofoil Special Trials Unit (HYSTU) was officially established as a tenant activity of the Puget Sound Naval Shipyard. The charter and operating plan for the Unit is reproduced in Appendix F.

As RADM Schultz had promised, the Host/Tenant Occupancy and Support Agreement, signed by PSNS and DTMB, made the following provision for the housing of the Trials Unit:

> The Tenant shall have exclusive use of the areas containing 1 2,700 square feet of Pier 3C and building 580 containing 4550 square feet of floor space.

This was an excellent location at the edge of the industrial area and permitted berthing of the test craft in close proximity to HYSTU offices and shop spaces as may be seen in Figure (63). (In this photograph HIGH POINT is in its cradle on a barge at the end of the pier. Actually, this photo was made some time later since the barge was first used to drydock the ship on 17 November 1967.) The Shipyard agreed to completely refurbish building 580 which was done in superior fashion. The HYSTU office spaces were, in fact, the envy of many Shipyard employees who did not enjoy the same quality of accommodations.

With respect to staffing HYSTU, LT Steve McGanka, OIC of HIGH POINT was initially given additional duty as Acting OIC of the Trials Unit. Sumi Arima was brought aboard from SUPSHIP Seattle, and shortly thereafter, Jim Gillam was hired from PSNS as Test Mechanic. LT(jg) George Moeckel. the

Figure 64. HYSTU Shop, Building 580, PSNS

Hydrofoil Program Officer back at Carderock, was given the challenging assignment of outfitting the small shop that was considered essential in meeting requirements for quick fixes and relatively routine maintenance support for the test craft. The problems of acquiring the equipment to outfit what was envisaged as a "destroyer shop" were considerably more formidable than anyone had anticipated. One of the most frustrating challenges was that of acquiring a fork-lift truck. It soon became obvious that this was one of the most sought-after pieces of equipment in the U.S. Navy and was rationed to only the most deserving activities. LT(jg) Moeckel was finally successful, but only after building a voluminous file of correspondence and spending many hours on the phone. It is considered likely that his experiences and frustrations in outfitting the HYSTU shop contributed in some measure to his later decision to leave the Navy. Some of the results of his efforts may be seen in Figure (64).

In view of his long-standing involvement with the HIGH POINT and the Hydrofoil Program, it was natural to consider recruiting Verne Whitehead as a Project Engineer in the Trials Unit. At this stage, however, it was clear that his role as PSNS Liaison Engineer was a critical one. His continuation in that role was considered crucial in maintaining good relations and accomplishing work expeditiously within the Shipyard. As a result, it was wisely decided to ask him to remain in this key position at least until the Trials Unit was firmly established and functioning effectively. (As it turned out, it was some two years later that Verne finally became a member of the HYSTU staff.)

The long awaited message from the CNO officially assigning HIGH POINT and PLAINVIEW to the newly-formed Trials Unit was sent on 2 1 December 1966, a fitting Christmas present for HYSTU and the Hydrofoil Project Office. This message, originally classified Confidential, but since made Unclassified, read as follows:

1. IN ACCORDANCE WITH REFS. A THRU F AND EFFECTIVE IMMEDIATELY, THE PCH-I IS ADMINISTRATIVELY ASSIGNED TO CO AND DIR OF DAVID TAYLOR MODEL BASIN FOR TECHNICAL DIRECTION AND COM 13 ASSIGNED OP CONTROL. COM 13 IS TO CHANGE STATUS OF CRAFT FROM "IN SERVICE" TO "IN SERVICE, SPECIAL". CRAFT WILL BECOME PART OF HYDROFOIL SPECIAL TRIALS GROUP NOW BEING FORMED. HOME PORT TO REMAIN BREMERTON, WASH.

2. BY SEPARATE CORRESPONDENCE, THE AGEH-1 WILL BE PLACED "IN SERVICE, SPECIAL" AFTER PRELIMINARY ACCEPTANCE TRIALS VICE BEING COMMISSIONED AS ORIGINALLY PLANNED. SHIP WILL BE ASSIGNED SIMILAR TO PCH-I ABOVE. HOME PORT WILL BE BREMERTON.

3. BOTH CRAFT WILL BE USED FOR HYDROFOIL R&D PROGRAM.

Thus, it was finally officially acknowledged by the CNO that the earlier decision to deploy HIGH POINT to the Fleet was premature and that more homework was required to ensure that this promising new capability would ultimately fulfill the expectations of its proponents. A review of some of the earlier operational experience with PCH, presented in Reference 45, provides further evidence of the need to consider this first Navy hydrofoil as an R&D craft.

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CHAPTER 7

Program in Transition

OVERVIEW 1967

The year 1967, following establishment of HYSTU, was a busy one and events of significance to the Hydrofoil Program continued to unfold, Reference 46. In early January. Enzo Marmentini joined the Development Program Office. He had a strong background in structures and aircraft hydraulic systems and, at one time. had been Chief Engineer for Chilean Airlines. His "chili-pepper" personality added considerable spice to the Office. (This was spread further when he transferred to HYSTU some time later).

HIGH POINT was host to two Italian flag officers on 27 January. VADM Guiseppe Roselli and RADM Luigi Tomasuolo were given a tour of the ship and a briefing on the Hydrofoil Development Program including motion pictures of rough water trials.

On 31 January, CAPT Deke Ela, the CO&D of DTMB, was relieved by CAPT Buck Vincent. A short time later LCDR Karl Duff, the SUPSHIP Project Officer on PLAINVIEW and TUCUMCARI, was given additional duty as the OIC of HYSTU. He had been steered into the Hydrofoil Program by CAPT Mac Nicholson who was in charge of the Navy Program at MIT where Karl earned his Doctorate in Marine Engineering and Naval Architecture. On 31 March, another notable event occured when the David Taylor Model Basin was merged with the Marine Engineering Laboratory in Annapolis, MD, to form the first "Center of Excellence", designated the Naval Ship R&D Center (NSRDC).

During the period 30 January to 8 February HIGH POINT conducted acoustic trials at Carr Inlet. These trials were interrupted on 8 February when a loss of hydraulic pressure was noted on the bridge and the ship was immediately returned to the hullborne mode. It was eventually determined that a drive shaft had failed on one of the hydraulic pumps driven off one of the Proteus gas turbine engines.

This was the first autopilot casualty experienced by the ship. Contrary to expectation, a complete loss of pressure resulted from loss of only one of the two installed hydraulic pumps.

To rectify deficiencies uncovered during underway radar accuracy checks made on 8 February, a general realignment of the tactical display system was accomplished. Several defective servo motor bearings were found and replaced. Subsequent dockside checks of ranges and bearings to known radar targets at PSNS established system accuracy in the single ship, dual ship, and navigation modes of operation. Results were found to be in accord with original specifications.

On 6 March. the foilborne disconnect couplings were disassembled for detailed inspection. These couplings had been a source of continual trouble. This inspection revealed significant deterioration of the starboard coupling, sufficient to make further foilborne operation inadvisable. Interim modifications were begun and, at the same time. plans were made for a permanent fix.

On 15 March. practice torpedoes were fired dockside at PSNS from the starboard tubes. This test was conducted to ensure operability of the launch system and to verify information regarding trajectories and clearances. This was the first torpedo launch from the ship.

The interim modification of the disconnect coupling was completed and installed on 24 March. Three days of foilborne operation were conducted and demonstrated satisfactory results with the coupling. On the first day of these tests, however, there was another autopilot casualty due to the failure of the quill shaft on the port autopilot hydraulic pump. Prior to these trials a closed circuit TV system was installed with cameras aligned to permit observation of the struts and foils. This proved to be of great value in evaluating foil performance and hydrodynamic flow phenomena. Cavitation and ventilation occurances were clearly visible when underway foilborne.

An experiment utilizing the ship's fathometer to collect hydrographic bottom survey date was also conducted on 29 and 30 March. Data were acquired in both the hullborne and foilborne modes of operation. Results demonstrated that foilborne hydrofoil craft are particularly effective in performing hydrographic charting.

Acoustic trials were conducted off Vashon Island on 6 April by personnel from the Naval Torpedo Station at Keyport, WA, Reference 47. The primary purpose was to investigate effects of high frequency radiated noise on a 75HZ sonic tracking device which it was proposed to install for tracking the ship on the Carr Inlet acoustic range. Results demonstrated the feasibility of using such a device.

On 8 April, Secretary of the Navy and Mrs. Paul H. Nitze and Congressman and Mrs. Floyd Hicks were given a demonstration aboard the ship. Scattered showers and winds gusting to 25 knots were encountered during the 22 minute transit to Pier 91 in Seattle. Mr. Nitze personally operated the ship while foilborne. On 20 April, the Undersecretary of the Navy, Hon. Robert Baldwin, also visited the ship and, the following day, the Assistant Secretary of the Navy, Hon. Graham Bannerman and the Chief of Naval Material, VADM Galantin, were given a foilborne demonstration. Both were given control of the helm during foilborne operations.

The first of a series of underway replenishment trials was successfully accomplished on 11 May in favorable weather. HIGH POINT, acting as the delivery ship, completed three hullborne approaches on USS TATNUCK (ATA- 195). Ship handling characteristics were evaluated at distances of 60 and 150 feet between ships. After a final approach, PCH maintained station alongside TATNUCK for 13 minutes to effect a light line transfer. Station speed was 8 knots at a distance of 60 feet. It was noted that even 4 knots of wind affected control of HIGH POINT.

A test of the newly installed autopilot hydraulic system starting bypass was successfully completed on 17 May. It was determined that there was adequate capacity in the ships service hydraulic system starting motors to obviate the need for the unloading valves that were installed. Satisfactory starts on both turbines were accomplished without the use of these valves. It was established that a simple modification would prevent complete loss of hydraulic pressure in the event of a single pump failure as experienced in past operations. This modification was made in the next RAV.

On 19 May. HIGH POINT made the transit through the Lake Washington ship canal and tied up at the Naval Air Station, Sand Point, for the celebration of Armed Forces Day. During the two-day Open House on 20 and 21 May, the ship was host to some 1500 visitors. They returned to PSNS on 22 May and, during the month of June. efforts were directed to the collection of baseline data to be used for a performance comparison following a nine week restricted availability scheduled to begin on 5 July. An interesting and significant discovery was made during tests on 16 June. The ship was unable to get foilborne even with full power. An underwater inspection by divers revealed extensive barnacle growth on the hull, struts, and foils, which had increased the drag to a point where the ship could not get over "hump". After the underwater surfaces were scraped clean by the divers, normal operation was restored.

HIGH POINT was drydocked at Pier 6 on 5 July as scheduled. Modifications accomplished during this availability included the following:

Installation of ventilation fences on the aft struts.
Installation of pressure transducers in the forward strut.
Installation of 5-bladed, wake-adapted propellers.
Repair of strut and foil coatings.
Autopilot modification to provide "elevon" control.

In March of 1967, RADM Schultz had been relieved by RADM W. F. "Pete" Petrovic as Shipyard Commander. As was originally feared, it was not long before the word got back to NSRDC that RADM Petrovic was considering ejection of HYSTU from Pier 3C. In a letter of 16 May he noted the need to use the HYSTU pier space for the outfitting of the AD-37 and proposed that consideration be given to location of HYSTU in a vacant building at the Naval Ammunition Depot (NAD) Annex near Bangor. Upon receipt of this letter, the Program Technical Manager made a hasty trip to Hremerton and, on 25 May, met with the Shipyard Commander to seek a resolution of whatever had raised the issue. It quickly became clear that the main issue was the provision in the Host/Tenant Agreement that HYSTU would have exclusive use of the assigned pier space. RADM Petrovic stated categorically that he was the Commander of the Shipyard and no one was going to dictate to him who would have exclusive use of any space. He particularly noted that this pier was used for aircraft carriers and was prime real estate. As a result, he wished to consider other possibilities for relocating HYSTU. In the weeks that followed, serious consideration was given to the NAD Annex as a potential site. This property was about to be put up for public sale. so immediate steps were taken to have the Naval Facilities Command put a hold on such action. To make a long story short, it was decided that this site would not really be suitable and, after considerable persuasion, RADM Petrovic allowed the Trials Unit to remain in the Shipyard, at least temporarily. However, he insisted upon removal of any reference to exclusive use from the Host/Tenant Agreement. (As it eventually turned out, the hold that was placed on disposal of the NAD property was most fortuitous in light of the later decision to build the TRIDENT Submarine Base at Bangor.)

A number of other significant events took place during the latter half of 1967. On 10 July, LT Steve Duich relieved LT Hugh Burkons as POIC of PLAINVIEW. LT DUICH had originally been slated to relieve LT Steve McGanka as OIC of HIGH POINT. However, with the agreement of all parties, including the Detailer, a switch was made to give LT Burkons an opportunity to take command of an operational hydrofoil before the end of his tour. He relieved LT McGanka as OIC of HIGH POINT on 17 July. It was only a short time later that PLAINVIEW made its first foilborne flight, on 4 August 1967. But, it was many many months before the ship was finally delivered to the Navy.

Upon completion of the RAV on 6 September 1967, HIGH POINT began a series of smooth water trials to establish a baseline and verify readiness for rough water and to evaluate the results of modifications that had been made. From September thru November a number of tests were conducted. These included magnetic field measurements made on 16 and 17 October, and underwater radiated noise measurements on the Dabob Bay range 27 thru 31 October and 7 November. All committments were met and the ship accumulated 47 hours of foilborne time during the period. A new record for continuous foilborne time of 7 hours and 17 minutes was also logged on 31 October.

Back at NSRDC, on 12 October 1967, Dr. Alan Powell replaced Dr. Alfred Keil as Technical Director. Shortly thereafter, The Mine Defense Laboratory, in Panama City. Florida. was merged with the Center in a marriage that was destined to be rather short-lived. In the Hydrofoil Development Program Office. LCDR Garrett M. Dyer reported aboard on 6 November as the Hydrofoil Program Officer replacing LT George Moeckel who had departed earlier. LCDR Dyer was a Naval Aviator who also had been a 4-engine commercial airplane pilot. As a civilian employee of Lockheed Ship, just prior to returning to active duty in the Navy, he was the first civilian pilot of the hydrofoil ship PLAINVIEW.

On 1' November, HIGH POINT was drydocked on the barge at Pier 3 to permit the following work to be accomplished:

Installation of a 40mm cannon on the bow.
Modifications to the galley and mess deck.
Refurbishment of foil coatings and patches.
Installation of new Zurn transmission couplings.

The installation of the Zurn coupling, along with the new 5-bladed propellers and improved strut/foil coatings was of particular significance in producing a much improved reliability and availability during the following year. By the end of 1967, HIGH POINT had accumulated only 183 foilborne hours since the first flight in Ma)- 1963.

OVERVIEW 1968

Following the two-month RAV, the ship was undocked 16 January 1968 and returned to Pier 3 for completion of dockside testing. The loss of hydraulic fluid was detected and it was necessary to again drydock the ship for replacement of the starboard inboard flap actuator. After undocking on 27 January, rough water trials, both hullborne and foilborne, were conducted from 5 February to 6 March 1968 off the entrance to the Strait of Juan de Fuca. Despite becalmed weather conditions at the beginning of the trials, rough seas finally did develop and HIGH POINT emphatically demonstrated her superior seakeeping capability.

Commencing with the February 1968 rough water trials, the ship's instrumentation had been augmented with a special "stable table" sensor package and a radar height sensor on the bow. not part of the ship's autopilot control system. The data from this system were used to determine the ship attitudes, velocities, and accelerations in all six degrees of freedom for various recorded wave profiles. The wave profile was determined by double integration of craft vertical acceleration and subtracting the height from the water surface from this reference height.

During the rough water trials period, on 23-26 February, the ship visited Esquimalt, B. C. for rest and relaxation of the crew. They were hosted by the HMCS SASKATCHEWAN (DDE-262), of the Canadian Pacific Maritime Forces. This was PCH's first visit to a foreign port.

In February 1968, Jim Mason, a former Navy Chief Petty Officer. had joined HYSTU as Instrument Technician. At about the same time, LCDR Karl Duff, was given Permanent Change Of Station (PCS) orders as OIC of HYSTU. At the same time, upon completion of PCH technical trials, attention was again turned to exploring the mission potential of hydrofoil ships, Reference 48. Mission trials included surveillance and reconnaissance, simulated gunfire, off shore patrol and search, and navigation exercises. Six instrumented MK-44 torpedoes were fired at Dabob Bay during March 1968. The torpedoes were launched at various foilborne attitudes and speeds up to 40 knots. The results were fully satisfactory. Later, during April and May, a series of 40mm gunfiring trials were conducted by trials personnel from the Naval Ordnance Laboratory, White Oak. Maryland. Tests were run in both the foilborne and hullborne condition. in calm and rough water. They were interrupted briefly when the foilhorne ship struck a log which was about 3.5 feet in diameter and 20 feet in length. They returned to PSNS on 2 May and, on 6 May, the ship was drydocked for repairs to the forward strut foundation and the starboard aft strut. The forward port propeller was also replaced. HIGH POINT then completed the rough water portion of the gunnery exercises during 13-24 May. Following these trials, from 3-6 June. further evaluations were made of the feasibility of using the ship's fathometer (Raytheon DE- 12 1 transducer) to conduct hydrographic bottom surveys.

The ship was again routinely drydocked on 7 June to undergo a scheduled 3-month RAV. During the first five months of 1968, HIGH POINT had nearly doubled the foilborne time accumulated prior to that time. Another contract was initiated with the Boeing Company to perform repair work and, on 5 July, the ship was towed on a barge to Boeing's Missile Production Center on the Duwamish River for the RAV. During inspection of the foilborne transmission gearboxes, it was found that extensive repairs were required and the RAV was extended 60 days in order to accomplish this work. The ship was returned to PSNS on 3 December 1968 for replacement of one of the Proteus gas turbines and application of new coatings and patches to the struts and foils.

Back in Washington, at NSRDC, LT Gilbert Perry reported on 20 November 1968 as the Hydrofoil Program Officer. He replaced LCDR Gary Dyer, who was temporarily detailed to HYSTU prior to reporting to an oceanographic research aircraft squadron at the Patuxent River Naval Air Station. (It is noted that, after an additional tour of duty in England, Gary Dyer left the Navy in late 1973 and joined Boeing Marine systems as one of their JETFOIL test pilots.)

OVERVIEW 1969

HIGH POINT was undocked on 2 January 1969. After conducting independent ship exercises (ISE), hullborne training, and checkout of systems, foilborne trials were resumed on 8 January. These trials showed variations in trim, forward foil submergence, and pitch, as a function of speed, were essentially the same as previously established. A slight change in flap angle positions resulted from a reduction

Figure 65. CAPT Buck Vincent, Commander NSRDC, Addresses PCH Crew

in ship weight of about 6 tons. The turning and dynamic response characteristics were found to be comparable to those obtained before the RAV.

While conducting foilborne trials on 15 January 1969, the ship struck an unidentified submerged object which caused moderate damage to the starboard forward propeller. Damage was sufficient to cause a noticeable vibration while foilborne, but did not otherwise impair operations. It was later discovered that there were cracks in the Devcon fairing at the juncture of the forward strut and foil. This required drydocking for a week to effect repairs. During this period, on 29 January, CAPT Buck Vincent, Commander of NSRDC, visited the ship. Figure (65) shows him giving a pep talk to the crew while LCDR Karl Duff, OIC of HYSTU looks on. LCDR Gary Dyer, also observes from the doorway to the mess deck.

Technical trials were resumed on 4 February and, on 24 February 1969, LT Hugh Burkons was relieved by LT James Ball as OIC. Shortly thereafter, beginning on 11 March, rough water trials again were conducted in the vicinity of Neah Bay. These trials were terminated on 16 March due to loss of the hull sonar fairing plate which significantly changed the hull drag characteristics. As a result. it was necessary to return to PSNS where the ship was drydocked. Since all earlier attempts to use the extendable sonar were unsuccessful, the decision was made to remove it and permanently close the hull opening with a new welded hull plate.

Figure 66. PCH and AGEH in Close Maneuvers

On 1 March 1969, with considerable reluctance, the Navy took delivery of the 320-ton hydrofoil ship PLAINVIEW (AGEH-I). at that time the world's largest. More details on PLAINVIEW are given in Appendix G. As originally specified by the CNO, the ship was assigned to HYSTU in the category "In-Service Special". This action, of course, placed a considerably greater workload on the Trials Unit and the decision was made to bring Verne Whitehead aboard as a permanent member of the HYSTU staff. He reported on 23 March.

With repairs completed, PCH was undocked on 16 April and two days later operated with the PLAINVIEW'. The two ships conducted close maneuvers at speeds in excess of 40 knots to provide photographic coverage, Figure (66). This generated particular concern on the part of the Program Technical Manager who was an observer during these exercises. When considering all of the potential failure mechanisms, he had visions of two twisted piles of aluminum at the bottom of Puget Sound along with the Navy's future hopes for the Hydrofoil Development Program. On the other hand, he recognized that it was particularly important to avoid creating an overly cautious attitude on the part of the OICs. After all, they were expected to probe the performance boundaries of the ships, and this could not be done without accepting some degree of risk. As a result, he maintained a white-knuckle silence during the exercises and breathed a deep sigh of relief upon their successful completion.

HIGH POINT returned to Neah Bay on 22 April to complete rough water trials and an evaluation of the Raytheon 723-D fathometer. Unfortunately, it was again necessary to terminate the trials prematurely when, on 30 April, a casualty occured in the forward foil flap. The ship returned to PSNS with two members of the British Royal Navy who were aboard as observers during a portion of the trials. This almost caused an international incident and early termination of the Navy career of OIC HIGH POINT. In view of PSNS being a nuclear submarine yard, there was a high degree of sensitivity regarding the entry of any foreign nationals. Bringing two officers from the United Kingdom into the shipyard unannounced and without proper clearance created quite a stir among the Security Force and the Shipyard Administration. Fortunately for the OIC of HIGH POINT and the OIC of HYSTU, the matter was successfully adjudicated without any serious consequences.

The ship was drydocked on 2 May 1969 to remove the forward foil and repair the forward flap actuation system. It was discovered that the flap bell crank had failed due to corrosion and excessive stress. Repairs were made and the ship was undocked on 13 June to continue trials in Puget Sound in the vicinity of Vashon Island. On 25 June, PCH attempted a vertical replenishment with a helicopter from the Marine Corps helo squadron at the Naval Air Station, Whidbey Island. The mission was aborted due to the loss of radio communications with the helicopter, but it did provide valuable information for future exercises. The following day. tests were conducted to establish the capability of the ship to take off and operate foilborne with only one of its two main propulsion turbines. It was established that the ship had adequate power to operate foilborne on a single turbine. Following these trials, the ship was drydocked on 2 July for a 3-month scheduled RAV.

After undocking on 10 October 1969, HIGH POINT continued to conduct various hullborne and foilborne trials. On 29 October the ship was host to the largest collection of "stars" adding to their long list of VIP visitors. They were scheduled to proceed to Pier 91 on that afternoon to take aboard The CNO. ADM T. H. Moorer and his party, including their ladies, for transport to attend a dinner in Tacoma. WA. Other flag officers in the party included ADM Jim Russell, USN (Ret), formerly VCNO and at that time a consultant to Boeing, RADM E. P. Yates, COMFAIR Whidbey, and RADM P. J. Hannifin, COM- 13ND. Underway from PSNS to Pier 91 HIGH POINT suffered a casualty which threatened to cause an abort of the mission. After a hasty consultation between LCDR Duff, OIC HYSTU, and LT Ball, OIC PCH. it was decided to attempt a repair. By dint of immediate reaction of the crew and their usual "can do" attitude, repairs were made and the ship arrived at Pier 91 right on time to pick up the Admiral and his party. They got underway for the Reserve Pier in Tacoma and as soon as the ship was foilborne. ADM Moorer took the wheel and proceeded to demonstrate his hydrofoil flying proficiency, This was not withstanding the skeptism regarding his skill voiced by Mrs. Moorer. HIGH POINT arrived in Tacoma after an uneventful foilborne trip and disembarked the VIP passengers, all of whom were greatly impressed by the ride. Just as the ship got underway for the return trip to PSNS. the electrical system went down. This made necessary a painfully slow return trip on the hull. Back in Washington. the Program Technical Manager kept a long vigil awaiting a report from LCDR Duff regarding the success of the mission. As the hours passed, he had visions of all sorts of dire occurrences, any of which could have doomed the Program. In the wee hours of the next morning (keeping in mind the three-hour time difference) the long-awaited call was finally received. LCDR Duff reported that they had found the "only window in the world" and all was well. In so far as is known, the CNO and his party never were made aware of the narrow margin between success and failure of their water taxi ride to Tacoma.

During the remainder of 1969, HIGH POINT continued to conduct various smooth water trials in the Puget Sound area. They accumulated 122 foilborne hours during the year, bringing the total to 469 hours, a significant improvement over the earlier experience. Back in Washington, the Hydrofoil

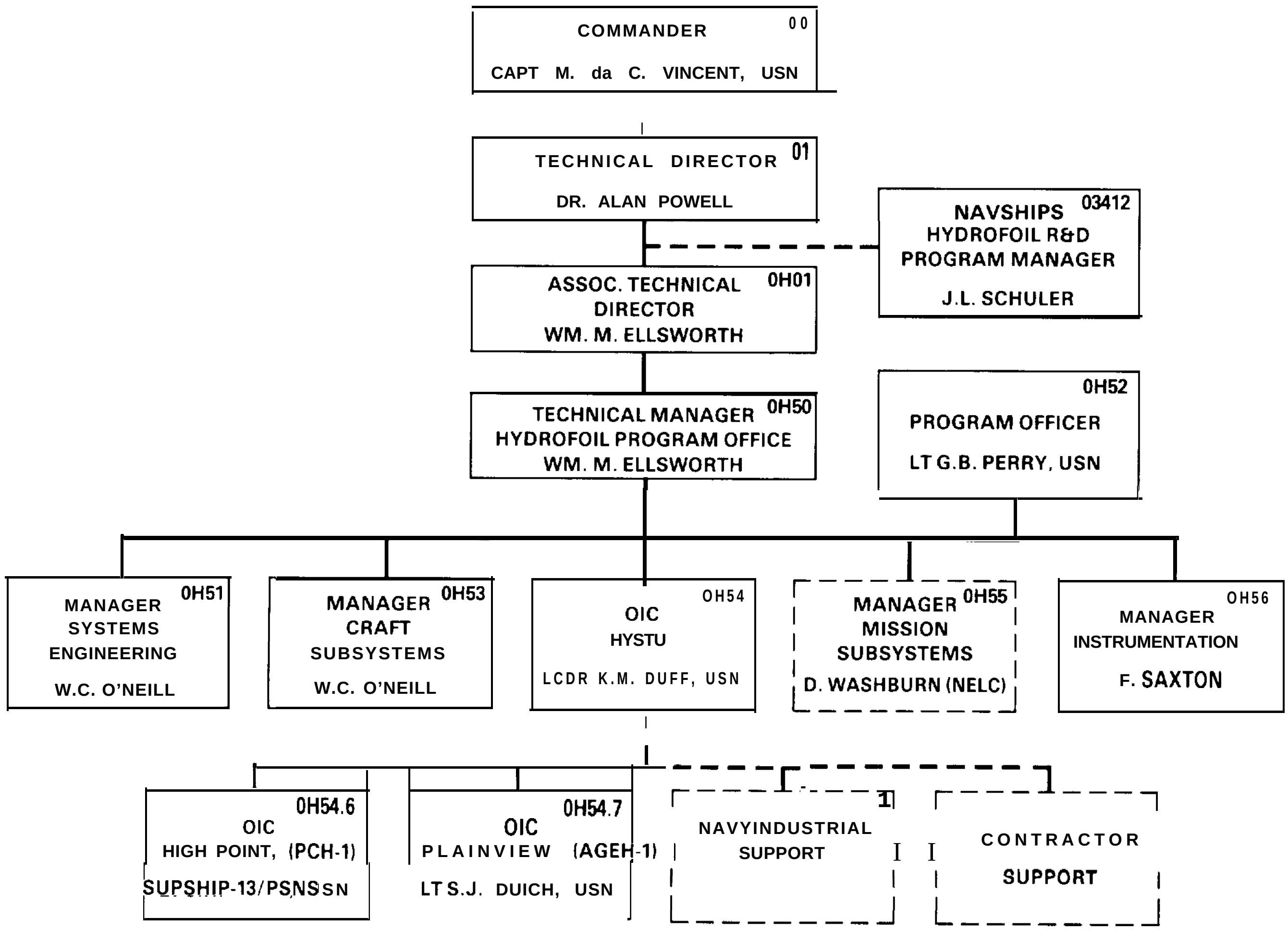


Figure 67. Hydrofoil Program R&D Organization, November 1969

Development Program Office continued to become more firmly established. The organization at this time was as shown in Figure (67).

OVERVIEW 1970

HIGH POINT remained dockside from 1 January to 15 February 1970, mainly for installation of special deck machinery and equipment for the forthcoming trials of an automatically-controlled variable-depth towed body to be evaluated by trials personnel from the Naval Electronics Laboratory in San Diego, CA. Almost all of 1970 was tic-voted to the conduct of these trials which are discussed in detail in 3 later section.

On 21 January PLAINVIEW began Final Contract Trials (FCT) and the ship was formally accepted by the Navy on 2 March 1970.

On 19 August 1970, HIGH POINT successfully completed the towed body trials and, on 22 August, they conducted a dependents cruise. This was an occasion which all hands looked forward to after a period of concentrated trials activity. The ship was then drydocked for removal of the towed system and installation of new instrumentation. Part of the new instrument package was a forward-looking collision avoidance sonar mounted on the forward foil. Tip extensions were also welded on the forward foil in an attempt to improve inflow conditions to the aft propellers. It had been determined that part of the problem of cavitation damage to these propellers was due to the fact that the tip vortex from the forward foil. intersected the disks of the forward propellers. The ship was undocked during December and proceeded to evaluate the effects of the tip extensions and the performance of the collision avoidance sonar.

On 17 December these tests were temporarily suspended in order to make a preliminary assessment of the feasibility of towing a kite-like parafoil to increase the height of an antenna used to interrogate ASW sonobuoys and to increase communication range. Further tests were planned to be conducted during the forthcoming deployment of the ship to Southern California.

The parafoil winch had been installed earlier on the centerline of the fantail just aft of the main strut trunks. The winch was powered by a 12-volt battery and contained 1000 feet of polypropylene line with a tensile strength of about 4000 pounds. The parafoil was a standard “kite” model, manufactured by Dutron Corporation of South Bend, Indiana, with a lifting area of about 200 square feet. It was equipped with a gravity stabilizing device comprising 15 pounds of shot bags to maintain equilibrium when subjected to in-flight pertubations such as gusts. Empty plastic bottles were attached to the shot bags to provide buoyancy in the event it bacame necessary to jettison the parafoil.

The trials were conducted in Puget Sound in clear weather with light and variable winds. The Boeing Project Manager was Edwin N. York. After the parafoil was deployed, launch was accomplished without incident with HIGH POINT maintaining a constant heading in the turbine-taxi mode at a constant speed of 16 knots. The tow length was increased to about 300 feet before it became necessary to effect recovery in order to resume the earlier trials program. Recovery of the parafoil was uneventful.

The parafoil trials were considered highly sucessful and stability was maintained during all phases of the flight. It was felt that there would be no problems in conducting further demonstrations.

Upon completion of the brief parafoil tests, the program to evaluate the effects of the foil tip extensions was continued. After these tests were completed, the tip extensions were removed by yard divers in a short dockside RAV and final preparations were begun for the first unaccompanied extended deployment to Southern California (SOCAL), scheduled for early 197 1. At the end of 1970 HIGH POINT had accumulated a total of about 537 hours of foilborne time.

Some of the highlights of the period 1967 through 197 1 are discussed in more detail in the sections which follow. During this period HYSTU became fully established and the future direction of the Hydrofoil R&D Program became more clearly identified.

TRIALS PLANNING

In the early days of HYSTU’s establishment, the need for definite guidelines and plans for the special trials program was recognized. A system was setup wherein the activities of the ships were divided into three categories. The first category comprised technical trials to establish the performance characteristics of the ships and their subsystems and generate criteria for the design of future hydrofoils.

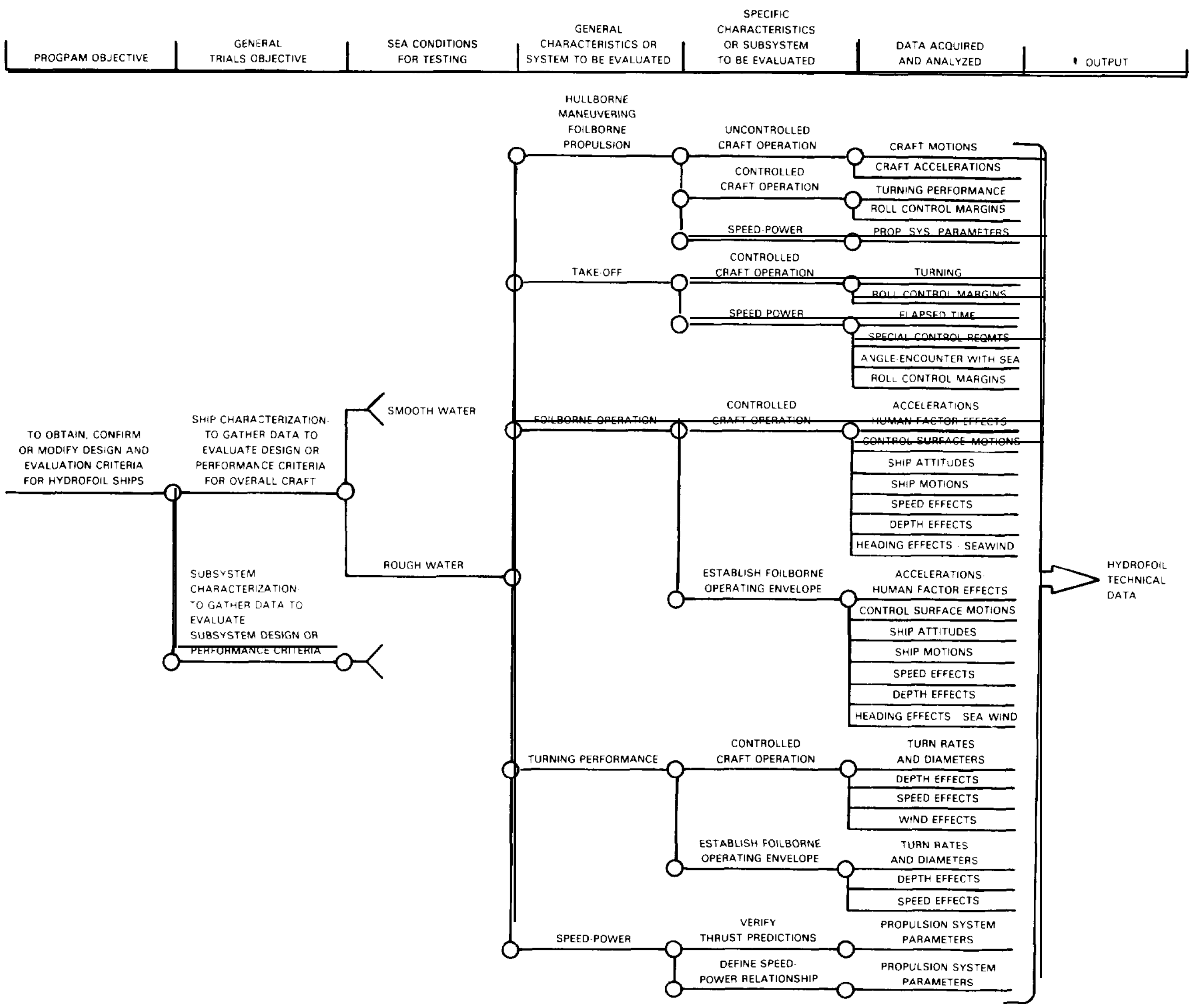


Figure **68.** Rough Water Characteristics Tree for Hydrofoil Data

Bill O'Neill, who was in charge of craft subsystem development, was designated as the responsible coordinator for the planning and conduct of all such trials. Figure (68) shows the rough water characteristics "tree" that was developed to identify all of the technical data required from ship technical trials. The second category of trials was that covering mission applications. The responsibility for planning and coordinating mission trials was assigned to Dave Washburn, at the Naval Electronics Laboratory in San Diego, CA. Finally. a third category of trials plans covered the accomplishment and verification of "fixes" to the craft during the course of the development program. Responsibility for this category was assigned to the OIC of the Trials Unit in coordination with the OIC of the ship involved.

RADIATED NOISE

Measurements of the foilborne radiated noise of HIGH POINT were made in Puget Sound in the East passage off Vashon Island on 6 April **1967.** The tests were under the direction of E. E. Grade of the

Naval Torpedo Station at Keyport, WA. Reference 47. The information was needed to determine the feasibility of tracking the ship on the Dabob Bay 3-D range. For tracking purposes it was proposed to use a 7 5KHz transponder and if the radiated noise levels at that frequency were too high they would mask the transducer output.

Two separate measuring systems were used to record the data. One covered the range from I to 20 KHz and the other the range of 20 to 100 KHz. The sound measuring equipment was placed aboard one of the Torpedo Station's sound **boats.** Hydrophone depth for all runs was 20 feet. HIGH POINT made 4 identical runs past the sound boat. The speed was 36 knots with a 4.75-foot submergence of the forward foil. Upon later analysis of the results, it was determined that the ship's radiated noise levels in the 75 KHz region were at least 20 dB below the effective **output** of the transponder. Since a 6 Db signal-to-noise ratio was sufficient to track on the 3-D range, this method could be used. providing the location of the transponder on the foil was in a cavitation-free environment.

EXTENDABLE SONAR

As was noted earlier, HIGH POINT was originally supposed to be outfitted with a hullborne SQS-20 sonar produced by the EDO Corporation. What was actually installed was an SQS-33-XN1 which had the SQS-20 electronics but a different transducer assembly. This was the only such unit that was built. although it was originally planned to make a similar installation in AGEH. The transducer was housed in a centerwell and was mounted on a strut which could be lowered below the keel. The installation was shown earlier in Figures (30) and (32).

The strut extended 16 feet. placing the 8-foot-diameter transducer assembly 8 feet below the hull. To keep steerage way, the hullborne drive had to be engaged and this resulted in a minimum speed of 6 knots. However, the strut was designed for a maximum speed of 4 knots and the resultant sideload on the assembly was unacceptably high.

Operation was intended to be in the "grasshopper" mode, listening at low headway speed hullborne, retracting the system. and then going foilborne to close the target. There was also a winch with 180 feet of cable and a variable-depth acoustic projector located off the centerline on the stern. This was supposed to permit operation below the surface sound layer. However. there were problems due to interference with the hullborne outdrive. Also, because of the off centerline location. the cable passed through the hot exhaust from one of the gas turbines.

It is noted that a tragic quirk of fate occurred in early 1963, before delivery of the ship. Dick Fuery, an engineer from EDO Corporation, had attempted to calibrate the sonar system. He spent several weeks on the job before returning to EDO. Sumi Arima. at that time Project Engineer with SUPSHIP Seattle, was dissatisfied with the results and called EDO to have Fuery return, emphasizing that he was the most knowledgeable individual on the system. As a result, Furey was reassigned to report back to HIGH POINT and another engineer was sent in his place on the other assignment. That assignment was to the U.S. Navy submarine THRESHER and his replacement went down with the submarine when it was lost at sea on 10 April 1963.

Because of the various problems with the sonar system on HIGH POINT, it was never considered acceptable and during the drydocking in March 1969, it was removed and the centerwell opening in the hull was permanently covered with a new hull plate. The centerwell space, which had housed the strut and sonar, and the OIC's cabin were converted and put to good use as an instrumentation compartment. This permitted removal of the trials instrumentation from its cramped location under the ladder in the galley and in the mess deck space. The sonar equipment room was converted into a cabin for the OIC.

TORPEDO FIRING

HIGH POINT had been delivered with two MK 32 torpedo launchers amidships on both the port and starboard sides. The tubes were trained 45 degrees off the bow with a zero depression angle. The depression angle could be increased to 5 degrees by introducing 7 degrees of roll with the ship's autopilot during a firing run.

Launches of dummy exercise torpedoes from the starboard tubes were first made dockside at PSNS on 15 March 1967. These tests were made to check out the launchers and familiarize the crew with the operation of the system. On 14 April, additional launches of practice torpedoes were made while foilborne in the vicinity of Vashon Island in order to evaluate the effects, if any, on the craft response and stability. Two practice units were launched from the starboard side and one from the port side at speeds of about 36 knots. There were no adverse effects on the operation of the ship.

It was almost a year later that trials were finally conducted to evaluate the effect of foilborne launch on MK 44 MOD 1 active acoustic homing torpedoes with inert warheads, Reference 49. On 20 March 1968, HIGH POINT took aboard six MK 44 torpedoes at the Naval Torpedo Station, Keyport. Four were loaded into the tubes and two more were lashed to the deck on a pallet. Movie cameras had been mounted amidships and forward on the main deck and were trained to obtain parallel and perpendicular views of the torpedo air trajectory. A 3-D tracking transducer was mounted on the ship centerline near the leading edge of the forward foil. Each torpedo was also equipped with 3-D tracking equipment and a 1 -i-channel oscillograph to record data on their operating characteristics.

A target boat was equipped with a cable-mounted echo-repeater target simulator which was suspended at a depth of 200 feet. A 3-D tracking transducer was mounted 5 feet above the target on the same cable. A target monitor and a two-channel recorder were provided on deck to record target echo transmissions and 3-D correlaf-ions. A torpedo retriever served as a guard and recover)' boat.

HIGH POINT arrived on the 3-D range at Dabob Bay at 0900 and conducted several dry runs to coordinate test procedures and ensure satisfactory operation of all systems.

In the first run, Figure (69), the torpedo was launched with the ship at 40 knots and zero roll. The target was at a range of about 1200 yards. Initial search depth was set at 150 feet. The torpedo went to depth immediately, and acquired the target at about 800 yards, homing on it and aborting after passing it. The second run was made with the ship at 45 knots and zero roll. Again the water entry was satisfactory. but the torpedo ran for about six seconds at the surface before going to search depth. It did not broach. however. In this instance. the torpedo homed on the target and aborted after passing it. but it then homed on the HIGH POINT's wake. The third run was accomplished successfully under similar conditions. In the fourth run. the ship's speed at launch was 40 knots with a 7-degree roll to port. Water entry was again satisfactory and the torpedo sucessfully acquired and homed on the target. The fifth run was at a ship speed of 40 Knots and zero roll. The target was at 360 yards and. after successful water entry, the torpedo immediately acquired and homed on it. After passing the target and aborting the torpedo again homed on the ship noise. The final run was at a ship speed of 40 Knots and a ?-degree starboard roll. The target was again at 360 yards and was immediately acquired and closed.

Figure 69. Mk 44 Torpedo Launching from PCH

In summary, the torpedo firings were completely successful. Speed and roll attitude of the ship appeared to have no significant effects on torpedo performance. All water entries were satisfactory, the torpedoes went to depth without broaching and executed normal target attacks. All were recovered in good condition.

40 MM GUN FIRING

During the November 1967 drydocking, a MK 3 (MOD 4) 40 MM cannon was installed in a gun tub on the bow of HIGH POINT, replacing the original 50 Cal machine gun. The purpose of this change was to evaluate the use of a hydrofoil as a high speed gun platform and to obtain baseline data for later comparison to a gun stabilization system which had been developed by the Naval Ordnance Laboratory at White Oak, MD. Figure (70) shows the gun on the bow with test equipment mounted on the barrel.

The gun installation introduced a flexible mode that coupled into the pitch rate gyro causing an oscillation in the autopilot control system. This required relocation of the rate gyro to a nodal point.

Preliminary 40 MM gun firings were conducted off Cape Flattery during rough water trials in February 1968, References 50 & 51. These early tests revealed a problem in the effect of the gunfire on the sonic height sensor. Return echoes caused spurious height signals. This, in turn, caused the ship to continually increase its flying height until the forward foil broached the water surface.

Figure 70. PCH 40MM Gun with Test Equipment on Barrel

On 3 April, a second series of firing trials were conducted in Navy OP AREA 6713 in the Strait of Juan de Fuca, Reference 52. The objectives were to:

(a) Further evaluate the effects of gunfire on height sensor operation and isolate the cause to either structureborne noise or direct acoustic transmission.

(b) Investigate human factors effects on the gun crew during foilborne operation.

(c) Determine the extent of any hazard to the gun crew created by the ejection of shell casings.

General quarters was set upon entry into the operating area. The gun was manned by ship's force with Petty Officer B. J. Jensen, BM1, as gun captain. The gun crew was dressed in foul weather gear with visored helmets and life jackets. They were either tied into their seats, tethered to the gun mount, or tethered to the handrail on the superstructure. Communication with the bridge was by an improved intercom circuit provided by Boeing. Gene Parsons of Boeing was the designated trials director.

In addition to the normal sonic height sensors port and starboard on the ship. a spare Model 300 height sensor from TUCUMCARI (PGH-2) was suspended over the port side near the foil guard. It was thus effectively isolated from any structureborne signals. Acoustic isolation was effected by wrapping one of the ship's height sensor transducers with a sound absorbent material.

The first segment of the trial was conducted foilborne at a speed of 36 knots in sea state 1. Fort) five rounds were fired. Visacorder traces showed that near range returns were received by both port and starboard height sensors. The second segment of the trial was conducted with the ship underway hullborne at a speed of 8 knots using the gas turbines for propulsion.

Results of the trial demonstrated that acoustic effects were the predominant source of the spurious signals to the height sensors. In all foilborne conditions, both port and starboard sensors received near range returns which caused a significant increase in f-lying height. A burst of four rounds fired in manual mode at a rate of 7 5 rounds per minute caused a two-foot height increase. Bursts of eight rounds fired in automatic at a rate of 150 rounds per minute caused more than a five-foot increase in flying height and led to broaching of the forward foil. Broaches were induced gradually and the ship remained fully in control at all times.

The maximum wind velocity across the deck was 45 knots and this did not adversely affect the performance of the gun crew. However, it was concluded that operation in rainy weather would cause problems unless a windshield was installed. It was also concluded that the **ejection** of shell casings offered no serious hazard to the gun crew. It was recommended, however, that a box or tray be installed to catch the casings and prevent them from being scattered about.

During the trials on 3 April, RADM Petrovic, COM PSNS, was aboard to observe. He was accompanied by his aide LT Graham, Bosco Welch, from NELC, and Mel Freitag. a consultant to NELC from Jakus Associates, were also aboard. On the return transit to PSNS, the Admiral took the helm and flew the ship in a series of maneuvers including turns. emergency landings. and normal landings and takeoffs. Figure (7 1) shows him receiving his “Hydrofoil Mariner” card from LT Hugh Burkons, OIC HIGH POINT.

Following this second series of trials. in order to eliminate the effect of gunfire on the height sensors, Boeing devised a temporary fix. This consisted of installation of a switch in the firing circuit which blanked the height sensor output at the time of generating a spurious input signal from the gun. This was evaluated on 18 and 19 April and proved to be effective although not considered a permanent solution.

The preliminary height sensor modification trials were conducted on the firing range off Smith Island in the Strait of Juan de Fuca. For the remainder of the gun firing trials. the ship operated out of the Ediz Hook Coast Guard station near Port Angeles and transited each day to the firing range in the Pacific Ocean off Cape Flatter),. There they made rendezvous with a target towing tug which was based at the Coast Guard Station at Neah Bay, near the entrance to the Strait.

The trials were continued on 29 April with a team of eight engineers from the Naval Ordnance Laboratory, White Oak, MD. The team was under the direction of Peter S. Hughes of NOL's Environment Simulation Division. The primary objective of this phase was to evaluate the gun stabilization system developed by NOL and installed on HIGH POINT's MK 3 (MOD 4) 40 MM gun.

Figure 71. LT Burkons Presents Hydrofoil Mariner Card to RADM Petrovic

The following day, 30 April, the ship got underway at 0820 and headed out of the Strait to meet the target tug. A number of practice runs were made and, at 1630, they headed back to Port Angeles. At about 1750, while foilborne at about 36 knots, they struck a log estimated to be about 3.5 feet in diameter and about 20 feet long. The damage to the ship could not be fully assessed and foilborne operations were suspended. This made it necessary to cancel the foilborne demonstration for RADM John E. Dacey, OP-038, which had been scheduled for 1 May. He was, however, given a briefing and a tour of the ship, Figure (72).

On 2 May, the ship returned to PSNS hullborne and from 6 thru 10 May was in drydock for repairs. There was damage to the forward strut foundation and several of the propellers. On 13 May, the ship returned to Port Angeles with the NOL team to continue the 40 MM firing trials. On that day. they logged a total of 5 hours and 11 minutes of foilborne time.

The trial on 23 May was for the purpose of making shock measurements. An orthogonal triaxial array of high frequency piezoelectric accelerometers had been installed at four locations to measure shock transients generated by firing the gun. One was mounted at the aft end of the breech and another at the forward end. The third was attached to the starboard side of the top carriage. The fourth was on the I-beam where the gun mount was welded to the deck.

Figure 72. RADM Dacey, OP-038, Visits PCH at Port Angeles

During the shock test, the highest recorded peak-to-peak acceleration occurred at the breech block and was about 400g. 'The peak velocity occurred at the barrel guide and was 1.28 ft/sec. The longest shock duration was about 193 milliseconds at the deck beam location. Detailed results of these tests are reported in Reference 53.

The 40 MM trials were successfully concluded on 24 May 1968. On that last day, the ship operated a total of almost 8 hours foilborne. The twelve operating days from 13-24 May were accomplished with no major casualties. During that period, HIGH POINT was foilborne a total of 58 hours and 30 minutes. This exceeded the foilborne time accumulated in the entire first two years of the ship's operation.

SINGLE-ENGINE OPERATION

During the underway trials of HIGH POINT prior to 1969, several instances occurred in which one or the other of the two main propulsion turbines lost partial power or shut down completely during foilborne operation. When this occurred, it was standard procedure to decrease power immediately on the other turbine and go hullborne. This procedure was followed because little was known about the characteristics and potential for operation with a single engine. As a result, a HYSTU Plan was generated to evaluate the potential for operation on a single gas turbine. Engineering calculations and a review of HIGH POINT'S design features indicated that when operating on one engine:

(1) Rudder control could compensate for the unbalanced thrust.

(2) Loads on the transmission remaining in operation would not rise to levels thar would endanger gears or bearings or cause a significant reduction in their expected life.

(3) The effect on the idled gears and bearings of the propellers "watermilling" would not be significant.

(4) Rotation of the idled turbine could be prevented by decoupling it from the transmission.

With this assurance, on 26 June **1969,** the test plan was initiated. After going foilborne, port turbine power was gradually increased until full throttle was reached and propeller speed stabilized at **1450** RPM. At the same time, the starboard turbine was reduced to idle, causing the starboard propeller speed to stabilize at 850 RPM. Craft speed in straight ahead operation stabilized at 34.5 knots. Turns were then made, both left and right, at rates up to 3 degrees-per-second.

The test was repeated with the starboard turbine at full power and the port turbine at idle. In this case the stabilized propeller speeds were 1400 RPM and 800 RPM respectively. Turns at 3 degrees-per-second were also repeated. Propeller torque during this event was 7570 foot-pounds forward and 7 160 foot-pounds aft on the starboard propellers. Torque-measuring instrumentation was not provided on the port side.

To find the minimum power required to remain foilborne, the power of the single operating turbine was slowly reduced until craft speed began a continuous decay. A propeller speed of 1350 RPM was the minimum which could be maintained without continuous loss of ship speed.

The third event on the trials agenda was to determine if the craft could take off on the power supplied by a single turbine. Takeoff was attempted first using the port turbine with the starboard turbine decoupled to prevent its rotation by watermilling of the propellers. The pitch trim control was set at a reference value of 486 (nominal 1 degree bow up at **36** knots) and the foil depth control was set to give a five-foot forward foil submergence. Initially the craft accelerated to 18 knots with full power on the single turbine and there the speed stabilized. To reduce flap drag, pitch trim was increased to a reference value of 505 and the craft accelerated up to 22.5 knots. Further adjustment to a value of 51 5 caused the speed to increase to 24 knots which is the threshold for takeoff. However, the craft remained hullborne. The stern appeared to be dragging so the pitch trim was reduced to a reference value of 495 and the craft became foilborne. This takeoff sequence took place over a period of 12 minutes and 10 seconds, much of which was spent in determining the conditions which would be most favorable for takeoff. A second attempt was made by varying the commanded forward foil submergence, but this was unsuccessful in achieving takeoff.

A similar sequence was tried with the starboard turbine whose shaft was the one instrumented for torque measurement. At the normal pitch trim reference value of 486, the craft stabilized at a speed of 17.5 knots. Pitch trim was increased to a reference value of 505 and the craft accelerated smoothly through takeoff. Elapsed time for this takeoff sequence was 3 minutes and 39 seconds including the time allowed for the speed to stabilize at intermediate points.

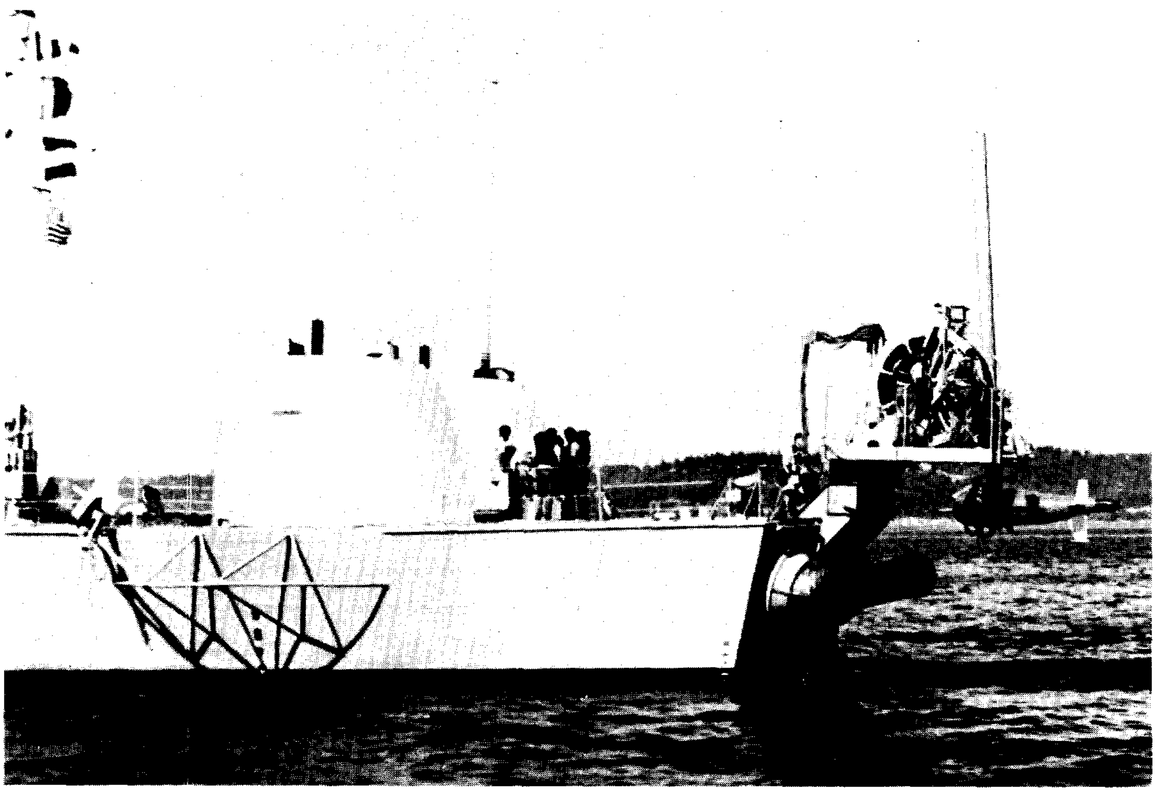


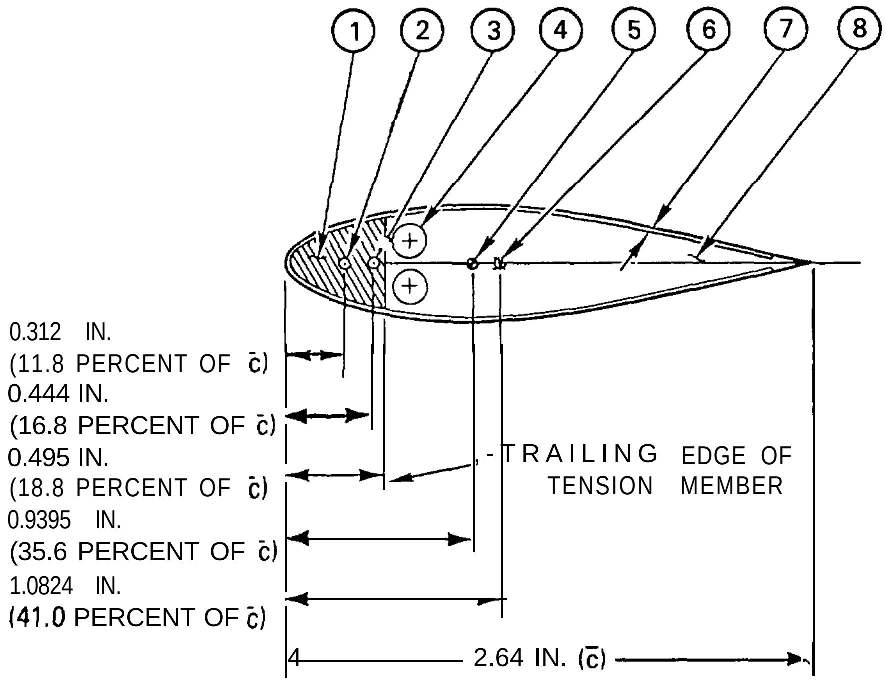
Figure 73. Towed Body and Winch Handling System on PCH

Finally, the takeoff sequence was repeated with the starboard turbine and the pitch trim set at a reference value of 505. With no further adjustments, the craft accelerated smoothly and took off in an elapsed time of 4 minutes and 19 seconds.

This completed the trial agenda with results clearly demonstrating the feasibility of single engine operation in calm water, Reference 54. Craft weight at the beginning of the trial was 109.4 tons decreasing to 106.5 tons upon completion of the trial.

TOWED BODY TRIALS

From 2 July until 10 October 1969, HIGH POINT was drydocked at PSNS primarily for the installation of a high speed towing system. This consisted of an automatically-controlled depressor body developed and constructed by Hydrospace Research Corporation; 600 feet of faired towline, designed by Boeing and constructed by Air Logistics; and a Boeing-designed winch handling system, constructed by Western Gear in Everett, WA. Figure (73) shows the winch handling system and depressor body on the fantail of the ship. The winch drum was rotatable in azimuth to angles of plus or minus 60 degrees to permit continuous tracking of the faired towline. The long retractable arm permitted secure launch and recovery of the body at the water surface. The angled extensions to the turbine exhausts were added later to deflect the hot exhaust gases and prevent overheating of the towline. The characteristics of the towline are given in Figure (74). As noted, the strength member in the nose section was made of continuous strands of glass fibers bonded in an epoxy resin.



SECTION PROFILE: NACA 63A022

TENSION MEMBER AREA: 0.15 IN.^{2}

WEIGHT/FT (AIR): 0.707 LB/FT

WEIGHT/FT (WATER): 0.269 LB/FT

WORKING TENSILE LOAD: 18,750 LB
(STRENGTH MEMBER)

WORKING TENSILE LOAD: 15,575 LB
(END FITTING)

} FACTOR OF SAFETY = 2.0

ULTIMATE TENSILE STRENGTH = 37,500 LB

NOTES:
1. FIBERGLASS TENSION MEMBER
2. CENTER OF TENSION
3. SHEAR CENTER
4. COAXIAL CABLES
5. CENTER OF GRAVITY
6. CENTER OF BUOYANCY
7. 0.02-IN. FABRIC COVERING (RUBBER IMPREGNATED)
8. AFT RUBBER FAIRING

COMPONENT	A (AREA), IN.^{2}	E (MODULUS OF ELASTICITY), LB/IN.^{2}
TENSION MEMBER	0.15	9.4×10^6
FAIRING RUBBER CORE	0.712	0.00295×10^6
FABRIC COVERING	0.105	0.00286×10^6
COAXIAL CABLES	0.025	0.511×10^6

Figure 74. Faired Towline Characteristics

The towing trials program was under the overall direction of Dale E. Calkins of the Naval Undersea Center, in San Diego, CA. This later became the Naval Undersea Systems Center. (Dr. Dale Calkins is presently a Professor at: the University of Washington in Seattle.) Other participants from NUC included C Charles N. (Chuck) Miller, Carral (Carl) Nieswanger, Edward B. Tunstall, and Edward Stiles. Bruce Bryant was the lead engineer from Boeing in supporting the trials program.

The trials objectives were to determine craft performance while towing a controlled underwater body at various speeds and depths; to demonstrate towing of a system similar to an underwater sonar at high speeds and in turns; and to verify computer simulations of system dynamic characteristics. NUC was supported in the test program by the Boeing Marine Systems and General Dynamics' Convair Aerospace Division. During the hullborne portion of the trials, HIGH POINT was under the command of LT Jim Ball. The following summary of the trials program was extracted from Reference 55.

During early 1970, events were directed toward the development of launch and recovery procedures and evaluation of the system during hullborne towing. The first hullborne underway trial occurred on 16 February with a 90-foot "practice" towline and the depressor body with the roll control inactive. Also, the practice towline had no electrical continuity and measurements of body characteristics were not made. The launch and retrieval exercises resulted in the formulation of a standard procedure that was used for the rest of the trials. The method provided a minimum of turbulence interference as the ship glided with power off during both launch and retrieval of the towed body.

Towing anomalies appeared during the first underway test. There was a significant side trail of the towline at short scope. After a series of investigations, it was concluded that the side trail was caused by the depressor rather than the towline.

The next underway trials involved both open loop and closed loop (roll control activated) depressor configurations, various elevator settings, 600 feet of tow line, and various hullborne speeds.

After extensive review of the data using the Boeing computer simulation, it was finally concluded that the depressor body was directionally unstable and had unacceptable "slop" in the rudder which caused oscillations in yaw. This led ***to*** a tightening of the rudder control and the addition of a vertical stabilizer to the depressor tail,

The next series of hullborne trials included these "fixes" and demonstrated greatly-improved directional stability of the depressor. However, the response to roll commands was reduced. During these trials a lateral vibration in the unwetted portion of the towline occurred at speeds between 14 and 16 knots. This was a resonant frequency condition which may have been excited by the turbulence in the ship's wake. The vibrations were violent enough to cause failures of the winch instrumentation. The condition was avoided subsequently by accelerating rapidly through the critical speed regime. During these trials, there was also a recurrance of the problem of side trail which increased with scope of towline and also with towing speed. Even so, hullborne speeds of 22 knots with 100 feet of towline were attained. Above 18 knots the above-surface vibration disappeared at the onset of another anomaly called towline ventilation. Here, the towline assumed an angle of attack of 10 to 15 degrees, either to port or starboard in a random pattern, and developed a large ventilation cavity at the water surface.

As a result of these ***tests,*** it was concluded that the towline was the problem. This led to another "fix" wherein brass tabs were taped to the trailing edge of the towline at lo-foot intervals. These tabs were 3/4-inch wide, 2 inches long, and bent to an angle of 30 degrees to counteract side trail to starboard. The tabs were later found to reduce depressor roll and winch azimuth by half for 50 and 100-foot depths and speeds up to 15 knots, but, they were not considered an acceptable solution.

Hullborne towing was completed on 20 June 1970 and on 24 June, LT Jim Ball was relieved by LT Joel Roberts as OIC of HIGH POINT. On 18 July, trials resumed with the first foilborne towing conducted at Carr Inlet.

The first takeoff with 100 feet of towline out was accomplished by gradually decreasing foil depth and increasing speed until a speed of 36 knots was attained. At this point the forward foil submergence was 7 feet. As in earlier tests, the towline was vented at the water surface and assumed either a port or starboard angle of attack. This condition prevailed for the remainder of the trials. After the initial straight line tow, another foilborne run was made with 150 feet of towline deployed. During this run, at 36 knots, the forward foil was at 5-foot submergence.

The remaining trials, which included the major portion of the foilborne data matrix, were conducted on the Dabob Bay Tracking Range at Bangor, WA. This facility was chosen because it had adequate water depth to accomodate greater towline lengths as well as the capability to track the craft and its towed system both optically and acoustically.

The first trial on the Dabob Bay tracking range was at 32 to 36 knots in a straight tow with 100 feet of towline and with tabs installed. This trial went very well and no new anomalies were experienced. During the next trial, the towline tabs were removed. At a scope of 150 feet. the side trail forced the winch to its starboard limit of 60 degrees from the longitudinal axis of the ship. A decision was made at this point to complete the scheduled foilborne turns part of the test matrix with 100 feet of towline before continuing with straight runs at 200-foot scope.

The trial of 7 August 1970 will long be remembered by the participants. In attempting the first takeoff, the depressor and towline rapidly moved 45 degrees to port, hesitated briefly, then again moved drastically to port to the azimuth limit of the winch as the turbine power was cut. Before the ship could slow sufficiently, the depressor body surfaced to port at the end of 125 feet of towline, rolled completely over to starboard, twisting the towline, and dove deeply to starboard before coming to rest astern as the turbines were secured. This was a deep sea fishing simulation clearly not anticipated.

Assessment of the damage revealed delamination of the fiberglas strain member at the lower fitting and sufficient damage to the towline at the 125-foot mark to require shortening of the towline to 450 feet.

After effecting repairs, a trial was conducted to investigate the cause of the surfacing incident and to characterize the new 100-foot immersed length of towline. It was found that the new immersed length had different side force characteristics than the length that had been cut off. The new length produced more side trail to starboard which necessitated reinstalling the tabs for the trials at 400-foot scope.

The next successful trial with 100 feet of scope included S-turns, spirals, simple 180-degree course reversals, and modified Williamson turns. This latter maneuver was frequently employed by HIGH POINT. It consisted of a 90-degree heading change (instead of 60 degrees) and then a shift of the rudder at the same turn rate for 270 degrees to complete the 360-degree turn.

Turns were made at 32 and 36 knots at turn rates up to 4 degrees per second and up to 360 degrees heading changes. Winch azimuth excursions did not exceed 15 degrees at the maximum turn rate. Results of the maneuvers correlated well with predictions of the computer program.

In the next to last foilborne trial on 18 August 1970, longer scopes of towline were involved. As the line was paid out to 200 feet, it began to vibrate violently. It was necessary to reduce speed in order to attach the towline follower instrumentation. The towline azimuth remained within limits and the towline scope was increased to 250 feet with recurring vibration necessitating a further reduction in speed. This was repeated as 300 feet were paid out, but the winch azimuth angle did not continue to increase as had been expected. This indicated it would be possible to pay out 400 feet of line at about 7 knots and still allow rapid acceleration through the critical vibration speed. The towline was then paid out to 210 feet and PCH went foilborne and stabilized at 32 knots. All 32 and 36-knot tows were successfully completed. Setup was then made for a 300-foot tow and the ship took off and completed all trial items for that scope. The depressor body elevator stalled several times during the later runs and the speed had to be reduced somewhat to regain elevator response.

The trials day concluded with a tow using a 400-foot scope of cable. Again all conditions were completed, establishing another milestone in the towing program. Later inspection of the depressor body when it was hauled up on deck revealed that the vertical stabilizer was missing, a victim of fatigue failure. Another fin was quickly manufactured and installed for the final trial which was conducted on 20 August 1970. This was to involve speeds of 40 knots or greater with 100 to 400 feet of towline.

Since PCH had not operated at speeds above 38 knots since the last RAV. it was necessary to make check runs at the higher speeds before attempting towing. Runs at the higher speeds were made and it was determined that the craft was capable of reliable turning at these speeds. There was also some concern over the increased cavitation erosion on the propellers at the higher speeds. As a result, the decision was made to proceed immediately to the 400-foot scope.

HIGH POINT took off and stabilized at 32 knots to allow setting the appropriate elevator angle on the depressor body. Speed was then gradually increased to 40 knots and finally to 42 knots at maximum propeller RPM. This procedure was repeated for another elevator setting before landing and decreasing scope to 300 feet. Towing the depressor on 400 feet of faired towline at a speed of 42 knots was a most significant milestone and the crowning achievement of the towing trials program.

Further tests with 300 and the 200-foot scope were carried out successfully until approaching darkness brought to completion this lengthy trials program which had begun more than eight months earlier and which had involved a total of 5 hours and 34 minutes of foilborne towing. The towed system was removed from the ship during a 95-day drydocking which began on 25 August 1970. More details of the towed body program are reported in Reference 56.

It may be noted that sometime later NELC installed a MK-42 torpedo head in the towed body with a stagnation-zone faceplate. In helicopter towing tests off San Clemente Island, they demonstrated predicted active sonar performance over the appropriate range of speeds. These tests were under Dan Andrews, Head of the Sonar Division, and were carried out by Art Roshon, Red Poynter, Chuck Miller. Dale Calkins, Fred Parker, and Francis X. Byrnes.

CHAPTER 8

197 1 Socal Deployment

MAKING PREPARATIONS

In January 197 1 HIGH POINT was scheduled for the first extended unaccompanied deployment to Southern California (SOCAL-71). Plans encompassed a wide spectrum of technical trials; demonstrations for various Fleet commanders and other visitors; participation in COMDESRON 13's COMPTUEX-7 1 Fleet exercise; and operations under COMFIRSTFLT during exercise ADMIXTURE off the California coast.

Before beginning the long voyage to San Diego, prudence dictated that the ship should first demonstrate a capability for foilborne transfer of personnel to a helicopter in the event of a medical emergency. A foilborne MEDEVAC was considered preferable due to the low ship motions in that mode compared to hullborne operation. HIGH POINT had been found to roll less than 1/2-degree in seas up to state 5 at speeds of 30 knots. A concerted effort, led by Chief Petty Officer Benjamin Woods, was made to develop shipboard procedures and conduct crew training necessary to make a safe foilborne personnel transfer. Upon completion of training, on 4 January a trial run with a Coast Guard CH52A helicopter was scheduled in the Strait of Juan de Fuca. A vertical exchange of light cargo between the ship and the helo was made at a speed of 37 knots. Communication procedures were then put to the test by passing station-keeping information to the helo while the ship did a slow figure-8 at 37 knots. Throughout this evolution the helo pilot was able to maintain station directly over the ship's fantail. The pilot stated that the steadiness and speed of the hydrofoil, **and** the VERTREP procedures that had been developed, made station-keeping "as easy as falling of a log". After this successful exercise, the ship returned to PSNS and made ready to begin the journey south.

TRANSIT TO SAN DIEGO

On 5 January 197 1, under the command of LT Joel Roberts, HIGH POINT got underway for the first leg of the voyage. They were preceeded by the four mobile support vans which contained spare

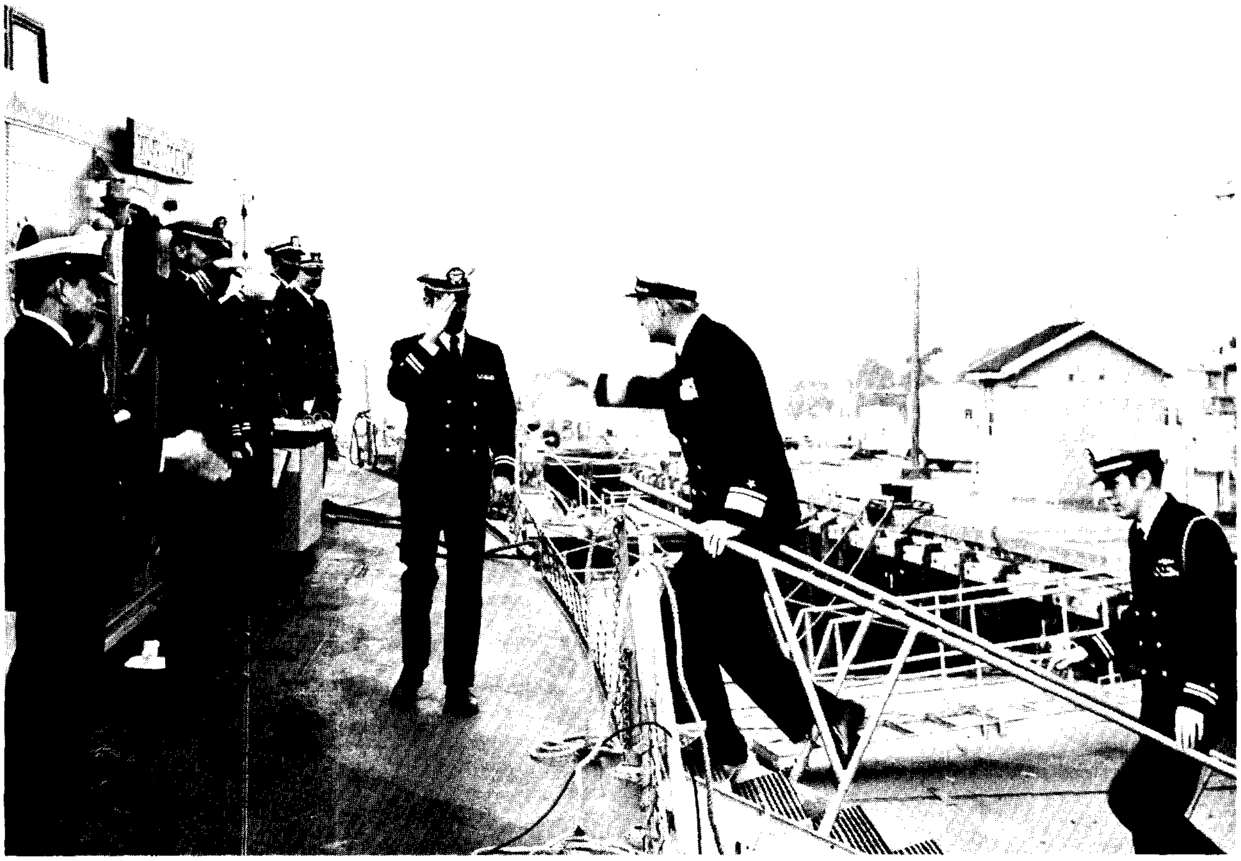


Figure 75. RADM Groverman, Commander Western Sea Frontier, Visits PCH

parts, hydraulic and electronic test equipment, and the ship's office. Arrangements had been made for refueling and an overnight stay in Astoria, Oregon, near the mouth of the Columbia River. They made port after seven and a half hours of foilborne flight. The following morning they again got underway and, after another seven hours foilborne, arrived at their second port of call, Crescent City, California. The next day, 7 January, after a flight of almost eight hours, they arrived at Treasure Island, San Francisco, for a 3-day layover. During this period, demonstrations were given to a large number of visitors including a number of VIPs. Figure (75) shows RADM Wm. H. Groverman, Commander Western Sea Frontier, being welcomed aboard HIGH POINT by OIC LT Roberts, OIC HYSTU LCDR Schmidt, and members of the crew. During this period they also engaged in joint operations with the 40-knot, turbine-powered, gunboats GALLUP (PC-85) and CHEHALIS (PG-84). (Several years later, the PG-84 was to be decommissioned, renamed ATHENA I and transferred to DTNSRDC for their use as a high speed test craft .)

On 11 January, the transit from San Francisco to Port Hueneme was made in about 11 hours of which 8 hours were on foils in spite of fog conditions. The average foilborne speed was 40 knots. The following day, there was a short foilborne transit to Long Beach. Operating out of Long Beach on 13 January, HIGH POINT conducted a test to determine the effectiveness of using a towed parafoil to raise up an IUW antenna, Reference 57. Parafoils were used routinely as an alternative to a parachute, offering greater directional control in free-fall, and were also used as a kite to lift weather instruments from

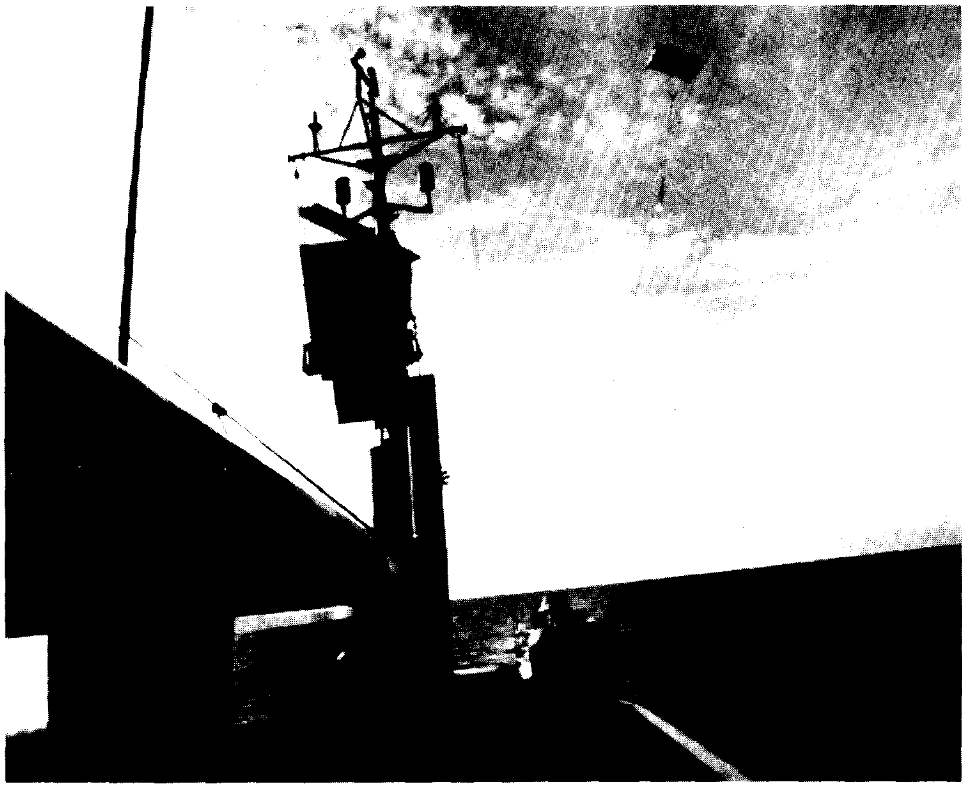


Figure 76. Parafoil Being Towed by PCH During SOCAL Deployment

a fixed location. However, they had not been deployed from a moving towpoint insofar as was known at the time. The first attempt to get the parafoil airborne at 8 knots was unsuccessful. The speed was increased to 14 knots into the wind to give a relative wind speed of about 22 knots. This was adequate to get the kite-like device aloft with the antenna, Figure (76). The ship went foilborne and the speed was increased to 36 knots. Unfortunately, a short while later the parafoil became unstable due to the downwash of an observer helicopter which was hovering above it. It finally crashed into the water on the port side. The ship was immediately landed after only about 10 minutes of foilborne operation and the test was terminated since there was inadequate time remaining to carry out further tests. (It is understood that shortly thereafter parafoil towing tests were conducted successfully from the SCHOFIELD DEG-3).

That same day, the ship also conducted the underway portion of scheduled magnetic signature trials. Runs were made over the range in six hullborne conditions beginning at 5-l/2 knots, followed by two hullborne runs at 10 knots using main turbine power. Finally, runs were made at 33 knots foilborne on four primary magnetic headings.

On 14 January, HIGH POINT gave demonstrations for numerous Fleet personnel, VIPs, and members of the press. Photos and motion pictures were also taken by members of the Combat Camera Team from Long Beach.

The following day the ship again got underway and made the transit to San Diego, her final destination. Enroute, radar cross-section measurements were made at the La Jolla facility of the Naval Electronics

Laboratory Center, (NELC). Measurements were made in lo-degree increments around the compass, both hullborne, at about six knots, and foilborne at 34 to 38 knots, using horizontal polarization. Only a few aspects using vertical polarization were taken due to the time required to change over the measuring equipment. The ship arrived in San Diego after almost 8 hours underway of which only 3-l/2 hours was on foils.

Saturday and Sunday, 16 and 17 January, were spent in port cleaning up the ship and allowing some time for recreation and relaxation of the crew. Monday brought forth another host of visitors who were given tours and a short foilborne demonstration. The following day was occupied in making infrared measurements by NELC off Harbor Island during both day and night operations.

EXERCISE COMPTUEX-7 1

The three days 20-23 January were spent installing special equipment required for participation in the Fleet exercise COMPTUEX-7 1, Reference 58. The ship was issued 20-power gyro-stabilized binoculars and fitted with Electronic Support Measures (ESM) equipment for radiation of launch and missile homing frequencies to simulate STYX missile attacks.

The exercise instructions called for HIGH POINT to make simulated small boat attacks against BAINBRIDGE (DLGN-25), EDSON (DD-946), and BERKELEY (DDG-15). The rules of engagement called for the hydrofoil to make a simulated KOMAR/STYX (Soviet small ship/missile) attack at a range of 6 to 8 nautical miles, followed by a simulated torpedo firing run on each designated target ship. Attacks were to be made from seaward, if possible. Upon completion of each sortie, they were to proceed to the next rendezvous, remaining clear of the exercise units. The event schedule also called for electronic drills in which HIGH POINT was to act as a high speed transiter for tracking by the Combat Information Center (CIC) teams of other ships.

Tactics were developed to accomplish HIGH POINT's assignment as a high speed raider during the sortie and transit phase of the exercise. Intelligence data concerning the three prospective targets included the port of scheduled departure (Long Beach), the location and time of first events, and specific electronic emission frequencies. The basic tactical approach was for the hydrofoil to cruise in a likely transit lane at low hullborne speed, hoping to be identified on radar as a fishing boat. Upon detection of the target, the hydrofoil was to close to missile range presenting a minimal radar image and minimizing electronic emissions while, at the same time, conducting a passive ESM search. Once within missile range, they planned to accelerate to 40 knots, launch missiles forward of the beam of the target, and follow up with a close-in torpedo attack. An intercept position midway between Long Beach and San Diego was chosen.

The ship got underway on the morning of 25 January. Additional radarmen were aboard who had been assigned from Beach Jumper Unit One and NELC to augment the CIC watch. Three civilian technical representatives were also aboard along with 20 Navy personnel. The estimated gross weight at takeoff was 124 tons.

HIGH POINT arrived at the intercept track well ahead of the first target ship, BAINBRIDGE. Their ESM receiver locked on to the navigation signal of BAINBRIDGE at 22 nautical miles and they closed the range on a reciprocal course at 6 knots. At a range of 9 nautical miles they went foilborne at a speed of 40 knots and came to an intercept course, closing at a relative speed of 70 knots. After positive visual identification of the target was made with the gyro-stabilized binoculars, they simulated firing four STYX missiles at 1,500 yards and a target angle of 030 degrees. When BAINBRIDGE identified

HIGH POINT, she immediately changed course to try and unmask her guns which were limited in their ability to fire forward. The hydrofoil closed the range to 3,500 yards and simulated launch of two 2 l-inch torpedoes such as those carried by a Soviet SHERSHEN Class patrol boat. At the end of the engagement BAINBRIDGE sent a flashing light signal "Good show! Will pick up survivors!" HIGH POINT was credited with sinking the ship.

While they were closing the range on BAINBRIDGE, a second radar contact had been detected steaming on a southerly course at the same speed as BAINBRIDGE and apparently in company with her. HIGH POINT'S ESM receiver picked up a signal at the same range and bearing which identified the target as EDSON. After breaking off the attack on BAINBRIDGE, the hydrofoil closed the second radar contact and made visual identification of EDSON. They again simulated firing STYX missiles at a range of 14,800 yards and a target angle of 060 degrees. This was followed by a torpedo attack abeam at a range of 3500 yards. During the final phase of the attack the port height sensor malfunctioned. The problem was eliminated by disconnecting it and cross-connecting the starboard unit. HIGH POINT was also credited with sinking the EDSON.

Contact with BERKELEY was made shortly after noon. HIGH POINT's ESM receiver first detected the target ship north of Catalina Island moving in an easterly direction at 8 knots. They closed to missile range on an intercept course at a speed of 5 knots. This took about 1-1/2 hours at this low speed. At a range of 14,000 yards they went foilborne and at 13,000 yards simulated launch of four STYX missiles at a target angle of 050 degrees. Missile launch was again followed by a simulated torpedo attack at 4,000 yards. Evasive maneuvers and a speed of 40 knots were used to quickly open the range after the attack. Once more HIGH POINT was credited with sinking the target ship.

During the exercise on 2 5 January, the ship was underway some 17- 1/2 hours which included 4- 1/2 hours of foilborne operation. Some ESM drills and exercises which required her to act as a high speed transiter for tracking by other ships were cancelled due to HIGH POINT's inability to establish effective UHF communications with other units. On the following day, the ship got underway shortly after midnight to return to port. They conducted independent exercises enroute and were underway for almost 12-1/2 hours, all hullborne.

OPERATIONS IN SAN DIEGO

On 27 January, a trial was scheduled to acquire technical and photographic data comparing craft performance in a seaway with other vessels. HIGH POINT got underway in the early morning and made rendezvous off San Clemente Island with BADER (DE-1025), CHEHALIS (PG-84), PTF-22. and a navy photo helicopter. Unfortunately, the sea did not cooperate and they found only relatively calm conditions for the tests. They did, however, get some good film of the ships running together. On board HIGH POINT during these tests was LT(jg) R. Cooper, OIC of the Grumman-built 67-ton hydrofoil gunboat FLAGSTAFF (PGH-1). During this operation, the ship made 22 take-offs and landings and was foilborne a total of 5-3/4 hours.

The following day was a big one for VIP visitors. The ship was host to Prince Juan de Carlos de Borbon (now King of Spain) and a large entourage comprising members of his party, representatives of the U.S. State Department, and a large number of security agents. Figure (77) shows the Prince being welcomed aboard by LCDR Hank Schmidt, the OIC of HYSTU. The ship provided a demonstration of its speed and maneuverability in a halfhour of foilborne operation during which the Prince was permitted to take the helm.

Figure 77. Prince Juan Carlos of Spain Visits PCH in San Diego

The next day was again occupied with entertaining visitors and providing demonstrations for VIPs. These included Dr. Joel Lawson, Director of Navy Laboratories; CAPT C. A. L. Swanson, OP-OOK, Dr. C. E. Bergman, Technical Director of NELC; Dave Washburn, NELC; and John Giblin, NAVSHIPS 003; shown in Figure (78).

For the next three days, 30 January thru 1 February, the ship remained in port putting things in shape and installing low-light-level television (LLL-TV) equipment and preparing for collision-avoidance trials scheduled for 2 and 3 February. During this two-day period, tests were run on two underwater collision avoidance devices installed on the forward foil. One was a pulsed doppler sonar provided by NSRDL, Panama City, Florida. The other was a Westinghouse forward looking sonar. A racetrack course was laid out and runs were made on targets which consisted of two 5-foot logs and spheres suspended beneath buoys. Night tests of the LLLTV system and other visual aids were also conducted. These trials, involving various mission equipments, were under the overall direction of Dave Washburn of NELC, who was double-hatted as Manager for Mission Systems in the NSRDC Hydrofoil Development Program Office.

Other visitors during this period included CAPT Robert Ripley, USN, a strong supporter of hydrofoil development in OPNAV 03; James L. Schuler, Hydrofoil R&D Program Manager in NAVSHIPS 03; Wm. M. Ellsworth, Associate Technical Director of NSRDC; and Robert J. Johnston, Manager of Marine Systems at Grumman (later to become Technical Manager of Hydrofoil Development at NSRDC).

February 4 was a day for hosting visitors mainly from various Fleet commands. VIPs included VADM N.C. Johnson, COMPHIBPAC, and RADM J.B. Davis, COMPHIBTRAPAC.

Figure 78. VIPs Hosted by PCH in San Diego

During the second and third weeks in February, HIGH POINT spent much of the time in port with only brief interruptions to conduct further demonstrations, Figures (79), (80), and (8 1). The main focus, however, was on preparations for participation in a second Fleet exercise, OPERATION ADMIXTURE.

EXERCISE ADMIXTURE

ADMIXTURE was the first large-scale PACIFIC Fleet exercise of 197 1. It was to involve 42 U.S. Navy ships. 5 Canadian Navy ships, 29 air squadrons, and 3 air detachments. As its name implied, it was to combine all phases of naval operations, testing the skills of the commanders and crewmen and the capabilities of their equipment.

The exercise plan called for friendly “BLUE” surface and antisubmarine warfare (ASW) forces to operate against the aggressor “ORANGE” forces. Jet fighters and attack aircraft from the carrier MIDWAY (CVA-4 1) were to fly against inland targets. The submarines HMCS RAINBOW (SS-75), USS CATFISH (SS-339). and USS DARTER (SS-376) as well as the nuclear submarine USS PLUNGER (SSN-595) were to be the targets of the ASW force.

It was planned to use HIGH POINT in an ASW role and as a plane guard for MIDWAY for a short period, Reference 59. It was anticipated that she would also be tasked as a BLUE fast-reaction surface pouncer against a range of ORANGE surface units during transit, evacuation, or retirement phases.

For its various roles HIGH POINT was assumed to have additional simulated weapon and ESM capabilities. These included two TARTAR missiles with 250-pound semi-armor-piercing warheads, a

Figure 79. CAPT Van Orden, Commander NELC, Takes PCH Helm

Figure 80. RADM Longino, COMASWPG-Three, at the Helm of PCH

Figure 8 1. RADM Butts, COMCARDIV-ONE, at the PCH Helm

MK 87 gunfire control system, and four MK 46 torpedoes. Some additional mission equipment was actually installed on the ship. This included a radar unit which used the ship's surface-search radar antenna for passive detection of x-band radars; a radar frequency measuring receiver; a high-frequency deceptor; and a remotely-trainable low-light-level television (LLL-TV) camera mounted on the pilot house. Other measures were taken to confuse or deceive ORANGE forces. The two strut retraction housings on the after deck were painted flat black and labeled with RF radiation hazard signs to simulate two height-finding radars. The LLL-TV camera atop the pilot house was also painted flat black and decorated with "Danger-Laser Light" signs. Finally, a deck-mounted fuel filter coalescer was covered with a 6-foot black plywood housing with radiation hazard signs to represent some exotic new ESM capability.

Except for two 200 nm transits, HIGH POINT was directed to remain within 100 nm of her designated support ship, SCHOFIELD (DEG-3). (In later years this ship was redesignated FFG-3). She was to UNREP daily from SCHOFIELD and was to have three primary operational roles:

1. Operation in an ASW screen as a passive EW platform.
   (3 to 5 hours daily for 4 to 7 days).
2. Operation as plane guard for MIDWAY.
   (6 to 10 hours for one day).
3. Action as a surface pouncer against surface units.
   (6 to 8 hours daily for 2 to 4 days).

The ship got underway early on 23 February and completed a minefield transit without any indication of a mine detonation. She took up station in an ASW sortie screen, as directed, and then conducted a random patrol of an assigned sector. They made rendezvous with SCHOFIELD as scheduled and received a delayed message directing them to plane guard TICONDEROGA (CVS-14). Unfortunately, the message was received too late to carry out the assignment. This was a disappointment to the OIC and crew who were awaiting the chance to demonstrate their ability to maintain 36 knots through sea state 5 in a plane guard role; a capability not possessed by conventional destroyers.

During the rest of the first day, HIGH POINT transited, maneuvered, made rendezvous, and investigated sonar and visual contacts. This continued through the night and into the second day, 24 February. Early in the day she made an ESM search, as directed, in state 3 seas. She also conducted shipboard emergency drills. Shortly after noon a request was made to SCHOFIELD for an UNREP to occur before sunset. Some time later HIGH POINT came alongside the DEG with seas now arisen to state 4. She took aboard fresh water with no difficulty. Then, SCHOFIELD had a fuel valve casualty which severely limited her rate of fuel delivery. As a result, HIGH POINT was forced to remain alongside for nearly seven hours before she was able to take on 2,400 gallons of fuel; only 68% of her capacity.

During the evening of the second day they alternated between 5 knots hullborne and 36 knots foilborne, leap-frogging other units with only a 15-knot speed of advance.

The third day, 25 February, the ship cruised hullborne on turbine power for some three hours. Shortly after sunrise she went foilborne for about half an hour enroute to another rendezvous with the mother ship. By this time the seas were up to between state 4 and 5 and SCHOFIELD still had nor corrected its fuel pumping problem. As a result, it was not considered worth the risk and HIGH POINT was given permission to return to San Diego for fuel. She proceeded at 30 knots in seas now at upper state 5. Enroute, she continued searches and close visual investigation of suspicious contacts but had no positive ORANGE sightings. The transit was made in four hours.

The ship was directed to remain in port on 26 and 27 February until seas abated enough to permit normal UNREP. On 1 March, pending receipt of further sailing orders from the Task Group Commander, she got underway to conduct a checkout of the ESM system. During this checkout they observed a submarine conning tower seaward of the entrance to White Harbor. They closed on the target until they were able to identify it as a designated ORANGE FOXTROT (SS CATFISH), proceeding at five knots. HIGH POINT, foilborne at 36 knots, made a simulated torpedo attack, firing a single MK 46 at 1200 yards. They were credited with causing extensive damage to the FOXTROT screws and pressure hull.

After the successful submarine attack, a vibration in the forward strut was noted. They returned to port and conducted a diver inspection which revealed 12 degrees of play in the forward port flap. NSRDC/HYSTU was contacted and, after consultation, they were advised to terminate any further participation in the exercise to conserve the remaining flap life for the return trip to PSNS.

Even though there were some disappointments, HIGH POINT did receive a positive upcheck on her performance in the exercise. SCHOFIELD, in a message on 2 March. reported:

> HIGH POINT was employed to investigate contacts as far as 10 miles from the task unit. Equipped with low light television, a good radar, secure voice equipment, H/F capability, and high speed, she was ideal for the task. These same qualities permitted her to be used well on the flank to provide a wide HF/DF base with our third unit. Had a bearing been obtained, HIGH POINT'S speed could have been utilized to reorient as necessary to increase the baseline and improve the accuracy of the HF/DF fix.

SCHOFIELD also noted that HIGH POINT may have usefully employed a passive sonar while she waited for accompanying units which had been passed in leap-frog fashion. "Equipped with an active and/or passive sonar, HIGH POINT could be used to advantage in assisting in acquisition and localization, and in confirming other unit contacts. She could be of great use in investigating 02 contacts."

THE VOYAGE HOME

After completing static magnetic tests on 4 March at the San Diego Degaussing Station, and additional infrared measurements, preparations were made for the voyage back to Bremerton. The ship got underway on 8 March and made the transit to Port Hueneme in a little over 5 hours of which 3-3/4 hours were on the foils. The following day she began the transit to Hunters Point, San Francisco, arriving after being underway for 9-1/2 hours including the conduct of additional trials. They were foilborne a total of 8-1/2 hours. The ship remained in port on 10 March and an underwater inspection of the propellers was made. The following day they began the transit to Crescent City but were ordered by COM- 13 to return to San Francisco to await abatement of storm conditions further north. It was necessary to lay over another day longer before permission was given to proceed on their way. Considering the layover port, this in no way made the crew unhappy. Underway again on 13 March, just north of the Golden Gate bridge they experienced severe propeller vibration and were forced to seek the nearest sheltered area to make an underwater inspection. They anchored in a sheltered cove and divers found that a blade had broken off the starboard aft propeller. The propeller was removed by the divers and the ship proceeded to Crescent City. The transit took a little over 16 hours of which 6 hours were on the foils. They arrived around 2230 hours, well after nightfall, and Chief Woods demonstrated his excellent shiphandling in docking the ship in gale force winds in the dark. This was no small feat since HIGH POINT draws only 5-feet with foils retracted, and presents a considerable sail area for a 120-ton craft.

After installing a spare propeller, the transit to Astoria, Oregon was made on 14 March in a little over 10 hours, 80% of which were foilborne. While crossing the Columbia river bar at the entrance to the port of Astoria, they encountered 30-foot waves which they managed to traverse in spite of some rather extreme excursions. Figure (82) gives some indication of the nature of this experience. Some time later, as a result of intermittent broaching of the forward foil in 12 to 18-foot seas, the wind direction vane and wind speed propeller assembly snapped off the mast and was lost overboard.

The following day, 15 March, they delayed their departure from Astoria until about 1100 hours to allow further abatement of high seastate conditions. Even so, they still encountered upper seastate 5 along the coast up to the entrance to the Strait of Juan de Fuca. Once inside the Strait they made turns for a speed in excess of 40 knots, arriving at PSNS around 1900 hours. They had been underway a little over 8 hours of which about 7 hours was on foils. Their average speed on this last leg was about 40 knots.

HIGH POINT'S first extended deployment to Southern California, References 60, 61, 62, and 63, was a significant accomplishment. It demonstrated the achievement of a substantially improved level of reliability and the outstanding competence and dedication of the crew. It also afforded the opportunity to gather a wealth of additional data of great value for the design of future hydrofoil ships. Future prospects for the use of ships of this type was certainly enhanced by the extensive first hand exposure of the ship's unique operational capabilities to a wide spectrum of visitors. Many of the visitors who were hosted aboard are listed in Appendix H, which was taken from the ship's manifests. Of particular significance, was the opportunity for the ship to participate in two Fleet exercises. Even though this

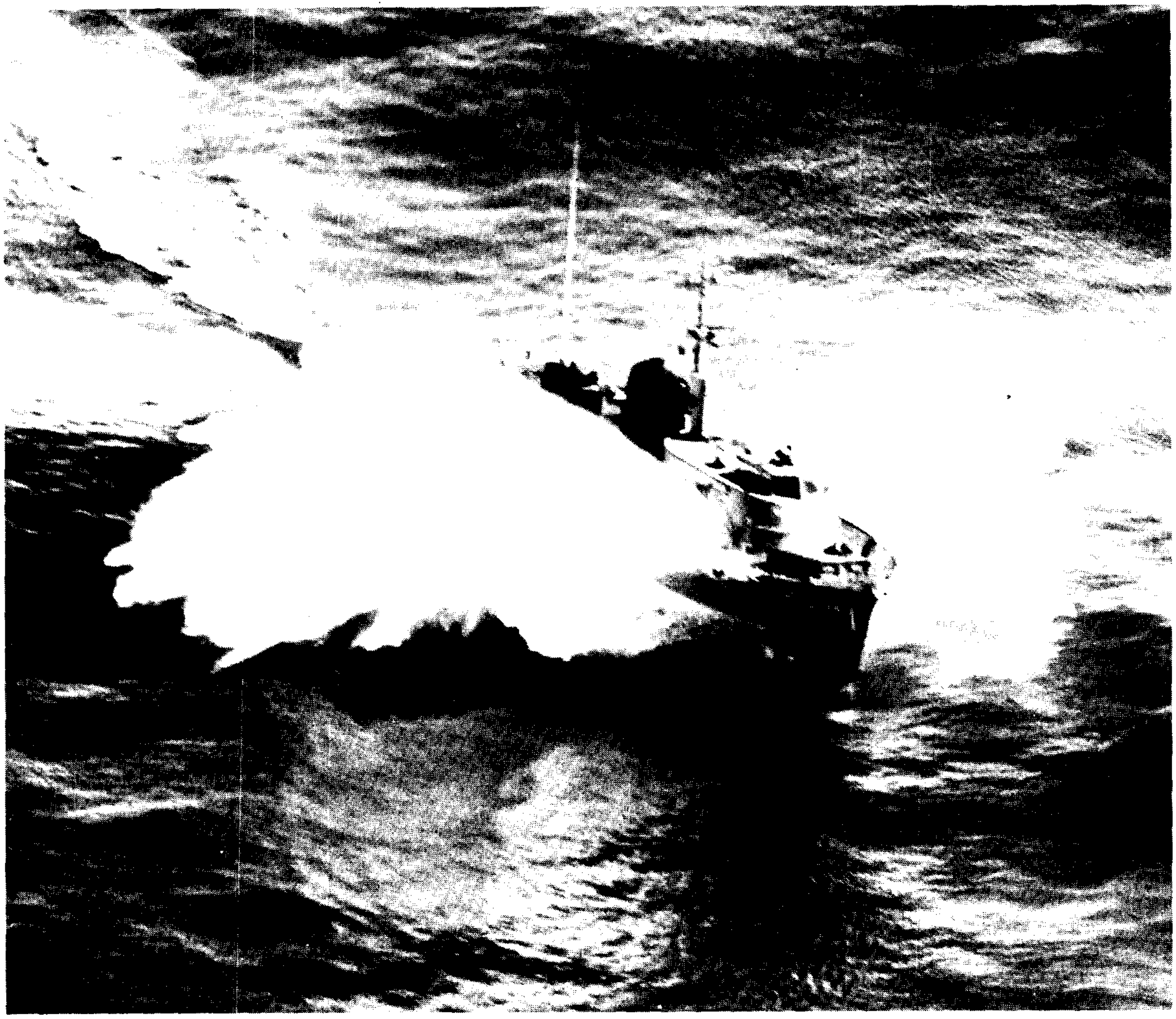


Figure 82. PCH Crosses the Columbia River Bar at Astoria, Oregon

exposure was brief and some of the scheduled events could not be met, the potential of hydrofoil ships to enhance Fleet capabilities was clearly demonstrated and acknowledged.

PROGRAM OFFICE CHANGES

During the early part of 1971, a number of changes took place in the Hydrofoil Development Program Office at NSRDC. On 25 January, Dennis Clark was transferred from the Structures Department to become the Manager of Systems Integration. He was to make a profound impact in his later generation of many innovative concepts in technical documentation. They included the computerized Hydrofoil Technical Data Bank; the Hydrofoil Analysis and Design (HANDE) computer program, developed by Boeing under his direction; the Hydrofoil Design Data Log; the Advanced Ships Information System—Technical (ASSIST); and many other concepts for organizing and utilizing the products of the R&D program.

On 18 April, in recognition of the growing number of advanced ship and ship systems development programs following the pattern of hydrofoil development, the Center formed the Systems Development

Figure 83. Hydrofoil Program Office Staff Discusses Design Changes

Department. This was first designated as Code HO1 and later became Code 11. Mm. M. Ellsworth was appointed as Department Head and Associate Technical Director for Systems Development. At the same time Dr. David Jewell was transferred from the Hydromechanics Department to become the Technical Manager of the Hydrofoil Development Program Office. This was first designated Code H-l 5 and later became Code 115. Dave Jewell was not a newcomer to hydrofoils, having been involved earlier in a number of hydrofoil hydromechanics projects.

On 7 May. LT Charles (Chuck) Rabel transferred from NELC to become Hydrofoil Program Officer, relieving LT Gil Perry. LT Rabel had already been involved in the mission side of the Hydrofoil Program working with Dave Washburn at NELC. He brought a considerable background in small craft operations to the program.

Figure (83) shows. left to right. LT Rabel, Dennis Clark, Dave Jewell, and Bill O'Neill, Manager of Subsystem Development, discussing proposed changes to PCH. It may be noted that members of the Program Office team were chosen to provide a broad technical base. Each, in addition to his management responsibilities, was expert in at least one technical discipline. Dennis Clark had a background in structures; Dave Jewell was experienced in hydromechanics; and Bill O'Neill, although recognized as having a particularly broad technical background, was also an expert in automatic control systems and gas turbine engines.

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CHAPTER 9

MOD-I

DESIGN

Boeing completed their studies of PCH deficiencies and needed improvements and submitted their recommendations to the Navy in late 1967. As expected, they recommended going to a waterjet propulsion system as well as a number of other changes patterned after the TUCIJMCARI. The Navy took some time in arriving at a decision regarding the changes proposed. It was finally decided that acceptance of all of Boeing's recommendations (referred to as the "Maxi-Mod") would be too costly in light of funds available. As a result, a less ambitious approach was selected which still provided the elements considered essential to achievement of reliable operation. This was referred to as MOD-I.

On 27 June 1968, Boeing was awarded a second contract which called for the detail design of the approved modifications. Major changes to be included were:

Complete rework and recoating of the strut/foil system.
Lengthening of the forward strut to permit operation in higher sea states.
'Making the forward strut fully-steerable, similar to TUCUMCARI.
Replacement of the automatic control system with an improved version.
Replacement of the gears in the foilborne transmission.
Provision for later installation of ventilated propellers.
Installation of a supplemental foilborne lube oil system.
Modification of the flight control and ship's service hydraulic systems.
Replacement of the Packard hullborne diesel with a GM 12V71 diesel engine.

After completion of the detail design and approval by the Navy, the process which had begun some six years earlier was culminated in April 197 1 by award to Boeing of a $2.6M production contract. This was to cover conversion of HIGH POINT and the performance of a major scheduled regular overhaul.

Figure 84. LT Roberts Presents PCH Plaque to SECNAV John Chafee

PRE-MOD-I OPS

After returning from the deployment to Southern California, HIGH POINT continued to conduct operations and give VIP demonstrations up to the time scheduled to begin RAV and MOD-I conversion. On 6 April 1971, RADM D. C. Plate, COMCRUDESPAC broke out his flag on PCH and was given a foilborne demonstration during which he took the helm. On 13 May, another demonstration was conducted with the Hon John Chafee, Secretary of the Navy aboard. Figure (84) shows LT Roberts presenting the PCH plaque and briefing book to SECNAV.

Vertical Fuel Replenishment

In evaluating the mission capabilities of hydrofoil ships, one of the trials plans called for conducting a vertical fuel replenishment from a helicopter. On 27 May 1971, HIGH POINT made a transit to an

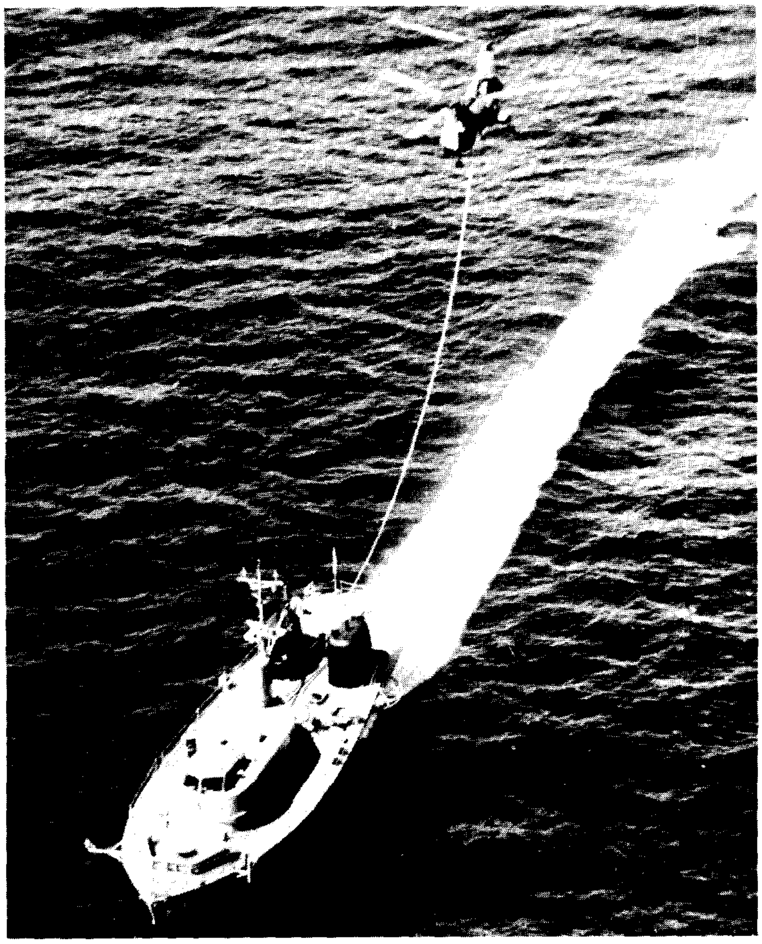


Figure 85. PCH Vertrep Trail with CH-46 Helicopter

area North of Port Angeles and made a rendezvous with a CH-46 Marine Corps helicopter from the Naval Air Station at Whidbey Island, Reference 64. Initially, it was determined that the helo could maintain station over the ship during both hullborne and foilborne operations. Then, with standard Navy refueling equipment and three crewmen on the after deck at the vertical replenishment station, an attempt was made to conduct a simulated vertical refueling. At this point it was determined that they had an insufficient length of 1-1/2-inch hard rubber hose to provide adequate clearance for the helo. As a result, the test was terminated.

On 1 June, the ship returned to the operating area with 300 feet of 1-1/2-inch hose made up of 50-foot lengths with a quick-disconnect coupling on one end. (PCH can actually handle up to 2-1/2-inch hose.)

In the first event, PCH maneuvered foilborne with the helo on station at 150-foot altitude and just aft of the stern of the ship. The helo easily maintained this station while the ship went from hullborne to foilborne and maneuvered at turn rates up to 3 deg./sec. and speeds of 35 to 40 knots. Due to the potential danger of the helo striking the mast, no landings were attempted with it on station.

In a second event, the ship passed the free end of a 175-foot nylon line up to the helo by attaching it to a lowered cargo hook, Figure (85). Red bunting markers were attached to the nylon line at 20-foot intervals to provide an accurate measure of the length and the catenary. The helo pilot, who maintained communication with the ship over a UHF circuit, noted that the fuselage obstructed his view of the ship when he was hovering directly over the fantail.

The first attempt at sending up the 1-1/2-inch fuel hose while foilborne, met with difficulty. The ship was at a speed of 38 knots with 45 knots of wind across the deck at a OOO-degree heading. The relative wind was such that the cargo hook trailed aft out of reach of the crewmen. The ship was landed, slowed to a speed of 12 knots, and came to a heading that put the wind 45 degrees off the port bow. The cargo hook was retrieved and the fuel line attached and winched up to the helo. The ship then accelerated slowly in increments of 100 RPM until foilborne. They then made turns for 38 knots and maneuvered at turn rates up to 3 degrees/second. Of the 300 feet of hose line, about 100 feet remained faked on the deck with the remainder in the catenary.

The final event called for injecting sine wave signals into the ship's autopilot to simulate the effect of rough water. This was vetoed by OIC LT Joel Roberts due to his concern over the possibility of creating a control anomaly that might endanger the helo. Instead, a limited seastate simulation was induced by manual cycling of the height-set control with the ship and helo on a steady course. This caused no adverse effects on the operation.

The trial was successfully completed. There were no adverse effects on the ship from the close proximity *to* the helo noise and the rotor downdraft. The crewmen reported the deck to be a very stable platform, even when the ship made pitch excursions manually induced by the height control. It was noted, however, that the CH-46 was really not suitable for such an operation due to the restricted visibility when hovering over the stern of the ship.

More OPS

On 4 June, demonstrations were given to a large group of students from the Naval War College at Newport, RI. The following list of those in the party illustrates the worldwide exposure given to the capabilities of the ship during this demonstration:

CAPT Thomas H. Nugent, Jr., USN, War College Director
PROF August C. Miller, Jr., Miles Chair of International Relations
COL Francis H. Thurston, USMC
CDR Russell B. Bridgham, USN
CDR Joe E. Tarlton, USN
CDR David T. Rogers. USN
LCDR Robert J. Hiebner, USN
CDR Sergio Rolando Alcaraz, Paraguayan Navy
CDR Jan Johan Binnendijk, Royal Netherlands Navy
CAPT Jose Carcelen, Peruvian Navy
CAPT Se Hwan Chang, Korean Navy
CAPT Yung-An Chiu, Chinese Navy
CDR Jose E. Cortines, Argentine Navy
CDR Constantine Cotaras, Canadian Armed Forces
CDR Yilmaz Dogrusog, Turkish Navy
CDR Paul Fischer, Federal Republic of Germany Navy
CDR Carlos Flores, Ecuadorian Navy
CDR Said Hassen, Imperial Ethiopian Navy

CAPT Toshihiko Hozumi, Japanese Maritime Self Defense Force
CDR Eric Johnston, Royal Australian Navy
CDR Porfirio Lopez, Mexican Navy
CAPT Reiar Kionig-Hasen, Royal Norwegian Navy
LCOL Abdul Madjid, Indonesian Navy
CDR Shoa Majidi, Imperial Iranian Navy
CDR Jesus Meneses, Venezuelan Navy
CAPT Subimal Mookerjee, Indian Navy
CDR Trinh X. Phong, Vietnamese Navy
CRD Peter A. Pinkster, Royal Navy
CDR Fazl Rab, Pakistan Navy
CDR Julian Ruiz de Gamiz, Spanish Navy
CAPT Andre J. P. Schlim, Belgian Navy
CDR Jelcias da Silva Castro, Brazilian Navy
CDR Chanai Suwannakitti, Royal Thai Navy
CDR Nicholaos Thodos, Hellenic Navy
CAPT Guillermo Uribe, Colombian Navy
CAPT Marcello Vacca-Torelli, Italian Navy
CDR Serapio C. Martillano, Philippine Navy

On 24, 25, and 28 June, trials were conducted to evaluate a collision avoidance sonar. A pod was attached under the center of the forward foil to house a forward-looking sonar. Its purpose was to detect submerged or semi-submerged objects such as the many logs floating in the Puget Sound area. The trials were only marginally successful and the solution to the problem of avoiding collisions with debris and other objects continued to elude the hydrofoil developers.

On 21 July, HIGH POINT made another transit to Neah Bay to establish a rough water baseline prior to XIOD-I. The trials were conducted on 22 July without incident. However, when they got underway the next day to return to PSNS, both disconnect couplings failed when they attempted to go foilborne. One coupling was judged to be serviceable in the turbine taxi mode and with increasing fog and lowering darkness, they proceeded at a hullborne taxi speed of 22 kts. As a further complication, the navigational radar had become inoperative and they were forced to proceed by dead reckoning using a lighthouse at the bend in the Strait of Juan de Fuca as a point of reference. Fortunately, Chief Perez managed to repair the radar just before they reached the lighthouse and they were able to complete their return to PSNS. During this trip, the value of foilborne operation was amply demonstrated when more than half the crew became seasick, This casualty prevented any further foilborne operations prior to beginning MOD-I.

During 1971. the ship was underway foilborne on 69 days, accumulating a total of 187 foilborne hours. This brought the total foilborne time since the first flight to 724 hours. The ship's complement at the end of the period comprised the following:

OIC LT Joel Roberts
QMC Ancil S. Hatton
ETC Alejo C. Perez, Jr.
BMC Benjamin F. Woods. Jr.
RD1 Patrick W. Keays
EN1 Stanley D. Chism
EN1 Donald L. Tew

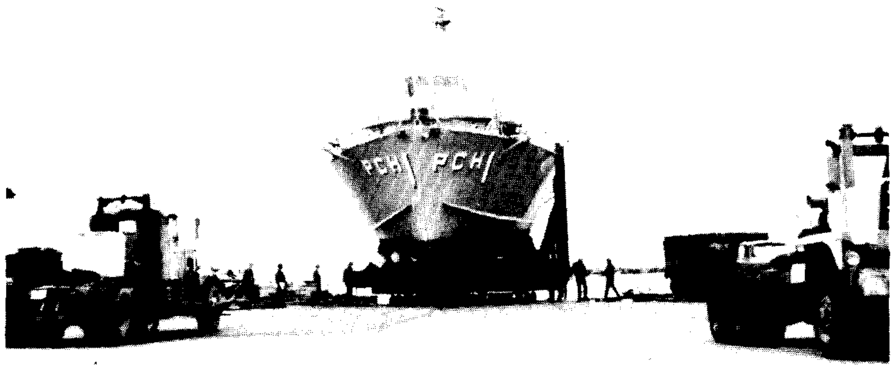


Figure 86. PCH is Hauled from Lake Washington at Boeing Renton Plant

CS1 Walter H. Zwieg
YN1 Mario S. Rojales
EN1 Floyd A. Templeton
SK1 Nicolas S Bayson
EN1 Jewel T. Etheridge
MM1 Rodney M. Zook
FTG2 Raymond G. Young
ETN2 Barry F. Allison
IC2 Grant Hinton
SN Robert A. Knox
ENFN Paul T. Baxter

MOD-I AT LAST

On 7 September 1971, the ship made the transit from PSNS through the locks into Lake Washington and down to the Boeing plant in Renton, WA. There it was hauled from the water in a "house-moving" operation and installed on high blocks in the building housing the PHM and JETFOIL production lines. It was to remain there for a total of 521 days. Figure (86) shows the ship being hauled out of Lake Washington on 8 September 1971 and Figure (87) shows the craft on 30 September 1971. with the struts and foils removed, being moved inside the Boeing plant.

MERITORIOUS UNIT CITATION

On 3 November 1971, HIGH POINT's outstanding performance during the deployment to Southern California was recognized by the award of a Meritorious Unit Citation. Figure (88) shows the presentation being made in the Boeing hanger by RADM Wesley L. McDonald, Commandant of the 13th Naval District, LT Roberts, LCDR Schmidt, and Dr. Dave Jewell, Technical Manager of the Hydrofoil Development Program, are seated behind RADM McDonald. Chief Boatswains Mate Benjamin F. Woods, USN,

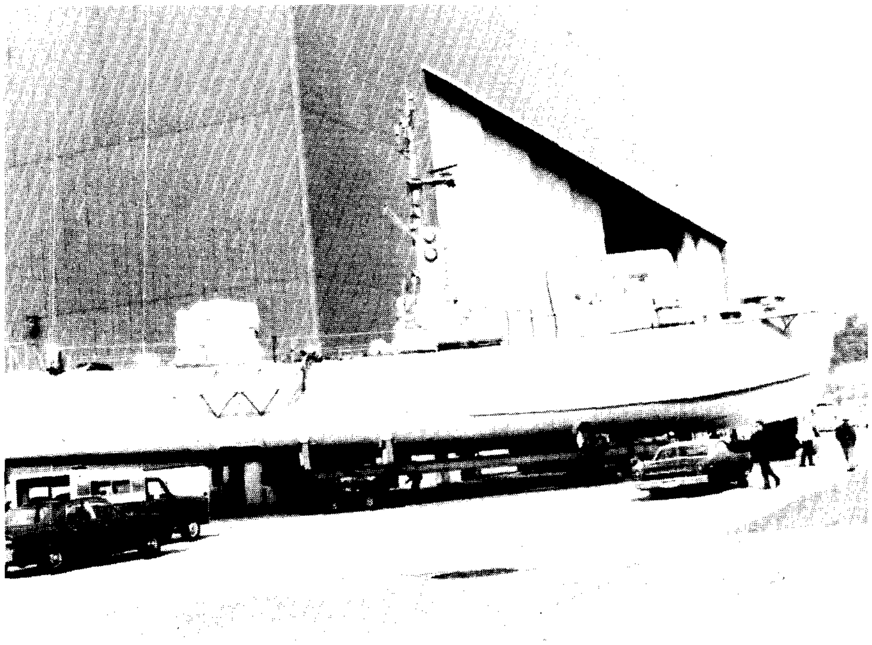


Figure 87. PCH is Moved into Boeing Hanger for MOD-I

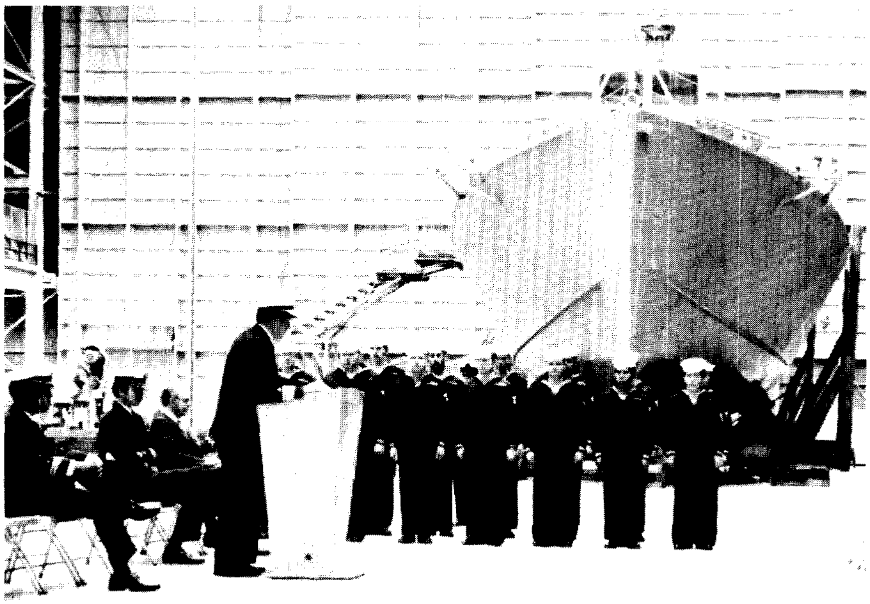


Figure 88. RADM McDonald, COM- 13, Presents PCH Meritorious Unit Citation

was also awarded the Navy Commendation Medal for his outstanding performance as Executive Officer, Weapons Officer, and Supply Officer during the deployment.

MOD-I CHANGES

Modifications to the ship during the major overhaul and conversion were quite extensive and were directed to correction of deficiencies identified during the early trials. Some of the major changes are discussed in the following sections.

Steering And Attitude Control

In the original configuration, steering was accomplished by means of a small trailing-edge flap on the forward strut, coupled to a spade or skeg rudder beneath the forward foil. This system had proved inadequate in spite of an earlier change to increase the size of the spade rudder. On numerous occasions the ship had been unable to maintain course in high winds or unable to come about into the wind. Also, small perturbations in the flow around the struts would cause side forces which made it difficult to turn in one direction. There were occasions when 2 deg/sec to starboard was the maximum turn rate attainable, even in smooth water. Clearly, there was a need to increase steering control authority, References 65 and 66.

In the original ship configuration, the flying height was controlled by flaps on the trailing-edge of the forward foil. Pitch was controlled by the inboard flaps on the main foil aft and roll was controlled by differential action of the outboard flaps on the main foil. This is referred to as "aileron" control, Roll control had also been found to be marginal. On several occasions when operating in beam seas, the control surfaces went to their stops and were overpowered by wave forces and moments. causing the ship to roll over slowly until the hull chine reached the water surface. This had prompted an earlier change in the autopilot system to achieve more roll authority. This had been accomplished by modifying the autopilot to move both the inboard and outboard flaps on each side of the main foil in unison, thereby using the complete rear foil span to produce roll forces. Pitch was controlled by moving each pair of starboard and port flaps in phase. Roll was controlled by moving them differentially. This is referred to as ''elevon'' control, which had been successfully demonstrated on TUCUMCARI.

In MOD-I, the complete autopilot system was replaced with an improved version which retained the principle of "elevon control". In addition, the main foil was modified to increase the span outboard of the struts from 7.75 feet to 10.25 feet and provide dihedral in these outboard sections. This was done to provide better banking geometry, increase lateral stability, and reduce the likelihood of broaching and ventilating a foil tip during a turn. The propulsion nacelles were moved down beneath the aft foil on short strut extensions to improve structural characteristics and propeller inflow conditions. Each pair of outboard and inboard flaps. port and starboard, were driven by a single hydraulic actuator located inside the strut. These were connected to the flaps by means of a bell crank and push rod. The old system had a separate actuator for each of the four flaps. These were subject to seawater contamination and were difficult to maintain. In addition. the new actuator design also eliminated the need for hydraulic lines between the servo-valves and the actuators by making them an integral unit.

Other changes included lengthening the forward strut by two feet to increase seastate capability and making it rotatable to angles of plus or minus 10 degrees. A roll-to-steer concept was adopted. In this mode, a helm command rolls the ship and the rotatable strut turns as a function of roll angle so as to essentially null the sideforce. Turning force is thus supplied by a component of the lift vector rather than by rudder or strut sideforce. This method of turning eliminates high angles of attack on the struts and thereby minimizes the tendency to ventilate in coordinated turns. Figure (89). taken from Reference 68, shows the geometry of the new strut/foil configuration.

As noted earlier, in the original configuration (MOD-O), the helmsman had the option of making a flat turn or a coordinated (banked) turn. The latter mode was provided by scheduling roll angle as a function of yaw rate. It was originally thought that a flat turn mode would be needed to facilitate training of a gun on a target. In gunfire trials, however, it had been found that the banked turn mode did not cause a problem in depressing or elevating the gun. Furthermore, the banked turn mode was much preferred from a human factors standpoint. In a fully-coordinated turn, the body's gravity vector remains perpendicular to the deck and there is no sideforce created as is the case in a flat turn. As a result, the flat turn mode was eliminated in MOD-I.

Another TUCUMCARI feature that was incorporated was the installation of heave accelerometers directly over each main strut. This was to permit individual correction of disturbing forces so as to eliminate the annoying "jiggle" which is otherwise associated with operation in steep bow seas when each foil section is in a different portion of a wave.

Steps were taken to increase the reliability of the automatic control system (ACS) electronics by elimination of interactions, elimination of manually-adjusted gain and trim controls, incorporation of an improved status check system, and use of the latest state-of-the-art in the hardware. A completely new computer and new power supplies, height sensors, pilot house controls, displays, and cabling were supplied. Figure (90) shows the schematic and block diagram of the MOD-I ACS.

Hydraulic System

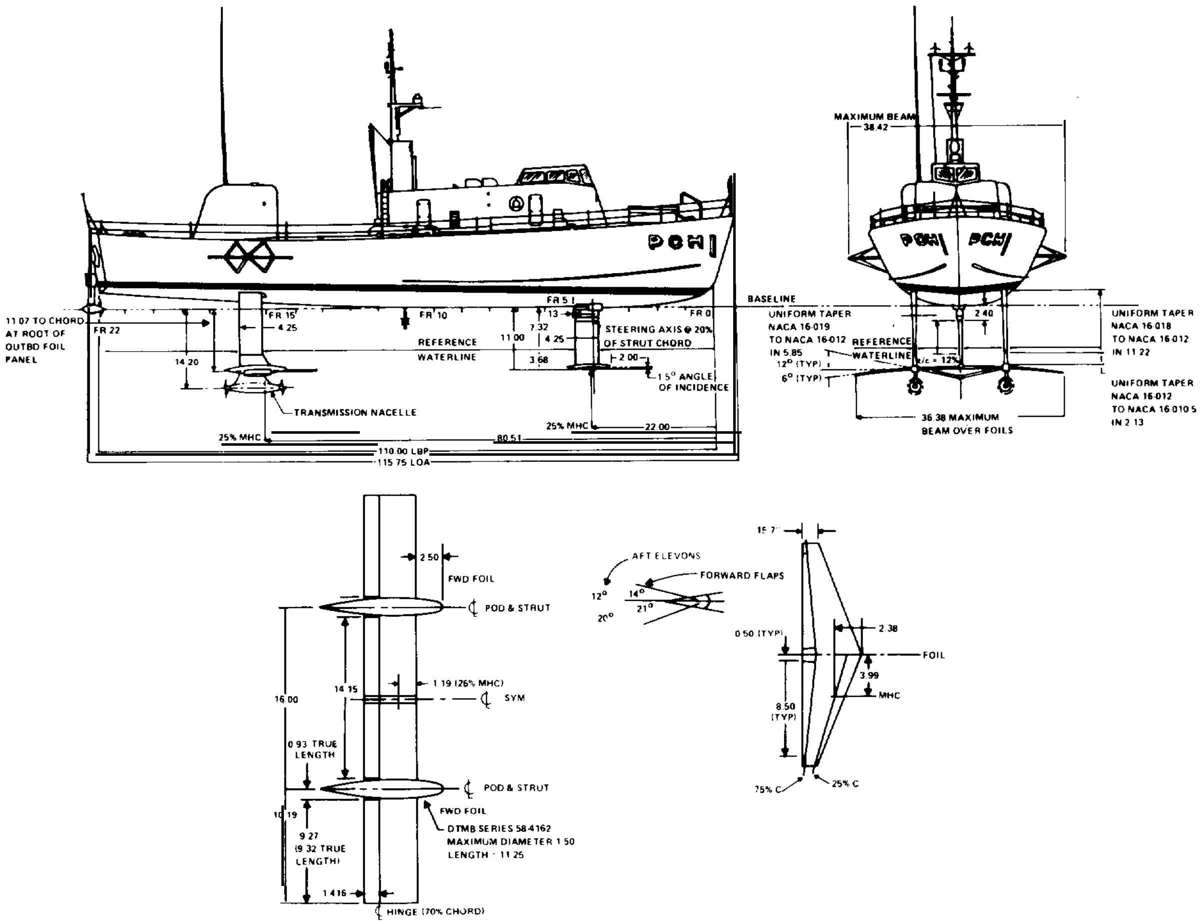
The original hydraulic system for the flight control included two axial piston pumps driven from the main turbines. The ship's service hydraulic system was supplied by two different pumps driven from a power takeoff on the prime mover for the ship's service generator. These ship's service pumps were old, were no longer being manufactured, and had been rebuilt many times. In MOD-I, all hydraulic pumps were replaced with one model including addition of a third pump to the two driven from the ship's service generator. This provided increased capability to perform a self-test on the autopilot system. Even though the original hydraulic system operated at 3,000 psi, the self-test hydraulic pump only operated up to 500 psi, making any such test of dubious value. The addition of the third pump allowed testing of the flight system at full operational pressures and flow rates.

Gears

Completely new gears were installed in the foilborne transmission system. Their pitch was increased, thereby providing greater tooth contact area and greater power handling capacity. The gears in the upper gear box were modified to provide "mirror-image" propeller rotation port and starboard, as shown in Figure (91). Previously, the two forward propellers rotated clockwise and the two aft propellers rotated counterclockwise. It had been concluded that this was a major cause of the steering bias which resulted in the ship always operating at a small but significant "crab" angle and turning differently to port than to starboard.

Propellers

One of the major problems that plagued PCH during the early years of operation was the short life of propellers for foilborne propulsion. As of November 1968, eighteen propellers had been manufactured for the craft, and sixteen of these had been installed at various times with varying degrees of success.



AFT FOIL		FORWARD FOIL	
w / s	1060 lbs/ft^2	W/S	1370 lbs/ft^2
S	172.85 ft^2	S	65.63 ft^2
AR	7.65	AR	6.1
b	36.38 ft	b	20.0 ft
C_R	4.75 ft	C_R	5.25 ft
C_T	4.75 ft	C_T	1.31 ft
λ	0.00	λ	0.25
MHC	4.75 ft	MHC	3.68 ft
tic	0.09	t/c	0.06
SWEEP $^C/4$	0”	SWEEP $^C/4$	15°
DIHEDRAL ANGLE	6” OUTBOARD 12” INBOARD	DIHEDRAL ANGLE	0”
% TOTAL FOIL AREA	72.46	% TOTAL FOIL AREA	27.52
TOTAL FLAP AREA	46.29 ft^2	TOTAL FLAP AREA	6.416 ft^2
FLAP CHORD / FOIL CHORD	0.3	FLAP CHORD / FOIL CHORD	0.25
SECTION	NACA 16-309	SECTION	NACA 16-309

Figure 89. PCH MOD-I Geometric Characteristics

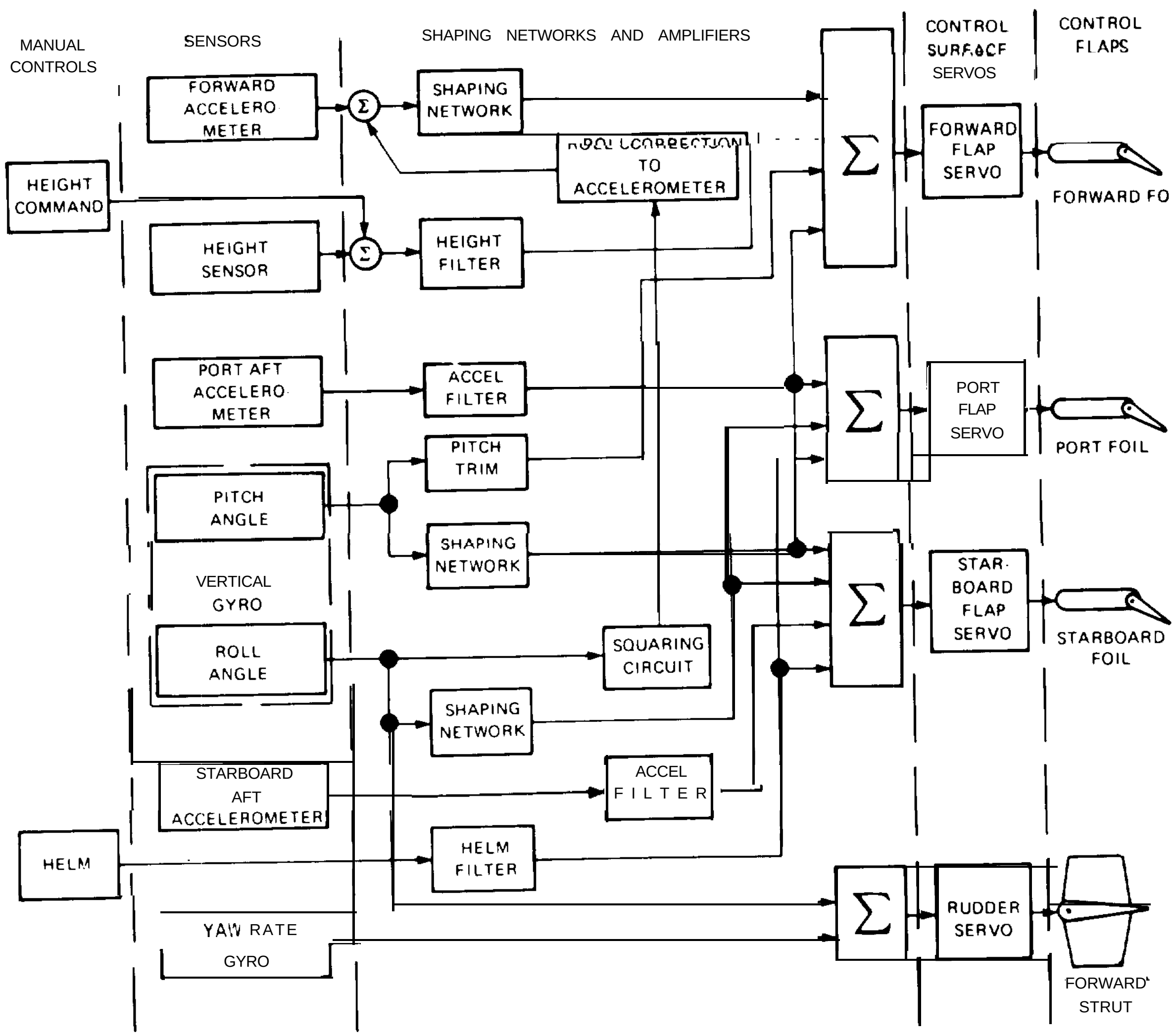


Figure 90. PCH MOD-I Autopilot Control System

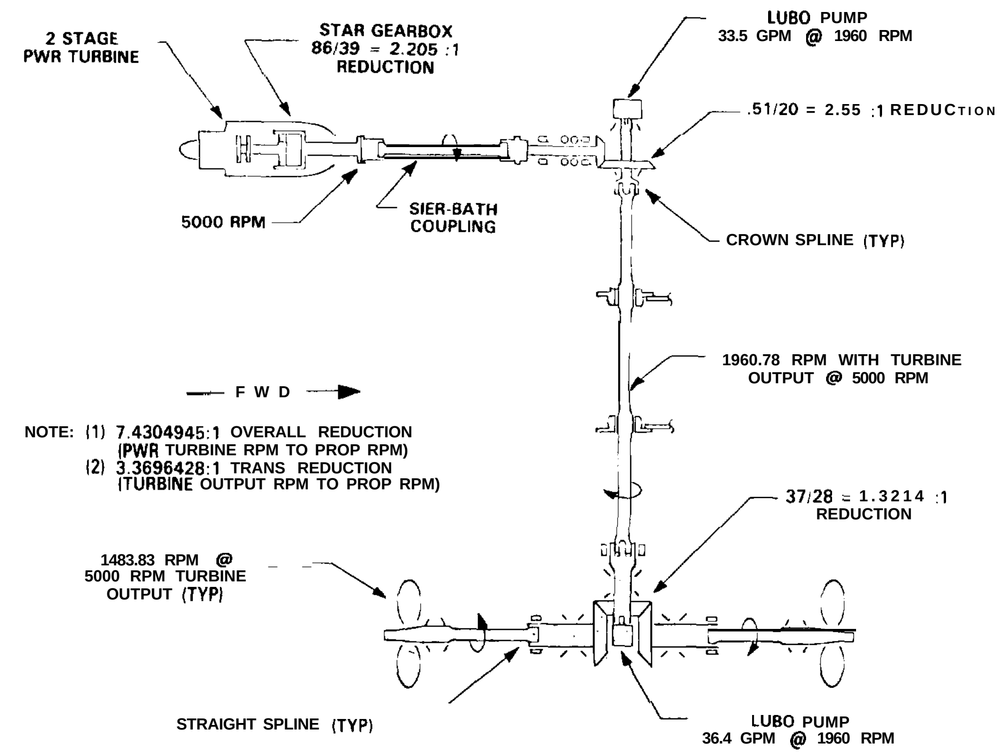


Figure 9 1 a. Starboard

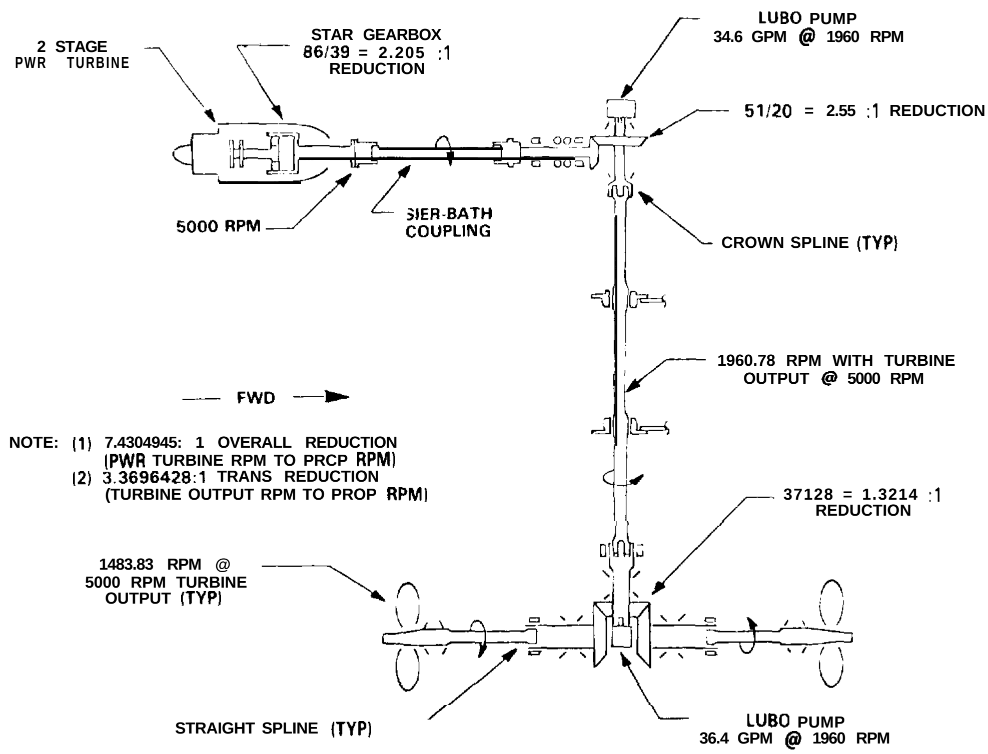


Figure 9 1 b. Port

Figure 9 1. PCH MOD-I Transmission Configuration

The original forward and aft propellers had three blades and were designed by the Propeller Branch, Code 644 of BuShips, under the direction of John Hill, the Branch Head. These designs were in accord with conventional practice for service propellers. Except for blade section camber corrections for flow curvature, the design procedure was based on lifting line theory and had proved successful in more conventional applications. The characteristics of these propellers had been evaluated by DTMB on a l&scale foil-equipped and powered model in a high-wing configuration, Reference 38. During these tests, stainless steel and aluminum models of the aft propellers had failed structurally. In addition, cavitation tests had revealed that significant cavitation developed at the foil/strut intersection of the high-wing configuration. As a result, the foil/pod design was modified to a mid-wing configuration and the blade thickness of the aft propellers was increased. In a later test series of this design, both forward and aft propellers showed significant cavitation at take-off conditions. The aft propellers also developed significant cavitation on the suction face of the blades when operating near the design point of 1,500 RPM.

Although this last series of model tests showed that propeller cavitation was likely to be a problem. the results were not available in time to make changes in propeller design without delaying manufacture of the full-scale propellers. As a result, the decision was made to continue with the existing S-blade design, recognizing that a later redesign might be required.

There were four forward and four aft 3-blade propellers available at **the** time of launching. At the end of the first contractor trials, which included only 2 hours and 28 minutes of foilborne operation, it was found that the aft propellers were damaged by both face **and** back cavitation. They also had bent tips and cracks at the hub leading edge juncture. The two spare aft propellers were installed after reworking the blade edge/hub junctures to relieve root stresses. During the following 2 hours and 39 minutes of foilborne operation, these aft propellers continued to suffer severe cavitation damage. In addition, the starboard aft propeller lost about 1/3rd of one blade at the tip leading edge. One forward propeller was also destroyed by structural damage during this period. The spare forward propellers were then installed along with the the original aft propellers which had been repaired. At this point, contractor trials were completed after accumulating an additional 20 minutes of foilborne time.

The first use of aft propellers with thickened blade sections was in January 1964. These were manufactured of manganese-nickel-bronze. After 24 hours and 28 minutes of foilborne operation, both required repair of cavitation damage on the face and back of all blades. They were replaced by SUPERSTON propellers which were used during the next 23 hours and 45 minutes of foilborne operation. At this point, they also required repair of both face and back damage due to cavitation erosion. It was also noted that the port aft propeller sustained heavier damage than the starboard one.

Loss of a second of the original 3-blade propellers occurred during July 1966 as a result of striking a submerged object. One blade was severely bent. It was replaced with one of the original spares.

The first attempt to use a j-blade propeller was in August 1966. A titanium propeller with 5 blades was installed on the port side forward and a nibral (nickel-bronze-aluminum) propeller of the same design was installed on the starboard side forward. Three-bladed bronze propellers were installed aft. The nibral forward propeller failed in about 2 minutes after craft take-off. One blade was bent forward near its tip and another was curled back almost 180-degrees near its tip. Failure was attributed to inadequate strength to withstand hydrodynamic forces. The titanium forward propeller failed after I hour and 7 minutes of foilborne operation. One blade was lost and another had a crack near the hub. Failure was determined to be the result of hydrogen embrittlement and stress corrosion cracking. This had been predicted by A. Wilner, an expert in metallurgy at DTMB where the propeller was manufactured. It may also be noted that machining of this titanium propeller from a single forging billet presented

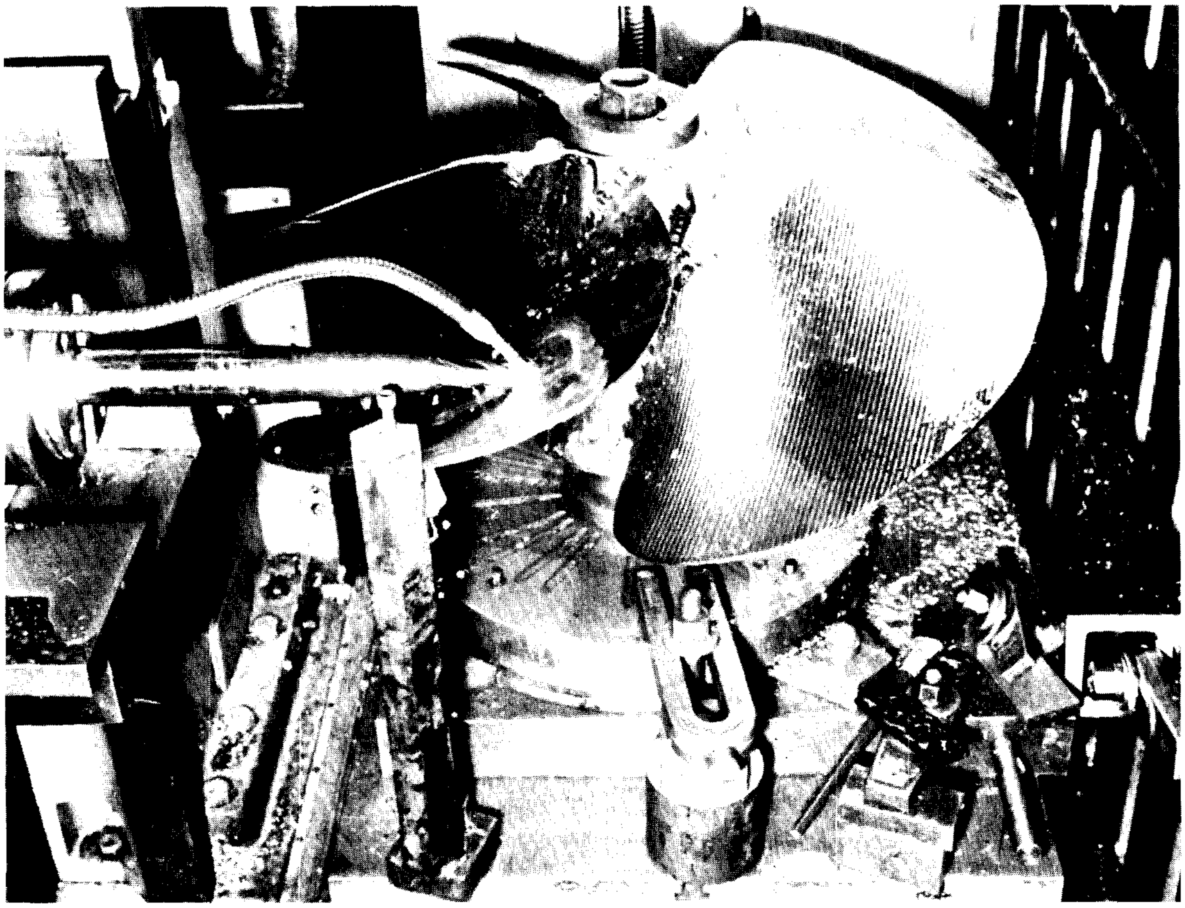


Figure 92. Titanium Propeller for PCH Being Machined at DTMB

quite a challenge. The forging was machined, Figure (92), with carboloy bits which were consumed at a high rate. It was said that they used all available bits within a 100-mile radius of Washington before the job was finished.

The first successful use of 5-blade propellers was during October 1967. These were of nibral and were operated foilborne for a total of 13 hours and 43 minutes before being replaced temporarily by 3-blade propellers during acoustic trials. They were reinstalled in January 1968 and ran for an additional 33 hours and 26 minutes of foilborne operation when removal was required due to damage from debris. Although during both periods of operation cavitation erosion damage continued to occur, it was much less pronounced than that with earlier designs.

During April 1968 the two SUPERSTON propellers were removed after 42 hours and 37 minutes of foilborne operation. The starboard propeller was found to be more heavily eroded than the one on the port side. However, neither had incurred any damage due to face cavitation. This was felt to be the result of limiting speeds to no more than 36 knots during most operations.

In another attempt to reduce cavitation damage, recessed areas were milled into the backs of the blades of two of the aft 3-blade manganese bronze propellers. Elastomeric inlays were cemented into the recesses, as shown in Figure (93). These propellers were installed on the craft in June 1968. After

Figure 93. Elastomeric Inlay in PCH 3-Blade Bronze Propeller

nine take-offs and a total of 1 hour and 43 minutes of foilborne operation, there were major failures in the inlays of both aft propellers.

This description of some of the problems with PCH propellers covers only the highlights up to the end of 1968. During this period. the difficulties which had been predicted by earlier model tests became a frustrating reality. It also became clear that the criticality of propeller manufacture and the effects of irregular inflow conditions were major factors to be considered in designing propellers for craft which operate at speeds in excess of 35 or 40 knots. It was only after the MOD-I conversion that propeller inflow conditions were improved so that erosion damage was reduced to manageable proportions. An important innovation during this early period did a great deal to ease the problem. This was a procedure, developed primarily by Chief Robinson of the HIGH POINT crew, whereby propellers could be removed and replaced underwater by divers in a short period of time. This saved many hours of drydocking time. It made possible the performance of routine inspection, maintenance, and repair of propellers, a practice still followed today.

Other Changes

During the refurbishment there were numerous other systems and components that were replaced or reworked. These included:

Inspection and painting of all void spaces.
Installation of a Halon fire extinguishing system in the machinery space.
Replacement of hydraulic starter on Solar turbine with an electric starter.
Replacement of radar navigation system and computer with digital system.
Modification of galley and mess deck.
Modification of 4 00-Hertz converters.
Installation of an integrated closed-circuit TV monitoring system.
Replacement of the high-pressure air compressor with electric drive type.
Rework of fuel system, frequency converters, and ventilation system.
Rework of flooding alarms, anchor handling system, and hullborne steering.
Rework of main propulsion disconnect couplings.
Installation of a new wave height measuring system.
Installation of ship lifting pads.

EXFOLIATION

At the beginning of MOD-I, Hing Dear, from the Navy's Mare Island Paint Laboratory, made an inspection of the voids and fuel tank of the ship, Reference 67. About a year prior to his inspection, the ship's voids had been completely painted. The condition of the voids had been periodically monitored and blistering of the paint had been observed. Up to this point. however, it had not been established that the problem was the result of a poor paint system. During the MOD-I inspection, no signs of corrosion were noted, bur the paint blistering had increased. Later, a study instituted by the Paint Laboratory led to recommendations for a change in the metal preparation procedure and an improved paint system for void preservation.

In the case of the fuel tank, a close. examination of the uncoated aluminum revealed exfoliation on the bottom plates of the center section. It was in the form of blisters rather than a delamination. Blistering of the metal was also observed on five of the inboard strakes in the port and starboard sections. Some minor blistering was observed on the keelson, but none on the stringers. Since the ship had been operating for several years with only a minor loss of metal in the fuel tank, it was recommended that grinding of the tank to remove exfoliation and applying tank coatings be given a low priority.

On 27 and 28 September. Gerald Bohm, a chemist from the Paint Laboratory, inspected the sandblasted underwater hull. He found severe exfoliation of a 7-foot by 27-foot hull plate on the port side of the keel just aft of the plate which had been installed earlier to permanently close the sonar well. There were areas which showed severe delamination which, in some cases, had led to loss of half the plate thickness, Other hull plates which had been replaced in previous drydockings showed no signs of corrosion or exfoliation, Severe exfoliation was also found in the lower four feet of the forward interior wall of both the port and starboard strut trunks. There, extensive peeling of the leaves of exfoliating aluminum was observed.

It was recommended that the large exfoliated plate be replaced and the affected areas of the strut trunks be ground and clad-welded where plate thickness was inadequate.

It was known at that time that aluminum alloy 5456 (H321), which had been used in the construction of HIGH POINT. was very prone to exfoliating corrosion. Most of the exfoliation had occured in the unpainted voids, however, paint did not appear to prevent it in the case of highly susceptible bottom plates. This could be the result of variations in plate batches.

For future aluminum hull fabrication, it was recommended that heat treats H 116 and H117 be used in place of H32 1. Also. it was noted that a test had been developed to grade the susceptibility of aluminum plates to exfoliation.

STRAIN GAUGES

Based on earlier data obtained with HIGH POINT in the MOD-O configuration, it was verified that strut/foil design loads criteria adequately defined the magnitude of the loads. However, they were not well related to the operating conditions which produced the loads. Furthermore, there was a need for additional data on loads associated with foil broach and extreme maneuvers induced by the helmsman. In light of this, a program of loads research was planned for the MOD-I configuration and. during the layup, strain gauges and video cameras were installed as shown in Figure (94), taken from Reference 68. These gauges were calibrated by applying point loads at two chordwise and several spanwise locations. (Unfortunately, except for those in the forward strut, many of the gauges failed prior to the MOD-I calm water trials.)

In order to correlate hydrodynamic conditions of flow during maneuvers, video cameras were mounted on each side forward and on the port side aft so that observations could be made of the flow. The video tape had a time code which made possible the correlation of strain data with flow anomalies.

ANTI-CLIMAX

HIGH POINT was returned to Lake Washington in its new configuration on 10 February 1973. After some turning tests, a hullborne transit was made to Pier 9 1 in Seattle. Highspeed hullborne tests were then conducted by Boeing, followed by initiation of foilborne testing on 19 March. Foilborne tests were immediately terminated due to a problem in the foilborne transmission. This made it necessary to return to Renton where, on 22 March, the ship was again hauled out. On opening and inspecting the faulty nacelle gear box, part of the cause of the problem immediately became apparent. Someone had left a red cleaning rag inside and this had been chewed up by the gears with the inevitable result. Boeing's face, needless to say. was as red as the rag. It was also found that the bolts in the nacelles were too short, not according to specification, and were incorrectly torqued. This allowed salt water to leak into the gear boxes.

It required another 52 days to effect repairs and make additional modifications. This included installation of wetted roller bearings in the steerable forward strut, installation of launcher foundations for the HARPOON missile, and overhaul of the outdrive which was required due to damage of the gears by having allowed the propeller to watermill. The ship was again launched on 18 May 1973. The first foilborne flight of PCH MOD-I finally took place on 2 1 May and lasted for 15 minutes. Boeing then continued verification trials with HIGH POINT'S crew operating the ship. After a third brief drydocking. the ship was returned to the Navy at PSNS on 20 June 1973.

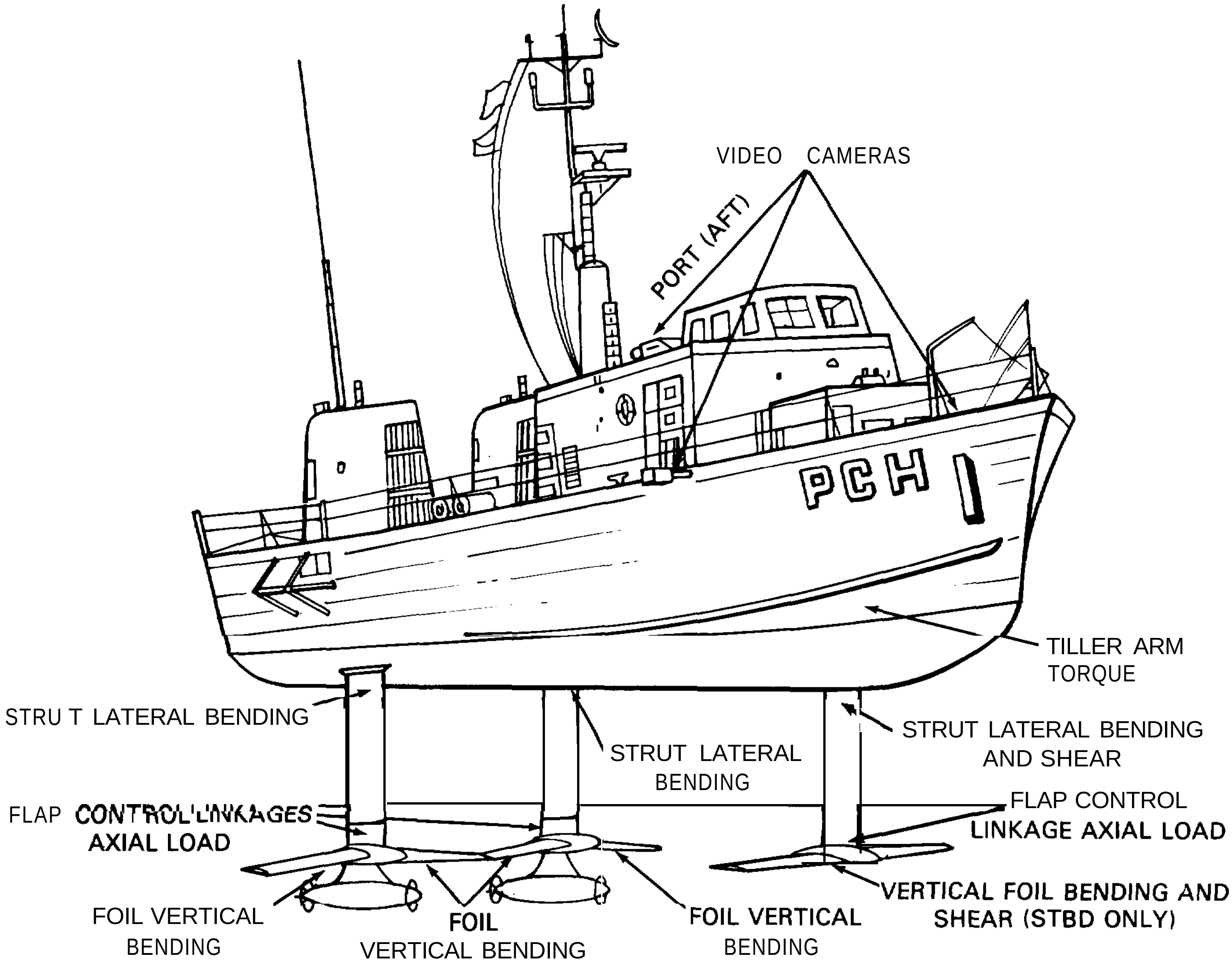


Figure 94. Location of PCH MOD-I Strain Gauges and Video Cameras

CHAPTER 10

Mission Trials 73-75

After completion of the MOD-I conversion, the latter half of 1973 was first devoted to retraining of the crew after the long RAV and debugging some minor problems with the new ship configuration. Also, a new perfornlance baseline was established to determine the effects of the configuration changes. The crew was amazed at the improvement in performance. The ship could go foilborne with ease and accelerate up to 48 knots with none of the vibration that had been characteristic of earlier operations. Furthermore, she could turn foilborne reliably at rates up to 6 or 8 deg./sec. with no evidence of earlier erratic steering behavior. After establishing the ship's new performance baseline attention was then turned to focus on additional mission trials to further demonstrate the effectiveness of hydrofoil ships as Fleet combatants.

PENAIDS TRIALS

On 26 June 1973, a conference was held at HYSTU to review plans for conducting an evaluation of various hydrofoil ship penetration aids (PENAIDS). These are devices and procedures to prevent track or break lock of hostile fire control radars and cruise missile sensors. These trials plans had been drawn up by Dave Ramey, of NELC, and Dale Beresford, a consultant to NELC and former Chief Quartermaster on PCH. Attendees at the conference included representatives of NELC. the Naval Research Laboratory, the Naval Air Station Whidbey Island, USS BRIDGET, USS LIND, the Hydrofoil Program Office, and Boeing.

The first series of trials was held during the third week of July, and were under the technical direction of C. Frank Sedivi from NAVELEX PME- 198. The Canadian Naval base at Esquimalt was used as the base of operations. The objective of the trials was to determine the effectiveness of chaff as a decoy against gun fire control radars using the new rapid-blooming off-board chaff (RBOC) launcher installed

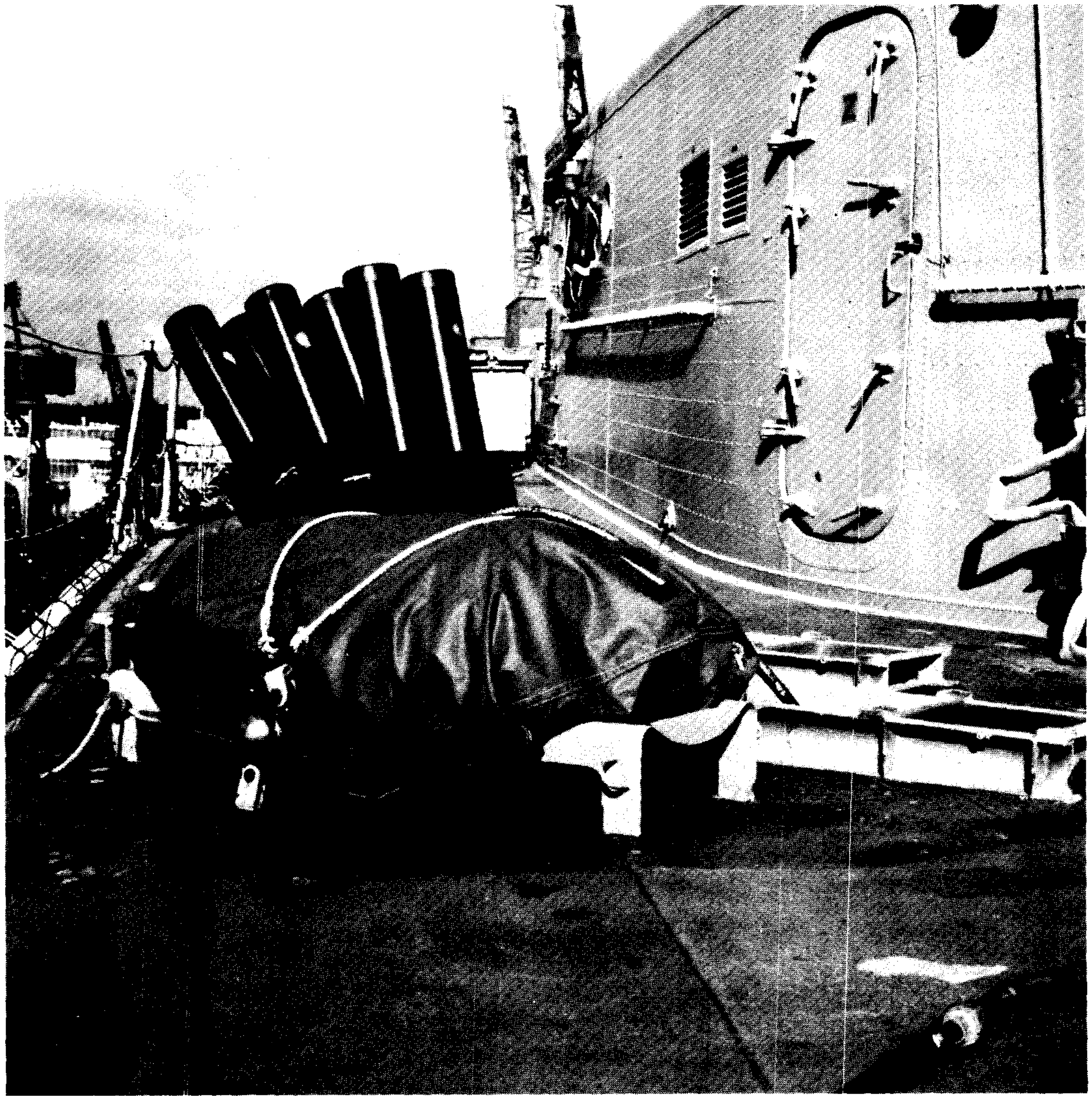


Figure 95. PCH Covered Torpedo Tubes and Chaff (RBOC) Launcher

on PCH, Figure (95). The chaff cloud when launched presented a radar reflective decoy larger than the radar cross-section of the ship. The surface combatants BRIDGET and LIND participated in these tests as the hostile force. A second objective of the trials was to evaluate the ability of electronic countermeasure (ECM) gear, installed on PCH, to prevent or break track of fire control radars by noise jamming. In a third series of tests, HIGH POINT conducted various maneuvers designed to defeat enemy weapons systems. Maneuvers included crash landings, hard turns, and sudden increases in speed. Finally, a series of tests were made in which noise jamming, chaff, and maneuvers were employed in various combinations.

Another series of trials was conducted the following week in the Strait of Juan de Fuca between Whidbey Island and Victoria. The objective was to determine the effectiveness of the same PENAIDS in providing anti-ship missile defense (ASMD) for hydrofoils. This also included developing design criteria

Figure 96. PCH Change of Command, 15 August 1973

for the PHM hydrofoil ships which were scheduled to be outfitted with a pair of six-barrel RBOC launchers.

In this last series of trials, C. Frank Sedivi was again the technical director and was assisted by William Schaefer from NRL and Dave Ramey and Dale Beresford from NELC. Aircraft participating in the trial included an NRL EC-12 1, an EA-3B from FEWSG, and an A-3 from Whidbey Island Naval Air Station.

These trials were of a very preliminary nature and the results were classified. It may be stated, however, that they did demonstrate the effectiveness of these PENAIDS in protecting hydrofoils against missile attack and gunfire.

HARPOON FIRING

On 15 August 1973, LT Jim Orvis relieved LT Joel Roberts as OIC of HIGH POINT. Figure (96) shows Bob Johnston, the Hydrofoil Program Technical Director making a few appropriate remarks at the change-of-command ceremony. Also present on the dias are, from left to right, BMC Mitte, LT Roberts, LT Orvis, and LCDR Hank Schmidt, OIC of HYSTU.

During the second week of August 1973, HIGH POINT began dockside installation of a bank of four canister launchers for the HARPOON missile. This missile was in production at McDonnell Douglas Astronautics in St. Louis, MO, under contract to the Naval Air Systems Command. It was designed for launching from submarines, surface ships, and aircraft, and was the missile proposed for installation on the U.S. variant of the NATO PHM. The objective of the tests on HIGH POINT was to identify any problems that might exist in employing the missile on a hydrofoil ship. Of particular interest was the effect of the noise on the height sensor. Earlier 40 MM gunfire trials with the PCH had shown that the sonic height sensor was momentarily subjected to spurious inputs due to the noise of the gun. This had led to consideration of replacing the sonic sensor with a radar version.

After a number of dry runs and familiarization exercises during November 1973, HIGH POINT took aboard a HARPOON canister blast test vehicle (CBTV) at Bangor, WA. On 12 December 1973, the ship made a transit to the joint U.S. and Canadian test range at Nanoose, British Columbia to conduct the firing test, References ‘70 and 7 1.

In preparation for the test, HIGH POINT had installed AHV-6 and AHV-8 radar height sensors which employed a swept frequency radar with a servo-driven tracking oscillator. ‘These units transmitted in the 40 GHz range and provided an analog height signal. The AHV-8 unit was a repackaged version of the AHV-6 unit loaned by the Sunstrand Corporation to demonstrate its capabilities. The original AHV-6 unit was fully qualified and was in use in the French EXOCET missile and the German F-10-i aircraft as well as in other applications.

The radar height sensors were installed to permit comparison of their resistance to interference with that of the sonic units, Reference 72. Up to this point, the PCH had used dual sonic sensors mounted port and starboard at the deck edge near the bow. These units operated on the principle of echo-ranging, which limited their height sampling rate to about 10 per second. For these tests, Boeing had introduced a circuit modification to sense noise levels in the height sensor return. The circuit was designed to hold the height signal sensed just prior to any noise and maintain that level until the noise diminished below a preset threshold. Boeing proposed to employ this design in the PHM.

On 14 December 1973, with smooth sea conditions prevailing. the first HARPOON CBTV was fired from HIGH POINT’s after deck with the ship in straight and level flight at a speed of 38 knots. There was a wind of about 20 knots at a direction of 033 degrees. The launcher was elevated at an angle of 30 degrees, and the firing was at 345 degrees relative to the ship’s heading. The automatic control system (ACS) height signal was provided by the normal ship sonic sensors. The sonic blanking circuit and the radar units were monitored and their signals recorded. Neither radar unit was affected by the launch. The ship’s sonic sensors gave early echo returns indicating to the ACS that the ship was closer to the water than the ordered flying height. In correcting for this false signal. the ACS ordered the ship to increase its flying height, which it did. To prevent the forward foil from broaching, the helmsman immediately commanded an emergency landing. All this occurred in a matter of seconds. The PHM modified circuit had sensed the excessive noise level and held the height signal sensed just prior to detecting the noise. It held this level for about two seconds when the noise subsided below the threshold level. However, by this time the helmsman had taken charge. Otherwise, the test firing was uneventful and considered to have been a complete success.

On 12 January, HIGH POINT again took a HARPOON CBTV aboard at Bangor and the following day made the transit back to Nanoose. On 14 January 1974, again with calm sea conditions, a second

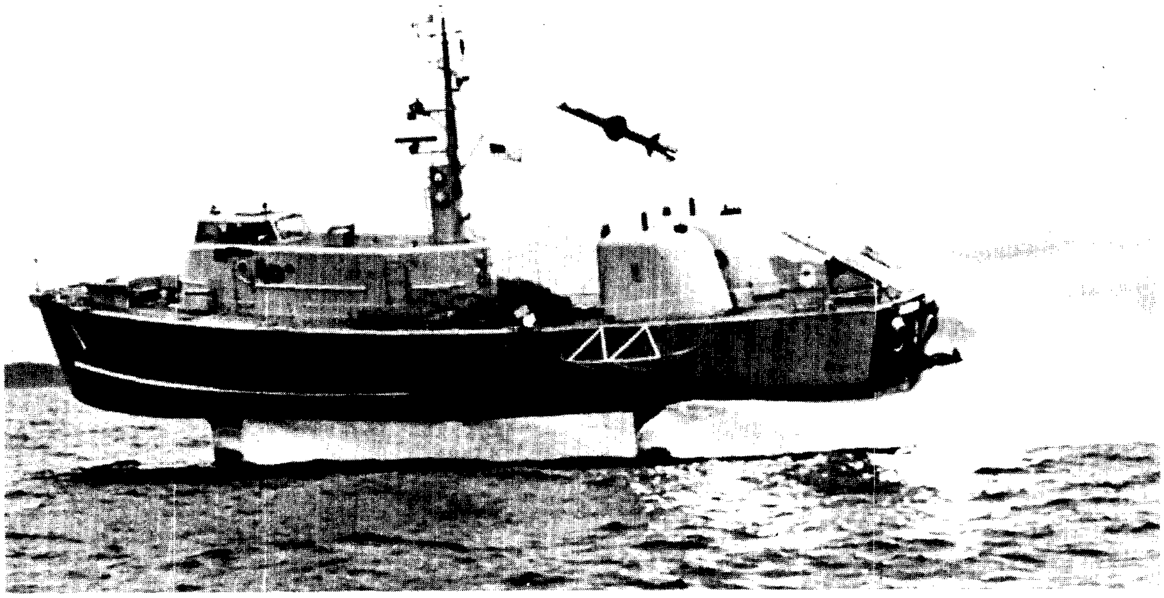


Figure 97. Harpoon Missile Firing from PCH

missile was launched. This time the ship was in a port turn at a turn rate of 4.2 degrees per second and a speed of 39.2 knots. There was about 35 knots of wind at 345 degrees. The launcher was at an elevation of 30 degrees and the launch was at 345 degrees relative to the ship's heading.

For this second test, the AHV-6 radar unit was in control of the ship's height. The signals of the sonic sensors were monitored and recorded, but Boeing had removed the PHM blanking modification from the circuitry. All systems performed as predicted and the radar height sensors were unaffected by the launch. The port and starboard sonic sensors again exhibited early return signals and indicated a decreasing flying height which actually did not occur. Again the test was judged to be fully successful.

Figure (97) shows the second HARPOON shot immediately after launch. This photograph later appeared on the cover of the 25 Febuary 1974 issue of Aviation Week Magazine. The tests were performed under the technical direction of the Naval Ship Weapons Systems Engineering Station at Port Hueneme, CA. They successfully demonstrated the capability to fire the HARPOON from a foilborne hydrofoil craft, an important step in the design of the PHM.

SCFCS TRIALS

HIGH POINT conducted tests of a Small Craft Fire Control System (SCFCS) during June 1974, Reference 73. This system was designed by Hughes Aircraft Company to control small caliber rapid fire weapons. It was developed under the Navy's Advanced Prototyping Program and later evolved into the Versatile Electra-Optical System (VEOS) for small craft fire control.

The SCFCS consisted of a pulsed laser for ranging, a TV camera for daytime visual monitoring, a Forward-Looking Infrared (FLIR) visual aid for nighttime viewing, a computer for calculating gun orders,

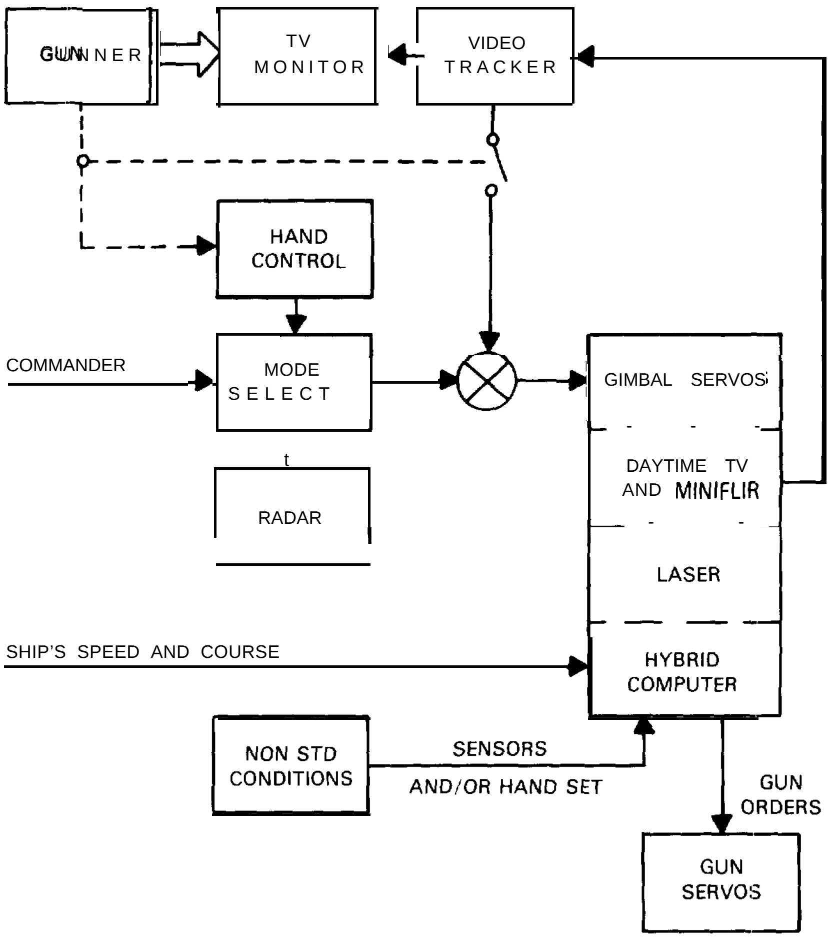


Figure 98. Small Craft Fire Control System (SCFCS) Block Diagram

and a control/display unit for manual video tracking and control. The system block diagram is shown in Figure (98). The rangefinder was a 1.06 micron neodymium laser, pulsed at 10 pulses per second. Daytime visual monitoring and tracking was done with the TV camera which was equipped with an automatically controlled zoom lens. The horizontal field of view could be varied from 23 to 2.3 degrees. Night observations were made with the FLIR which was sensitive to infrared radiation in the 8. 12 micron region of the spectrum. The FLIR optical system had two fields of view; one wide (4.8 x 10.8 degrees). used for search and acquisition; and one narrow (1.6 x 3.6 degrees), used for tracking. The desired field of view was selected by switching a lens in and out of the optical path. The computer was a hybrid with both analog and digital circuitry.

The system was installed aboard HIGH POINT at PSNS on 11 and 12 June. The 62 j-lb director was mounted on an aluminum plate bolted to the roof of the bridge. The control and instrumentation consoles were located in the ship instrumentation space. An argon gas bottle with a valve and filter was located in an alcove of the CIC space. Gas was fed to the FLIR in the director. In addition to a TV monitor in the control console, monitors were also located in CIC and on the bridge. Figure (99).

Tests were conducted dockside on 13 June during which the system was boresighted, laser safety cutouts and interlocks were verified, and effects of the ship's RF devices were investigated. Finally,

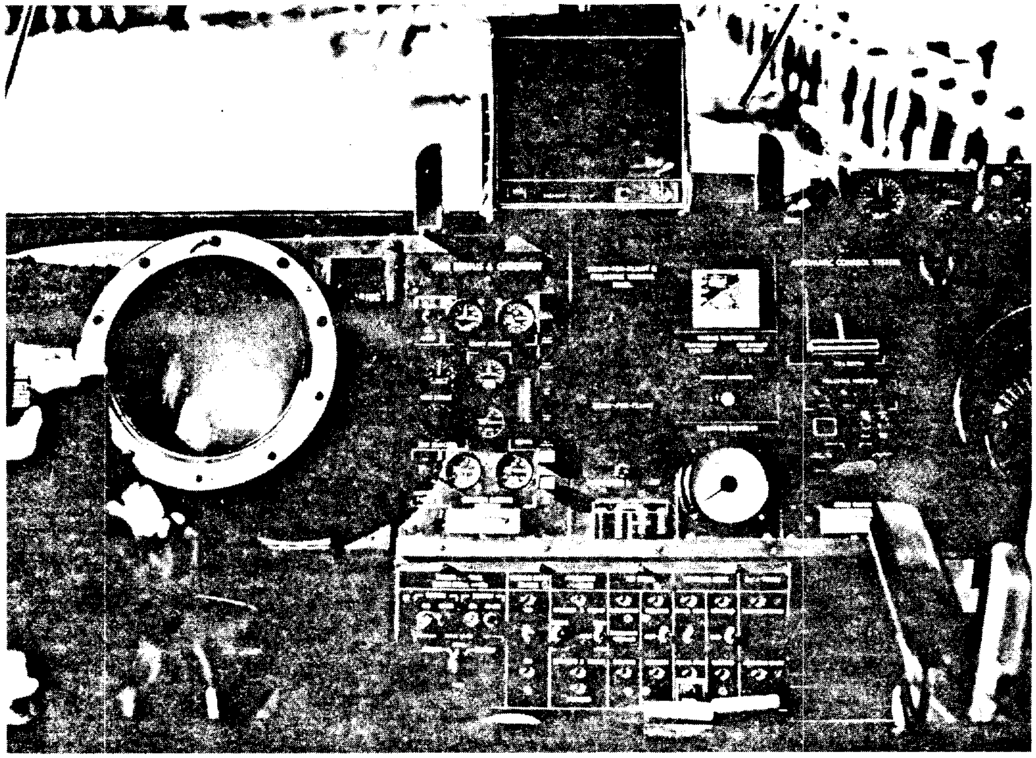


Figure 99. SCFCS Monitor on PCH Bridge

a static test was made in Puget Sound Operating Area 6713 to verify boresighting of the sensors and provide practice time for the operating team. In this test a helicopter began hovering at a 500-foot altitude and a 2000-yard slant range from the stationary HIGH POINT, Figure (100). The SCFCS operator attempted to detect and acquire the target using the TV sensor, and then automatically track it. This procedure was repeated using the FLIR sensor. After each event, the slant range was increased by 2000 yards until the helicopter was no longer detectable.

Foilborne testing began on 17 June, again in Op Area 6713. Tests were scheduled day and night against air and surface targets. An A-4C aircraft was used for the air tests. It was augmented with a pod-mounted Luneberg lens radar reflector which gave it an effective x-band radar cross section of 25 square meters. This was necessary in order to increase the range at which HIGH POINT's navigational radar could detect the aircraft. Each test event consisted of about 15 runs or passes at the ship. Runs were both radial direct and maneuvering. A total of 117 daytime passes were completed with the A-4C at speeds of 300 to 450 knots and altitudes of 200 to 1000 feet. During maneuvering runs, the aircraft was limited to a maximum of 3g turns because of structural limitations of the pod-mounted reflector. HIGH POINT maintained a straight course at 40 to 45 knots during all runs.

During transits to and from the op area, navigation and surveillance exercises were conducted informally. At the direction of the OIC, the SCFCS operator would slew the director to a designated landmark or other navigational reference point, lock on, and make a determination of range and bearing. The OIC was provided with "target" imagery by means of the TV monitor on the bridge. The SCFCS was also employed for surveillance using various targets of opportunity including surface craft and commercial aircraft.

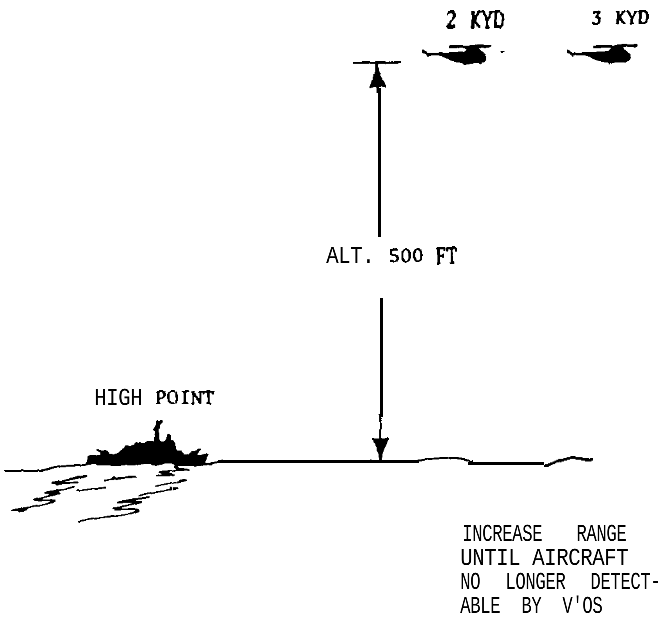


Figure 100. SCFCS Helicopter Test Configuration

An obstacle avoidance test was conducted dockside at night using a tugboat towing a line to which was attached a standard buoy, a spar buoy, and a log. The tug started at a distance of about 1500 yards from HIGH POINT and maneuvered the string of objects in an "S" pattern, ever closer to the ship. Periodically the tug stopped to allow observers to sight on the targets visually. Ranges were determined using HIGH POINT's Pathfinder radar. At each range five observers described the scene using the FLIR display. Since the test was run at night, only the FLIR sensor was used for observing the targets.

On both 17 and 18 June, HIGH POINT operated for about 8 hours on the foils. Even so, only a portion of the scheduled air tests and none of the surface tests were completed. This was somewhat ironic since part of the test program involved determining the capability to avoid collision with obstacles during foilborne operations. On 25 June, while conducting SCFCS foilborne trials, HIGH POINT struck a large log at a speed of 42 knots and a forward foil depth of nine feet. The log was of unknown length with a diameter estimated to be about 3 feet; a typical Puget Sound "deadhead". It was floating nearly submerged in almost a vertical orientation with no more than a few inches protruding above the water surface. Later inspection, after the ship had returned to port, indicated that the hit had been about 2 feet inboard of the port foil tip. It then must have slid off the forward foil and hit the aft port foil pod and salt water inlet pipe. The part of the fiberglass pod forward of the strut was completely destroyed and the inlet pipe was bent to 90 degrees. The forward steerable strut was jammed at 14 degrees to port and the positive stop had been sheared.

The ship was drydocked on 27 June for repairs. The shipyard manufactured and installed a new pod fairing and repaired the water inlet pipe. They also welded a 6-inch crack and replaced the rotatable strut stop. A spare hydraulic actuator was on hand and used by the crew to replace the one damaged on the forward strut. Repairs and other maintenance items took about a month in drydock and no time was available for further tests prior to the next scheduled deployment of the ship to Southern California. As a result, further testing of the SCFCS was cancelled. The results that had been obtained were, however, of considerable value in further development of the VEOS, Reference 74.

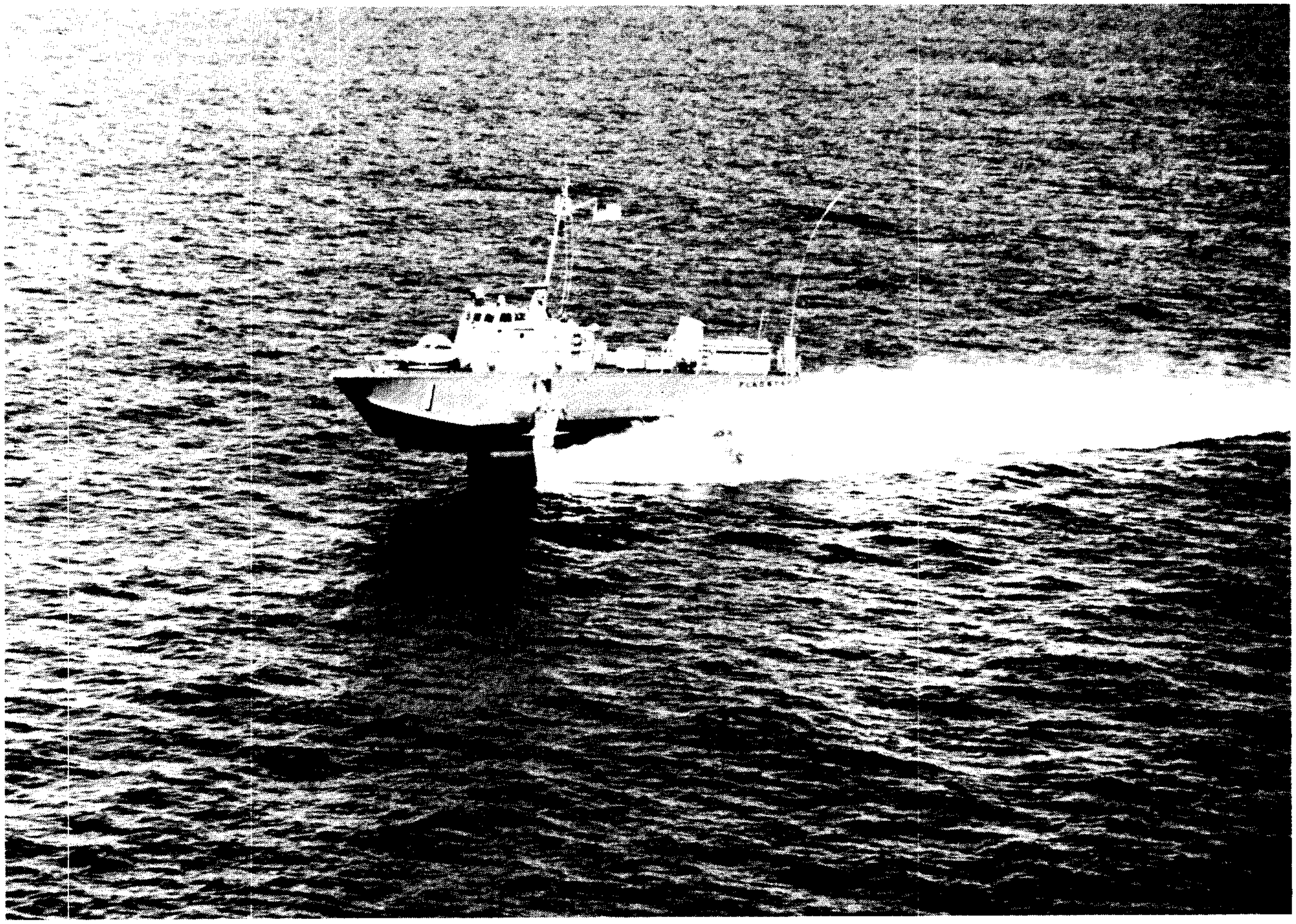


Figure 101. Grumman-Built Hydrofoil Gunboat, FLAGSTAFF (PGH-1)

SOCAL-74 DEPLOYMENT

On 2 August 1974, HIGH POINT departed Bremerton for the second extended deployment to San Diego, CA. The ship was to be under the operational control of COMCRUDESPAC with technical control by the Naval Electronics Laboratory Center in San Diego. The objectives of the deployment were to demonstrate to Fleet observers the unique capabilities of hydrofoils and. in coordination with the Grumman-built 67-ton hydrofoil gunboat FLAGSTAFF (PGH-l), Figure (101), to assist in developing preliminary tactical doctrine for the PHM hydrofoil missile ships being constructed by Boeing.

In order to increase unrefueled range during the transit, a 2, 500-gallon rubber fuel bladder was firmly anchored to the deck of PCH. This was intended to avoid earlier problems of getting clean JP-5 fuel at small West coast ports, provide a range capability more comparable to the PHM, and permit a more rapid transit to San Diego. (The use of this bladder proved quite satisfactory and it presented no fuel transfer problems. With it aboard, the maximum displacement of the ship was increased to 14 1 tons.)

Three hours out of Bremerton the navigation system failed and from that point for the next 2500 nm HIGH POINT navigated by estimating ranges using the range rings on the master radar. The transit to Crescent City, CA, was made in about 12-1/2 foilborne hours, but the plan for continuing this rapid transit was again rudely interrupted by problems with the rotatable forward strut steering system. As a result, the ship did not get underway from Crescent City until 12 August, arriving in San Francisco after 7 hours foilborne. The following day, after 7-1/2 hours on the foils they arrived at Port Hueneme. The final leg to San Diego was completed in 3-1/2 foilborne hours on 14 August.

HIGH POINT joined FLAGSTAFF in FLEETEX 3-74 on 19, 20, and 21 August, Reference 75. They explored dual hydrofoil tactics and carried out other assigned missions with Fleet units. For these exercises, both ships were outfitted with additional surveillance, communication, and countermeasure equipment. Even so, a number of communications problems developed during the course of operations. None were hydrofoil unique, but were basically the result of a lack of equipment routinely supplied to Fleet units. For example, HIGH POINT lacked a teletype (TTY) system which is a necessity in order to remain abreast of the latest changes in operational orders.

Both hydrofoils conducted surveillance missions utilizing both active and passive (ESM) methods of search, localization, and tracking. The ESM operator on FLAGSTAFF was unable to keep up with information provided by the installed automatic ESM equipment. However. both ships were able to search large ocean areas and localize and track targets with the ESM packages. The large number of ships in the area which were not involved in the exercise also caused considerable confusion.

FLAGSTAFF's lack of adequate navigational equipment reduced the accuracy and effectiveness of surveillance when they were operating out of sight of land. Accurate positioning and targeting information could not be provided by the ship, however, Task Group movements, disposition, and operations were successfully relayed.

The forward-looking infrared (FLIR) visual aid built by Texas Instruments and installed on HIGH POINT was extremely valuable in contact identification and piloting in restrictive waters at night. The operators used it to verify buoys, identify other ships and boats, and scan the pier area during night dockings. The capability to passively identify targets at night was essential to success of the operation.

HIGH POINT and FLAGSTAFF conducted simulated attacks on high-value targets during periods of type training as well as cold and hot war phases of the exercise. Attacks were conducted using various combinations of passive ESM cross bearings, active sensor targeting information, and coordination with other surface and air units. It was found that, as hydrofoil speeds increased over 35 knots. manual plotting of multiple contacts became almost impossible.

HIGH POINT conducted alongside refueling from the destroyer USS AGERHOLM using onboard helicopter m-flight refueling (HIFR) equipment. FLAGSTAFF, with a conventional rather than canard strut/foil configuration, conducted a simulated refueling astern of the destroyer USS STEIN. The destroyer towed the hydrofoil at speeds up to 8 knots with a firehose passed to simulate a refueling rig since they had an insufficient length of HIFR hose.

Participation of HIGH POINT in FLEETEX 3-74 was limited by their five-day late arrival and various materiel problems. Their planned participation in COMPTUEX 3-74 was cancelled, although FLAGSTAFF was able to meet most of the commitments. From 21 August until 7 September, it was necessary to make repairs to the disconnect couplings and the pod fairings. Following this, after a few more VIP demonstrations, the ship departed San Diego and made a transit to the Long Beach Naval Shipyard. There, from 17-24 September, it was drydocked for repairs to the strut/foil coatings. On 17 September, OIC LT Jim Orvis received the following message from COMCRUDESPAC:

UPON COMPLETION OF YOUR EMPLOYMENT WITH COMCRUDESPAC I EXTEND A SINCERE WELL DONE TO YOU AND THE MEN OF HIGH POINT FOR THE PROFESSIONAL MANNER IN WHICH HIGH POINT PERFORMED DURING THE HYDROFOIL FAMILIARIZATION PERIOD. ADDITIONALLY YOUR PARTICIPATION IN THE FLEETEX 3-74 FOR THE PURPOSE OF DEVELOPMENT OF TAC D&E FOR THE FOLLOW-ON l?HM'S HAS PROVIDED MEANINGFUL DATA WHICH WILL BE OF SUBSTANTIAL ASSISTANCE IN PLANNING FOR OUTFITTING, EMPLOYMENT, AND SUCCESS OF THE PHM PROGRAM. A HEARTY WELL DONE TO ALL ONBOARD HIGH POINT.

After making performance checks in the Long Beach area, on 25 September HIGH POINT got underway for San Francisco, their second port on the voyage home. This was to be a most eventful day.

THE COHO-II RESCUE

At 1610 on 25 September, enroute from Long Beach to San Francisco, HIGH POINT picked up a distress call from the commercial fishing vessel DUNDEE to the Coast Guard Station at Monterey, Reference 76. DUNDEE reported that the fishing vessel COHO-II was taking water and in need of assistance. During the next several minutes, additional calls from DUNDEE indicated that COHO-II was in immediate danger of sinking unless assistance was forthcoming quickly. After confirming their position, noting their remaining burnable fuel, and verifying COHO-II's position, HIGH POINT contacted the Monterey USCG Station. They gave their position and estimated time to arrive on scene and offered to assist. The answer was affirmative and, at 1618, they altered course and made for COHO-II at 43 knots. They arrived on scene at 1654. By this time, there were some 30 other boats standing by and observing, so flares were dropped by a USCG HC-130 aircraft circling overhead to assist in their location of the stricken vessel. Communications were established on VHF channel 16.

As soon as HIGH POINT landed, pumps were rigged and an approach on COHO-II was initiated. As seen in Figure (102), she was listing about 35-40 degrees to port and was well down by the bow. Her foredeck was awash with the port gunwale submerged. The engine room and forward spaces were completely flooded. A swell of 2 to 4-foot was running. Fortunately, there were few waves. COHO-II's Captain had transferred earlier to another fishing vessel in the vicinity and the crew were in a skiff nearby. There were two pumps in the skiff which had been dropped by the Coast Guard aircraft. At about 1712, HIGH POINT's port bow was brought alongside COHO-II. Figure (103) shows Dick Dougan, of Boeing, working with LT Jim Orvis, HIGH POINT's OIC, as they put a fender between the two vessels. Two of the ship's divers, in wet suits and snorkel gear, had previously boarded in order to place suction hoses and a submersible pump in the flooded spaces and to determine the extent of the damage. About 15 minutes later, the Seattle-based fishing vessel RED BARON, carrying her own pump, made up to the port side of COHO-II. This countered the effect of the swell and provided an additional platform for the pumps. Altogether, one P-250, one electric submersible, one eductor (fed by HIGH POINT's primary fire pump), and three USCG portable pumps were used to de-water the vessel. All spaces, including the bait tanks, were pumped out to achieve maximum buoyancy.

During pumping operations, the HC-130 dropped inflatable life rafts and one additional pump to further assist in the salvage. The rafts were to be inflated in COHO-II's bilges to provide additional floatation. By this time, however, the vessel had begun to rise and the rafts were not used. The cause of the flooding was determined by HIGH POINT's engineers and the COHO-II crew to be a 2-1/2 inch salt water hose in the bait tank circulating system which had blown off a fitting. This was repaired by the COHO-II crew using a length of hose and a plug furnished by HIGH POINT. Pumping was secured at about 1838. At 1845, HIGH POINT continued her transit to San Francisco, arriving at Treasure Island

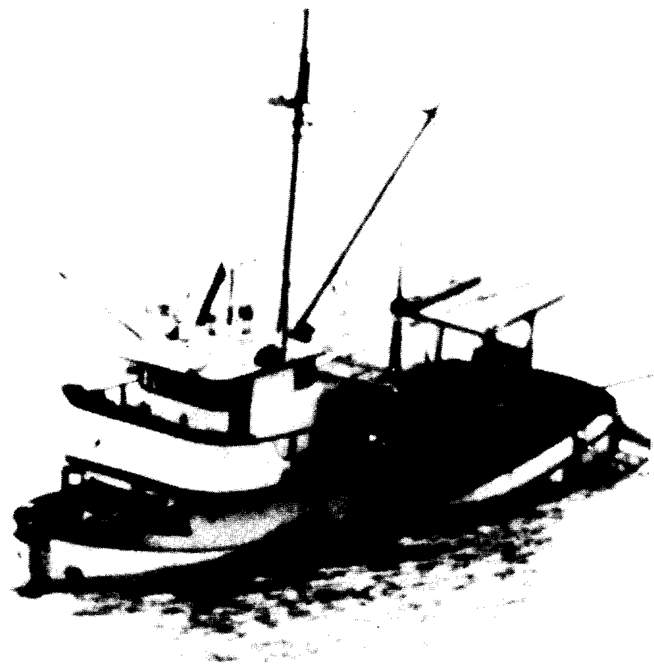


Figure 102. Fishing Vessel COHO-II Near Sinking

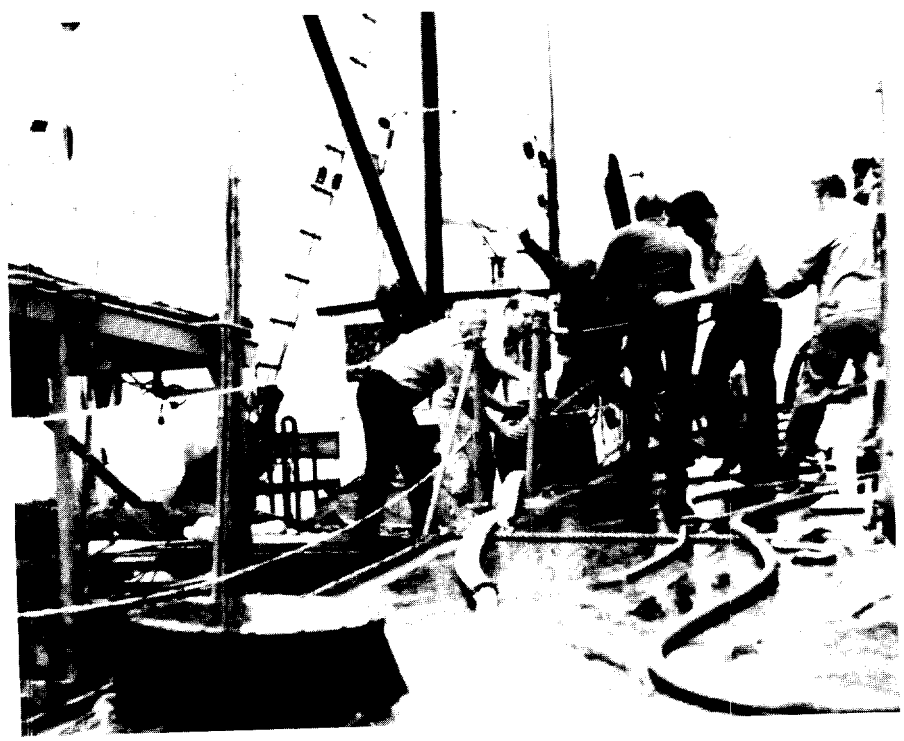


Figure 103. LT Orvis and Dick Dougan Assist in COHO-II Rescue

at 2050. COHO-II had been left with the RED BARON alongside and she was later towed in by the Coast Guard Cutter CAPE WASHINGTON. Fuel considerations and an unreliable radar prevented HIGH POINT from remaining any longer on the scene.

OIC HIGH POINT later received the following message from the Secretary of the Navy, J. William Middendorf:

> THE PROFESSIONALISM DISPLAYED BY THE CREW OF HIGH POINT IN TRAVELING 30 MILES IN 38 MINUTES TO HELP SAVE COHO-II WAS A DEMONSTRATION OF SKILL AND OPERATIONAL EXPERTISE THAT MERITS CONGRATULATIONS. AT A TIME WHEN WE OFTEN SPEAK OF THE NAVY OF THE FUTURE YOU HAVE SHOWN THAT PART OF THAT NAVY HAS ALREADY ARRIVED AND WORKS TO PERFECTION. WELL DONE.

BACK TO PSNS

After a brief period of rest and relaxation and more VIP demonstrations, the ship got underway from San Francisco on 30 September. They made an uneventful 9-hour foilborne transit to Coos Bay, OR. The following day, they became the center of attention of the local citizenry during demonstrations for the press. Finally, on 2 October, they again got underway and completed the last leg of the return voyage to Bremerton in 10-1/2 foilborne hours.

On 7 and 8 October, tests were conducted with a Hydrofoil Universal Digital Autopilot (HUDAP). This system was proposed by Dr. Pierre Dogan of the Draper Laboratory of Massachusetts Institute of Technology (MIT). It was designed and built by a Draper team headed up by Brian Cuevas. After the HUDAP tests, HIGH POINT was drydocked on 10 October for the remainder of 1974. During this RAV, which was to last for five months, a number of major work items were accomplished. These included refurbishment of the main shaft torque measuring system, the addition of 30 new data channels to the onboard instrumentation suite, new coatings on the struts and foils, and weld repair of cracks found in the lower strut assembly.

Meanwhile, after their experience of 2500 nautical miles with inadequate coastal navigation capability, crewmen OS 1 Richard Plumb and ET 1 Richard Elmore resolved to do something about the navigation problem. This was entirely in keeping with the dedication and personal involvement in the development program that was always characteristic of the members of HIGH POINT's crew. In early October, a chart and radar overlay system was assembled. Results were promising and, during February 1975, new video displays and a zoom lens were acquired and installed. The ship was undocked on 17 March and two days later, what came to be called the Tactical Navigation and Collision Avoidance Video (TANCAV) system was given its first underway test in Puget Sound, Reference '77. The concept was simple yet most effective. Commercially available equipment was used to provide a TV picture of a nautical chart superimposed on a TV picture of the radar screen. By matching the radar video to the chart (positioning the chart beneath the camera), it enabled own ship position to be shown relative to the charted shoreline contours, buoys, channels, and hazards to navigation. In effect, it permitted flying the ship with a real-time roadmap. The TV display was presented to the bridge as well as CIC. This system was later used effectively by the Coast Guard during the evaluation described in a later section. It also resulted in a personal letter of commendation from President Gerald Ford to OS1 Plumb and ET1 Elmore for their ingenuity and resourcefulness in creating TANCAV. (When a similar requirement was identified on the PHM-3 Class, the ideas first exploited in TANCAV were adopted by Sperry. Under a Navy contract, they made many refinements to the basic concept and created the first Highspeed Collision Avoidance and Navigation System-HICANS and, later, the AN/SSQ-87(V) Hydrofoil Collision Avoidance and Tracking System--HYCATS. As of this writing, this system has been approved for service use and is to be installed on all PHM hydrofoils.)

The remainder of the month of March was spent in conducting performance checks, training of Coast Guard crewmen, and preparing for a turnover of the ship to the Coast Guard for evaluation.

COAST GUARD OPERATION

Under the terms of a memorandum of agreement between the U.S. Navy and the U.S. Coast Guard, signed on 25 October 1974, HIGHPOINT was turned over to the Coast Guard on 4 April 1975 and was operated by them until 5 May 1975.

The Coast Guard crew was made up of volunteers who had been screened to meet the special qualifications deemed necessary for this test operation. They were highly trained and motivated, capable of working without close supervision, and possessed a broad knowledge of Coast Guard missions. Many had also been in a similar earlier evaluation of the Grumman-built Navy hydrofoil gunboat FLAGSTAFF (PGH-1). Under the command of LT Douglas F. Gehring, USCG, the crew of eleven men comprised the following rates:

BMC (CPO)	MKCM (Gas turbine-trained CPO)
BMI	MKI
(2) BM2	MK2
QM2	MK3
ET1	EM1

The crew had reported to Bremerton on 26 February 1975 for orientation in HIGH POINT maintenance and operation. Training also included four days devoted to enhancing team performance in high stress situations. This latter training concentrated on the interpersonal relationships of team members to better understand themselves, their team relations, and their individual influence on the team. Training in the operation and maintenance of the Proteus gas turbines was also given during evening classes.

On 3 April, HIGH POINT had a Navy change of command with LT Ralph D. Bianco relieving LT James W. Orvis as Officer-in-Charge. The following day, LT Bianco, USN, temporarily relinquished his new command to LT Douglas Gehring, USCG. HIGH POINT was officially commissioned as the Coast Guard vessel WMEH-1, complete with a new coat of white paint and the conventional red “racing stripes”. Figure (104) shows LT Orvis discussing his experiences aboard HIGH POINT with the new Coast Guard skipper LT Gehring as LT Bianco observes from his seat on the bridge. Figure (105) shows HIGH POINT with her new paint job. That same day, 4 April 1975, the ship got underway and made the 280 nautical mile transit from Bremerton to Astoria, OR, where they refueled and remained over night. The trip was essentially uneventful with 7.4 hours foilborne time and 1.4 hours on the hull in seas averaging 4 to 6 feet. The average speed was about 31 knots. The one noteable event was the foilborne crossing of the Columbia River Bar which was similar to that show earlier in Figure 82. The forward foil broached with the flaps down 20 degrees. This was followed by a sharp speed loss and a crash down on the hull. The craft rolled 26 degrees to port and pitched 6-i/2 degrees bow down with the bow becoming submerged in the face of the oncoming next wave. Actually, the experience was not as traumatic as it sounds and the craft recovered without difficulty. As had long been known by the Navy crew, HIGH POINT was a very forgiving ship.

The following day, they got underway again and made another 280 nm transit from Astoria to Crescent City, CA, where they remained for the second night. The transit time was 8.5 hours of which 7.4 hours was foilborne. The average speed was 33 knots in seas running an average of 6 to 8 feet.

Figure 104. LT Orvis, USN, and LT Gehring, USCG, Aboard PCH

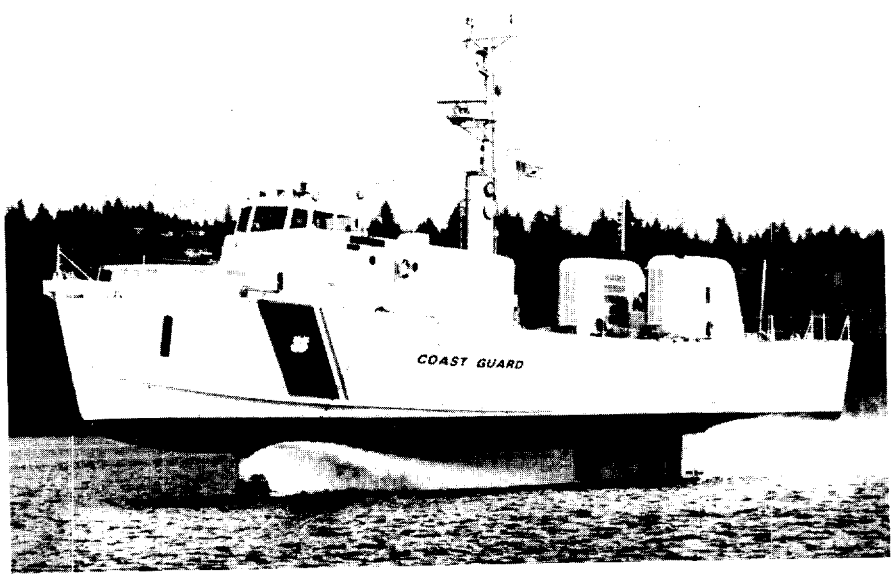


Figure 105. PCH with Coast Guard Colors

On Sunday 6 April, they began the final 290 nm leg of the trip to their designated operating base at the Naval Air Station, Alameda, CA, near San Francisco. After 2.6 hours foilborne, it was decided to complete the last 217 nautical miles hullborne due to heavy weather. They could have remained on the foils but elected to go hullborne to avoid possible damage to equipment. The seas were running an average of 10 to 12 feet with "sneakers" up to 20 feet and winds gusting to 40 knots. The total transit took 13.6 hours with an average speed of 2 1.3 knots. They remained on turbine power hullborne in a taxi mode and burned about 5,300 gallons of fuel, or an average of 18 gallons per nautical mile. Operating in the taxi mode on both turbines they made about 26 knots and on a single turbine about 14 knots. (Here, it may be noted that HIGH POINT has a useable fuel capacity of about 6,700 gallons. In high speed operation at 4 1 knots she has an endurance of about 1 1.5 hours. The fuel burnoff is 1.75 long tons per hour at 43 knots in calm water.)

During this taxi operation they found that operating both turbines at 890 RPM gave an average speed of 20 knots and used about 40% more fuel per mile than foilborne operation at 42 knots. Running only one turbine at 850 RPM gave an average speed of 14 knots and used 10% less fuel per mile than foilborne operation at 42 knots.

The total transit distance from Bremerton to San Francisco was 855 nm and took a total of 3 1 hours. Of this time 17.4 hours were on foils. The average speed was 27.6 knots and 13,800 gallons of fuel were burned; an average of about 16 gallons per nautical mile.

The Coast Guard operation of HIGH POINT was under the operational control of the 12th Coast Guard District. Technical control was exercised by the Coast Guard R&D Center, Groton, CT. in connection with their High Performance Water Craft Project. LCDR P. L. Ehrman USCG was assigned as the Project Task Manager for the R&D Center. LTjg D. G. Beck USCG was assigned as Project Task Manager for the District. The objective of the evaluation was to determine the ability of a hydrofoil to perform Coast Guard missions, including search and rescue (SAR); enforcement of laws and treaties (ELT); and marine science activities (MSA).

The Coast Guard and the U.S. National Marine Fisheries Service conducted joint patrols to enforce U.S. laws and treaties for conservation of marine resources. At the same time, these patrols maintained surveillance of foreign fleets not under such agreements but, who might operate in waters contiguous to the U.S. Since 1946, Japan and the Soviet Union had continued to increase their catch of fish throughout the world and, at that time, had mounted extensive high seas, fisheries in the Eastern Pacific Ocean. The location of some 50 ships of the Soviet fishing fleet off the coast of San Francisco prompted the choice of this area for HIGH POINT operations.

After arrival at Alameda, the following two days were spent in further crew training, general ship clean up, and underwater inspection of the struts, foils, and propellers. A press day and demonstration, scheduled for 8 April, was cancelled due to a malfunction of the indicator on the disconnect coupling of the port turbine shaft. The next day, 9 April, they got underway for a scheduled fisheries patrol but had to return to port due to an indication of low lube oil pressure in the starboard main transmission. The ship remained in port with intermittent underway checks to identify the lube oil system problem. Repairs were finally effected on 15 April. The following day, they got underway to conduct a fisheries surveillance patrol and also a marine sciences evaluation. This latter mission consisted of running a pre-established 124 nm track with stops at selected stations to make measurements of the surface temperatures, take salinity samples, and make bathythermograph traces. Data were correlated with those taken by aircraft. Enroute to station #12 the Soviet fishing fleet was sighted and the decision was made to skip the last two stations in favor of surveying the fleet.

Upon return to port, excessive wear was found in the port disconnect coupling. They had made 16 takeoffs and landings that day which undoubtedly contributed to the wear problem. A refurbished coupling was flown down from Seattle and installed on the following day. They got underway again on 18 April for another fisheries patrol proceeding to sea in the pre-dawn hours to again locate the Soviet fishing fleet. It was found some 40 nm Southwest of San Francisco. HIGH POINT remained foilborne and maneuvered thru the fleet, photographing and identifying over 40 vessels in about 1 and 1/2 hours. It was estimated that this would have taken 12 to 14 hours to accomplish with conventional Coast Guard surface units. They returned to port around noon to embark VADM McClelland, USCG, COMPACAREA. and give him an at-sea demonstration for about 1 and 1/2 hours. After he had disembarked, they proceeded to Cordell Bank, Northwest of San Francisco, and identified three more Russian fishing vessels. An additional eleven vessels were sighted visually or on radar before returning to port.

HIGH POINT remained in port 19-23 April for crew logistics, preventative maintenance, and further briefings. On 24 April, they again got underway and conducted a 200 nm fisheries patrol with USCG Cutter RESOLUTE (WMEC-620). RESOLUTE acted as an intruder violating the 200 nm limit. Coast Guard aircraft reported the violation and HIGH POINT was directed ***to*** proceed to the area for apprehending and boarding. The seas averaged 6 to 8 feet with 10 to 20 knots of wind and visability limited by rain, fog, and haze. It was necessary to go hullborne on one occasion outbound due to poor visibility. Upon arrival on the scene, HIGH POINT lowered a Zodiac boat and simulated boarding RESOLUTE.

After returning to port, the ship received a call from Rescue Command Center. this time for real, directing them to respond to a SAR mission involving the possible sinking of a small pleasure craft 10 nm South of San Francisco. They proceeded to search the area in company with two helicopters. Later, they were joined by an 82-foot Cutter for close inshore search. After about l-112 hours. HIGH POINT returned to port to refuel. They remained there when the SAR case was cancelled as a likely false report

In port, routine diver inspection revealed that large sections of the epoxy fairing on the propeller nacelles had torn away. It was necessary to make repairs using an underwater hardening putty.

The following day, 25 April, after completion of an operations debrief aboard RESOLUTE at Government Island, HIGH POINT refueled and proceeded to sea for a night fisheries patrol off the coast of San Francisco. While enroute, they were diverted to a SAR case involving a capsized sailboat South of Golden Gate. HIGH POINT, using night vision goggles and forward-looking infrared (FLIR), cleared the harbor foilborne and proceeded South about 10 miles before the SAR case was cancelled. They then went hullborne and continued with the scheduled fisheries patrol. Seas were averaging 10 to 20 feet with winds in excess of 30 knots. The heavy seas encountered while hullborne in the taxi mode caused pounding which eventually resulted in a malfunction of the scan converter in the Tactical and Navigation Collision Avoidance Video (TANCAV) system. Eventually, the heavy seas, equipment casualties. overheating hydraulic oil, and high fuel consumption using the turbine drives in the hullborne mode, dictated a return to port for the remainder of the night.

On Saturday morning, 26 April, HIGH POINT again headed to sea to complete the scheduled fisheries patrol and continue observance of the Soviet fishing fleet. This was not to be. however. Just outside the Bay area a loud bang was heard and engineering reported a sudden loss of oil pressure in the starboard foilborne transmission. After a quick check, both turbines were shut down and the starboard shaft was locked. The ship returned to port using the port turbine in the hullborne taxi mode. Later inspection of the starboard upper gearbox revealed that one of the two brass oil supply nozzles had vibrated loose and had been chewed up by the gears. It was clear that a complete overhaul was necessary. Due to the long lead time for procurement of special bearings for which there were no spares, it was decided to decommission HIGH POINT as a Coast Guard craft and turn her back to the Navy. On 29 April, preparations for the turnover were begun, including repainting of the hull with Navy gray. On 5 May 1975, the ship was officially returned to Navy control. The following day, the Coast Guard crew members were transferred to other Coast Guard units.

Repairs of the gearbox, the cost of which was borne by the Coast Guard, were started on 27 May and completed on 2 June. Spin tests were conducted on 3 June and the next day foilborne tests verified that the repair was successful. The transit back to Bremerton was begun on 15 June and completed with their arrival at F'SNS on 17 June 1975.

Of the total of 3 1 days during which HIGH POINT was under Coast Guard control. 14- 1/2 days were spent out of service due to mechanical and electrical failures. A total of 79.6 hours were spent underway during 11 days of operations with 44.8 hours foilborne and 34.8 hullborne. This was not considered unusual, however, since the ship was 12 years old; it was a one-of-a-kind, first-of-a-kind model; and it was used as an R&D platform without the many support features and spares of a normal Navy ship. Except for the assistance from a 6-man Navy contingent. the Coast Guard crew accomplished all repairs except the overhaul of the upper gearbox. It should also be noted that the Coast Guard crew frequently operated the ship in the hullborne taxi mode at speeds as high as 25 or 26 knots. This was not the normal mode in which the ship was designed to operate and it undoubtedly put a considerable strain on many of the subsystems. particularly the foilborne transmission.

During the Coast Guard operation, the TANCAV system conceived by PCH crewmen Plumb and Elmore, was of great value. It was used during the coastal transit to San Francisco supplemented by Omega and Loran fixes. It was used as a DRT when there was no land or radar. The DR position was periodically up-dated with Omega and Loran positions. By this method a continuous position display was maintained even with no radar returns. TANCAV was also used effectively to count and fix positions of the numerous Soviet fishing vessels West of San Francisco. As contacts appeared on the screen. the operator needed only to mark the position on the chart. It was also found useful in conducting search and rescue (SAR) patterns. Any area not covered was immediately shown, allowing a thorough search with no missed areas.

In spite of the reliability and maintenance problems. HIGH POINT demonstrated excellent potential for hydrofoils to enhance Coast Guard mission capability. A considerable volume of data was accumulated and many recommendations were generated which were to be of great value in later design studies. The entire evaluation and the recommendations therefrom are reported in considerable detail in References 79 and 80.

ASSIST

Coast Guard operations with HIGH POINT also offered an opportunity to try out a new system for collecting data on the reliability and maintainability of hydrofoil ship systems.

The decision to develop such a system resulted from discussions during a Hydrofoil Trials Planning Workshop held at NSRDC on 1 2 & 13 June 197-t. This meeting was attended by more than 50 representatives of government and industry. It had already been recognized that hydrofoil mission and support requirements were different from those of most conventional ships. Unlike the month-long self-sustaining fleet voyages of conventional ships, hydrofoil voyages tended to be limited to only a few days followed by a one or two-day turn-around. Space and weight limitations of hydrofoils also drastically constrained onboard spares and repair capabilities. Frequent voyages required these craft to be maintained in a high degree of readiness during the short turn-around periods. In many respects, concepts for support of hydrofoil ships were recognized as being more similar to those of aircraft. As a result, it was concluded that a new data base of operations and maintenance experience was required to communicate lessons learned and to provide a basis for establishing improved criteria for future designs.

Workshop participants expressed concern over the lack of information on operational experience and history of the few Navy hydrofoils existing at that time. Specifically, such items as lack of comprehensive reporting of failures, maintenance actions, equipment changes, and results of inspections were cited. A plan to develop an advanced ship information collection system was approved and, a short time later, Boeing was tasked to develop such a system. It was to provide for collecting significant technical information from the operations of test and lead ships of use to engineers and designers in validating and improving criteria for design and specifications of future systems. Data collected were to consist of technical descriptions and statistics of scheduled and unscheduled, aboard and ashore experiences with hydrofoil equipment. To be included were voyage debriefing reports, equipment time and cycle records, ship identification and dates, equipment problems, and crew suggestions and recommendations. Failure and maintenance reports were to provide detailed hardware identification, time of failure. mode and cause of failure, repair action, hardware disposition, and manhours expended for inspection and repair. Boeing's approach to the task was to:

(a) Identify potential users of the data;
(b) Determine user requirements;
(c) Identify data needed to satisfy the requirements, and;
(d) Relate these **data** to the Navy's existing 3-M system.

The system developed by Boeing, Reference 81, came to be designated the ASSIST (Advanced Ships Information System-Technical) Program. A significant and unique feature was the provision of an <u>information system engineer as</u> an integral part of the data collection process. Such an individual was considered a key factor in the collection of meaningful technical data. He is primarily shore-based **and** applies engineering judgement in the assessment of maintenance actions, failures, and problems as they occur. He checks the validity and accuracy of all reports, and obtains detailed information on the causes of failures. He also assesses subsystem design, operations, **and** support; initiates problem reports; follows up on contractor failure analyses; and assesses the effectiveness of reporting procedures. He completes a voyage assessment after each voyage, usually by debriefings of the crew and examination of the opera tions log.

The testing of ASSIST on HIGH POINT definitely proved the worth of the system and, a short time later, it was fully implemented on the PHM-1 and ultimately the entire PHM Squadron of six ships. (As a result of the use of ASSIST, the PHM Squadron today has considerably more data on operation, maintenance. and repair than any other ship or class of ship in the Navy. This has been a significant factor in their achieving an extremely high level of reliability.)

AGAIN AT PSNS

During the remainder of June 1975, HIGH POINT was engaged in a number of activities. On 18 June, they operated with PEGASUS (PHM-1), Figure (106). This was a 235 metric-ton NATO patrol hydrofoil missile ship built by Boeing. It was the result of an agreement between the Federal Republic of Germany,

Figure 106. Boeing-Built Patrol Hydrofoil Missile Ship PEGASUS (PHM- 1)

Italy, and the United States. FRG and Italy shared in the funding for the design and technical data package, but eventually decided not to participate in the construction program. The keel of PEGASUS was laid on 9 May 1973 and she was christened and launched on 9 November 1974. She made her first flight on 25 February 1975. (The ship was delivered to the Navy on 15 June 1977 and was commissioned on 9 July 1977 after completing extensive technical trials and Operational Evaluation at Port Hueneme, CA. Her Commanding Officer at that time was LCDR Erich Ashburn and her Executive Officer was LT Joel Roberts. She was the first of a squadron of six ships eventually procured by the Navy. Others in the squadron, designated PHMRONTWO, include HERCULES (PHM-2), TAURUS (PHM-3), AQUILA (PHM-4), ARIES (PHM-5), and GEMINI (PHM-6). The squadron, as of this writing, is based in Key West, Florida.)

On 25 June, PCH conducted demonstrations for RADM L. W. Zech, Jr., COM-13, and the Hon Lawrence Hughes, Congressman from Ohio. The same day a demonstration was given to members of NATO Special Working Group Six. The 26th of June was devoted to the first dependents cruise in over two and a half years.

On 3 July the ship was drydocked to determine the extent of cracking in the starboard nacelle. The crack was repaired without modifying the structure. During this two-month drydocking the strut and foil coatings were also refurbished.

Local operations were continued in September and included another exercise with PHM- 1 to evaluate their MK 94 fire control system. An evaluation of the effectiveness of injecting air into a propeller to eliminate cavitation was also accomplished during this period.

On 3 November HIGH POINT departed for Port Angeles to begin rough water trials with the Hydrofoil Universal Digital Autopilot (HCDAP). Data were acquired for various seaway conditions including seastate 5 accompanied by large swells. The trials were interrupted briefly with a return to Bremerton on 13 November. While at PSNS, CDR Nick T. Bennett of the Royal Navy, a long time enthusiast for advanced craft, was given a foilborne demonstration.

The ship returned to Port Angeles on 1 December and continued evaluation of the HUDAP system, References 82 and 83. Upon successful completion of these tests on 4 December, they returned to PSNS and the system was removed for installation in PLAINVIEW.

On 16 December, HIGH POINT was drydocked for the remainder of 1975 for repairs of the forward port propeller shaft. At this point, the ship had accumulated a total of almost 1200 hours of foilborne time, 475 hours of which occurred after the MOD-I conversion.

CHAPTER 11

The Second Decade

After completion of MOD I, HIGH POINT attained a level of availability that was significantly higher than that experienced before the modification. Many of the earlier problems had been corrected although leaks of saltwater into the lower foilborne transmissions continued to plague the craft. Also, periodic drydockings, necessary for refurbishment of the strut/foil coatings, continued to interrupt operations. Even so, major emphasis could finally be shifted to investigations of mission applications for hydrofoil ships and support of the PHM program. PCH- 1 also continued to host a variety of visitors and provide demonstrations of her capabilities.

In this chapter, a year by year overview is given of operations from 1976 through 1985. This is interspersed with sections containing more detailed discussions of specific trials or other events of special note.

OVERVIEW 1976

HIGH POINT undocked on 16 January after repairs were made to the forward port propeller shaft. The period from the last half of January thru April was spent with intermittent trials to study cavitation on the forward foil. During this period, the ship made a transit to Vancouver, B. C.. The return trip to PSNS on 23 January included a stop at Esquimalt where they took aboard CAPT D. R. Boyle, CDR G. J. Grioux, and COMMO J. Allen, of the Canadian Armed Forces, and CAPT J. L. Dick, USN, for a foilborne demonstration.

On 5 February, CAPT Mike Davis, Commander DTNSRDC, sent the following message to HIGH POINT:

> IT IS WITH GREAT PLEASURE THAT I OFFICIALLY NOTE THAT ON 23 JANUARY HIGH POINT LOGGED HER 1200TH FOILBORNE HOUR SINCE DELIVERY TO THE NAVY. PASSING THAT MARK MAKES HER THE U. S. NAVY'S LEADER IN FOILBORNE OPERATIONS.

IT IS APPROPRIATE TO NOTE AT THIS TIME THAT THIS ACCOMPLISHMENT OCCURS ON THE EVE OF THE COMMENCEMENT OF THE OPERATIONAL EVALUATION OF THE PATROL HYDROFOIL GIJIDED-MISSILE (PHM-1). IT ALSO MARKS THE 13TH YEAR OF HIGH POINT'S EFFORTS IN HYDROFOIL RESEARCH AND DEVELOPMENT-- EFFORTS WHICH MADE ADVANCED HYDROFOILS A REALITY.

THE OFFICERS AND CREW MEMBERS OF HIGH POINT, OVER THE YEARS, HAVE PERFORMED WITH PROFESSIONALISM, DEDICATION TO DUTY, AND PERSONAL INVOLVEMENT IN THE HYDROFOIL PROGRAM. YOU, THE PRESENT OIC AND CREW, HAVE CONTINUED THIS TRADITION IN THE FINEST MANNER AND YOU CAN BE JUSTLY PROUD OF YOUR CONTRIBUTIONS IN ACHIEVING THIS MILESTONE IN HYDROFOIL HISTORY.

I AM SURE YOUR CONTINUED SUPPORT, ALONG WITH THAT OF HYSTU, COMTHIRTEEN, PSNS, AND OTIIERS WILL GUARANTEE SUCCESS TO OUR NAVY'S HYDROFOIL RESEARCH AND DEVELOPMENT PROGRAM. WELL DONE!

On 18 February. the special accomplishment of two members of the crew was also recognized. RADM I.. W. Zech, Jr., COM- 13, came aboard the ship at PSNS to present OS 1 Plumb and ET 1 Elmore with letters signed by President Gerald Ford recognizing their conceptual design and development of the Tactical and Navigation Collision Avoidance Video (TANCAV) system. He was also given a foilborne demonstration.

Don Rieg, who had been working in the hydrofoil program for some time as a Boeing engineer, joined the staff of HYSTU as Trials Engineer on 23 February 1976. He was a most welcome addition to the Navy's hydrofoil trials team which. at that time, consisted of LCDR Eric Nystrom. Sumi Arima, Verne Whitehead, Jim Mason. and Jim Gillam. They were ably supported by the indispensable Shirley Yates, Administrative Assistant, and secretaries Vickie Williams and Debbie Ramsdell.

The ship was again drydocked on 1 March, this time to replace the forward port propeller shaft seal. Repairs were completed and the ship was undocked on IO March to continue forward foil cavitation tests.

In April, under pressure from the shipyard to relinquish the valuable space in Building 580 on Pier 3, HYSTU agreed to move to the second floor of building 495, Figure (107a), at the head of Pier 7. As was the case when HYSTU first occupied Building 580, PSNS did an excellent job of refurbishing the new space, as may be seen in Figure (107b).

On 13 April. RADM Wm. C. Barnes, Commander of the Naval Ship Engineering Center, and Dr. Robert S. Johnson. Head of the Advanced Technology Branch in NAVSEC, were given a foilborne demonstration. Two days later the forward foil cavitation tests were completed.

The remainder of April and the month of May saw further VIP demonstrations and tests of the TANCAV system as well as tests of an Anti-Clutter Radar (ACR) system provided by North American Rockwell. Early in June. HIGH POINT got underway for Everett, WA. just North of Seattle, where they participated in the "Salty Sea Days Festival". Further exposure to the public was given on 2 July when the ship also participated in bicentennial festivities held at Port Orchard. WA, just across Sinclair Inlet from PSNS. An open house was held during which more than 5,000 guests toured the ship.

On 3 June, PEGASUS (PHM- I) completed its Operational Evaluation (OPEVAL) in San Diego. finally arriving at Pier 91 in Seattle on 28 June. Meantime, personnel changes of note included CAPT Frank

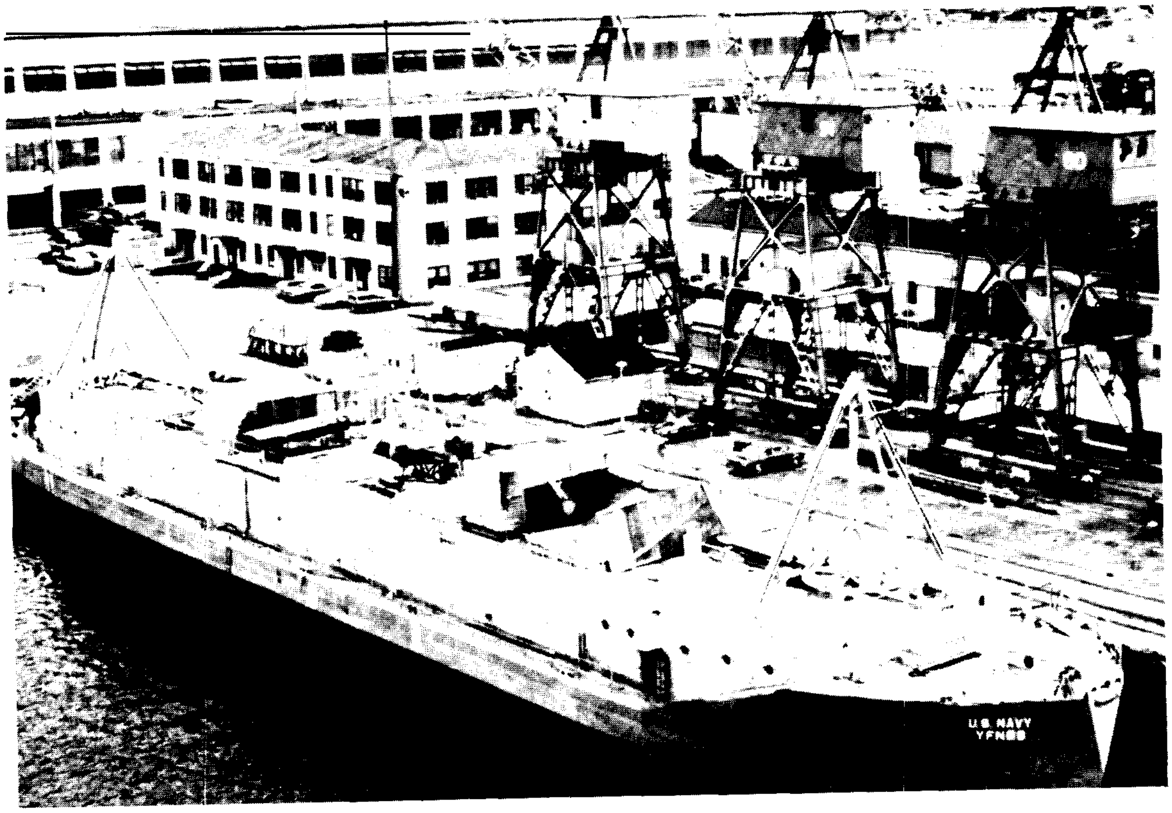


Figure 107a. View of HYSTU Barge and Building 495

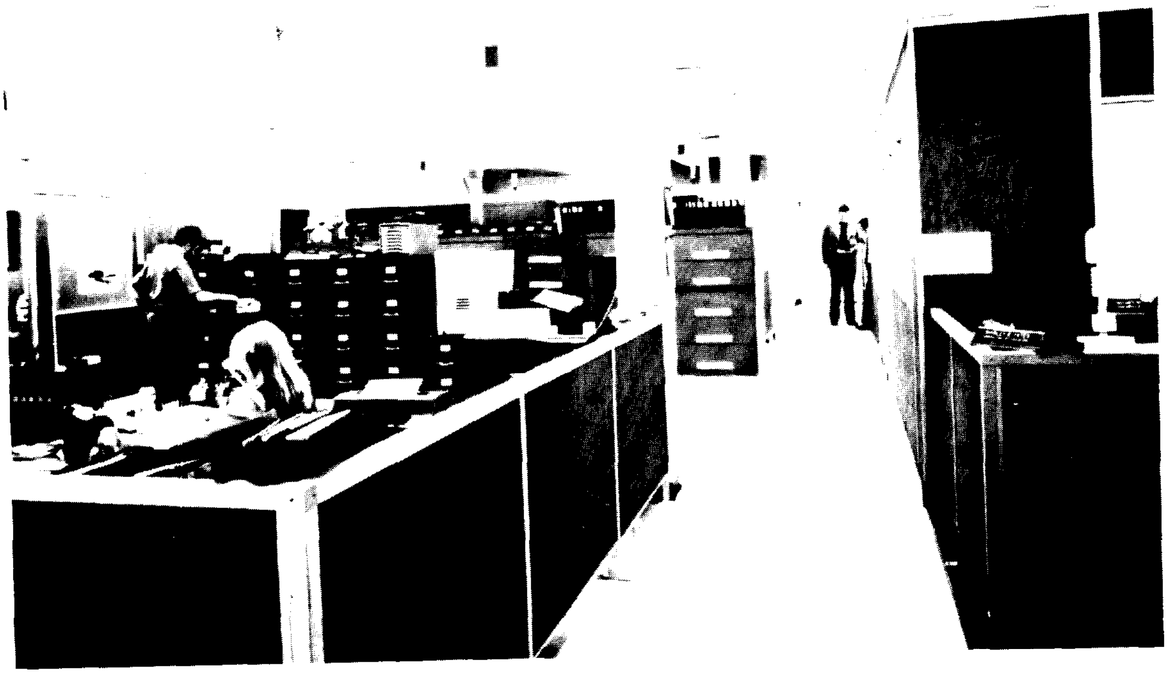


Figure 107b. HYSTU Offices

Figure 107. HYSTU's New Offices at the Head of Pier 7 at PSMS

Manganaro's relief of CAPT Jim Nunneley as COM PSNS, and relief of CDR R. Eric Nystrom, OIC of HYSTU, by LCDR Lou Tedeschi on 17 June.

After further VIP demonstrations and joint operations with PLAINVIEW (AGEH-1), on 16 July, it was again necessary to drydock HIGH POINT to effect repairs of the lower port transmission. The ship was undocked at the end of July. Much of the month of August was spent in conducting tests of a doppler velocity speed log obtained from the Naval Air Development Center in Johnsville, PA. The foilborne transmission continued to be a problem and, on 17 August, the ship was once more drydocked for an inspection and overhaul of the transmission. She remained in drydock for the remainder of 1976. During this period, Neville Banbury, a gas turbine expert from Rolls-Royce, Ltd., who were the manufacturers of the main propulsion Proteus gas turbines installed in HIGH POINT. made an inspection of the turbines. He also conducted training in maintenance and operation of the engines.

HIGH POINT completed a total of 51 hours and 26 minutes foilborne in 1976. This brought the total accumulated foilborne time since her first flight in 1963 to 125 1 hours and 52 minutes. Of this, 526 hours and 54 minutes were accumulated subsequent to completion of the MOD-I conversion.

OVERVIEW 1977

A chain of events began in February 19 /77 which almost resulted in the deactivation of HIGH POINT and did result in such action for the PLAINVIEW. This grew out of a hassle between the Carter Administration and the Congress over the FY-78 budget request which contained no funds for continuation of PHM production. These events are described in more detail in a later section.

On 20 April. HIGH POINT was undocked upon completion of repairs to the port transmission. Engineering checks were conducted the latter part of April. The beginning of May was spent in conducting towing tests of a dummy thin-line depressor towed array system (DTAS) in both smooth and rough water. On 19 May, HIGH POINT got underway in company with PLAINVIEW for a transit to the Canadian Forces Base at Esquimalt, British Columbia, to join in the celebration of the Queen's birthday. The following day, they made a transit from Victoria, B. C. to Keyport, WA with some of the members of SUBGROUP G of the Technical Cooperation Program aboard. SUBGROUP G was comprised of:

COMMO A. A. Willis, Dir. Genl., Naval Operation Reqts., Australia
Mr. I. A. Hagan, Asst. to the Defence R&D Attache, Australia
LCDR C. W. Fitzgerald, Australian Naval Attache Staff
Dr. J. H. Greenblatt, Counsellor (Defence R&D), Canadian Embassy
Dr. Derek Schofield, Chief, Canadian Def. Resch. Estab., Atlantic
DR. Todd Garrett, Dir., Tech. Div., DREA. Canada
COL F. R. Anderson, National Defence Headquarters, Canada
Mr. B. L. Olsson, Defence Scientific Estab.. New Zealand
Mr. I. L. Davies, Dir., Admiralty Underwater Weap. Estab., UK
Mr. D. H. 0. Hider, Hd. Maritime Gp., British Defence R&D Staff
Dr. I. Roebuck. Principal Went. Off., AUWE, UK
RADM R. H. Blount, USN, Dir. OPNAV Nuclear Energy Dev. Div.
CAPT J. P. Williamson, USN, Office of Naval Research

At the Naval Torpedo Station in Keyport, they took aboard other members of the SUBGROUP for a return transit to Victoria. The round trip took a total of 4 hours and 45 minutes of foilborne time. On 22 May. the ship returned to Bremerton.

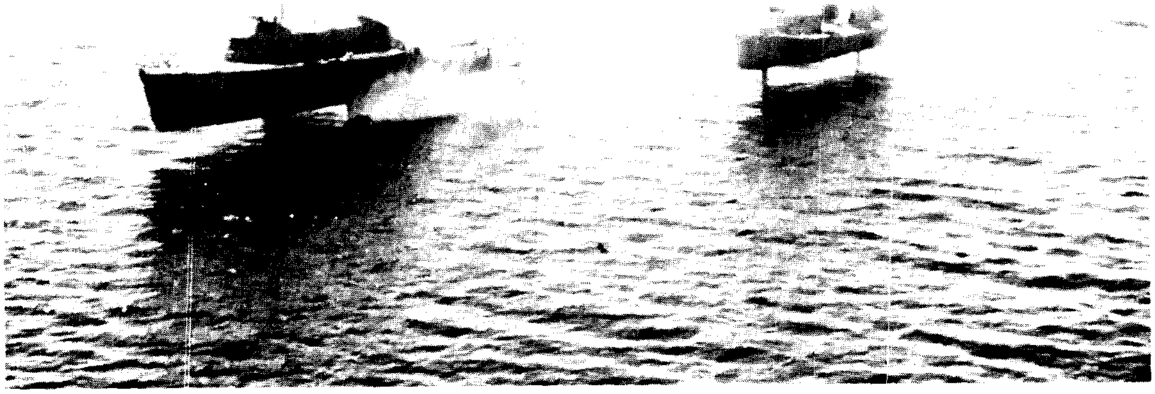


Figure 108. PCH and AGEH in Tandem Operation to Enhance Pressure Signature

On 15 June, the stern of the ship was lifted at the pier for removal of the pod fairings which required repair. Then, from 1 thru 5 July, she was moored at Port Orchard. across the inlet from PSNS, to participate in the 4th of July celebration by holding open house for the public. Again, more than 5,000 visitors toured the ship.

On 14 July, replacement of the pod fairings was completed. However, the next day the starboard propeller was lost during takeoff. It was replaced by the ship's divers on 18 July. On 19 July, the ship was foilborne a total of 4-3/4 hours during the conduct of tests of the speed log in Hood Canal. On 2 1 July, they transited to Pier 9 1 and took aboard members of the Israeli Defense Force for a foilborne demonstration. In the party was RADM J. M. Barkai, CAPT Ely Levy, CAPT Moshe Tabak, and CAPT Yaacov Nitzen, all of the Israeli Navy. (Here it may be noted that, some time later, Israel contracted with Grumman to design and build a 100-ton gunboat, similar to the FLAGSTAFF, which was christened SHIMRIT. This craft was transported to Haifa. Later, a follow-on sister ship was constructed in Israel).

PCH-1 spent the remainder of July in the conduct of trials to measure the pressure signature of the ship alone and in company with PLAINVIEW and PEGASUS. Figure (108) shows HIGH POINT and PLAINVIEW operating in tandem during these trials. This project was under the direction of V. H. VanBibber, an engineer from the Naval Coastal Systems Center (NCSC) in Panama City, FL. He had been Project Manager during early construction stages of the PLAINVIE'W at Lockheed Shipbuilding and Construction Company.

On 2 August, HIGH POINT was lifted onto its cradle to replace the starboard propeller shaft. She was undocked on 25 August, and a week later, again drydocked to begin a major overhaul of the starboard upper and lower gear boxes. This was performed mainly by the ship's force. During this same period, the foundation for a Canadian variable-depth sonar winch was installed on the fantail. The ship was undocked on 13 December weighing 124.7 tons. Check-out trials of the transmission were short-lived due to the failure of a main supply hose from a fuel pump. After this was repaired, on 20 December, they again got underway with 5 tons of dead weight onboard to assess the effects of the VDS system on ship performance.

The year 1977 was ended with the relief of LT Ralph Bianco by LT W. Scott Slocum as OIC. The ship had completed a total of 5 1 hours 15 minutes of foilborne time, bringing the total to 1302 hours 7 minutes. Of this, 578 hours 28 minutes was accumulated after MOD-I conversion.

THE DEACTIVATION AFFAIR

President Carter's FY-78 budget request, which went to the Congress in February 1977, contained no funds for further production of PHMs. SECDEF's Program Budget Decision #3 12, dated 6 April 1977, ordered termination of PHM production. The following month, President Carter sent a proposal to the Congress calling for cancellation of PHM production. In July, however, the Congress failed to support the rescission proposal and, on 20 October 1977, SECDEF released $ 178M to fund the PHM procurement. The very next day, NAVSEA PMS-303 awarded Boeing a fixed-price incentive-fee contract (NO02477-C-205 1) for five production PHMs.

This hassle between the Congress and the Carter Administration led to other congressional action in the FY-78 budget hearings. The House of Representatives Conference Report No. 95-45 1, dated 2 I June 1977, recommended that the hydrofoil research ships HIGH POINT and PLAINVIEW be deactivated/mothballed during FY-78. This recommendation was supported by the House Appropriations Committee chaired by Congressman George Mahon.

On I December 1977, Navy Secretary W. Graham Claytor, Jr., sent letters to Congressman Mahon and Senator John L. McClellan, Chairman of the Senate Appropriations Committee. in which he stated the following:

> The Joint Conference on the FY-78 Appropriations Bill reduces the Hydrofoil Craft (Advanced) line from $2,132,000 to $500,000.
>
> In its report on this bill, your Committee specified that these funds were provided to deactivate/mothball HIGH POINT (PCH-1) and PLAINVIEW (AGEH-l), the Navy's two research and development hydrofoil craft. The report also observed that the Navy planned to terminate this program in FY-78.
>
> Subsequent to this Committee action, Congress did not act on the President's proposal to rescind the SCN funds previously appropriated for production of five follow NATO PHMs. Accordingly, the Navy has awarded the production contract to Boeing Marine Systems.
>
> It is most desirable to exploit and further refine the PHM technology. Furthermore, the Navy has recently initiated a program aimed at development of additional missions for the PHM class of hydrofoil ship.
>
> In order to continue this technological support and mission development effort, it will be necessary to retain PCH-1 through FY-78 at a minimum, and to retain AGEH-1 at least through FY-83.

Subject to your concurrence, we desire to retain PCH- 1 and AGEH-1 in service beyond the end of FY-78 and to use the funds appropriated in FY-78 to pursue the technological and mission development program discussed above, with continued effort in FY 1979 and the outyears.

A similar letter has been sent to Chairman McClellan (Chairman of the Senate Appropriations Committee).

The Navy's request fell on deaf ears as demonstrated in a letter dated 15 December 1977, from Chairman Mahon to the Honorable Harold Brown Secretary of Defense, which apprised him of various actions on DOD's request for reprogramming. In this letter, the following statement was made regarding Hydrofoil Craft (Advanced):

The Committee considered Secretary Claytor's letter of 1 December 1977, which proposes to retain HIGH POINT (PCH-1) and PLAINVIEW (AGEH-1) in service beyond the end of FY 1978 and to initiate an RDT&E effort to develop additional missions for the NATO PHM class of ships. As pointed out in the letter, $500.000 was appropriated in FY 1978 for the purpose of deactivating/mothballing the PCH-1 and AGEH- 1. The Committee directs that the funds appropriated be used for the purpose identified in House Report 95-451. The funds estimated to be used for development of additional missions for the PHM are considered to be far in excess of the funds required for a reasonable and prudent effort at this time.

At this point, the situation looked grim indeed and Bob Johnston, Hydrofoil Program Technical Manager, and Jim Schuler, NAVSEA's Hydrofoil R&D Program Manager went to general quarters in a final effort to save the PCH- 1. It was agreed that the AGEH- 1 was a lost cause since it was not considered likely that a hydrofoil ship of this configuration would ever be built again. Furthermore, the cost of maintaining and operating the larger ship was considerably more than that of the PCH- 1. This decision was not made lightly, particularly in view of the fact that AGEH-1 had never been tested to its design sea state 6.

Although Boeing played a behind-the-scenes role of considerable importance, they were forced to maintain a low profile to avoid further conflict over the PHM program. The assistance of Congressman Norman D. Dicks, from the State of Washington, was solicited and, in a letter to HAC Chairman Mahon, dated 13 June 1978. he urged that the Navy be allowed to retain PCH-1 in service.

On 19 July 1978. Secretary Claytor sent another letter to Chairman Mahon in which he restated the Navy's need to retain PCH- 1 in service until the end of FY-80 and urged relief from congressional direction to deactivate the ship by the end of FY-78 (30 September 1978). He sent a similar letter to Senator Warren Magnuson, then Chairman of the Senate Appropriations Committee.

During this period, there was much backstage maneuvering, particularly by Bob Johnston who spent many hours working with various staffers on Capitol Hill. In a letter of 13 September 1978 from Congressman Dicks to Congressman Bob Sykes, of the House Defense Appropriations Subcommittee, it was requested that he support continuance of PCH-1 during the Subcommittee's consideration of a number of reprogramming questions. A short time later, in a meeting in Congressman Dicks' office with representatives of Senator Magnuson. Bob Johnston, and other supporters, language was drafted for insertion by the Senate in the FY 1979 Defense Appropriations Bill which approved continued operation of the PCH- 1.

Chairman Mahon did not reply to SECNAV's letter until 29 September 1978 when he stated the following:

> Reference is made to your letter of July 19, 1978, requesting the Committee to reverse its position that the PCH-1 HIGH POINT research and development hydrofoil be deactivated by September 30, 1978.
>
> The Committee has reconsidered your request and finds no compelling reason to reverse the decision that it made on two previous occasions. The Committee believes that PHM-1 is the most ideal platform available to investigate alternate missions and equipments to expand the capabilities of the planned PHM squadron. PHM-1 should be used for the proposed tests while the five other PHM ships are under construction.

Meantime, however, language was inserted in Senate Report No. 95-1264, dated 2 October 1978, covering action on the 1979 DOD Appropriations Bill, stating that the Senate Committee agreed with the Navy position regarding the need to continue research and development related to the use of PCH- 1 as a test bed for the PHM program. The report further recommended that PCH-1 be retained as a test vehicle through FY 1980. In the House of Representatives Conference Report No. 95-1764, dated 11 October, the Conferees adopted the position of the Senate and agreed that PCH-1 be retained as a test vehicle through FY-80. Finally, in the 1979 DOD Appropriations Bill itself (P.L. 95-457 dated 13 October 1978) there was no language restricting retention of PCH-1.

Thus, the battle of more than a year to save the "Queen of the Hydrofoil Fleet" was finally won, even though the AGEH-1 was lost. In retrospect, several valuable lessons were learned from this experience with activities on Capitol Hill. It was somewhat surprising to discover the significant influence exerted on the legislative process by congressional staffers, many of whom were in their twenties or early thirties. The demands placed on the time of the Members of Congress are so overwhelming that they must. of necessity , rely heavily on their staff to supply the background and basis for decision making. The extent to which the legislative process is influenced by the exchange of political favors also became abundantly clear during this protracted interaction between members of the R&D community and the Congress. Finally, the value of patience and continued perseverance cannot be overemphasized. It is not a game for those who are of faint heart.

OVERVIEW 1978

On 7 January, Jim Gillam, HYSTU Test Mechanic and one of the "Plank Owners", retired from government service. Since the formation of HYSTU some ten years earlier, the value of having a shop and a test mechanic/machinist as part of the small full-time staff had been demonstrated many times over. On numerous occasions, it made possible the continuation of trials schedules with a minimum of disruption and downtime.

After spending some time in early January in support of the Navy Recruiting Command in Seattle, and a brief drydocking for minor repairs, HIGH POINT got underway on 2 February for preliminary trials in connection with the Canadian Variable Depth Sonar Project (HYTOW). The HYTOW equipment was installed on the ship starting on 23 February. Foilborne trials were begun on 3 March. These were destined to be short lived due to the loss of the sonar body when it parted from the tow cable at the weak link. Here. it may be noted that the series of HYTOW trials in this joint Canadian-US project took place in several phases for a considerable period into the future. A more detailed discussion of the entire project is given in a later section of this chapter.

In accord with the direction of the Congress. SECNAV, on 3 March. had directed that PLAINVIEW be stricken from the naval vessel register on 30 September 1978 and authorized disposal of the ship in a manner most advantageous to the government, pursuant to existing law. In a message from the CNO on 14 March, further instructions were given regarding the decommissioning and disposal of PLAINVIEW. This message contained only a brief reference to HIGH POINT, stating that, for planning purposes, she would be retired and placed out of service on or before 30 September 1978. This reflected some degree of optimism that such action eventually might be circumvented by further appeals to the Congress.

On 15 April, a dependents cruise was held with the thought in mind that the opportunity might not exist in the future. .A demonstration was also given for RADM Bruce Keener, OP-32, on 27 April. On 11 May, they operated with a Boeing JETFOIL which had the CNO aboard.

During June, PCH- 1 conducted additional trials to measure the bottom pressure signature for evaluation of hydrofoil ships capability to sweep pressure mines. These trials included dual ship operations with the PLAINVIEW and a Boeing commercial JETFOIL. Measurements were made by means of a bottom array of pressure transducers. Near the end of June, problems were encountered with the port transmission nacelle and it became necessary to drydock the ship to effect repairs. After undocking and conduct of a demonstration for ADM Al Whittle, Chief of Naval Material, the ship got underway for a hullborne transit to Keyport to resume trials of the Canadian VDS.

On 2 j August, ENCS Charles McDowell relieved LCDR Scott Slocum as OIC of PCH-1 in anticipation of failure in efforts to retain the ship in active service. She was drydocked on 29 August to prepare for inactivation, but the guidance was to "proceed with inactivation plans only to the point where additional expense would be incurred to reactivate should there be favorable action by the Congress". On 30 September, the crew was transferred to the Commandant of the 13th Naval District. The following day. they were given temporary additional duty back to the ship to continue activities in support of the deactivation. Although initial word of a reprieve was received verbally on 10 October, the ship continued in a hold status and, on 16 October, QMC R. W. Lovelace relieved ENCS Charles McDowell as OIC. Finally, on 25 October, the long-awaited message from the CNO was received cancelling the deactivation. Unfortunately. only about half of the crew were transferred back to the ship. the rest having been sent to other assignments.

The ship stood down during the remainder of 1978 while plans were made to resume the trials program. A composite flap, which had been constructed earlier for evaluation on an aft main foil was, however, installed during December. The scoreboard at the end of the year showed that HIGH POINT had accumulated an additional 42 hours 27 minutes of foilborne time for a total of 1344 hours and 34 minutes since the first flight, including 620 hours j j minutes since the MOD-I conversion. Not a particularly impressive year, but at least it ended on a happy note.

OVERVIEW 1979

HIGH POINT spent most of 1979 in drydock. In February, both lower transmission nacelles were disassembled and delivered to a commercial machine shop for repairs. On 10 April, CAPT Myron V. Ricketts, Commander of DTNSRDC, inspected the ship which was still under the command of QMC R. W. Lovelace. On 7 June, LT Joel D. Givens relieved QMC Lovelace as OIC HIGH POINT.

In September, both lower gear boxes were reinstalled and the ship was undocked on 1 October. The 2nd and 3rd of October were spent conducting post overhaul checkouts and crew training. For many of the crew this was their first experience on a foilborne craft. On the second day, the starboard high-pressure fuel line parted and the ship had to return to port for repairs. The following day, 4 October, they again got underway to complete checkout tests. Due to air ventilation of the foils and loss of lube oil suction on the port side, they had to return once more to PSNS for repairs.

On 5 October, they again got underway, but again the tests were interrupted when a vibration was experienced in the port propeller. They returned to PSNS using the starboard turbine hullborne. On 11 October, the ship was lifted and placed on the blocks to correct the problem. The port nacelle was removed and refurbished and, on 17 October, the ship was undocked.

Having finally verified that all systems were functioning properly, HIGH POINT got underway on 21 October to begin further trials of the Depressor Towed Array System (DTAS). They moored outboard of the USCG Cutter CAMPBELL at the Coast Guard Air Station in Port Angeles, WA. From 22 October through 5 November, DTAS Mark 30 trials were conducted on the range at Nanoose, B. C., and in the Straits of Juan de Fuca. On 6 November. the return transit was made to PSNS on the hull. Vibration measurements on the starboard transmission were made on 8 November. Based on the results, the ship was drydocked the following day for transmission repairs.

The remainder of 1979 was spent in drydock. It was not a banner year for foilborne operations with only 5 hours and 5 minutes foilborne time being accumulated for a total since the first flight of 1349 hours 39 minutes.

There were other events of note relative to the Hydrofoil Program which occurred in 1979. On 26 March, Jim King, a Naval Architect graduate of Webb Institute, joined the Hydrofoil Program Office at DTNSRDC, replacing Dennis Clark, who transferred to the Advanced Concepts Office. PEGASUS (PHM- 1) completed RAV and returned to San Diego in early April. The following month saw the disposal of the world’s largest hydrofoil, PLAINVIEW (AGEH-I), by sale to a private purchaser for the sum of $128,000. The struts, gas turbines, instrumentation, and other equipment had been removed. However. the sale price was a far cry from the $21M purchase price.

On 4 June, PEGASUS departed San Diego for her new homeport in Norfolk, VA. She arrived in Norfolk on 3 July after a record transit through the Panama Canal. It was reported that the ship broke all speed records (and supposedly a few laws) when foilborne during portions of this historic Canal transit. (CAPT Mac Nicholson recalls that SEA LEGS, on her trip to Annapolis in 1958, transited the Chesapeake-Delaware canal at a speed of 27 knots in disregard of the posted speed limit of 6 knots.) Shortly after the ship’s arrival at the Little Creek Amphibious Base in Norfolk, where she was berthed, LCDR Charles W. Penque, Jr. relieved LCDR Wm. J. Erickson as Commanding Officer. He had been aboard the ship during its transit from San Diego. Unfortunately, his tour was to be of short duration. On 20 August, PEGASUS was underway foilborne in the York River in a transit to Yorktown, VA, to load ordnance. The river bottom in that area is, to say the least. very irregular with many shallows. While attempting to maneuver around numerous small craft operating in the vicinity. PEGASUS ran aground. As is often the result in such cases, the Commanding Officer was relieved. On 24 August. CDR J. (Jim) W. Orvis became the new CO of PHM-1.

A final event of note during 1979 was the launching, on 9 July, of Boeing JETFOIL Model 929- 115, hull #014 in their series of commercial hydrofoils. This commercial craft was modified to become the HMS SPEEDY (P-296), ordered by the UK as a fisheries-protection vessel Figure (109) is a photograph of SPEEDY foilborne.

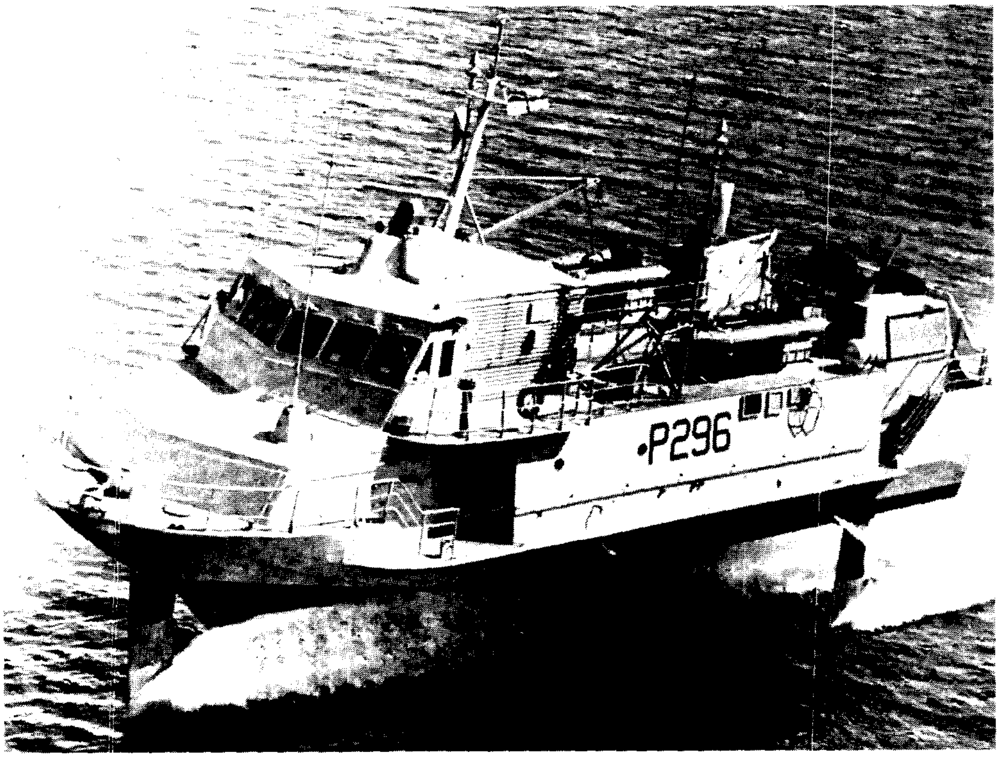


Figure 109. Modified JETFOIL HMS SPEEDY

OVERVIEW 1980

HIGH POINT was undocked on 14 January and spent the remainder of the month conducting hullborne towing trials of a Coast Guard sled. On 4 February, the ship was again put on the blocks for a transmission overhaul that was to last until 15 July. This was performed mainly by the ship's force. Upon completion. six Enginemen from the crew and support group were given letters of commendation from the Commander of DTNSRDC for their outstanding efforts during the overhaul.

About a week later, after conducting post RAV checks of all systems, the ship got underway for Nanoose, B. C. The port gas turbine failed on the trip north and the voyage was completed on the hull. During the remainder of July and the first week of August, an extensive series of trials were conducted in Canadian waters with the Depressor Towed Array System (DTAS) using either the hullborne diesel or the starboard gas turbine. The return hullborne transit to PSNS was made on 9 August. During the following week, the port turbine was replaced.

The turbine installation was checked out on 15 August. During this foilborne run RADM W. A. Williams, Commandant of the 13th Naval District, was aboard as an observer. Preparations were then made for HIGH POINT'S 3rd deployment to Southern California (SOCAL) and the conduct of Phase IIB of the DTAS trials from Port Hueneme, CA. The ship got underway for the first leg of the trip on 22 August. Unfortunately, after about 2-1/2 hours on the foils. off the coast of Washington near the Oregon border, the ship suffered a failure of the starboard propeller shaft spline. They turned back to Bremerton hullborne, but before they could complete the return trip, they experienced a failure in the hullborne diesel propulsion linkage and were forced to finish the final leg back to PSNS hullborne on the port turbine. Meantime, the author and Bob Johnston were in Long Beach, CA, planning to join the PCH when it arrived in Port Hueneme. This was not to be, however. After a series of telephone conferences with the Hydrofoil Special Trials Unit, the decision was made to cancel the SOCAL deployment.

After repairs were effected, hullborne acoustic tests were conducted on the Carr Inlet Acoustic Range on 9 and 10 September. The week following, tests were conducted in the local area to calibrate an air-venting ring installed ahead of the port aft propeller. This system was being evaluated as a means to reduce propeller cavitation and associated radiated noise. On 22 September, the ship transited to the Nanoose range to continue DTAS tests. The following day, measurements were made to determine hullborne radiated noise when the ship was operating with a single gas turbine propulsion system. After a problem was experienced with the lube oil system in the port transmission, both gas turbines were secured and tests were continued on the diesel drive. When the towed depressor became badly fouled in a fish net, the operation was terminated on 23 September and the ship returned to Bremerton. This was the completion of the DTAS trial program. A more detailed discussion of the DTAS Project is presented in a later section of this chapter.

On 26 September, HIGH POINT was again drydocked for an overhaul of the lower transmissions and reinstallation of the Canadian HYTOW system. The ship remained in drydock the rest of 1980. The foilborne time during the year was only 13 hours and 18 minutes, bringing the total to 1362 hours and 57 minutes.

Several other events of note occurred during 1980. On 25 May, HYSTU personnel began performance trials of PEGASUS operating out of Guantanamo Bay, Cuba. On 19 June, CAPT Ross E. Sugg relieved LCDR Louis C. Tedeschi as OIC of HYSTU. CAPT Sugg was OIC of DTNSRDC Annapolis and had intended to retire after that assignment. He was prevailed upon to delay his retirement and accept assignment as OIC HYSTU. Having an EDO of his rank and background was of significant benefit to the Trials Unit, particularly with regard to dealings with the Shipyard and military commanders.

During August. HYSTU personnel also participated in trials to measure the pressure, acoustic, and magnetic signatures of PEGASUS. These trials were conducted at the Naval Coastal Systems Center at Panama City FL. Later on, in September, HYSTU, with assistance from the PHM Mobile Logistics Support Group (MLSG), installed a radar height sensor on PEGASUS in Key West, FL. the new home base for the PHM Squadron (PHMRONTWO). On 18 November, the first of the production PHM MLSG personnel reported to HYSTU where they were to be attached until the last of the six PHM's were delivered and outfitted.

On 30 September, Fred Saxton retired as Manager of Hydrofoil Instrumentation. He was one of the program plank owners and had been responsible for overseeing the instrumentation systems on both the PCH and AGEH. In the latter case, he conceived and specified a state-of-the-art 236-channel FM data recording system which was procured and installed on PLAINVIEW. On 1 October. John Meyer, an engineer with considerable background in industry working with new system concepts, transferred from the DTNSRDC Advanced Concepts Office to the Hydrofoil Development Program Office. He was initially placed in charge of the Extended Performance Hydrofoil Project (EPH). He developed the concept of adding a buoyancy fuel tank as shown on PCH in the artist rendering in Figure (110) and described in Reference 84. On 17 October, another plank owner at HYSTU, Jim Mason, former Navy Chief, who had been the Trials Unit's invaluable Instrumentation Technician since the early days, retired after 37 years of government service. He was replaced by Art Brown, an Electronic Engineer. Finally, Quarter

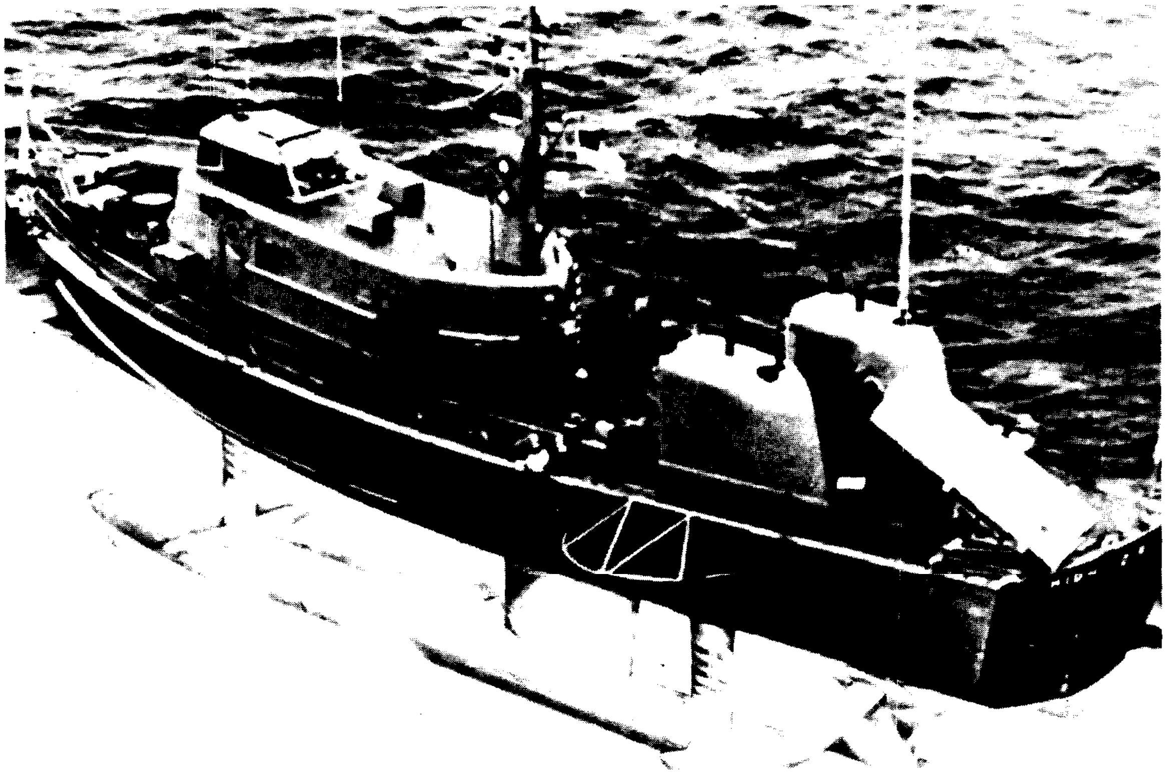


Figure 110. HIGH POINT with Buoyancy Fuel Tank Concept for Extended Range

Master Chief Petty Officer Ronald W. Lovelace retired from HIGH POINT on 31 December 1980 after 21-1/2 years of continuous active duty service in the U.S. Navy.

DEACTIVATION REVISITED

It will be recalled from the earlier discussion of the attempt to deactivate HIGH POINT at the end of FY-78, that the Navy had asked that such action be delayed until the end of FY-80. As the end of FY-80 started to draw close. the question of deactivation again arose. Here. it should be noted that there was no language relative to this question in the FY-79 Defense Appropriations Bill, nor was there any reference to it in the House of Representatives Conference Report No. 96-696 on the FY-80 Defense Appropriations Bill dated 11 December 1979. In view of the background of the issue, however, the Navy was in somewhat of a quandary regarding the position to be taken concerning the future disposition of HIGH POINT. They could go back to the Congress and ask for clarification which might result in reopening the whole issue with a possibly unfavorable result, or they could act as if there was no longer any issue and continue the ship in service as long as there were useful functions for her to perform. In the latter case, there was still much to be done in support of the HYTOW Project, the DTAS Project, further evaluations of hydrofoils utility for mine and anti-submarine warfare, and other R & D tasks. However, neither position was considered to be fully acceptable.

In a letter dated 8 July 1980 to the CNO (OP-37), via CNM, DTNSRDC stated the following:

> 1. In order for the David Taylor Naval Ship R&D Center to properly plan for use of the hydrofoil HIGH POINT and associated personnel during the coming fiscal years, it is considered essential that this Center receive a commitment that the craft will remain in service. Severe disruption

was experienced at the end of FY-78 when permission to retain HIGH POINT was delayed until the very end of the year. The OIC and the crew had been detached, and a new OIC and crew rebuild was necessitated.

2. It is the position of this Command that retention of HIGH POINT as an R&D platform is mandatory as long as the Navy is acquiring and operating PHMs. Research into material cracking problems. improved navigation, more reliable height sensors, weapons compatibility, and alternate missions are just examples of required R&D support to operational hydrofoils. Enclosures (1) and (2) provide specific details of current funded and potential programs and the associated utilization schedule. Informal dialog with COMSURFLANT indicates Fleet hydrofoil assets are not available for dedicated R&D purposes, and support for the necessity of a R&D hydrofoil platform was indicated.

3. There appears to be a common misconception that HIGH POINT is linked solely to the Advanced Hydrofoil Program which is currently unfunded. While that program would utilize HIGH POINT. the PHM's have separate and continuing needs for HIGH POINT support.

4. Accordingly, it is requested that DTNSRDC receive appropriate planning guidance to the effect that HIGH POINT will remain in service.

In September 1980. a letter was drafted in OP-03, mission sponsor for hydrofoils, which was to be sent by SECNAV Edward Hidalgo to Congressman Joseph Addabbo, Chairman of the House Subcommittee on Defense Appropriations. and Senator John Stennis, Chairman of the Senate Defense Appropriations Subcommittee. In the draft letter, the Navy's intent to continue use of HIGH POINT as a test craft was stated and support of the Navy requirement by the Subcommittee was solicited. To the best of this writer's knowledge, these letters were never actually sent. It is understood that the Navy's position was informally cleared with Congressional staffers and a favorable response to DTNSRDC's request was prepared for signature by OP-03. Unfortunately, OP-03 questioned the value of retaining HIGH POINT and the relation of its planned use in support of future requirements. This caused further delay and. in a memorandum to CNM dated 19 December 1980, the Commander of DTNSRDC. CAPT Myron Ricketts soughr Flag Officer assistance in resolving the issue of HIGH POINT's future disposition. Whether this action was responsible for generating the desired result is not actually known. However, in a letter to the CNM, dated 24 December 1980, VADM William H. Rowden, Deputy Chief of Naval Operations for Surface Warfare (OP-03), stated the following:

1. Reference (a) requests approval for retention in service of HIGH POINT (PCH- 1) beyond FY-80.

2. The retention of HIGH POINT (PCH-I) is approved subject to the following guidelines:

a. Retention in service will continue only as long as a valid requirement for hydrofoil high speed test craft services exists. Specific technical programs will be responsible for funding the required technical trial evolutions.

b. Funding for fuel, supplies, equipment, alterations, repairs, and regular overhauls will continue to be budgeted as a part of RDT&E Ships Support. Program Element (PE 65836N).

3. If additional funding is required in PE 65863N to support the program as delineated in Reference (a), adequate justification should be addressed through normal programming channels by separate correspondence.

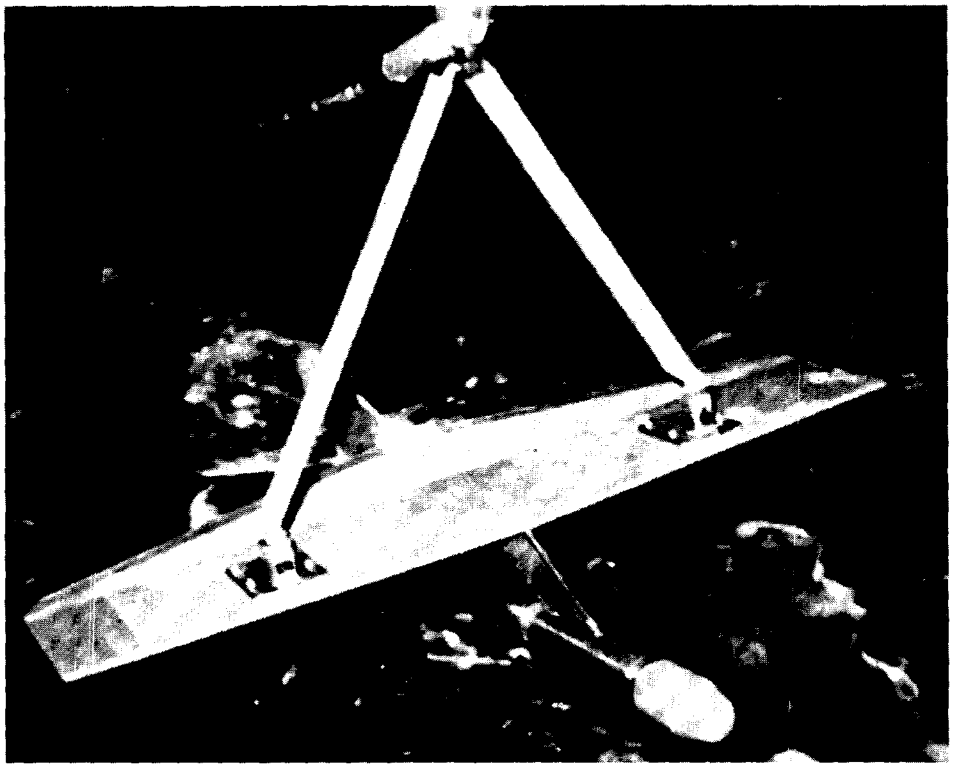


Figure 111. DTAS Depressor

Once again disaster had been averted at the very last minute and HIGH POINT survived to continue its vital R&D role. It was clear, however, that the likelihood that she would continue to survive ever more frequent R&D budget drills was somewhat dubious. The Blue Water Navy's apparent lack of any real enthusiasm for small hydrofoil craft, or for that matter craft in general, did not bode well for the future.

DTAS

As noted earlier, HIGH POINT was initially equipped with a mid-ship retractable strut-mounted sonar (SQS-33, XN-1) and a variable depth acoustic projector which was lowered from a winch on the stern. This was supposed to give the ship a capability to detect submarine targets at a headway speed of no more than five knots. This was the beginning of the so-called "sprint-drift" concept of ASW. Unfortunately, this one-of-a-kind system proved to be unsatisfactory. It was removed from the ship in the late 1960's without ever having been tested operationally.

The Depressor Towed Array System (DTAS) also had the objective of demonstrating an ASW sprint-drift capability with lightweight equipment suitable for use on a highspeed hydrofoil. It was conceived by Stanley Rupinski., an employee of the Naval Undersea Systems Center (NUSC), New London, CT, Reference 85.

The DTAS was comprised of a towing winch mounted on the stern of HIGH POINT, a towing cable, and a depressor *to* which was attached a "thin-line" sonar array. The depressor, Figure (11 1), was

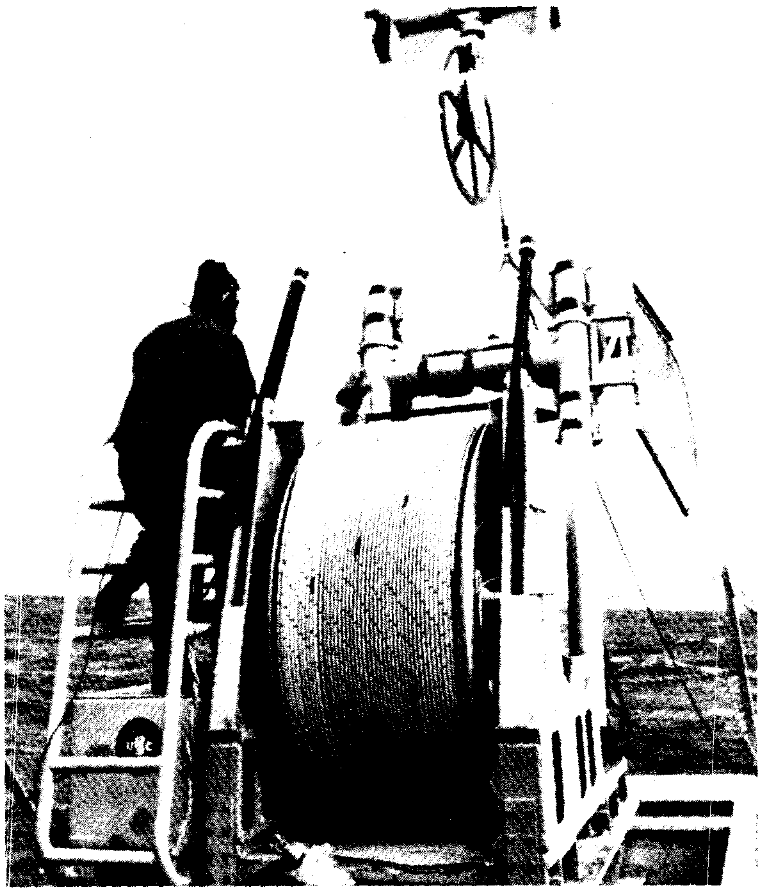


Figure 112. DTAS Winch and Handling System

a modified version of a developmental minesweeping paravane which was furnished by the Towing Problems Branch at DTNSRDC. It was modified by NUSC to increase its size. They also added control surfaces, redesigned the tail, and added an instrument pod.

The towline was a double-armor coaxial cable with a fully-enclosed sectional fairing. The cable was made by Vector Cable Corporation and the fairing by Fathom Oceanology, Ltd., of Canada.

The hydraulically-operated winch, Figure (112), was designed and constructed by the Naval Research Laboratory. It was made mostly of aluminum for light weight. Powering was provided by an air-cooled diesel engine. The winch was very compact and had a high speed cable inhaul rate.

Figure (113) shows the components of DTAS. During deployment hullborne, the array is paid out and the depressor is launched at headway speed and lowered to the desired towing depth. The system is then towed at a speed consistent with the requirement to minimize self-noise. This is the "drift mode" for detection of the target. In the "sprint" mode, the depressor is hauled in until it is just below the outboard towing sheave. The ship is then free to transit at high speed on the last target bearing. The array must be able to withstand the forces associated with the sprint speed.

During the period from November 1978 through June 1979, the winch and handling system was tested and debugged on the NUSC landing craft LCU- 1647. During May 1979, the array was also towed

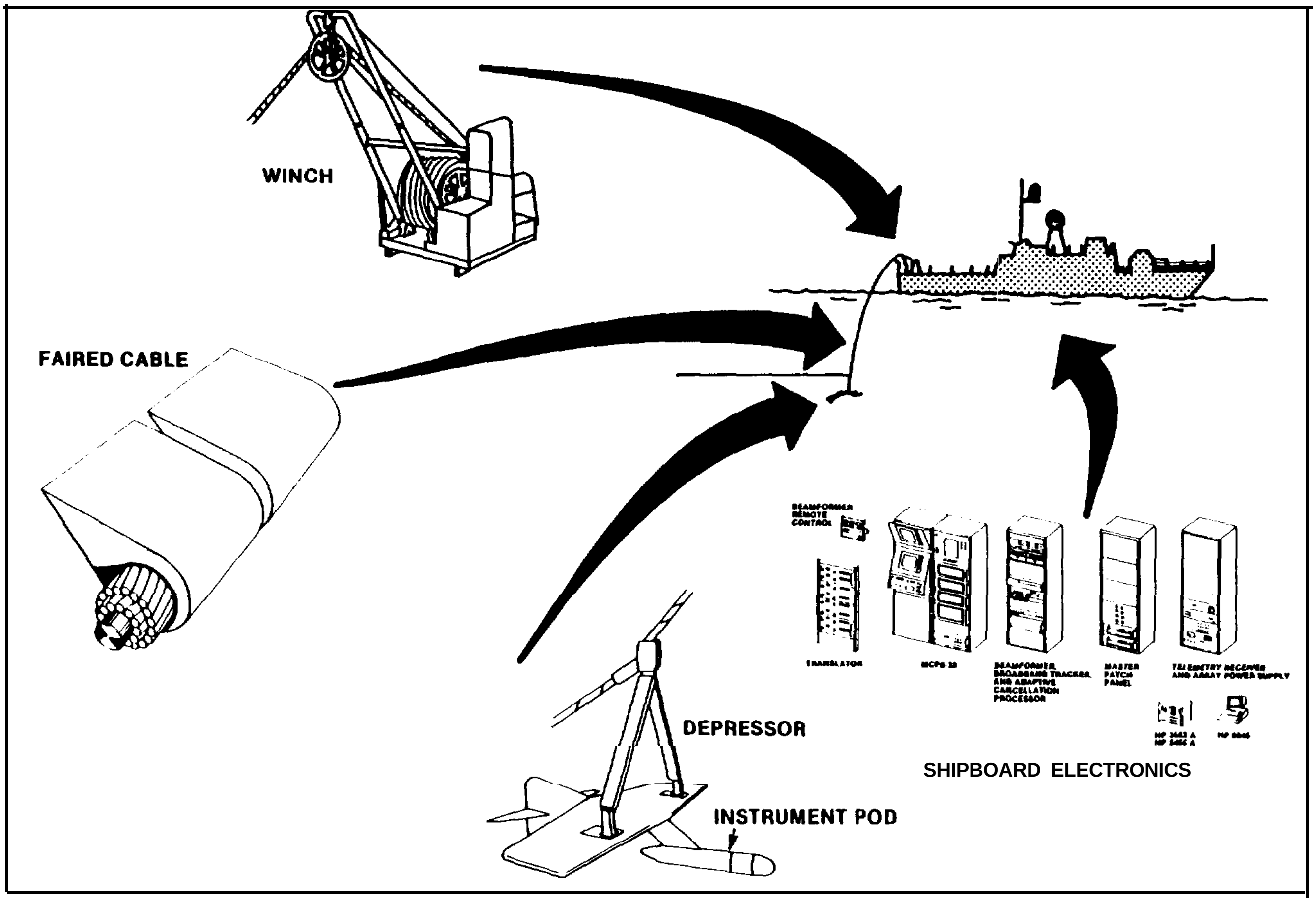


Figure 113. DTAS Components

at its critical angle by the research vessel R/V HARRIS. The objective was to evaluate the self-noise of the array in a quiet environment.

DTAS (MK-30) was installed on HIGH POINT in early October 1979. Hullborne trials began on 18 October. On 21 October, the ship made a transit to Port Angeles to continue hullborne testing on the Nanoose Range and in the Strait of Juan de Fuca. Trials were completed and HIGH POINT made the return transit to PSNS on 6 November.

Phase IIA of the DTAS trials began with a return transit to Nanoose on 24 July 1980. During the following two weeks, an extensive series of trials were conducted. They included self-noise tests and tests with a sonar target. On 8 August, the ship had a propeller failure and it was necessary to return to PSNS hullborne on the following day. Preparations were then made for a deployment to Southern California for Phase IIB DTAS tests on the range off San Clemente. As noted earlier, this deployment was cancelled when they had a propeller shaft failure after the ship had been underway for only about 2 hours. Back at PSNS, HIGH POINT was drydocked for repairs on 23 August.

The ship was undocked on 25 August and DTAS testing continued in the local area and on the Carr Inlet acoustic range. During this period, tests were also conducted with an air-vented propeller. On

22 September, a transit was again made to Ranch Point for further DTAS trials on the Nanoose Range. It was also planned to demonstrate array survivability during foilborne sprints and at-sea operations against a towed sonar target. Unfortunately, on the following day, they suffered another casualty with saltwater contamination of the lube oil in the port transmission. The gas turbines were secured and tests were continued until the depressor became fouled in a fish net. They secured from further trials and HIGH POINT returned to PSNS without completing the final series of tests on the agenda. Although the results of this program were promising, it was clear that further development of the system was required.

OVERVIEW 1981

HIGH POINT remained in drydock until August for completion of an overhaul of the outdrive (hullborne propulsion unit), the ship's generator, and the foilborne transmissions. Modification of the foilborne lube oil system. hull modifications to accommodate planned installation of a minesweeping system, installation of a Raytheon RN 1220-6XR radar from PLAINVIEW to replace the model 1605, and other modifications and repairs were made. The Canadian Variable-Depth Sonar gear (HYTOW) was again installed during this period. On 19 August, a hydraulic hose burst in the forward strut due to age and deterioration. As a result, the decision was made to replace all of the hydraulic hoses in the strut.

The ship was undocked on 3 1 August. After a delay caused by the need to rebalance the propellers, the next series of HYTOW' tests began. These tests continued from 23 September to 12 October and included the first successful towing of the VDS body at foilborne speeds. After conclusion of this test program, the ship made a foilborne transit to Esquimalt B. C.. They also made a trip to Port Angeles, WA. to refuel. They were accompanied by RADM Hughes, Canadian Maritime Forces Pacific. On 19 November. further tests were aborted when a high concentration of salt water was found in the port transmission. The lube oil was replaced overnight and, on 20 November, the ship returned to PSNS where she was drydocked for removal of the VDS gear and the beginning of installation of the Hydrofoil Pressure Acoustic and Magnetic (HYPAM) minesweeping system. She remained in drydock the remainder of 1981.

Even though HIGH POINT spent 10 of the 12 months of 1981 in drydock, she still accumulated 32 hours and 30 minutes of foilborne time. This was more than the total for both 1979 and 1980 and brought the total accumulated time since first flight to 1395 hours and 27 minutes.

Several other events of significance occurred in 198 1. On 1 May, CAPT Barrick (Barry) F. Tibbitts relieved CAPT Myron V. Ricketts as Commander of DTNSRDC. CAPT Ricketts was promoted to COMMODORE and assigned to NAVSEA as Deputy Commander for Ship Design & Engineering (SEA-W). On 8 May, TAURUS (PHM-3) was launched at Boeing. Figure (1 14). She was really the first PHM Class ship since she represented a substantial redesign of the PEGASUS based on the extensive data that had been acquired from the PEGASUS trials and the correction of a number of deficiencies. A short time later. on 27 May, the Grumman-built Israeli hydrofoil gunboat (SHIMRIT)., shown in Figure (1 15), was launched at Lantana. FL.

On 29 June, while HIGH POINT was still in drydock, LCDR Daniel G Mulhall relieved LCDR Joel D. Givens as OIC. Figure (I 16) shows HYSTU's Sumi Arima shaking hands with LCDR Givens as LCDR Mulhall and Don Rieg look on.

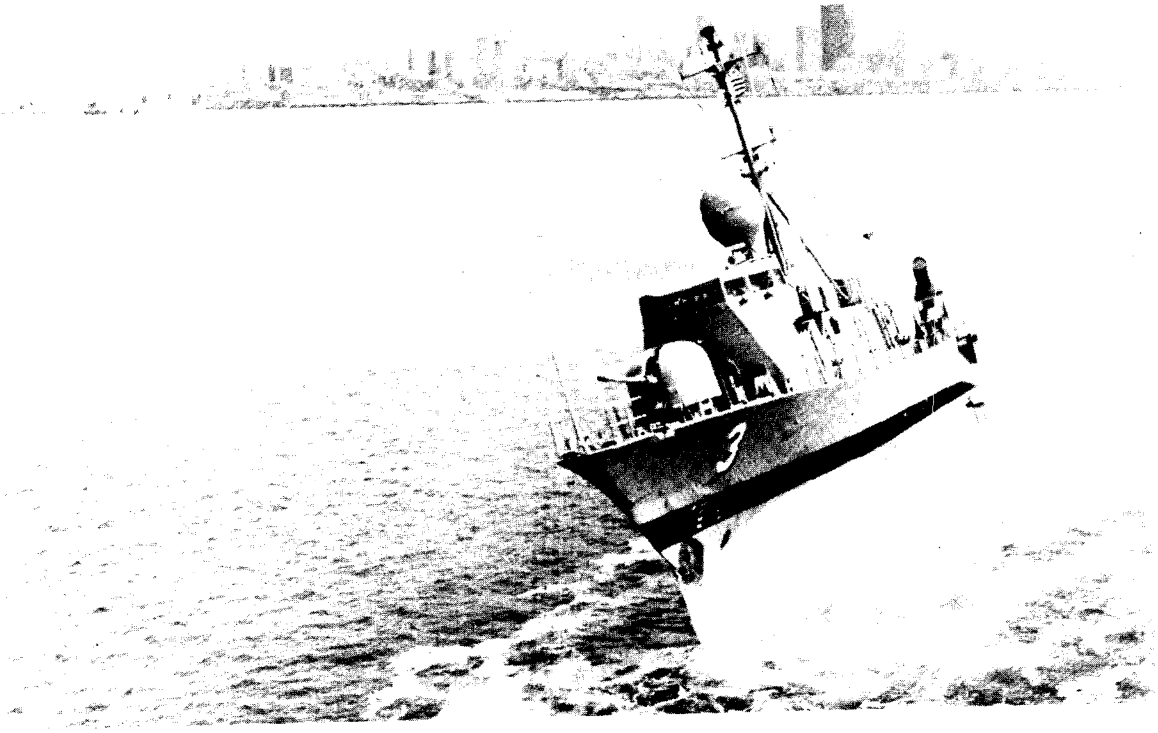


Figure 114. TAURUS (PHM-3) Foilborne in Seattle Harbor

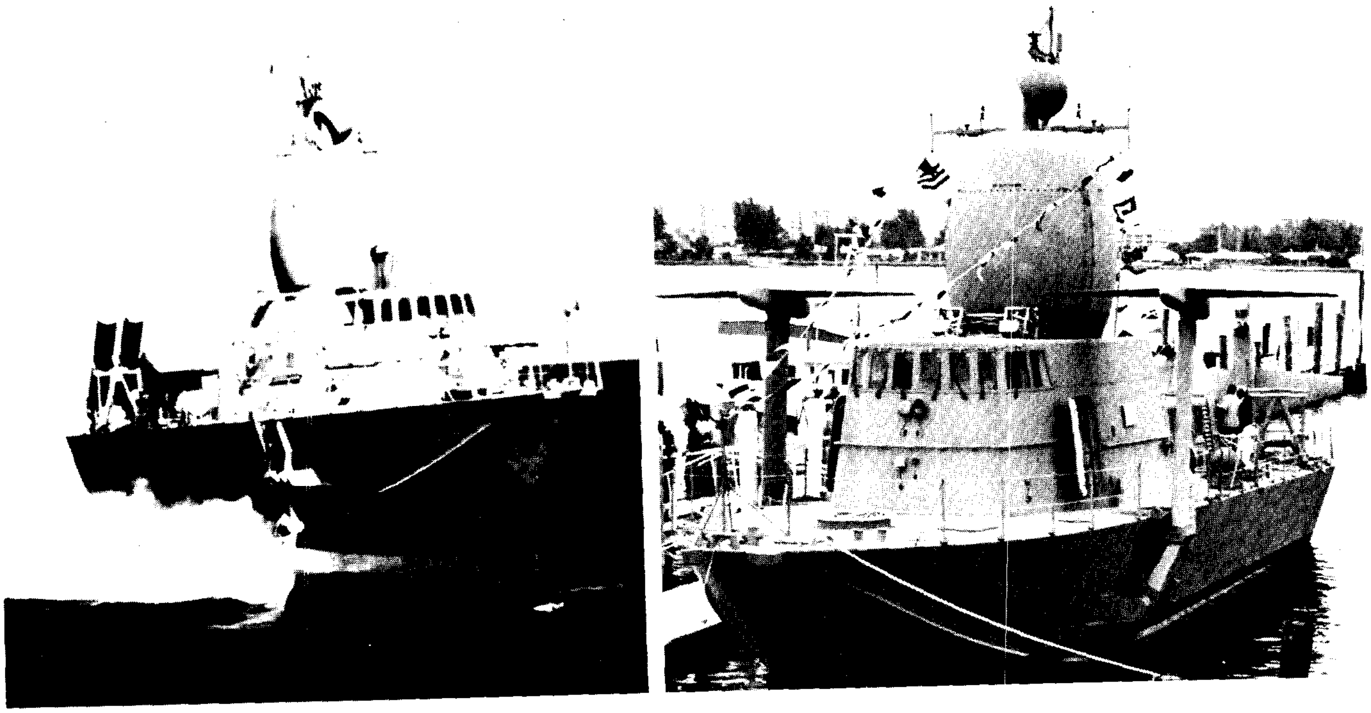


Figure 115. Grumman-Built Israeli Hydrofoil Gunboat SHIMRIT

Figure 116. HYSTU's Sumi Arima Shakes Hands with LCDR Joel Givens

During the latter part of August, HYSTU personnel conducted baseline performance trials on PEGASUS out of Pascagoula, MS. Towing trials were also conducted to determine optimum conditions for towing the ship to increase its range of operation. On 5 November, the ARIES (PHM-5) was launched at Boeing.

OVERVIEW 1982

The year 1982 could be considered a banner year for HIGH POINT. The ship met all commitments and remained operationally ready for the entire year with few major equipment failures and no transmission problems.

The year began with the ship drydocked for installation of the Hydrofoil Pressure Acoustic Magnetic (HYPAM) minesweeping system. This multiple influence minesweeping system concept grew out of earlier tests which demonstrated the potential for using hydrofoils singly or in tandem to sweep pressure mines. The HYPAM project was conceived by the Naval Coastal Systems Center in Panama City, FL, and came under the direction of NAVSEA Program Manager Bill Steadly. The HYPAM towing boom was installed on 12 January and tests of the hydraulic system were conducted on the following day. The installation was completed on 15 January. Three days later. the ship was undocked, and on 19 January, a foilborne demonstration was given for CAPT Barry Tibbitts, Commander of DTNSRDC. On 25 January, preliminary foilborne handling trials of the HYPAM system were conducted, Figure (117).

On 28 January, HIGH POINT transited to Everett, WA. This was used as a base for HYPAM ranging trials. These trials were conducted until 10 February when the ship returned to PSNS. After rerunning a baseline ship characterization, the ship was drydocked to remove the HYPAM gear, overhaul the

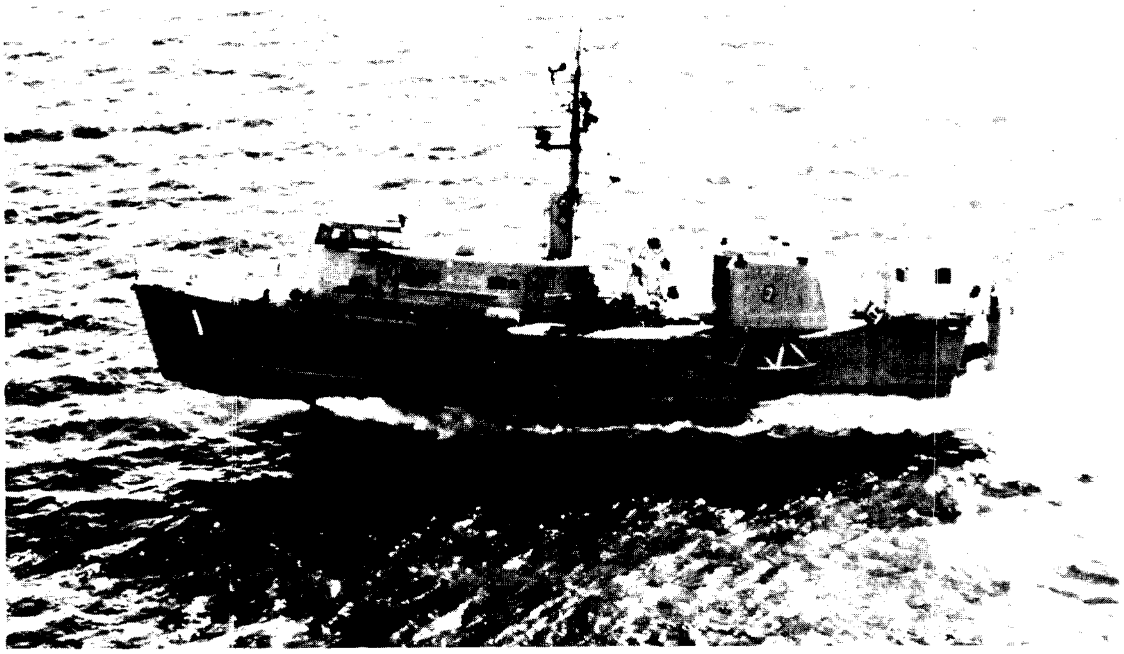


Figure 117. HIGH POINT Foilborne with HYPAM Installed

hydraulic system, and replace the emergency generator. HIGH POINT was undocked on 24 May and, for the next two weeks, was engaged in crew training and checks of various subsystems.

As recounted in a voyage report by the OIC of HIGH POINT, LCDR Dan Mulhall, the ship and her complement were participants in the Portland Rose Festival during June 1982. On 8 June, HIGH POINT was scheduled to depart Bremerton at 0800, embark Channel 11 newsmen at Manchester, and proceed to Portland, OR, for the Festival. They planned to remain overnight in Astoria, OR. However. their departure was delayed due to failure of a starboard high pressure hydraulic hose which occurred during checkout of the automatic control system. Attempts to replace it were frustrated by a problem with the fittings on the new hose. Chief Mustoe resolved the problem by using armored hose and special fittings which he manufactured on the HYSTU barge. They finally got underway shortly after noon. However, by this time the Channel 11 News crew had cancelled out. Another temporary interruption of the transit occurred after about 55 minutes on the foils. It was necessary to go hullborne briefly to torque down the port strut downlocks. They were then able to resume foilborne operations and completed an uninterrupted flight of more than 6 hours, the longest sustained foilborne transit since 1974. Seastates were relatively low and the Columbia River Bar was relatively calm when they passed over it.

The ship was tied up on the east side of Pier 2 in Astoria at 2049 that evening. They refueled with 4,000 gallons of JP-5 which had been trucked down from Manchester. Electrical service was not available on the pier and they used the new John Deere emergency diesel generator which had been installed earlier. They were scheduled to get underway at 0500 the following day to complete their transit up the river to Portland. Seventeen guests from the Rose Festival were supposed to accompany them and they had been instructed to be on board by 0430. As might have been expected, it was necessary to delay their departure until 0615 to ensure that all guests were aboard.

The transit to Portland was made on the foils in about 2 hours, During this transit, they had a pilot aboard and, although he did not conn the ship, his presence and familiarity with the Columbia River was reassuring. They went hullborne in the vicinity of St Johns Bridge and proceeded to the Naval Reserve Pier, Swan Island, where they waited until 1700 to move to their assigned berth in downtown Portland east of the Hawthorne Street Bridge. They moored outboard of USS IMPLICIT and a float was provided between the two ships.

From 9 until 11 June. HIGH POINT remained moored in Portland. Open house was held each day from 1300 to 1600. Some 2,700 visitors were given tours of the ship, which was less than had been expected based on past experience. This was attributed to their being tied up some two blocks east of the carnival area and away from the central focus of the Festival. The ship was highlighted in several newspaper articles, receiving front page coverage in the "Oregonian", the "Journal", and the "Columbian". Also, she was featured in several news broadcasts. Ship's plaques were presented to the Mayor, the Rose Festival Committee, and the Navy League of Oregon; all told, another good media event for hydrofoils.

HIGH POINT got underway for the journey home at 06 15 on 1-i June with 29 Navy and Navy League guests aboard, The transit to Astoria was made foilborne in 2 hours without incident. The following day, six of the Navy League guests reboarded the ship and they made the final leg to PSNS in a total of 7 hours of foilborne time. State 3 and 4 seas were encountered, but were negotiated without difficulty. They sat down briefly at the mouth of the Straits of Juan de Fuca to enjoy a "fish call" for the crew. Fog was prevalent in the Straits but the return to Bremerton was routine. The trip was an excellent experience for all hands and resulted in outstanding public relations for the Navy, for hydrofoils in general, and HIGH POINT in particular.

HIGH POINT was again drydocked on 16 July where she remained for the next two months. During this period the Canadian Variable-Depth Sonar system HYTOW) was once again installed. The ship was undocked on 16 September and on 19 September new disconnect couplings were installed. A short time later, they began hullborne trials of HYTOW. These were completed and they began the foilborne phase of the trials program on 8 November. These trials continued thru the end of November. During the month of December, efforts were devoted to crew training until standing down for the Christmas holiday. During 1982, HIGH POINT logged over 72 foilborne hours, its most prolific year since 1976. The foilborne total at year end stood at 1468 hours 49 minutes.

There were other events of note which took place during 1982. On 1'7 February, GEMINI (PHM-6) was launched at Boeing and on 13 April, HERCULES (PHM-2), the last of the six PHM's, went into the water. It was the last to be launched due, in part, to the earlier budget problems and the delay in initiation of the PHM production program.

On 1 July, the hydrofoil Advanced Development Program lost one of the stalwarts of U.S. hydrofoil development when Bob Johnston retired from Federal Service. As discussed earlier, he had been associated with the Navy's hydrofoil efforts since the beginning; first as a naval officer, then as a Grumman manager, and finally, as a civilian technical program manager with DTNSRDC. (As might be expected, Bob Johnston has continued to remain active in matters associated with advanced craft. Upon his retirement, he founded a small R&D firm called Advanced Marine Systems Associates (AMSA). As of this writing, he remains as its president. AMSA recently completed an extensive "Study of Highspeed Waterborne Transportation Systems", Reference 85. It was sponsored by the Urban Mass Transportation Agency (UMTA) under the Department of Transportation. The UMTA Program Manager was Ms. Patricia Cass.)

On 15 July, TAURUS (PHM-3) and AQUILA (PHM-4) departed for Key West, FL, in company with an LST. They arrived at PHMRONTWO on 11 August. GEMINI (PHM-6) was placed in service on 13 November. ARIES (PHM-5) departed Seattle for Key West on 23 November.

On 22 November, CAPT Thomas Sherman, USN (ret), reported to DTNSRDC as the fourth Technical Manager of the Hydrofoil Development Program. He had retired from the Navy only a short time earlier and joined the Center after a brief tour in private industry. During his Navy career, he had been Commander of Destroyer Development Group II, had spent some time in activities associated with anti-submarine warfare and, shortly before his retirement from active duty, was assigned to the UK where he was engaged in the analyses of war games.

OVERVIEW 1983

After some independent steaming exercises in the first half of January, HIGH POINT got underway on 23 January for a transit to Esquimalt, B. C. and a continuation of the HYTOW trials program. On 27 January. they made a transit to Nanoose with RADM Gordon Edwards, CF, aboard. (The author regrets that he could not also be aboard during this trip since Gordy Edwards was an old friend from earlier days in the hydrofoil program. As a Commander, he was Skipper of the Canadian hydrofoil ship BRAS D'OR (FHE-400) described in Chapter I. On 14 May 1971, the author, accompanied by Tom Ray of Boeing and others involved in the L7.S. Hydrofoil Program, were guests aboard BRAS D'OR for about five hours during a demonstration in St. Margaret's Bay, Nova Scotia. The weather was most foul with heavy fog and state five seas, It soon became clear that Gordy Edwards was determined to show the ruddy Americans that his ship was a match for any U.S. craft. He proceeded to put the throttles to the firewall, the poor visibility notwithstanding, and plunged through the heavy seas at speeds up to fifty knots. From the bridge one could observe the lightly-loaded "diamond-shaped" forward foil come completely clear of the water surface before plunging back into the face of an oncoming wave. Finally, the Captain relented and brought the ship down on the hull. Unfortunately, this created a new problem for the author when he rapidly fell victim to a bad case of mal de mer. A hasty retreat was made to the bunk in the Captain's stateroom which he had graciously offered. He also offered a scotch and soda. which was regretfully declined, another "first". Needless to say, it was with considerable gratitude that foot was set on solid ground upon the return to Halifax. The author has never allowed Mike Eames. Canada's hydrofoil pioneer, to forget this trip and the fact that Mike never experienced such an extended ride in such high seas aboard the ship of his creation.)

The HYTOW trials were interrupted on 28 January by a saltwater leak in the forward lube oil seal of the port transmission. The following day HIGH POINT returned to PSNS and, on 1 February, she was drydocked to effect repairs of the transmission and the fibreglass fairing of the port nacelle. She was undocked on 23 February, but it was then discovered that there was saltwater contamination of the lube oil in the starboard transmission. This required another drydocking. Finally, after repair of the starboard transmission and further independent steaming exercises, it was established that the ship was ready to continue the HYTOW trials. They returned to Esquimalt on 4 April and continued the trials until 12 April. After a return transit to Bremerton, the final phase of the test program was completed in the Puget Sound area. On 20 April, removal of the VDS gear got underway.

During the last series of VDS tests. an overheating of the starboard main turbine had been detected. As a result. the decision was made to change out the hot section. Replacement was made with the section from the Rolls Royce Proteus engine which had been installed in the TUCUMCARI (PGH-2j. The change out was performed in three days by the ship's force with assistance of the HYSTU test mechanic and Shipyard riggers. This outstanding performance led to a commendation of the crew members by the Commander of DTNSRDC.

After checkout of the starboard turbine, on 28 April. HIGH POINT made an 8-1/2 hour foilborne transit to Newport, OR, to participate in the city's Loyalty Day Festival. Public relations during their stay were good, but the port visit was marred somewhat by the fact that the ship's berth was far removed from the main pier. This made accessibility to the public and pier services such as water, fuel. and stores very difficult.

The ship made the return transit to Bremerton on 1 May and set a new record of 10 hours 19 minutes continuous foilborne operation. A short time later, on 12 May. LCDR Mike Dunaway relieved LCDR Dan Mulhall as OIC.

On 17 May HIGH POINT was placed in her cradle on Pier 7 and began a regular overhaul which was to include a much needed refurbishment of the ship's service and autopilot hydraulic systems. The overhaul was scheduled to run through September. However, in August, the decision was made to extend the overhaul to remove the forward strut and disassemble the kingpost roller bearing assembly. This had not been done in the ten years since the MOD 1 conversion when the steerable forward strut with the wetted roller bearings was first installed. This was done primarily to establish the validity of this design as a solution to problems that had been experienced with the forward strut bearing on the PHMs. Upon inspection. it was verified that the bearing was in excellent condition. Some stress cracking was, however, discovered in the structure and the necessary repairs prolonged the overhaul well into 1984.

During 1983, HIGH POINT accumulated another 61 hours and 12 minutes of foilborne time. This brought the total since first flight to 1530 hours.

Other events of some note which occurred in 1984 included the author's retirement. on 31 January, as Head of the Systems Development Department. Code 1 1, of DTNSRDC. (This position was filled temporarily by Ed O'Neill, who had been Head of the Marine Corps Program Office in the Department. Later, in a set-ies of transfers, Ed O'Neill became Director of Technology, Code 012, and Dr. Warren Dietz was transferred from his position as Head of the Propulsion and Auxiliary Systems Department, Code 27, in Annapolis, to take over the Systems Development Department in Carderock).

In February, Boeing was awarded a $ 14M contract to continue support of the PHM Squadron in Key West, FL. This was essential in maintaining operational readiness of these six new Navy advanced ship concepts. HERCULES (PHM-2), the last ship of the Squadron to be delivered. was commissioned at PHMRONTWO on 12 March 1983.

HYTOW

In both the Canadian and U.S. hydrofoil programs antisubmarine warfare had always been considered a prime mission application for hydrofoil craft. Their high speed in rough seas with excellent platform steadiness, their ability to carry a reasonable payload, and their cost effectiveness made them attractive candidates for this role. There were, however two serious limitations; their limited range and the unavailability of a look-while-fly detection system.

In the Canadian program, a SQS-507 variable-depth sonar was built for installation on the BRAS D'OR. However, the hydrofoil development program was terminated before the system could be installed and tested.

The beginnings of what was to become Project HYTOW can be traced back to the 1972-73 time frame. During this period, Boeing Marine Systems had discussions with several sonar manufacturers regarding the use of hydrofoils for ASW. In early 1975, Westinghouse Canada, Ltd., contacted Boeing and advised them that a small ship VDS sold to Sweden was in storage and might be available on a loan basis. Westinghouse approached Canada's Department of Trade, Industry, and Commerce (DTIC) for government support of a joint Canadian-US test program. This was looked upon favorably and Boeing and Westinghouse formally submitted a joint proposal to DTIC.

In a related action in 1975, an offer was made by the U.S. in a meeting of the NATO Special Working Group Six (SWG-6) to make available the HIGH POINT or the PLAINVIEW for trials involving a participating nation ASW sensor systems.

As a result of these actions, Project HYTOW was officially begun in 1977 with the signing of an agreement between the U. S. Navy and the Canadian Department of Defence Production. represented by DTIC. Under the terms of the agreement the project was to be divided into five phases; planning, installation and checkout. trials, documentation. and evaluation for possible use on PHM-1. The primary trials goals were to determine:

- The physical effects on the VDS system from towing by a hydrofoil over a range of speeds under operational conditions.
- The effect of the VDS on the performance and handling characteristics of the hydrofoil
- The effects of high speed towing on the acoustic characteristics of the sonar including radiated noise from the ship and sonar self-noise.
- The potential for use of the VDS system on a PHM.

The HYTOW system (initially borrowed from Sweden and later purchased) comprised the Westinghouse Canada HS- 1001/1 sonar, a model 9-330 hoist produced by Fathom Oceanology, Ltd, and a nine-foot sonar body with a cable and sectional fairing, also produced by Fathom. The frequency was 10KHz with 360-degree coverage in azimuth using 24 preformed beams. The horizontal beam width was 15 degrees and the vertical beam width was 1 7 degrees. The transducer was 24 inches high and 24 inches in diameter. Figure (118) shows the transducer in the Fathom body. Figure (1 19) shows the hoist with the body in the launch position. Figure (120) shows the system console installed in the instrumentation compartment aboard the ship. The system was installed on HIGH. POINT during a drydocking from 2 September through 13 December 1977. It added about 5 tons to the ship weight making the total displacement about 125 tons. The first phase of the trials program did not begin until 2 February 1978.

The 1978 trials were primarily for evaluating the handling and towing, Figure (12 1), characteristics of the system. Sonar operations were conducted only on an informal basis in parallel with the towing trials. The operations area for these trials was off Vashon Island as shown in Figure (122). In this area the ship did not have full freedom of operation due to the limited confines and the presence of other surface traffic. Furthermore, water depths were only 450 to 600 feet and reverberations from the bottom and the shore lines did not make for good sonar conditions.

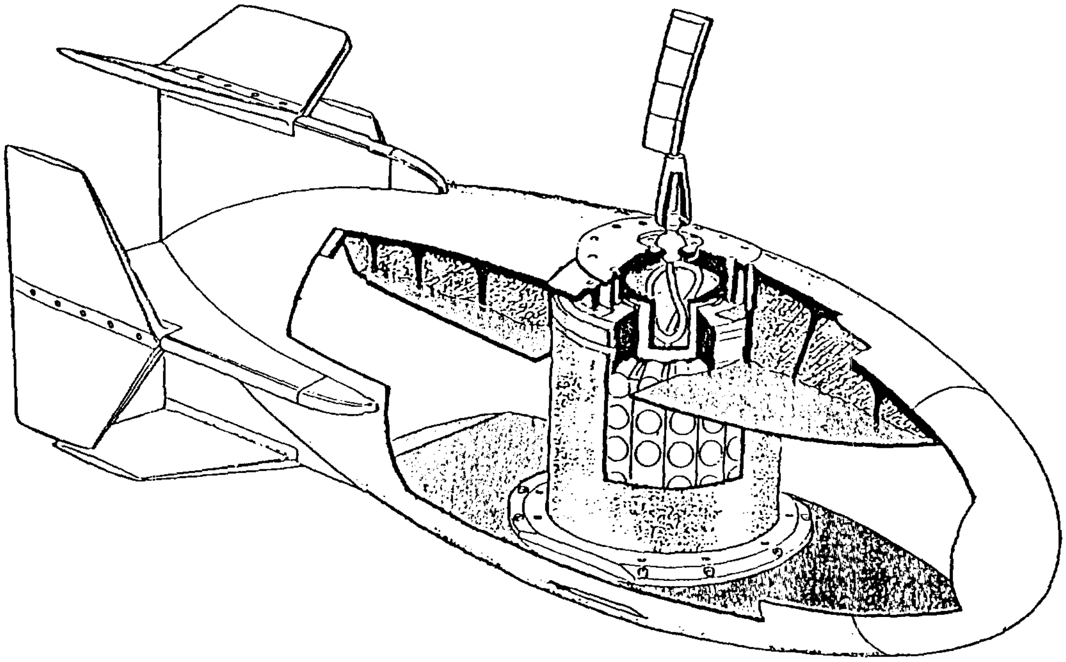


Figure 118. Canadian Variable Depth Sonar Body (Original Configuration)

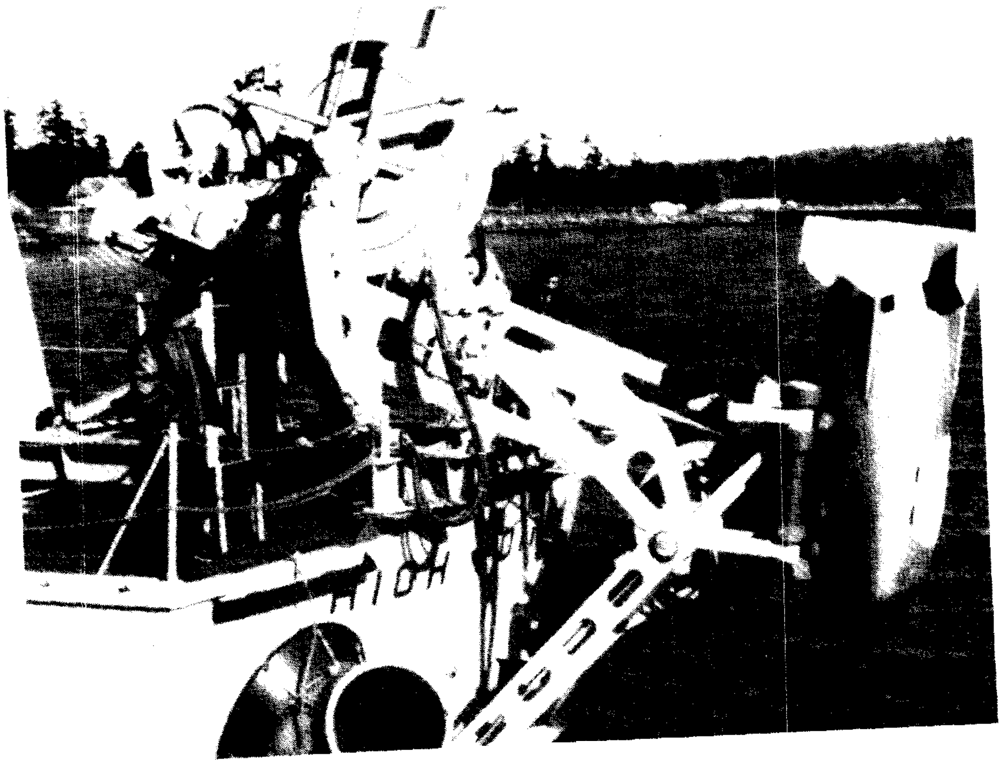


Figure 119. Fathom Oceanology 9-330 Hoist and VDS Body on PCH

Figure 120. Westinghouse HS- 100 1 Sonar in PCH Instrumentation Compartment

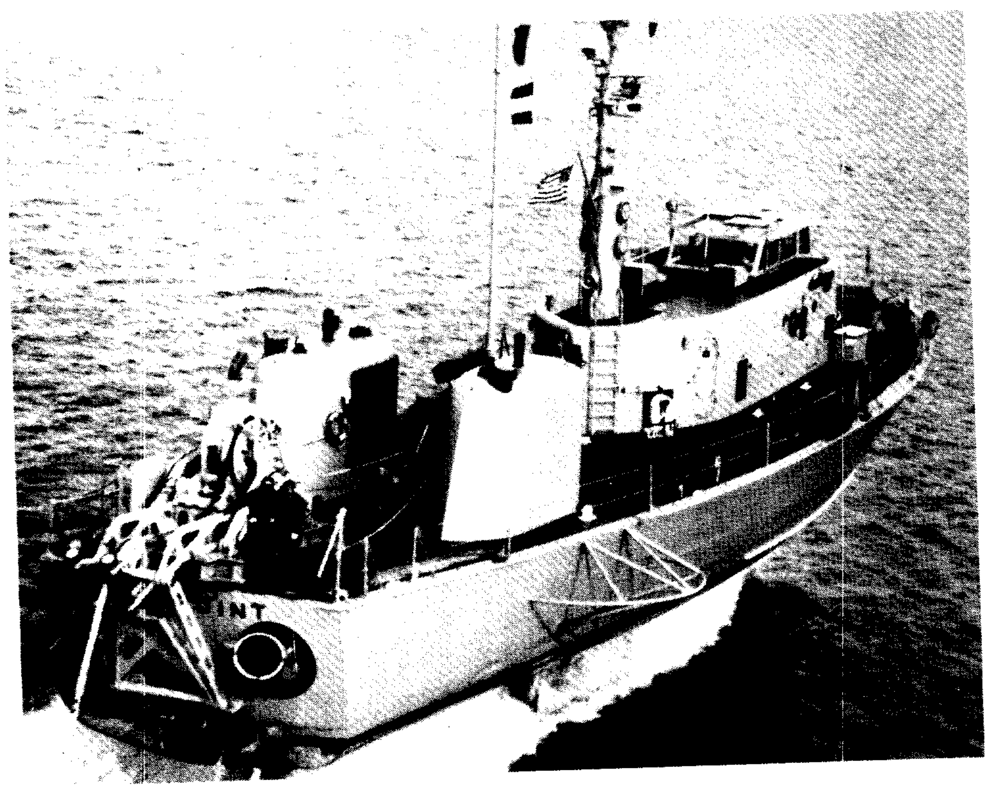


Figure 12 1. HIGH POINT Towing Canadian VDS

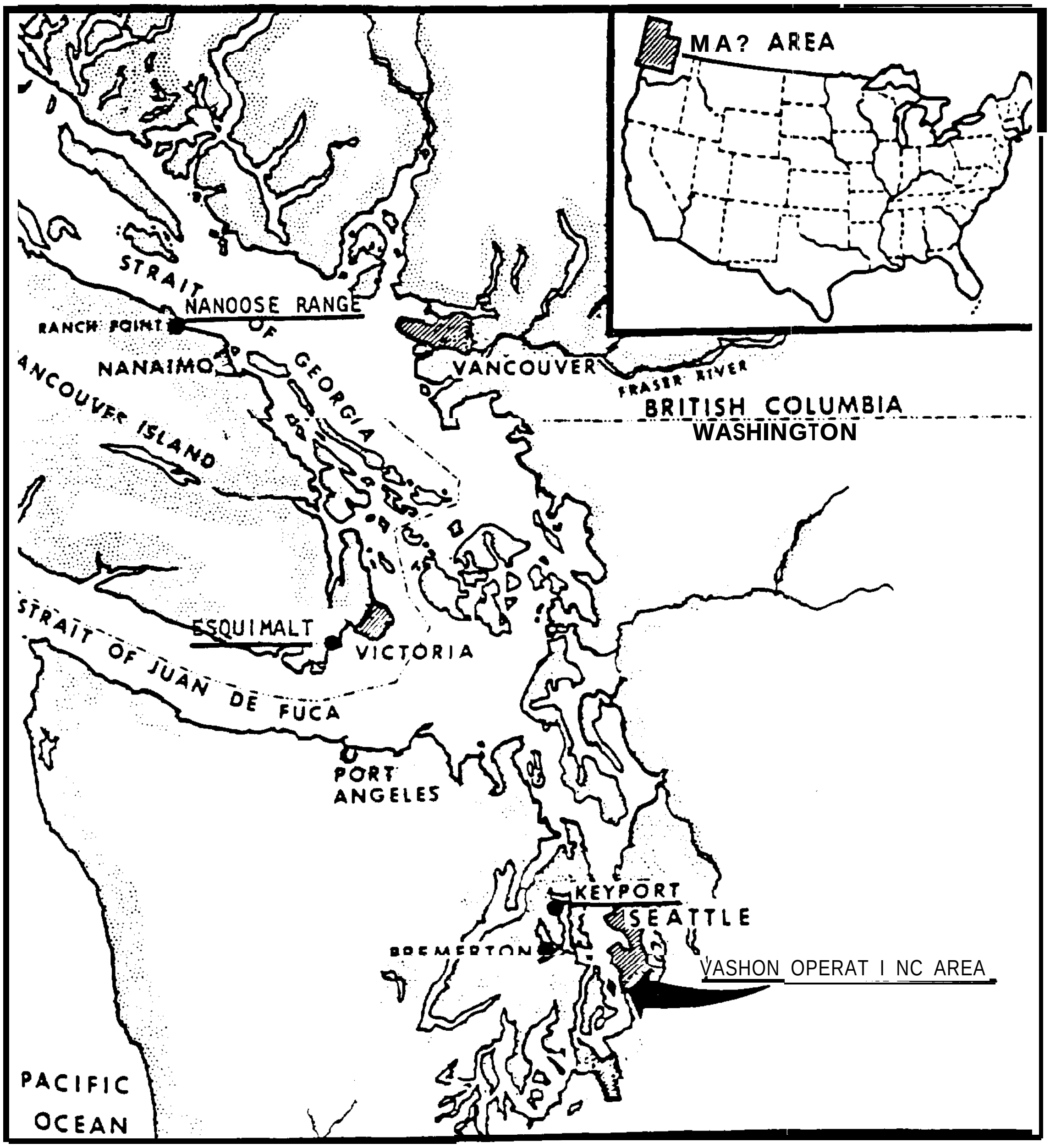


Figure 122. Map of HYTOW Operating Area

The only target available for these trials was a Marine Resources Inc. buoy transponder set, model 1204, provided by the Naval Engineering Unit (Pacific). It was equipped with an **X-band** radar for tracking.

The operational plan consisted of launching the buoy. taking a bathythermograph record. and maneuvering the ship to make sonar runs on the target. It was necessary to place the buoy in midchannel, clear of the traffic lanes. and positioned so that tidal currents would keep it in the operating area.

The original plan was to obtain maximum contact range in the forward, beam, and aft quadrants of the sonar. However, the limited maneur-c-ring room made this impractical and runs were limited to the forward and aft quadrants.

During the trial on 3 March 1978, the towed body (which had been borrowed from Sweden) was lost when it parted from the tow cable at the weak link. At the time. it was assumed that the body had struck a submerged object. The body had a pinger in it to facilitate its recovery in the event of its loss. However, the body was insured and the decision was made not to attempt its recovery. In this regard, it may be noted that the Swedes were quite happy to collect the insurance.

A second instrumented towed body was acquired and trials were resumed in August 1978. This time, at a foilborne speed just above 30 knots. the body broached and again parted from the cable at the weak link. The motion records that were obtained indicated that the body was apparently unstable above 30 knots. Reference 87 describes the 1978 trials in more detail.

As a result of the losses of the two Fathom towed bodies, a series of investigations were undertaken in 1979 to determine the causes and to develop corrective measures. These investigations were carried out by DTNSRDC with Canadian cooperation and support. Canada supplied a 1/5th-scale model of the body which was towed at DTNSRDC. initial model tests verified the instability problem. The Towing Problems Branch of the Center. headed by Reece Folb, was responsible for the model program. Shelton M. Gay. Jr., an expert in cable towed systems. proposed a solution which consisted of replacing the streamline afterbody with a truncated conical section, increasing the body weight, and increasing the static pitch moment. Reference 88. The effectiveness of this fix was adequately demonstrated in a final towing test in the model basin. Furthermore, when the model was restored to its original configuration. it exactly reproduced the instability and broaching that had resulted in loss of the second full--scale body.

Based on the results of the model tests, Fathom Oceanology added the truncated cone to the Y-foot body and reballasted it They also put the V-fin stabilizer on the bottom of the tail instead of the top.

Planning for the next series of trials began in 1980. On 15 January. a joint Canadian/US meeting was held which included the following attendees:

Canadian Representatives

CDR J. Watson, CF, Canadian Embassy
Max Reid. Defense Program Branch, DTIC. HYTOW Program Manager
LCDR Robert Stat-chuck. CF, DTNSRDC Canadian Liaison Officer
Jim Tremils, Defense Research Establishment Atlantic
Eric Jones, Canadian Joint Staff. Washington, DC
Doug Caston, Canadian Embassy, Washington. DC
Henry Baker, Department of National Defence, DMCS, Ottawa
Jim Empey, Fathom Oceanology Ltd.
T. Slupski, Fathom Oceanology, Ltd.

US Representatives

CDR Wm. Erickson. USN, OPNAV 373D
Jim Schuler, NAVSEA 032R, Hydrofoil R&D Program Manager
Robt. J. Johnston, DTNSRDC 115, Hydrofoil Program Technical Manager

Wm. C. O'Neill. DTNSRDC 115, Hydrofoil Program Deputy Technical Manager
LCDR Wm. Stolgitis, USN, DTNSRDC 11 j, Hydrofoil Project Officer
Verne Whitehead, Project Engineer, Hydrofoil Special Trials Unit

Following this meeting, new agendas were prepared and a new instrumentation package was fabricated. Since only limited information had been obtained from the 1978 trials, it was necessary to devise a test program that would satisfy the original objectives and attempt to avoid the loss of a third body. Final agendas were completed during the summer of 1981. However, resumption of the trials was delayed by the unavailability of HIGH POINT until late October when HYTOW testing was again begun in the Vashon operating area. These trials ran until mid November and were quite successful. The towed body no longer showed any instability even at speeds above 40 knots.

After a brief transit to Esquimalt on 15 November 198 1, and a foilborne demonstration for RADM Hughes, of the Canadian Navy, HIGH POINT returned to PSNS on 20 November. The ship was then drydocked for removal of the VDS gear and installation of the HYPAM system.

In light of the encouraging results of the 1981 HYTOW tests, it was recommended that additional sonar trials be conducted in an area more suitable for sonar evaluation. It was felt that sonar tests had suffered from two problems; the sonar itself had not been operating properly, and the Vashon operating area imposed severe limitations both acoustically and operationally. It was proposed that further tests be conducted in the Strait of Georgia and that trials in rough water also be included.

The recommendations regarding further tests were accepted and. beginning on 16 July 1782. the HYTOW system was once more installed on HIGH POINT. On 20 October, the ship moved to the Torpedo Range at Keyport and the following day hullborne VDS trials were begun. Trials were interrupted due to a ruptured fuel line. After its repair and a foilborne run to make turbine adjustments, the trials program resumed on 8 November. This test series was completed on 19 November and the next phase was not scheduled to begin until January 1983.

From 13 to 19 January 1983 a Westinghouse engineer effected repairs of the sonar system. The ship then got underway for a transit to Esquimalt, B. C. and the final HYTOW test series. Unfortunately, trials on the Nanoose range on 28 January had to be aborted when saltwater was found in the port transmission. The ship returned to PSNS the following day and was drydocked on 1 February to fix the leak and repair the fiberglass pod fairing. It required a second drydocking to finally take care of the transmission leaks. Resumption of HYTOW testing was delayed until 4 April when the ship again transited to Esquimalt. After returning to Bremerton on 12 April, the final phase of the HYTOW program was completed on 18 April 1983 in the Puget Sound area. During this final phase, HIGH POINT reached an important milestone of 1.500 foilborne hours since her first flight.

At this writing, there is continued interest in both Canada and the U.S. in further development of a high-speed, towed VDS system. For the present, however, funding litnitations and other programs of higher priority have caused further efforts to be held in abeyance. Nevertheless, the final results of the HYTOW tests, which are classified, may be said to have verified the potential for development of an operational f'oilborne VDS system.

OVERVIEW 1984

Installation of the forward strut was completed on 27 January. However, HIGH POINT remained in drydock for the first half of 1984 while the crew repaired and refurbished a number of ship systems and components. On 2 March, a forward strut retraction motor was found to be defective and all three motors were removed and shipped to Hydro-Science Corporation for overhaul. They were shipped back on 23 March. During April work was begun on refinishing the anti-skid deck coating'and the struts were prepared for sand-blasting. Re-coating of the struts was completed in May. Finally. on 6 June, the ship was undocked.

During the first half of 1984, there was a considerable turnover in the crew. Nevertheless, after undocking, the crew was trained and ready for sea in record time. This was due in major part to the masterful job of training performed by QMSC Philip R. Henderson and QMCM W. C. Wylie. It was particularly important to reach full operational status as soon as possible. since HIGH POINT was scheduled to serve as the towing vehicle for a series of trials on the BQR- 15 submarine towed array. scheduled to begin in June 198-i.

The objective of the BQR-15 trials was to acquire data needed to solve what was thought to be a hydromechanical problem experienced in towing the array from a submarine. The trials program was under the direction of engineers from the American Telephone & Telegraph (AT&T) Company. They arrived at HYSTU on 1X June to load the BQR- 15 equipment aboard the ship. After some familiarization runs the next several days, HIGH POINT got underway for the Nanoose Range on 23 June arriving after 3 hours and 40 minutes foilborne. Trials began the following day off Trxada Island. On 27 June, CAPT Barry Tibbitts. the Commander of DTNSRDC, came on board and remained during all night operations. The trials were successfully completed on 29 June, the ship having suffered no casualties during the operation. The transit back to Bremerton was made on 1 July and, the following day, the BQR- 1 equipment was removed from the ship.

On 10 July, HIGH POINT was host to a number of guests from Boeing in recognition of the many years their engineers had provided support to HYSTU and the operations, repairs. and modifications of the ship, They were given a foilborne demonstration cruise. Shortly thereafter the decision was made to drydock the ship to replace a bearing in the starboard transmission. Upon inspection. metallic particles were found on the access cover and the transmission was completely removed for overhaul.

Meanwhile. back in Washington, a new budget crisis had arisen which boded ill for the future of HIGH POINT. Funding for operation of the ship came from Program Element 65863N which supported a number of other R&D platforms. A shortfall had developed in the FY 1985 budget due to previously unforeseen requirements for additional funding in support of the test submarine DOLPHIN and the R&D support ship NORTON SOUND. In a memorandum addressed to the Director of the Surface Warfare Division (OP-32) dated 18 April 1984, RADM J. T. Parker (OP-983). advised of the intent to delete HIGH POINT from the RDT&E ships inventory in order to divert the funds (about $2M) budgeted for operation of the hydrofoil to meet other requirements. Again the hydrofoil, R&D community marshalled its forces and sought a reversal of the decision, emphasizing the excellent material condition of the ship and a number of programs associated with hydrofoil mission applications that were planned in future operations of HIGH POINT. This time, they were not successful. On 17 July, in a CNO letter to the Chief of Naval Material, signed by RADM Parker. it was directed that PCH-1 be inactivated on 30 September 198-i. It was also directed that the ship not be transferred or disposed of without CNO approval.

In a letter dated 2' August 1984, addressed to CNO (OP-983) via NAVMAT (MAT-05). DTNSRDC submitted a Plan of Action and Milestones (POA&M) for inactivation of HIGH POINT as directed. In this letter it was pointed out that requirements specified in the pertinent OPNAV Instruction dealing with ship inactivations made it impossible to meet the 30 September date. Accordingly. it was proposed to extend the inactivation date until 1 February 1985.

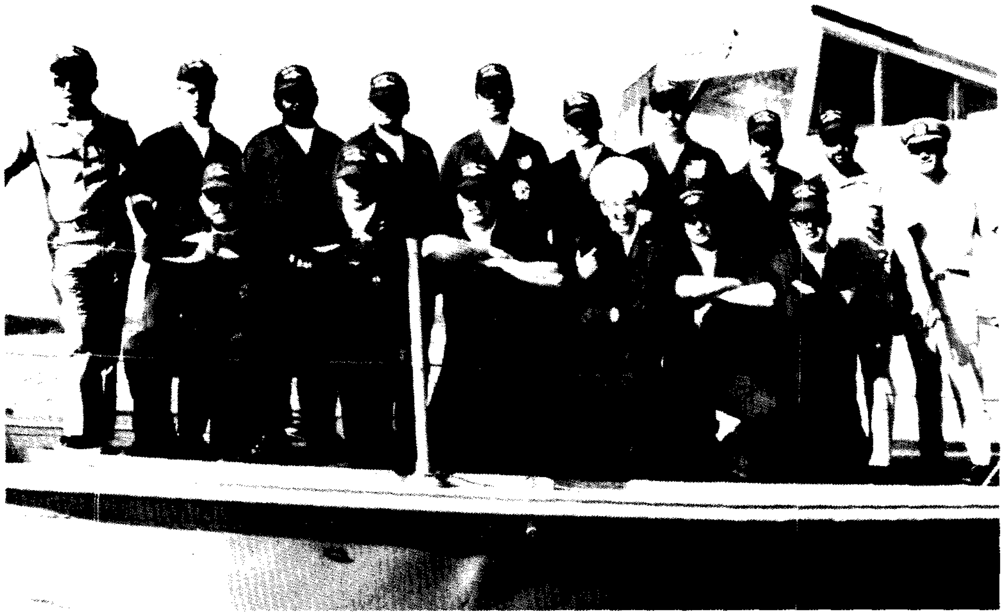


Figure 123. HIGH POINT Crew Says Goodbye

Repairs of the starboard transmission were completed and it was reinstalled on 8 August. The ship was undocked on 1 3 August and satisfactory **tests** of the transmission were conducted. The following day they got underway for Oak Harbor, WA, to conduct tests of the ALR-66 ESM (Electronic Support Measures) system which it was proposed to back fit in the PHMs. The TAC-105 ESM system was originally installed in the PHMs. Even when it worked properly it was inadequate and not representative of the state-of-the-art. The ANIALR-66 (V)2 represented an improved version of a system which had been installed in helicopters and approved for service use. It was produced by General Instruments. The unit tested on HIGH POINT also included a new spinning antenna which had not been approved for service use although approval was expected. (The tests on HIGH POINT demonstrated the merits of this system and led to a later decision to procure units in FY-86 for installation in the PHMs during FY-87).

On 2 1 September. a message from CNO granted a delay in the deactivation until 1 December 1984. As a result, it was possible to utilize the ship for additional tests of the BQR- 15 submarine towed array to verify the fixes resulting from the earlier tests. On 9 October, the ship again transited to Port Angeles. Trials began on 10 October and were successfully completed six days later. The ship returned to Bremerton on 18 October and the BQR- 15 gear was offloaded.

On 19 October. a farewell dinner party was given for LCDR Mike Dunaway, OIC of HIGH POINT. One week later, he was transferred to COMCRUDESGRU THREE in San Diego. He was relieved by QMCM W. C. Wylie. On 30 October, he took the ship out on a long-deferred sea trial, Reference 89. to test a significant development of the radar height sensor. It involved modification of the basic unit and the addition of a special antenna. This allowed the sensor to look ahead and detect oncoming large wave crests and troughs. Finally. as his last official act, It became QMCM Wylie's responsibility to terminate the long career of HIGH POINT **in** U.S. Navy service, as directed, on 1 December 1984. Figure (123) shows the last Navy crew as they said goodby to the dowager Queen of the U.S. Navy's hydrofoil fleet. Up to this point in time, the ship had accumulated 1,614 hours and 12 minutes on the foils since her maiden flight.

Figure 124. HIGH POINT MASCOT MOD I

In a somewhat ironic twist of fate, December not only was the occasion for final dispersal of the HIGH POINT crew, but it also saw the sad demise of "MOD I", the ship's black cat mascot of many years, Figure (124). Mrs. Virginia Conn, DTNSRDC Public Affairs Officer and long time strong supporter of the Hydrofoil R & D Program, wrote a piece in the Center's house organ "CENTERLINE" covering the checkered career of MOD I. It is reproduced below as a fitting memorial:

MOD I may seem an unusual name for a cat, but the crew of HIGH POINT (PCH-1) insists she was aptly named.

It was 1973 when a crewman carried her on board, a spunky six-week black Siamese/Burmese kitten. HIGH POINT at the time was undergoing a major conversion termed "modification number one". When the Officer in Charge agreed to let the kitten stay, she was named after the conversion.

Throughout her 11 years of duty aboard HIGH POINT, MOD 1 delighted the crew with her systematic investigations of the craft and her affection which. says OIC HYSTU CDR Duane Duff, was liberally distributed to the crew.

"She was a very loyal member of the crew," CDR Duff recounted. "She even learned to stand inport watches. but only in fair weather."

MOD I attracted considerable publicity from the press. The Port Angeles, WA., *Daily News* called her the "fastest cat on the water," and the *Portland Oregonian* noted she was the senior member of the crew.

Her duties were simple. No rats and no roaches. Pests aside, her time was her own, but CDR Duff noted, she was not a "stay at home cat."

"She was a true sailor in every sense of the word and she hit the beach just like the rest of the crew. One time when we were visiting San Francisco, MOD missed movement and we had to leave her behind. She was later picked up by the Shore Patrol and flown home to Bremerton. much to the relief of the crew."

In October 1984, while HIGH POINT was in Port Angeles, MOD I again took liberty and barely made it back in time.

"The Officer of the Deck spotted MOD running down the pier at flank speed. She tripped, did two somersaults, landed on her feet. and ran up the brow and right into his arms."

MOD I spent most of her days on HIGH POINT in the pilot house, where she could observe the comings and goings of both crew and visitors, but on cold days, said CDR Duff. she could he found on top of fluorescent light fixtures, soaking up the warmth. "Many an unwary sailor has had his head slapped walking under MOD's light fixture," he added.

The crew was saddened by MOD's death in December. but her passing coincided with the deactivation of the ship and few were left to mourn.

Epilog

CHANGING OF THE GUARD

As is the case with many other former members of the Navy's Hydrofoil Development Program, HIGH POINT's retirement from the U.S. Navy did not mean the end of her career. When the directive calling for her deactivation was received, Jim Schuler, CDR Dave Patch (OP-32 1), Tom Sherman, and others associated with Hydrofoil Development Program began to explore other avenues to keep the ship actively available for continued R&D support. They finally came up with the idea of turning the ship over to Boeing to maintain and operate for DTNSRDC in support of various R&D projects requiring HIGH POINT'S unique capabilities. This plan was submitted to OPNAV for approval, In the OPNAV message extending the deactivation date to 1 December 1984, approval was granted to enter into a contract with Boeing to implement the proposed plan. The plan called for HIGH POINT to be turned over to the contractor as Government Furnished Property.

On 22 January 1985, there was a ceremony at Bremerton marking the establishment of a new Center Puget Sound Detachment. The detachment was formed by a merger of the Hydrofoil Special Trials Unit with the Ship Silencing Division of Carr Inlet. The latter was formerly assigned to the Puget Sound Naval Shipyard. Brief remarks were made by Dr. Alan Powell, DTNSRDC Technical Director, CAPT Dick Garritson, Center Commander, and DR. Maurice Sevik, Head of the Center's Ship Acoustics Department. Charles (Chuck) Henson, Director of the new Detachment, was the master of ceremonies.

Early the following day, 23 January, another ceremony was held on the foredeck of HIGH POINT, After a few remarks about the long and distinguished career of the dowager Queen of the Navy's hydrofoil fleet, CAPT Garritson presented the key to HIGH POINT to Richard Crowley. Boeing's Director of Engineering. Figure (125) shows this milestone event.

Figure 12 5. CAPT Garritson Gives PCH Keys Over to Boeing Dir. of Eng. Dick Crowley

As of this writing, Boeing has continued to maintain and operate HIGH POINT under a contract with DTNSRDC. The Boeing crew consists of a Captain, first mate, chief engineer, assistant engineer, and two mechanics. All systems are checked out biweekly and the ship is available, at cost, for tests by any activity approved by DTNSRDC. Since turnover, one such test was a further evaluation of the BQR- 15 submarine towed array. Today, HIGH POINT is still in excellent materiel condition and offers unique capabilities as a test platform; a most fitting retirement career.

LESSONS LEARNED

The preceding chapters are liberally sprinkled with lessons learned in the twenty some years of HIGH POINT operations. It is neither intended nor really appropriate to review them in depth here. However, as a final tribute to this gallant lady it is felt to be appropriate to summarize some of her particularly noteworthy accomplishments and the more important issues that were addressed and resolved.

First, and most importantly, the PCH experience amply demonstrated the fallacy of considering a first-of-a-kind, one-of-a-kind, complex hardware system to be ready for deployment as a Fleet asset before it has been thoroughly debugged. Even when such a system has been thoroughly rung out, modified. and redesigned, further growth pains may be expected upon its first introduction to the actual operating environment.

From the very beginning, the HYSTU operation was conceived as a teaming of civil service engineers, military crew, and industrial contractors. Furthermore, it was formed as a project organization rather than adopting a functional approach. The former focuses all activities on the success of achieving project objectives whereas the latter usually tends toward preservation of the function at the expense of the project goals. The wisdom of this choice was demonstrated over and over. Regardless of where they fit in the team, each member made important contributions to the success of the project. The development of the TANCAV/HICANS/HYCATS system was a good illustration of the result of this team effort, It should also be noted that the decision to operate the ship with a Navy crew, in spite of its developmental nature. was a good one. Having Fleet personnel as members of the team provided many benefits. It was a unique source of hydrofoil-trained personnel which proved invaluable in manning the PHM ships. It also provided invaluable inputs to the development program with respect to maintenance and operations of hydrofoil ships, tactical employment, effects on personnel, and the mix of skills and numbers of crew best suited for hydrofoil operation. Furthermore, there were many intangible benefits of HIGH POINT being a "real" Navy ship as opposed to a civilian manned test platform. It was particularly important in selling the idea of this new ship type to the operational community.

During her many years of operations HIGH POINT provided much data essential to resolving such important design issues as the following:

- Canard vs. Conventional (Airplane) Foil Configuration.
- Flap vs. Incidence Foil Control.
- Platforming vs. Contouring of Waves.
- Submerged vs. Surface-Piercing Foils
- Banked Turns vs. Flat Turns.
- Water jet vs. Propeller Propulsion.
- Fixed vs. Rotatable Forward Strut.
- Retractable vs. Nonretractable Struts & Foils.
- Subcavitating vs. Supercavitating Propellers
- Radar vs. Sonic Height Sensors
- Analog vs. Digital Autopilots.

With respect to mission equipment and tactical applications of hydrofoil ships, HIGH POINT also made many contributions to the knowledge base. Many of the mission systems on the PHMs were first evaluated on PCH. She also participated in several Fleet exercises which gave visibility to this new ship concept and offered the opportunity to evaluate hydrofoil mission applications. Examples of some of the systems tested on PCH and roles evaluated include:

- HARPOON Missile Firing
- Canadian Variable-Depth Sonar (HYTOW).

- Depressor Towed Array System (DTAS).
- Hydrofoil Pressure Acoustic Magnetic (HYPAM) Minesweep. Sys.
- MK 44 Acoustic Torpedo Firing
- 40mm Gun Firing.
- Helicopter Refueling Foilborne.
- Helicopter Foilborne Personnel/Supply Transfer.
- ALR-66 Electronic Support Measure (ESM)
- Hydrofoil Collision Avoidance & Tracking System (HYCATS).
- Ship At Sea Refueling & Cargo Transfer
- Deception & Decoy Systems.
- Aids to Night Foilborne Operations (LLTV, FLIR, etc.).
- Bottom Contouring & Oceanographic Survey Systems,
- Coast Guard Coastal Roles.

No one can question the value of HIGH POINT'S many contributions to the design and utilization of both commercial and military hydrofoil craft. Figure (126), a rare photograph of the entire Squadron of six PHMs, is perhaps the best testimonial to her rightful place in the long history of hydrofoil development. May she long continue to sail in rough seas and aid further development and wider employment of the hydrofoil concept.

Figure 126. PHM Squadron · Two Foilborne

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APPENDIX A

Chronology of Significant Events

PROLOGUE

1907-1957

1907 Wilbur and Orville Wright conduct experiments with a hydrofoil catamaran on the Ohio river.

1911 Alexander Graham Bell witnesses tests of 1.6-ton hydrofoil conducted by Enrico Forlanini on Lake Maggiori, Italy.

1919 Bell's hydrofoil HD-4 sets world speed record of 70.85 mph at Baddeck, Nova Scotia.

1927 Baron Hanns von Schertel begins experiments with hydrofoil craft in Germany.

1935 Baron von Schertel abandons fully-submerged foil configuration and adopts surface-piercing configuration with hoop foil.

1937 Cologne-Dusseldorf Steamship Co. places with the Sachsenberg Shipyard the world's first order for a commercial passenger hydrofoil.

1941 von Schertel and Sachsenberg launch 17-ton German minelaying hydrofoil V-6.

1941 Japan bombs Pearl Harbor on 7 December and the U.S. enters World War II.

1947 The U.S. Office of Naval Research, Bureau of Ships, and Bureau of Aeronautics initiate a research program to develop the hydrofoil craft concept.

1951 Canadian Navy begins to explore military potential of hydrofoil craft and contracts with Phillip Rhodes to build the 'i-ton hydrofoil MASSAWIPPI (R-100).

1952 von Schertel founds SUPRAMAR A. G. in Lucerne, Switzerland, and completes the hudrofoil PT-10. It begins first commercial hydrofoil passenger service on Lake Maggiori.

1952 The U.S. Navy sponsors the construction of a number of hydrofoil test craft. The LANTERN (HC-4) experimental hydrofoil is constructed by the Hydrofoil Corporation of

America, the experimental Carl hydrofoil (XCH-4) is completed by John H. Carl and Sons, and the hydrofoil test craft HIGH POCKETS is built by Baker Manufacturing Co.

1953 The U.S. Navy focuses on hydrofoil landing craft. HIGH POCKETS conducts demonstration of hydrofoil capability for CNO ADM Carney.

1954 Gibbs and Cox, a New York naval architecture firm, begins modification of a Chris-Craft hull to become the first fully-submerged hydrofoil craft with an electronic autopilot control system. The craft is named SEA LEGS.

1954 The Rodriquez Shipyard in Messina, Sicily, is licensed to build hydrofoils of SUPRAMAR design.

1957 SEA LEGS makes first flight.

1957 The hydrofoil test craft HALOBATES is completed by Miami Shipbuilding Co. The U.S. Army contracts with Miami Ship to build the Flying DUKW amphibian hydrofoil.

1958

24 JAN CNO requests BuShips to perform a design study of hydrofoils for harbor defense and coastal patrol.

31 JAN American satellite EXPLORER I launched.

07 MAR Results of BuShips feasibility study reported to OPNAV. Recommended that PC(H) replace PC(S) and SC in FY60 shipbuilding program.

16 JUL Hydrofoil craft SEALEGS arrives from New York and begins one month of demonstrations in Washington DC area.

25 JUL Ship Characteristics Board issues proposed characteristics for PC(H), SCB Project No. 202.

04 AUG LCDR Ken Wilson, BuShips Hydrofoil Project Officer, briefs PC(H) design concept to OPNAV Antisubmarine Plans & Policies Group.

18 AUG SEALEGS performance compared to Supramar surface-piercing hydrofoil SKIMMER at Annapolis, MD.

(PCH Preliminary Design continued thru remainder of 1958.)

1959

05 MAR PC(H) Preliminary Design completed by BuShips Code 420 and turned over to Hull Design Branch, Code 440, for contract design.

29 APR RADM R. K. James relieves RADM Albert Mumma as Chief of BuShips.

12 MAY PC(H) Ship characteristics revised by SCB.

07 OCT Russia's LUNA-3 sends back images from the Moon's far side.

(PCH Contract Design continued thru remainder of 1959.)

1960

18 JAN PC(H) Contract Plans and Specifications signed off. Maritime Administration contracts with Dynamic Developments for HS DENISON.

19 FEB PC(H) Design History issued.

15 MAR PC(H) "Letter of Promulgation" issued by RADM James.

JUN Fixed price Contract NOBS 4359 for PC(H) awarded to Boeing for $2.08M.

20 JUN HS DENISON keel laid at Grumman Plant 2, Oyster Bay, NY.

18 NOV Boeing approved PC(H) faired Lines prepared by W. C. Nickum & Sons

(PCH Detail Design continued thru the remainder of 1960)

1961

20 JAN John F. Kennedy becomes 35th president succeeding Dwight D. Eisenhower.
27 FEB PCH keel laid at Martinac Shipyard in Tacoma, WA.
12 APR Soviet cosmonaut Yuri Gagarin orbits the earth in VOSTOCK I.
05 MAY CDR Alan B. Shepard makes 15-minute suborbital flight in FREEDOM 7.
-- JUN Navy awards Boeing a $1.46M contract (NObs 4472) for FRESH-I.
06 JUN Boeing high speed aquaplane test craft (HTS) launched.
21 JUL Air Force MAJ Virgil Grissom makes 2nd suborbital flight.
01 AUG ADM George W. Anderson relieves ADM Arleigh A. Burke as CNO.
07 AUG Russia cosmonaut Gherman Titov completes 17 orbits in VOSTOCK II.
09 SEP Navy's first nuclear surface ship, USS LONG BEACH, launched in Boston.
26 OCT BuShips awards cost-type contract to Grumman for Guidance Design of AGEH
09 NOV X-l 5 sets new speed record for manned aircraft; 4093 mph.
25 NOV Nuclear-powered carrier USS ENTERPRISE joins Fleet at Newport News.
(PCH Construction continued thru the remainder of 1961.)

1962

17 JAN BuShips letter to CNO requests availability of PCH for Special Performance Trials.
23 JAN CNO letter redesignates Puget Sound Naval Shipyard as PCH delivery point vice San Diego, CA, and assigns ship to BuShips for period of Special Performance Trials.
20 FEB COL John H. Glenn, Jr., USMC is first U.S. astronaut to orbit the earth piloting FRIENDSHIP 7 through 3 orbits.
24 MAY LCDR M. Scott Carpenter makes 2nd orbital space flight; 4-1/2 hours.
05 JUN HS DENISON launched at Oyster Bay, NY.
30 JUN HS DENISON attains speed of 72 knots in trial run.
15 JUL French explorers, in bathyscaphe ARCHIMEDE, decend to 30,365foot depth in Pacific's, Japan Trench.
17 JUL X-15 sets new manned aircraft altitude record; 59.6 miles above earth.
17 AUG PCH launched at Martinac Shipyard, Tacoma, WA; christened HIGH POINT
09 OCT Contract drawings and final draft of specifications for AGEH signed by RADM James, Chief of BuShips.
-- NOV LT Henry G. Billerbeck reports as POIC PCH.
13 NOV CINCPACFLT letter tentatively assigns PCH to COMASWFORPAC for operations & COMINPAC for administration.
27 NOV Boeing waterjet test craft LITTLE SQUIRT launched.
14 DEC MARINER II passes within 21,600 miles of Venus.

1963

28 JAN Final Acceptance Trials of PCH completed.
06 FEB In a letter to CNO the POIC questions the classification of the PCH as "Combatant Patrol Ship".
07 FEB FRESH-I launched by Boeing.
18 FEB ASN (I&L) approves conditional acceptance of PCH by Navy.
-- MAR Dr. Alfred H. Keil appointed first Technical Director of DTMB.
-- MAR Hydrofoil ADO S46-06X issued by CNO.
09 MAR LT Henry Billerbeck becomes first OIC of PCH.
-- APR Hydrofoil Technical Development Plan approved by OPNAV.

10 APR U.S. submarine THRESHER is lost with all hands.
29 APR RADM W. A. Brockett relieves RADM R. K. James as Chief of BuShips
-- MAY Grumman completes guidance design of AGEH- 1.
22 MAY PCH first foilborne lift of hull clear of water.
29 MAY PCH first Builder's Trial.
31 MAY Dr. Karl E. Schoenherr, Head, Hydromechanics Laboratory. DTMB, retires and is replaced by Dr. W. E. Cummins.
14 JUN CAPT J. M. Ballinger relieves CAPT J. A. Obermeyer as CO&D of DTMB.
16 JUN Russia orbits VOSTOCK VI with first female, Valentina Tereshkova.
09 JUL BuShips awards fixed-price contract for AGEH-1 detail design and construction to Puget Sound Bridge and Drydock (later became Lockheed Shipbuilding & Construction Co.).
18 JLJL FRESH-I capsizes during acceptance trials.
15 AUG PCH delivered to Navy at Puget Sound Naval Shipyard.
03 SEP PCH placed in service.
22 NOV President Kennedy is assassinated: Lyndon B. Johnson becomes 36th president.
02 DEC Office of Naval Material redesignated Naval Material Support Establishment.

1964

-- JAN Construction of AGEH-1 begins at Lockheed.
28 JAN PCH conditionally accepted for restricted service.
15 FEB End of PCH guarantee period.
19 FEB Meeting at PSNS of Navy reps and Boeing team to define PCH problems.
24 FEB Boeing presents the results of their PCH technical audit and recommendations for action in a letter to PSNS.
02 MAR W. M. Ellsworth returns to DTMB as Hydrofoil Coordinator in Hydromechanics Laboratory. At PSNS, Bremerton, WA, Verne Whitehead is assigned as Hydrofoil Coordinator for the Shipyard.
01 APR Meeting at BuShips on PCH trials.
15 APR Ellsworth nnakes first trip to Seattle to inspect PCH.
25 APR PCH foilborne demonstration for Dr. James H. Wakelin Jr., ASN (R&D).
06 MAY PCH demonstrations for Italian visitors.
0' MAY CNO approves PSNS request for O-Month extension in PCH availability for Special Performance Trials.
08 MAY AGEH keel laid at Lockheed, Seattle WA.
22 MAY PCH weighed on barge in drydock at PSNS.
22 OCT Decision made to effect extensive repair and refurbishment of PCH.
14 DEC Dr. Robert Morse. ASN (R&D), directs BuShips to review Hydrofoil Program. S 1.8M of FY66 R&D funds frozen.
31 DEC RADM Brockett asks DTMB to undertake review of Hydrofoil Program.

1965

20 JAN Lyndon B. Johnson takes office for full term as president.
02 MAR Boeing establishes PCH Office at PSNS with Art Anderson as Resident Engineer for PCH under contract NObs 4838.
18 MAR Aleksei Leonov makes first walk in space from VOSKHOD II.
22 MAR W. M. Ellsworth briefs Dr. Morse, ASN (R&D), on program review.
28 MAR BuShips requests DTMB to become Technical Agent for Hydrofoil R&D.
06 APR First commercial communications satellite INTELSAT I is launched.

01 JUN CNO revises -Hydrofoil Advanced Development Objective (S46-06XR1).
01 JUN COMINPAC requests BuShips assume responsibility for funding PCH.
03 JUN Edward White makes first American spacewalk outside GEMINI IV.
28 JUN AGEH launched and christened PLAINVIEW.
28 JUN LT Steven W. McGanka relieves LCDR Henry G. Billerbeck as OIC PCH.
-- JUL BuShips issues RFP for two hydrofoil gunboats (PGH's).
09 JUL In a letter to DCNM (D), ASN (R&D) requests recommendations for improvements in Hydrofoil Program management organization.
14 JUL MARINER IV provides close-up images of Mars.
20 JUL BuShips requests detail of W. M. Ellsworth to Code 341.
26 JUL W. M. Ellsworth reports as BuShips Code 341-H for 6 months.
03 AUG Conference at BuShips on PCH Technical Performance Improvement Program.
12 AUG BuShips assigns DTMB responsibility for test & evaluation of PCH (and AGEH when delivered.)
27 AUG Marad turns HS DENISON over to the U.S. Navy. Craft is towed to Brooklyn Navy Yard and put aboard SS LOS ANGELES for transport to Long Beach, CA.
13 SEP Draft of revised Hydrofoil Technical Development Plan (TDP) delivered to DDR&E.
01 OCT Revised Hydrofoil TDP approved by OPNAV.
19 OCT HS DENISON arrives at new homeport in Port Hueneme, CA.
08 NOV William C. O'Neill joins DTMB Hydrofoil Group as contract employee.
23 NOV BuShips requests proposal from Boeing for study of major modifications to PCH.

1966

31 JAN RADM Edward J. Fahy relieves RADM W. A. Brockett as Chief of BuShips.
03 FEB Soviet Moon probe LUNA 9 transmits pictures from lunar surface.
13 FEB LCDR Karl M. Duff reports to SUPSHIPS Seattle as Project Officer for AGEH-1 (and later also for PGH-2).
-- MAR NELC assigned technical lead for hydrofoil mission subsystems R&D.
01 APR Navy R&D Labs put under Director of Navy Laboratories in NAVMAT.
-- APR BuShips lets contracts to Grumman and Boeing for hydrofoil gunboats PGH-1 and PGH-2.
19 APR DTMB establishes Hydrofoil Development Project Office, Code 050, headed by W. M. Ellsworth reporting to Technical Director.
26 APR DTMB accepts responsibility as Technical Agent for BuShips Hydrofoil Development Program.
-- MAY LT(jg) George P. Moeckel re-assigned as first DTMB Hydrofoil Project Officer.
01 MAY BuShips becomes the Naval Ship Systems Command (NAVSHIPS) & the Naval Material Support Establishment becomes the Naval Material Command (NAVMAT).
02 JUN U.S. unmanned spacecraft SURVEYOR I makes a soft landing on the moon.
03 JUL Fred Saxton assigned to DTMB Hydrofoil Office as Instrumentation Manager.
27 JUL SEA LEGS presented to the Smithsonian Institution in Washington, DC.
16 SEP RADM Edward J. Fahy, Commander of NAVSHIPS, visits HIGH POINT.
24 OCT PCH trials temporarily suspended due to observation by Soviet trawler.
05 NOV Fire destroys main machinery space of the Canadian hydrofoil ship FHE-400 during construction.
10 NOV Hydrofoil Special Trials Unit (HYSTU) established by DTMB as a tenant activity of PSNS, Bremerton, WA.; Sumiyasu Arima transferred from SUPSHIPS- as HYSTU engineer and Jim Gillam transferred from PSNS as Test Mechanic.

14 DEC Dr. Robert Frosch, ASN (R&D), briefed on Hydrofoil R&D Program by W. M. Ellsworth.

21 DEC PC(H) designat.ed "In Service, Special" by OPNAV. Technical and Administrative control assigned to DTMB and Operational Control assigned to COM-13.

1967

03 JAN Enzo Marmentini joins DTMB Hydrofoil Office as Structural Engineer.

10 JAN RADM Fahy, Commander of NAVSHIPS, briefed on Hydrofoil Program.

27 JAN Gus Grissom, Roger Chaffee, and Ed White die in APOLLO I fire on launch pad at Kennedy Space Center in Florida.

27 JAN PCH visited by Italian naval officers, VADM G. Roselli and RADM L. Tomasuolo.

31 JAN CAPT Dennett K. "Deke" Ela relieved by CAPT M. da C. "Buck" Vincent as CO&D DTMB.

-- FEB LCDR Karl M. Duff given additional duty as OIC HYSTU.

23 FEB CNO Executive Board and SECNAV Hon. Paul H. Nitze briefed by W. M. Ellsworth on Hydrofoil Program.

-- MAR RADM F. B. Schultz relieved by RADM W. F. Petrovic as Commander PSNS.

09 MAR W. M. Ellsworth briefs CNO on Hydrofoil Program.

31 MAR David Taylor Model Basin, Carderock, MD, merged with Marine Engineering Laboratory, Annapolis, MD, to become Naval Ship R&D Center (NSRDC).

08 APR PCH makes foilborne transit from Bremerton to Seattle with SECNAV Hon. Paul H. Nitze and Mrs. Nitze aboard, accompanied by Congressman and Mrs. Norman Dicks of Washington State.

20 APR Under Secretary of the Navy, Hon. Robert H. Baldwin visits PCH.

21 APR ASN G. C. Bannerman and Chief of Naval Material VADM I. J. Galantin given foilborne demonstration on PCH.

06 MAY NSRDC Hydrofoil Development Office moves to new space as a tenant of the Ship Structures Laboratory, Bldg. 19 at Carderock, MD.

12 MAY PCH hosts visitors from National Geographic Magazine.

20 MAY PCH hosts the public at NAS, Sand Point during celebration of Armed Forces Day. Over 1500 visitors came aboard during the two-day open-house.

25 MAY W. M. Ellsworth meets with RADM Petrovic, Commander PSNS, regarding changes to the HYSTLJ Host/Tenant Activity Agreement.

10 JUL LT Stephen J. Duich relieves LT Hugh Burkons as POIC of PLAINVIEW (AGEH-1).

15 JUL Boeing hydrofoil gunboat TUCUMCARI (PGH-2) launched.

17 JUL LT Hugh Burkons relieves LT Steven W. McGanka as OIC PCH.

04 AUG PLAINVIEW underway hullborne for first time.

21 AUG LTjg George Moeckel leaves position as Hydrofoil Program Officer.

12 OCT Dr. Alan Powell appointed Technical Director of NSRDC.

27 OCT Revised Technical Development Plan (TDP) S46-06 XR1 approved by CNO.

01 NOV Mine Defense Laboratory, Panama City, FL, merged with NSRDC.

01 NOV LCDR Garrett M. Dyer reports to NSRDC as Hydrofoil Program Officer.

1968

-- FEB Jim Mason joins HYSTU as Instrumentation Technician.

-- MAR LCDR Karl M. Duff given PCS orders as OIC HYSTU.

02 MAR Grumman- hydrofoil gunboat PGH-1 christened FLAGSTAFF.

07 MAR Boeing hydrofoil gunboat TUCIJMCARI (PGH-2) delivered to Navy.
21 MAR AGEH-I makes first flight for 11 -1/2 minutes.
22 MAR Status of Hydrofoil Program briefed to ASN (R&D), Dr. Robert Frosch.
27 JUN Boeing awarded contract for detail design of major modifications to PCH (MOD-I).
01 JUL FLAGSTAFF: (PGH-1) completes Preliminary Acceptance Trials.
17 JCJL Canadian hydrofoil ship BRAS D'OR (FHE-400) arrives Halifax, N.S. in slave dock.
05 AUG HS DENJSON arives at HYSTU aboard USS DULUTH, for stripping of useable parts and ultimate disposal.
14 SEP Grumman hydrofoil gunboat FLAGSTAFF (PGH- 1) delivered to Navy.
07 NOV NSRDC command title changed from CO&D to COMMANDER.
20 NOV LT Gilbert B. Perry reports to NSRDC as Hydrofoil Program Officer.
24 DEC APOLLO 8 astronauts Frank Borman, Jim Lovell, and Bill Anders make 10 circuits around the Moon.

1969

20 JAN Richard M. Nixon takes office as 37th president.
03 FEB PLAINVIE W begins Preliminary Acceptance Trials.
2-i FEB LT James H. Ball relieves LT Hugh Burkons as OIC PCH.
01 MAR PLAINVIEW (AGEH-1) delivered to Navy at HYSTU.
23 MAR Verne Whitehead transfers from PSNS to HYSTU as Project Engineer.
09 APR First flight of Canadian hydrofoil ship FHE-400.
25 APR PGH follow ships deleted from FY 1971 Shipbuilding Program.
20 JUL APOLLO 11 spacecraft EAGLE lands and CDR Neil Armstrong walks on the moon.
31 JUL RADM Nathan Sonenshein relieves RADM Edward Fahy as Commander of NAVSHIPS.
-- NOV FLAGSTAFF (PGH-1) and TUCIJMCARI (PGH-2) transported to Viet Nam for deployment in MARKET TIME operation.
19 NOV APOLLO 12 spacecraft INTREPID makes second landing on moon.

1970

21 JAN PLAINVIEW begins Final Contract Trials (FCT).
02 MAR Navy accepts PLAINVIEW (AGEH-1).
05 MAR PLAINVIEW completes Final Contract Trials.
27 APR Discussions with Boeing on HIGH POINT MOD-I held at HYSTU.
15 MAY Systems Development Office of NSRDC reorganized.
26 MAY LT Terry Efird relieves LT John Welch as Engineering Officer on AGEH.
08 JUN LT John G. McDonald reports as HYSTU OPS Officer.
23 JUN PCH foilborne demonstration for Dr. Alfred Keil, and other members of Navy Research Advisory Committee, (NRAC).
2-i JUN LT Joel Roberts relieves LT James H. Ball as OIC PCH.
09 JUL LT Wm. J. Erickson relieves LCDR Stephen J. Duich as OIC PLAINVIEW.
23 JUL LCDR Henry Schmidt, Jr., relieves LCDR Karl M. Duff as OIC HYSTU.
31 JUL CAPT Randolph W. King relieves CAPT Manuel da Costa Vincent as Commander NSRDC.
04 DEC PLAINVIEW completes RAV at Todd Shipyard.

1971

15 JAN	HIGH POINT arrives in San Diego, CA, on first SOCAL deployment.
25 JAN	Dennis J. Clark transferred from NSRDC Structures Department to Hydrofoil Development Office (Code OH50) as Systems Integration Manager.
28 JAN	Prince Juan Carlos of Spain visits HIGH POINT in San Diego, CA.
15 MAR	HIGH POINT returns to PSNS after SOCAL deployment.
25 MAR	TUCUMCARI deck loaded on LST USS WOOD COUNTY and underway for Northern Europe demonstrations.
-- APR	$2.6M contract awarded to Boeing for PCH MOD-I conversion.
10 APR	TUCUMCARI offloaded and begins operations with Royal Dutch Navy.
18 APR	Systems Development Department, Code OHO 1, established at NSRDC encompassing Hydrofoil Development Program Office and other advanced ship development offices: Headed by Wm. M. Ellsworth as Associate Technical Director for Systems Development.
19 APR	Dr. David Jewel1 appointed Technical Manager of Hydrofoil Development Program Office.
-- MAY	Bill Ellis joins HYSTU as Electronics Technician.
07 MAY	LT Charles R, Rabel reports to Hydrofoil Development Program Office as Program Officer.
13 JUN	TUCUMCARI arrives Portsmouth, England for exercises with Royal Navy.
08 SEP	HIGH POINT drydocked in Boeing plant at Renton to begin overhaul and modification.
24 SEP	TUCUMCARI logs 1000th foilborne hour during deployment to Europe.
-- OCT	NATO Naval Armaments Group decides to proceed with NATO PHM.
02 OCT	TUCUMCARI loaded on WOOD COUNTY for trip back to U.S. after additional demonstrations in Federal Republic of Germany, Denmark, Scotland, France, Italy, Greece, Turkey, and Sicily.
05 OCT	LT Edward Bond relieves LT Richard Stedd as CO of TUCUMCARI.
17 OCT	TUCUMCARI arrives back in US.
-- NOV	MOU for PHMs signed by US, Italy, and Federal Republic of Germany.
03 NOV	HIGH POINT receives Meritorious Unit Commendation from RADM Wesley L. McDonald, Commandant 13th Naval District. Given for "Meritorious Service from j January to 15 March 1971 during extended foilborne operations along the western coast".
24 NOV	Boeing awarded $5.9M contract for Phase I design of NATO PHM.

1972

11 JAN	LT Joel H. Roberts awarded Navy Commendation Medal for meritorious service as OIC HIGH POINT.
24 JAN	Naval Ship R&D Laboratory, Panama City, Florida, separated from NSRDC and renamed Naval Coastal Systems Center.
-- MAR	Boeing PHM feasibility design completed.
07 MAR	2nd revision of Hydrofoil ADO (S46-06 XR2) approved.
-- APR	2nd revision of Hydrofoil TDP (S46-06 XR2) approved.
-- APR	NATO Patrol Hydrofoil Missile Ship (PHM) Project Office established in NAVSHIPS under CAPT James Wilkins, USN.
03 APR	Hon John H. Chafee resigns as SECNAV.
14 MAY	TUCUMCARI has "Open House" at Pier 2, Navy Yard, Washington, DC.

15 MAY TUCUMCARJ transits to Annapolis, MD.
-- JUN RADM W. F. Petrovic relieved by CAPT F. F. Manganaro as Commander PSNS.
06 JUN PLAINVIEW reaches 100th foilborne hour.
13 JUN CAPT Perry W. Nelson relieves CAPT Randolph W. King as Commander NSRDC.
TUCUMCARI transits to Amphibious Base, Little Creek, VA.
01 AUG RADM Robert C. Gooding relieves RADM Nathan Sonenshein as Commander of NAVSHJPS.
01 OCT David P. Halper joins Hydrofoil Program Office as Code 11 59.
-- NOV Memorandum Of Understanding (MOU) signed by US, Italy, and Federal Republic of Germany (FRG), for design and development of two lead PHMs.
13 NOV Harry H. Wallace joins Hydrofoil Program Office as Code 1157.
14 NOV AGEH visits Esquimalt. British Columbia.
15 NOV TUCUMCARI runs aground on a coral reef during night exercises off Vieques Island, near Roosevelt Roads, Puerto Rico.

1973

19 JAN Keel laid for first Boeing JETFOIL Model 929-100.
20 JAN Richard M. Nixon begins 2nd term as president.
-- FEB Boeing awarded a $42.6M contract by NAVSEA to begin design and construction of two PHMs.
10 FEB HIGH POINT launched into Lake Washington after MOD-I conversion.
21 MAR Navy barge YFNB-8 assigned to HYSTU for mobile storage and maintenance facility.
09 APR Robert J. Johnston appointed Technical Manager of Hydrofoil Development Program Office. Code 115, at NSRDC.
09 MAY Keel of PI-JM-1 laid at Boeing, Renton, WA.
-- MAY First Italian hydrofoil gunboat SPAVJERO launched at La Spezia, Italy.
20 JUN Boeing returns MOD-J PCH to the Navy.
06 JUL PLAINVIEW moved by tug from Lockheed Ship to PSNS, Bremerton.
12 JUL LT Edmund Woollen relieves LT Wm. J. Erickson as OJC PLAINVIEW.
15 ALJG LT James W. Orvis relieves LT Joel H. Roberts as OJC HIGH POINT.
21 SEP LT Joel H. Roberts reports to NSRDC as Hydrofoil Program Officer.
04 OCT LCDR Robt. Eric Nystrom relieves LCDR Henry Schmidt, Jr. as OJC HYSTU.
07 OCT Equipment salvaged and TUCUMCARJ (PGH-2) stricken from Navy Register.
03 DEC PIONEER 10 sends back pictures of Jupiter and its moons.
06 DEC HIGH POINT fires HARPOON missile while foilborne.
19 DEC HIGH POINT demonstration for Naval Research Advisory Committee (NRAC).

1974

29 MAR First Boeing commercial Jetfoil, KALAKAUA, launched into Lake Washington at Renton, WA.
18 APR HIGH POINT demonstration for COMCRUDESPAC.
14 MAY Edward Whitehurst joins Hydrofoil Office as Program Assistant.
16 MAY PLAINVIEW begins overhaul and modification at Todd Shipyard, Seattle.
29 JUN ADM James Holloway becomes CNO.
01 JUL NAVSHJPS & NAVORD merged to form Naval Sea Systems Command (NAVSEA).
01 JUL Lt Joel H. Roberts transferred to PEGASUS (PHM-1) as PXO.

01 JUL CNO message changes HIGH POINT status from "In-Service Special" to "In Service" in recognition of R & D mission.
12 JUL LT Wm. J. Erickson awarded Navy Commendation Medal for meritorious service as OIC PLAINVIEW.
-- AUG Enzo Marmentini leaves HYSTU and returns to private industry.
01 AUG LCDR Rex B. Fitch reports to NSRDC as Hydrofoil Program Officer.
02 AUG HIGH POINT begins 2nd deployment to San Diego.
-- AUG Work on PHM-2 at Boeing suspended due to increased costs.
09 AUG President Nixon resigns and Gerald R. Ford becomes 38th president.
-- SEP LCDR Henry Schmidt, Jr. awarded Navy Commendation Medal for meritorious service as OIC HYSTU.
25 SEP HIGH POINT assists in rescue of fishing vessel COHO-II near San Francisco, CA.
03 OCT HIGH POINT returns to Bremerton after second SOCAL deployment.
22 OCT Second Boeing Jetfoil MADEIRA launched at Kenton, WA.
25 OCT U.S. Navy and U.S. Coast Guard sign a Memorandum of Understanding to make HIGH POINT available for Coast Guard evaluation.
09 NOV USS PEGASUS (PHM-1) launched into Lake Washington at Renton, WA.

1975

25 FEB PHM-I makes first foilborne flight.
2' MAR LT Frank Hudson relieves LT Edmund Woollen as OIC PLAINVIEW.
03 APR LT Ralph D. Bianco relieves LT James W. Orvis as OIC HIGH POINT.
04 APR HIGH POINT placed under operational control of U. S. Coast Guard for transit to San Francisco and one month evaluation in Coast Guard missions. LT Douglas F. Gehring USCG assigned as OIC.
05 MAY HIGH POINT returned to Navy under command of LT Ralph D. Bianco.
15 JUN Boeing Jetfoil hull numbers 00 1, 003, & 004 begin commercial passenger service in Hawaiian Islands. Operated by SEAFLIGHT, Inc.
25 JUN PHM-1 fires 75 rounds from 76 MM Oto Melara gun.
25 JUN HIGH POINT conducts demonstrations for RADM L. W. Zech, Jr., COM-13; Hon. Larry Hughes, Rep. from Ohio; and NATO Special Working Group 6 (SWG-6).
01 JUL David Taylor added to name of NSRDC to become DTNSRDC.
14 AUG CAPT M. C. Davis relieves CAPT P. W. Nelson as Commander DTNSRDC.
30 SEP PEGASUS (PHM- 1 j transits from Seattle to San Diego in 34 hours, including one refueling stop in Eureka, CA.; a distance of I225 nm.
03 OCT Demo for ADM James Holloway, CNO, aboard PEGASUS in San Diego.
29 OCT PHM-1 conducts HARPOON Blast Test Vehicle (BTV) firing.
-- NOV CAPT Edward Molzan relieves CAPT James Wilkins as PHM Program Manager.

1976

-- JAN Boeing Marine Systems formed as a separate operating Division of the Boeing Company.
10 JAN FLAGSTAFF (PGH-1) transferred to U.S. COAST GUARD base Woods Hole, MA.
-- FEB HIGH POINT crewmen Richard L. Plumb and Richard E. Elmore receive Presidential Citation for invention of TANCAV navigation system. This later evolved into Hydrofoil Collision Avoidance And Tracking System, HYCATS, AN/SSQ-87(V).
04 FEB PHM-1 begins return transit from San Diego to Seattle.

23 FEB Donald Rieg joins HYSTU as Test Engineer.
-- APR HYSTU moves from bldg. 580 on Pier 3 to the 2nd floor of bldg. 495 at the head of Pier 7.
-- JUN CAPT F. F. Manganaro relieved by CAPT J. K. Nunneley as COM PSNS.
03 JUN PEGASUS (PHM- 1 j completes Operational Evaluation.
17 JUN LCDR Louis C. Tedeschi relieves CDR Robert Eric Nystrom as OIC HYSTU.
23 JUN Sumi Arima becomes Senior Civilian Engineer at HYSTU.
28 JUN PHM- 1 arrives at Pier 91 in Seattle.
09 AUG LCDR Donald C. Wight, CF, reports to DTNSRDC Hydrofoil Program Office as Canadian exchange officer.
30 SEP FLAGSTAFF (PGH-1) transferred to U.S. Coast Guard.

1977

10 JAN Deputy SECDEF advises SECNAV that PHM production can proceed.
20 JAN Jimmy Carter becomes the 39th president.
-- FEB President Carter's FY 1978 budget request deletes the PHMs.
19 FEB Space shuttle ENTERPRISE makes its first flight on a Boeing 747.
1' MAR LCDR Wm. C. Stolgitis reports to DTNSRDC as Hydrofoil Program Officer.
24 MAR LT Victor W. Ackley relieves LT Frank W. Hudson, Jr. as OIC PLAINVIEW.
06 APR SECDEF memo (PBD #312) orders termination of PHM production.
-- MAY President Carter submits proposal to Congress calling for cancellation of PHM production.
18 MAY HIGH POINT and PLAINVIEW transit to Esquimalt, B. C. to join in celebration of the Queen's birthday.
26 MAY R&D responsibility for PHM- 1 assigned to DTNSRDC/HYSTU.
02 JUN LCDR Wm. J. Erickson relieves LCDR Eric H. Ashburn as CO PEGASUS.
15 JUN USS PEGASUS (PHM-1) delivered to Navy at Pier 91 Seattle.
18 JUN Shirley Yates, HYSTU Admin Asst., transfers to Bangor.
-- JUL Congress fails to support PHM recission proposal.
09 JUL CSS PEGASUS (PHM-1) commissioned and homeported in San Diego under COMDESRON-9.
29 JUL Began pressure ranging tests with PCH-1. AGEH-I, and PHM-1.
03 AUG Completed pressure ranging tests.
09 AUG PHM-1 transits to San Diego.
10 AUG PHM-I arrives San Diego in record time (less than 34 hours).
12 AUG Space shuttle program takes wing as orbiter ENTERPRISE makes first atmospheric test flight.
21 AUG Shirley Yates (later Furmeister) returns to HYSTU as Admin Asst.
29 AUG CAPT Myron V. Ricketts relieves CAPT Michael C. Davis as Commander DTNSRDC.
20 OCT SECDEF releases $178M for PHM production.
21 OCT Navy PMS-303 awards a fixed-price incentive-fee contract (NO002477-C-20 5 1) to Boeing for five production PHMs.
16 DEC Remotely Piloted Vehicle (RPV) launched and recovered from AGEH-1.
29 DEC LT W. Scott Slocum relieves LT Ralph D. Bianco as OIC HIGH POINT.

1978

0' JAN James R. Gillam, HYSTU Test Mechanic, retires from federal service.
30 JAN OP-03 POA&M issued calling for deactivation of PLAINVIEW and HIGH POINT by 30 September 1978.

-- MAR PHM-I transits to Hawaii for Fleet exercises.
14 MAR CNO message directing deactivation of PLAINVIEW and HIGH POINT.
23 MAR LT Victor H. Ackley relieves LCDR Frank W. Hudson as OIC PLAINVIEW.
-- MAY PHM-1 returns to San Diego.
17 JUL Last foilborne flight of PLAINVIEW; 268 total foilborne hours.
14 AUG LT (later LCDR) W. Robert Starchuck, CF, relieves LCDR Don Wight, CF, as Canadian exchange officer in Hydrofoil Program Office.
25 AUG ENCS C. A. McDowell relieves LCDR W. Scott Slocum as OIC HIGH POINT.
01 SEP PHM-1 passes 900 foilborne and 1990 hullborne hours.
22 SEP PLAINVIEW inactivated and towed to INACTSHIPFAC. Bremerton. WA.
30 SEP HIGH POINT crew transferred to COM-I 3 pending action on reclama of decision to inactivate ship.
25 OCT CNO confirms decision to keen HIGH POINT in active service.
31 OCT HIGH POINT crew transferred back to ship for duty.
16 OCT QMC Ronald W. Lovelace relieves ENCS Charles A. McDowell as OIC HIGH POINT.

1979

10 JAN PHM- 1 arrives PSNS Bremerton for 60-day restricted availability.
05 MAR Unmanned spacecraft VOYAGER I sends back pictures of Jupiter.
26 MAR James H. King joins Advanced Hydrofoil Systems Office as replacement for Dennis Clark.
06 APR PHM-I completes RAV and returns to San Diego.
-- MAY PLAINVIEW (AGEH-1) sold to private party for $ 128K.
-- JUN CAPT J. K. Nunneley relieved by CAPT J. H. Boyd as COM PSNS.
04 JUN PEGASUS (PHM-1) departs San Diego for new homeport in Norfolk, VA.
07 JUN LCDR Joel D. Givens relieves QMC Ronald W. Lovelace as OIC PCH.
03 JUL PEGASUS arrives in Norfolk after record transit thru Panama Canal.
09 JUL Jetfoil hull #014, model 929-1 15, launched and modified as HMS SPEEDY (P-296) for evaluation by UK as a fisheries-protection vessel.
31 JUL LCDR Charles W. Penque, Jr. relieves LCDR Wm. J. Erickson as Commanding Officer of PEGASUS.
20 AUG PEGASUS runs aground in York River near Yorktown, VA.
24 AUG CDR Wm. J. Orvis assigned as CO of PEGASUS.
01 SEP Unmanned spacecraft PIONEER II flies past Saturn.

1980

15 JAN Joint US/CANADA meeting on Project HYTOW.
25 MAY HYSTU personnel begin PHM-I performance trials, Guantanamo Bay, Cuba.
19 JUN CAPT Ross E. Sugg relieves LCDR Louis C. Tedeschi as OIC HYSTU.
18 AUG Began pressure, acoustic, and magnetic trials of PHM-1, Panama Cty, FL.
23 SEP Completed PCH-1 trials of Depressor Towed Array System (DTAS).
30 SEP Fred Saxton retires as Hydrofoil Instrumentation Manager.
01 OCT John R. Meyer transferred to Hydrofoil Office as Project Engineer.
17 OCT Jim Mason, HYSTU Instrumentation technician. retires.
31 DEC QMC R. W. Lovelace retires from HIGH POINT.

1981

20 JAN Ronald Reagan becomes 40th president.
12 APR John Young and Bob Crippen pilot orbiter COLIJMBIA on inaugral voyage of the Space Transportation System.

01 MAY CAPT Barrick F. Tibbitts relieves CAPT Myron V. Ricketts as Commander DTNSRDC.
08 MAY USS TAURUS (PHM-3) launched.
27 MAY Grumman-built Israeli hydrofoil gunboat SHIMRIT launched at Lantana FL.
-- JUN CAPT J. H. Boyd relieved by COMO R. B. Horne, Jr. as COM PSNS.
29 JUN LCDR Daniel G. Mulhall relieves LCDR Joel D. Givens as OIC HIGH POINT.
16 SEP USS AQUILA (PHM-4) launched.
10 OCT USS TAURUS (PHM-3) commissioned.
05 NOV USS ARIES (PHM-5) launched.

1982

01 FEB HIGH POINT begins HYPAM towing trials.
17 FEB USS GEMINI (PHM-6) launched.
13 APR USS HERCULES (PHM-2) launched.
01 JUL CAPT Robert J. Johnston, USNR, retires as Technical Manager of DTNSRDC Hydrofoil Developmen't Program Office (Code 115).
15 JUL PHM-3 and PHM-4 depart for Key West, FL, in company with LST.
11 AUG PHM-3 and PHM-4 arrive PHMRONTWO in Key West.
13 NOV USS GEMINI (PHM-6) commissioned.
22 NOV CAPT Thomas Sherman, USN (ret), reports to DTNSRDC as Technical Manager of the Hydrofoil Development Program Office.
23 NOV USS ARIES (PHM-5) departs for Key West, FL.

1983

31 JAN Wm. M. Ellsworth retires as Head DTNSRDC Systems Development Department (Code 11).
-- FEB Boeing awarded $ 14M contract for logistics support of PHM Squadron.
12 MAR HERCULES (PHM-2) is commissioned at PHMRONTWO Key West, FL.
12 MAY LCDR Wm. Michael Dunaway relieves LCDR Daniel G. Mulhall as OIC HIGH POINT.
13 JUN PIONEER 10 is first spacecraft to exit the Solar System as it speeds past the orbit of Neptune.
18 JUN Sally Ride aboard orbiter CHALLENGER becomes the first American woman to fly in space.

1984

26 JUL CNO/CNM directs deactivation of HIGH POINT.
30 JUL CAPT Barry Tibbitts relieved by CAPT G. R. Garritson as COM DTNSRDC.
-- AUG COMO R. B. Horne, Jr. relieved by CAPT J. W. Sanford as COM PSNS.
21 SEP CNO message grants extension of HIGH POINT deactivation to 1 2/01/84.
26 OCT QMCM W. C. Wylie relieves LCDR W. M. Dunaway as OIC HIGH POINT.
01 DEC HIGH POINT is deactivated; crew members reassigned.
-- DEC HIGH POINT'S prized black cat "MOD-I" departs for "cat-heaven".

1985

20 JAN President Ronald Reagan begins second term in office.
22 JAN DTNSRDC combines HYSTU and Carr Inlet Ship Silencing Group (formerly under PSNS) to form a new Center Detachment.

23 JAN CAPT Dick Garritson, DTNSRDC Commander, turns over the keys to HIGH POINT to Richard Crowley, Boeing Marine Systems Director of Engineering; Boeing to operate the craft for the Center as a test platform with a civilian crew.

01 MAR J. Lee Schuler retires as NAVSEA R & D Program Manager.

06 MAY Naval Material -Command is abolished. DNL and CNM Centers/Laboratories placed under Chief of Naval Research.

APPENDIX **B**

HIGH POINT Operations Log

DATE	ON FOILS HR:MIN	ACCUM. F/B TIME HR:MIN	COMMENT	
05/22/63	00:08	00:08	First foilborne run	
05123163	00:52	01:00	Foilborne tests	
05/24/63	00:41	01:41	Foilborne tests	
05/29/63	00:47	02:28	First Builder’s Trial	
05/31/63	--------	02:28	*Ship in drydock	(15)
06/14/63	--------	02:28	Ship undocked	
07/02/63	00.35	03:03	Second Builder’s Trial	
07/09/63	00: 32	03:35	Third Builder’s Trial	
07/11/63	00:50	04:25	Preliminary Acceptance Trials	
07/17/63	00: 17	04:42	Demo for RADM Brockett, Chief BuShips	
0’123163	--------	04:42	*Ship in drydock	(8)
07/31/63	--------	04:42	Ship undocked	
08/08/63	00:06	04:48	Foilborne tests	
08/12/63	00:19	05:07	Foilborne tests	
08/15/63	--------	05:07	Ship delivered to Navy	
09/04/63	--------	05:07	*Ship put in cradle on dock at PSNS	(9)
09/13/63	--------	05:07	Ship undocked	
09/26/63	00:20	05:27	Navy trials and training	
10/21/63	--------	05:27	*Ship in drydock	(81)

Ship drydocked for remainder of 1963

*Ship drydockings (days)

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01/10/64	--------	05:27	Ship undocked	
01/15/64	00:11	05:38	Navy trials and training	
01/17/64	00:32	06:10	Navy trials and training	
01/20/64		06:10	*Ship in drydock	(4)
01/24/64		06:10	Ship undocked	
01/25/64	01:02	07:12	Transit to Dabob Bay; DTMB tests	
01/27/64	00:15	07:27	Final Acceptance Trials	
0 1/29/64	00:49	08:16	Height sensor checks	
01/30/64	00:56	09:12	Height sensor checks	
01/31/64	00:32	09:44	Height sensor checks	
02/01/64	01:56	11:40	DTMB tests at Dabob Bay	
02/03/64	00:13	11:53	Autopilot (ACS) checks	
02/04/64	--------	11:53	*Ship in drydock	(42)
03/18/64		11:56	Ship undocked	
03/20/64	00:55	12:48	ACS checks	
03/21/64	00:46	13:34	Demo for OPTEVFOR	
03/24/64	01:20	14:54	Rudder ventilation tests	
03/26/64	01:36	16:30	Forward foil ventilation tests	
03/27/64		16:30	*Ship in drydock	(28)
04/24/64	-------	16:30	Ship undocked	
04/24/64	00: 16	16:46	Forward strut pitot tube & fence test	
04/25/64	00:41	17:27	Demo for Hon.James Wakelin, ASN	
05/04/64	00:56	18:23	Forward strut ventilation test	
05/06/64	01:05	19:28	Demo for Italian visitors	
05/22/64	···· ····	19:28	*Ship in drydock	(27)
06/18/64		19:28	Ship undocked	
06/19/64	02:42	22:10	Tests with “clean” forward strut	
06/29/64	00:49	22:59	Transit to Neah Bay	
06/30/64	01:31	24:30	Roughwater trials	
07/01/64	01: 19	25:49	Roughwater trials	
07/02/64	00:57	26:46	Transit to Puget Sound Naval Shipyard	
07/10/64	01:00	27:46	Demo for VADM Bush, RN	
07/13/64	02:11	29:57	Test of spade rudder	
07/ 15164		29:57	*Ship in drydock	(9)
07/24/64		29:57	Ship undocked	
07/27/64	01:01	30:58	Acoustic trials at Carr Inlet	
07/28/64	02:54	33:52	Acoustic trials at Carr Inlet	
07/29/64	02:59	36:51	Acoustic trials at Carr Inlet	
07/30/64	04:12	41:03	Acoustic trials at Carr Inlet	
08/03/64	00:22	41:25	Speed and power trials	
08/04/64		41:25	*Ship in drydock	(24)
08/28/64		41:25	Ship undocked	
08/28/64	00:29	41:54	Demo for RADM's Farrall & Dornin	
08/31/64	01:14	43:08	Test of spade rudder	
09/03/64		43:08	*Ship in drydock	(7)
09/10/64		43:08	Ship undocked	
09/14/64	03:38	45:46	Test of spade rudder	
09/18/64	02:23	49:09	Spiral turning tests	
09/21/64	02:41	51:50	Transit to Neah Bay	

09/22/64	01:31	53:21	Roughwater trials	
09/25/64	--------	53:21	*Ship in drydock; MOD O overhaul	(529)
	Ship in overhaul remainder of 1964			

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Ship in overhaul all of 1965

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06/08/66	--------	53:21	Ship undocked	
06/22/66	02:06	55:27	Boeing trials	
07/12/66	00:24	55:51	Salt water in port transmission	
07/14/66	--------	55:51	*Ship in drydock	(45)
08/29/66	--------	55:51	Ship undocked; Boeing trials hullborne	
08/30/66	00:02	55:53	Boeing trials	
08/31/66	01:08	57:01	Boeing trials: titanium propeller failed	
09/02/66	01:05	58:06	Boeing trials	
09/07/66	03:38	61:44	Boeing Trials	
09/09/66	02:23	64:07	Boeing trials	
09/14/66	03:48	67:55	Boeing trials	
09/16/66	02:43	70:38	Boeing trials; demo for RADM Fahy	
09/22/66	01:27	72:05	Boeing trials; rudder anomoly	
09/30/66	01:54	73:59	Boeing trials	
10/10/66	01:20	75:19	Demo for RADM Michaelis, OP 72	
10/13/66	02:05	77:24	Boeing trials; ACS checkout	
10/14/66	01:26	77:08	Boeing trials	
10/19/66	03:19	80:27	Transit to Neah Bay	
10/20/66	01:13	81:40	Boeing trials in rough water	
10/21/66	01:55	83:35	Boeing trials with USCG CAPE HENLOPEN	
10/25/66	01:40	85:15	Boeing trials; Russian trawler, Neah Bay	
10/26/66	02:12	87:27	Boeing trials	
10/27/66	01:09	88:36	Boeing trials	
10/28/66	--------	88:36	Abort FB transit; disconn. coup.; ret HB	
11/23/66	--------	88:36	*Ship in drydock	(22)
12/14/66	- -	88:36	Ship undocked	
12/20/66	02:32	91:08	Boeing trials; highspeed runs	

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01/27/67	--------		In port visit by Italian flag officers
01/30/67			Transit to Carr Inlet; acoustic trials
01/31/67	--------		Hullborne acoustic trials
02/01/67			FB acoustic trials; damaged range gate
02/01/67			Returned to PSNS
02/07/67			Transit to Carr Inlet
02/08/67			Acoustic trials; ACS hydr pump failure
02/09/67		103:53	Complete acoustic trials: transit to PSNS
03/13/67			Complete alignment of tactical display
03/15/67			Practice torpedo firing, dockside
03/17/67			HB tests of integrated fire control
03/21/67			HB evaluation of MK 16 attack plotter

03/24/67			Install MOD to disconnect-coupling
03/27/67	00: 10		Foilborne ops to verify coupling fix
03/28/67	------ -		Install closed-circuit TV
03/29/67	--------		Dockside tests; fathometer transducer
03/30/67	01:54		Foilborne tests of NEL fathometer
04 /06/67	01:00		Noise survey at Keyport
04/07/67	00:47		Demo for Dr Powell & CAPT Vincent, NSRDC
04/08/67	01 :00		Demo for Hon. Paul H. Nitze, SECNAV
04/14/67	01:17		FB dummy torpedo firing; 2 stbd, 1 port
04/19/67	--------	117:11	In port visit; Hon. R Baldwin, UNDSECNAV
04/21/67	01 :00	118:11	Demo for VADM Galantin & ASN Bannerman
05/04/67			Visual/radar navigation trials
05/05/67			Visual/radar navigation trials
05/08/67			Visual/radar navigation trials
05/10/67			Visual/radar navigation trials
05/11/67			UNREP with TATNUCK (ATA- 145)
05/12/67			Demo for National Geographic Magazine
05/17/67			Complete ACS hydraulic start bypass test
05/19/67			Transit to Sand Point, NAS, Lake Wash.
05/20/67		125:06	Armed Forces Day Open House
05/21/67			Open House; total of 1500 visitors
05/22/67			Transit to PSNS
05/24/67			Fathometer transducer calibration
05/25/67			Fathometer tests
05/26/67			Fathometer tests
05/31/67			Complete retraction system torque test
06/14/67			Measurements on FB disconnect couplings
06/16/67			Evaluate effect of marine growth on foils
06/21/67			Disconnect coupling tests
06/22/67			Disconnect coupling tests
06/28/67			Evaluate steering anomolies
06/29/67		136:54	Pre-drydock reference tests
06/30/67	--------	136:54	Pre-drydock reference tests
07/05/67	--------	136:54	*Ship in drydock; Pier 6 (63)
07/17/67	--------	136:54	LT Burkons relieves LT McGanka as OIC
09/06/67	--------	136:54	Ship undocked
09/12/67			Radar/sonar calibration tests; PSNS
09/18/67			Post RAV verification trials
09/21/67	00:22		Post RAV verification trials
09/22/67	02:36		Post RAV verification trials
09/29/67	01:06		Smooth water response trials
10/04/67			Smooth water response trials
10/16/67			Magnetic field measurements
10/17/67			Magnetic field measurements
10/27/67			Acoustic trials at Dabob Bay
10/28/67			Acoustic trials
10/30/67			Acoustic trials

10/31/67	07: 17		Longest continuous foilborne time to date	
11/02/67	03:33		ACS adjustment trials	
11/03/67			ACS adjustment trials	
11/07/67	05:33		Complete acoustic trials	
11/09/67	03:57		Speed & power, take-off margin tests	
11/13/67	01:18		Foilborne & hullborne baseline tests	
11/14/67	00:09		Complete baseline tests	
11/17/67	--------	183:07	*Ship drydocked on barge at Pier 3	(61)
	Ship in drydock remainder of 1967			

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01/16/68	--------	183:07	Ship undocked	
01/24/68	--------		*Ship in drydock; repl. flap act.	(2)
01/27/68	--------		Ship undocked	
01/29/68	02:05		Operations with USS READY (PG 87)	
02/05/68			Transit to Port Angeles for roughwater	
02/21/68		205:07		
02/23/68			R & R in Esquimalt B.C.	
02/26/68			Continue roughwater trials	
03/06/68		249:07	Complete trials & return to PSNS	
03/12/68			Began mission trials off Vashon Island	
03/19/68			Completed mission trials	
03/20/68			Fired six MK 44 torpedos at Dabob Bay	
03/21/68			Conducted speed and power trials	
03/26/68			Foilborne ops to check out gas turbine	
04/03/68	01:47		40mm gunfire trials; RADM Petrovic aboard	
04/09/68		255:07	Evaluate foilborne turning	
04/11/68			Maneuvers with TUCUMCARI (PGH-2)	
04 / 18168			Transit to Port Angeles for 40mm trials	
04/19/68			40mm trials; CAPT W. M. Nicholson aboard	
04/29/68			Transit to Port Angeles	
04/30/68			Struck 20-foot log in Port Angeles harbor	
05/01/68			RADM John E. Dacey, OP-03G, visits ship	
05/02/68	--------	267:37	Returned to PSNS hullborne	
05/06/68	--------	267:37	*Ship in drydock	(4)
0 j/10/68	--------	267:37	Ship undocked	
05/13/68	05:11		Return to Port Angeles: 40mm trials	
05/14/68			40mm trials	
05/15/68			40mm trials	
05/16/68			Fathometer trials	
05/17/68			40mm trials	
05/18/68		305:07	Complete 40mm gunfire trials	
05/24/68	07:56		Fathometer trials	
05/28/68			Foilborne propeller tests	
05/29/68			Open house and flyby demo	
06/03/68			Evaluate Othometer and inlaid props	
06/06/68			40mm gun removed	
06/07/68			*Ship in drydock	(210)
07/05/68			Ship barged to Boeing Miss. Prod. Center	

07/08/68			Dr. Robt. Frosch, ASN (R&D), visits ship	
12/03/68		346:51	Ship barged to PSNS; turbine replaced	

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01/02/69	--------	346:51	Ship undocked	
01/03/69			Hullborne training and systems checks	
01/08/69			Begin foilborne checkout	
01/15/69			Ship strikes submerged object	
01/20/69			*Ship in drydock; repair prop damage	(8)
01/28/69			Ship undocked	
02/04/69			Resumed technical trials	
02/18/69	03:25		Measure forward foil tip loads	
02/19/69	02:24		Measure forward foil tip loads	
02/24/69			LT Ball relieves LT Burkons as OIC	
02/26/69			*Ship in drydock	(9)
03/06/69			Ship undocked	
03/11/69			Roughwater trials at Neah Bay	
03/16/69			Trials terminated; sonar well cover lost	
03/19/69			*Ship in drydock; removed sonar	(29)
04/16/69			Ship undocked	
04/18/69			Operations with PLAINVIEW (AGEH- 1)	
04/22/69			Returned to Neah Bay	
04/23/69			Tests of Raytheon 723-D fathometer	
04/30/69			Trials terminated; forward flap casualty	
05/02/69			*Ship in drydock	(43)
06/13/69			Ship undocked	
06/25/69			Attempted helo vertrep foilborne	
06/26/69	01:35		Single engine takekoffs and flights	
07/02/69			*Ship in drydock; install towed syst	(101)
10/10/69			Ship undocked	
10/29/69			Demo for ADM Moorer, CNO; trip to Tacoma	
		468:59		

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01/05/70	--------	468:59	Towed system dockside equipment tests	
02/16/70	--------	468:59	Launch and retrieval training	
02/19/70	--------	468:59	Hullborne towing in Sinclair Inlet	
02/20/70	--------	468:59	Hullborne depressor towing	
02/24/70	--------	468:59	Hullborne depressor towing	
02/26/70	--------	468:59	Hullborne depressor towing	
03/01/70	--------	468:59	Begin dockside repairs: turbine exhausts	
03/29/70	--------	468:59	Complete dockside repairs	
03/30/70	--------	468:59	Foilborne engine and ACS checks	
03/31/70	01:08	470:07	Foilborne towed body trials	
04/12/70	00:47	470:54	Demo flight	
04/13/70	00:37	471:31	Demo for ADMR I. J. Galantin, CNM	
04/20/70	--------	471:31	Hullborne towed body trials	
04/22/70	00:07	471:38	Hullborne towed body trials	
04/23/70	--------	471:31	*Ship in drydock; coating repair	(33)

05/24/70	--------	471:31	Ship undocked at Pier 6
05/25/70			Crew training and ship checks
05/28/70		475:11	Investigate steering anomoly
06/02/70	01:22		Towed body trials; check heading hold
06/04/70	00:42		Towed body trials
06/11/70	02:14		Towed body trials
06/12/70			Foilborne crew training
06/13/70			Foilborne crew training
06/16/70			Towed body trials
06/20/70			Complete HB towing; conduct FB checks
06/22/70			Demo for Navy Research Advisory Comm.
06/24/70			LT Roberts relieves LT Ball as OIC
06/25/70		487:45	Foilborne demo
07/14/70			Foilborne crew training and ACS checks
07/18/70	02:25		1st FB straight tow of depressor
07/22/70			Demo for Shipyard Commanders Conference
07/27/70	01:50		Transit to Bangor and Dabob Bay range
07/28/70	01:11		Foilborne towed body trials
07/30/70	01:48	499: 18	Foilborne towed body trials
08/07/70	00:52		Foilborne towing-fish goes wild!
08/12/70	00:53		Foilborne towed body trials
08/14/70			Towed body trials
08/15/70	02:33		1st Foilborne towing in turns
08/17/70	--------		Install trim tabs; hullborne tests
08/18/70	02:33		Foilborne towed body trials
08/19/70			Crew training exercises
08/20/70	03:36		Towing trials completed
08/22/70			Dependents cruise
08/24/70			Transit from Bangor to PSNS
08/25/70	--------	513:50	*Ship in drydock; removed towed syst (95)
11/27/70	01:10	515:08	Ship undocked; foilborne check out
12/03/70			Evaluate forward foil tip extension
12/04/70			Evaluate forward foil tip extension
12/10/70			Evaluate forward foil tip extension
12/15/70			Evaluate forward-looking sonar
12/17/70			Complete evaluation of sonar
12/18/70			Transit to Port Angeles; radiation check
12/21/70			Complete foil tip extension evaluation
		536:38	

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01/04/71	04: 15	540:53	To Port Angeles & ret; helo MEDEVAC test
01/05/71	07:31	548:24	Transit to Astoria, OR
01/06/71	07:12	555:36	Transit Astoria to Crescent City, CA
01/07/71	07:40	563: 16	Transit Crescent City to San Francisco CA
01/08/71	01:02	564: 18	Trials with PGs 85 & 94 and VIP demos
01/11/71	08:00	572: 18	Transit to Port Hueneme, CA
01/12/71	01:46	574:04	Transit to Long Beach, CA

01/13/71	01: 17	575:21	Magnetic signature and parafoil trials	
01/14/71	01:33	576:54	Demos for Fleet Commanders and Press	
01/15/71	03:25	580: 19	Transit to San Diego-meas radar x-section	
01/18/71	00:20	580:39	VIP demos	
01/19/71			IR photos; Harbor Island	
01/20/71			Install special FLEETEX equipment	
01/21/71			Install special FLEETEX equipment	
01/22/71			Dockside checks	
01/23/71			Install stable table for motion measts	
01/25/71	04:31	585: 10	Participated in COMPTUEX l-7 1	
01/26/71	--------		Returned to San Diego hullborne	
01/27/71	05:45	590:55	Seakeeping trials off San Clemente	
01/28/71	00:31	591:26	Demo for Prince Juan Carlos of Spain	
01/29/71	00: 30	591:56	Demo for Dr. Joel Lawson, DNL	
02/02/71	02:13	594:09	Hazard avoidance sonar trials	
02/03/71	04:14	598:23	LLTV and hazard avoidance trials	
02/04/71	01:07	599:30	Demo for VADM N. C. Johnson, COMPHIBPAC	
02/08/71	04:14	603:44	Infrared signature trials	
02/12/71	01:09	604:53	Demo for RADM J. L. Butts, COMCARDIV ONE	
02/16/71	01:44	606:37	Demo for VADM Ray Peet, COMFIRSTFLT	
02/22/71	00:32	607:09	Machinery checks	
02/23/71	01:05	608: 14	Operation ADMIXTURE (ROPEVAL 1-7 1)	
02/24/71	02:30	610:44	ADMIXTURE; (underway 24 hours)	
02/25/71	06:25	617:09	ADMIXTURE; returned to port	
03/01/71	01:01	618:10	Simulated torpedo attacks on Orange sub	
03/04/71	--------	618:10	Magnetic & infrared signature trials	
03/08/71	03:45	621:55	Transit to Port Hueneme; trials enroute	
03/09/71	08:33	630:28	Transit to Hunters Point: trials enroute	
0311 1/71	00: 53	631:21	Abort transit to Crescent City; storm	
03/13/71	06:20	637:41	Transit to Crescent City, CA	
03/14/71	07:49	645:30	Transit to Astoria, OR	
03/15/71	07:12	652:42	Transit to PSNS Bremerton	
03/30/71	--------	652:42	Crew training off Vashon Island	
03/31/71	--------	652:42	Crew training	
04/05/71	--------		Crew training	
04/06/71	00:30	653: 12	Demo for RADM D. C. Plate, COMCRUDESPAC	
04/07/71	--------		Crew training; turbine checks	
04/08/71	--------		*Ship in drydock; repair fwd foil	(33)
05/10/71	--------		Ship undocked at pier 6	
05/11/71	00: 10	653:22	Post RAV checkout	
05/13/71	00: 30	653:52	Demo for Hon John Chafee, SECNAV	
05/18/71	00:34	654:26	Checkout and demos	
05/24/71	01:19	655:45	Crew training and steering trials	
05/27/71	03:02	658:47	To Port Angeles & ret; vertrep refueling	
0512817 1	01:28	660:25	Speed and power trials	
06/01/71	04:59	665:24	To Port Angeles & ret; helo vertrep	

06/03/71	03:13	668:37	Speed and power trials off Vashon Island	
06/04/71	01:41	670:18	Demo for students of Naval War College	
06/07/71	01:32	671:50	Speed and power trials	
06/08/71	01:35	673:25	Speed and power trials	
06/09/71	01:40	675:05	Speed and power trials	
06/10/71	01:17	676:22	Speed and power trials	
06/11/71	01:53	678:15	Speed and power trials	
06/14/71	02:51	681:06	Crew training; EM log calibration	
06/16/71	01:24	682:30	Speed and power trials	
06/17/71	02:00	684:30	Speed and power trials	
06/24/71	01:27	685:57	Hazard avoidance sonar trials	
06/25/71	01:13	687:10	Complete hazard avoidance trials	
06/27/71	05:01	692:11	CH-56 helo vertrep trials	
06/28/71	02:40	694:51	Sonar trials	
06/30/71	02:50	697:41	Speed and power trials	
07/01/71	05:00	702:41	CH-56 helo vertrep trials	
07/02/71	00:59	703:30	Crew training	
07/07/71	00:59	704:29	Crew training	
07/09/71	01:13	705:32	Crew training	
07/13/71	01:34	707:06	Crew training; demo for NSRDC staff	
07/14/71	01:35	708:41	Crew training	
07/15/71	02:14	710:55	Crew training	
07/20/71	02:06	713:01	Complete crew training and craft checks	
07/21/71	03:19	716:20	Transit to Neah Bay	
07/22/71	01: 13	717:33	Conduct roughwater trials	
07/23/71	06:04	723:37	Return to PSNS	
09/01/71	--------	723:53	Hullborne crew training	
09/07/71	------	723:53	Transit to Boeing, Renton for MOD-I	
09/08/71	--------	723:53	*Ship in drydock; Boeing. Renton	(521)

Ship in drydock for remainder of 197 1

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Ship in modification & overhaul all of 1972

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02/10/73	--------	723:53	Ship undocked in Lake Washington	
02/28/73	- - ----	723:53	Hullborne turning tests	
03/02/73	-------	723:53	Transit to Pier 91 hullborne	
03/10/73	-------	723:53	Highspeed hullborne tests	
03/11/73	--------	723:53	Practice foilborne procedures	
03/19/73	-------	723:53	Checkout foilborne transmission	
03/20/73	--------	723:53	Transit Pier 91 to Renton	
03/22/73	--- ----	723:53	*Ship in drydock; Boeing, Renton	(52)
05/12/73	-------	723:53	Ship undocked	
05/21/73	00:15	724:08	First MOD I foilborne flight	
05/23/73	00:53	725:01	Second MOD I foilborne flight	
05/25/73	01:38	726:39	Transit to Pier 91 in Seattle	
05/29/73	02:17	728:56	Boeing verification trials	
05/30/73	02:36	731:32	FB height steps-5 to 7 deg/sec turns	

06/04/73	03:46	735:18	Foilborne to 48 kts; return to Renton	
06/06/73	--------	735:18	*Ship in drydock	(12)
06/18/73	-------	735:18	Ship undocked	
06/19/73	00:26	735:44	Boeing verification trials	
06/20/73	01:45	737:29	Ship returned to Navy at PSNS	
06/21/73	02:11	739:40	Navy trials, ISE to Tacoma up to 48 kts	
06/22/73	--------	739:40	Ship returned to Renton for repair	
07/06/73	--------	739:40	Ship returned to PSNS	
07/09/73	04:57	744:37	Ship exercises & training	
07/10/73	04:29	749:06	Independent ship exercises (ISE)	
07/11/73	03:17	752:23	ISE and demo	
07/12/73	02:06	754:29	Foilborne ship strikes 20-foot log	
07/16/73	02:07	756:36	ISE and demo	
07/18/73	04:10	760:46	Complete Navy trials & training	
07/20/73	02:35	763:21	Transit PSNS to Victoria/Esquimalt, B.C.	
07/21/73	03:49	767:10	PENAID trials: rudder problems	
07/22/73	03:31	770:41	Foilborne takeoffs and landings	
07/23/73	07:03	777:44	Regular ops; debris avoidance maneuvers	
07/25/73	04:16	782:00	Smooth water characterization	
07/26/73	04:28	786:28	PENAID trials: forward strut noise	
07/27/73	03:31	789:59	Takeoffs and landings; rudder sticking	
07/29/73	01:28	791:27	VIP demo	
07/30/73	00:33	792:00	FB tests to investigate sticking rudder	
07/31/73	--------	792:00	Anti-ship missile defense (ASMD) trials	
08/01/73	--------	792:00	ASMD trials	
08/03/73	--------	792:00	Transit to PSNS hullborne	
08/06/73	--------	792:00	Dockside; install HARPOON launcher	
08/15/73	--------	792:00	LT Orvis relieves LT Roberts as OIC	
11/18/73	--------	792:00	Smooth water verification trials	
11/19/73	01:30	793:30	Smooth water verification trials	
11/21/73	--------	793:30	Smooth water verification trials	
11/23/73	00:45	794:15	Transit to PSNS	
11/26/73	01:44	795:59	Transit to Bangor; HARPOON tests	
11/29/73	--------	795:59	HARPOON performance test	
11/30/73	01:28	797:27	HARPOON performance test	
12/03/73	03:13	800:40	Transit to Nanoose	
12/05/73	03:15	803:55	HARPOON practice runs	
12/07/73	04:27	808:22	Transit to Bangor; load HARPOON	
12/12/73	01:01	809:23	Transit to Nanoose	
12/14/73	02:25	811:48	First HARPOON missile launch	
12/15/73	02:58	814:46	Transit to Bangor	
12/17/73	01:20	816:06	Return to PSNS	
12/18/73	01:18	817:24	ISE; height sensor check	
12/19/73	02:07	819:31	Demo; NRAC, VADM Moran, and Dr. S. Koslov	

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01/09/74	--------	819:31	*Ship in drydock	(2)
01/11/74	--	819:31	Ship undocked	
01/12/74	01:07	820:38	Transit to Bangor; load HARPOON	

01/13/74	03:18	823:56	Transit Bangor to Nanoose	
01/14/74	02:47	826:43	Second HARPOON missile launch	
01/15/74	04:48	831:31	Return to PSNS via Bangor	
01/18/74	03:56	835:27	Smooth water characterization trials	
01/21/74		835:27	Smooth water structures tests	
01/25/74	01:12	836:39	Structures tests	
01/30/74	--------	836:39	*Ship in drydock	(13)
02/12/74		836:39	Ship undocked	
02/20/74	03:02	839:41	Structures tests	
02/21/74	02:04	841:45	Checkout hydrof. univ. digital autopilot	
02/22/74	01:52	843:37	HUDAP check	
02/26/74	03:11	846:48	Navigation checks; roughwater trials	
02/27/74	06:31	853:19	Navigation system evaluation	
02/28/74	05:06	858:25	Roughwater trials	
03/01/74	00:49	859: 14	Navigation system evaluation	
03/08/74	01:34	860:48	Machinery noise characterization	
03/11/74	04:43	865:31	Roughwater trials	
03/12/74	02:45	868: 16	Navigation system evaluation	
03/13/74	03:04	87 1:20	Roughwater trials	
03/14/74	04:08	875:28	Navigation system evaluation	
03/15/74	03:04	878:32	Roughwater trials; transit to PSNS	
03/18/74	04:06	882:38	Transit to Neah Bay; roughwater trials	
03/19/74	05:20	887:58	Roughwater trials; transit to PSNS	
03/20/74	0 1 :oo	888: 58	ISE; demo	
03/22/74		888:58	*Ship in drydock	(4)
03/26/74	01:30	890:28	Ship undocked; post drydock checkout	
03/27/74	03:07	893:35	Roughwater HUDAP tests	
03/28/74	03:28	897:03	Roughwater trials	
03/29/74	00: 39	897:42	VIP demo	
03/30/74	03:13	900:55	Roughwater trials; transit to PSNS	
04/03/74	01:18	702: 13	HUDAP check	
04/04/74	02:54	905:07	HUDAP check	
04/09/74	01:41	906:48	Evaluate low-light-level TV	
04/11/74	01:30	708: 18	Evaluate low-light-level TV	
04/16/74	01:25	909:43	Multiple influence tests	
04/18/74	01:22	911:05	ISE; Demo for COMCRUDESPAC	
04/19/74	02:57	914:02	Mission trials	
04/29/74		914:02	*Ship in drydock	(23)
05/22/74		914:02	Ship undocked	
05/23/74	--------	914:02	Test Universal Digital Data System	
05/24/74	01:47	915:49	ISE; machinery check	
05/29/74	05:16	72 1:05	Underwater radiated noise measurements	
05/31/74	04: 10	925:15	ISE; transit to Everett, WA	
06/03/74	--------	925:15	Transit to PSNS hullborne	
06/06/74	01:09	926:24	ISE drills	
06/13/74	03:02	929: 26	Test of Small Craft Fire Control System	
06/14/74	05:43	935:09	Check navigational accuracy off Vashon	
06/17/74	08:06	943:15	SCFCS tests	
06/18/74	07:58	951:13	SCFCS tests	

06/25/74	01:40	952:53	SCFCS tests; log strike in Puget Sound	
06/27/74	--------	952:53	*Ship in drydock	(29)
07/26/74	--------	952:53	Ship undocked	
07/31/74	03:52	956:45	Post RAV checkout	
08/02/74	12:26	969:11	Transit PSNS to Crescent City. CA	
08/06/74	00:01	969:12	Aborted transit; ISE	
08/08/74	00:15	969:27	Check ACS	
08/12/74	07:02	976:29	Transit Crescent City to San Francisco	
08/13/74	07:25	983:54	Transit San Francisco to Port Hueneme	
08/14/74	03:25	987:19	Transit Port Hueneme to San Diego	
08/19/74	01:38	988:57	FLEETEX; PHM tactics development	
08/20/74	04:45	993:42	FLEETEX	
08/21/74	07:10	1000:52	FLEETEX	
09/07/74	00:11	1001:03	San Diego; check out	
09/08/74	00:23	1001:26	VIP demos in San Diego	
09/09/74	00:38	1002:04	VIP demos	
09/12/74	01:57	1004:01	Transit San Diego to Long Beach	
09/17/74	--------	1004:01	*Ship drydocked Long Beach Navy Yard	(7)
09/24/74	00:21	1004:22	Ship undocked; made performance checks	
09/25/74	09:07	1013:29	Enroute San Francisco; rescue of COHO II	
09/27/74	01:30	1014:59	San Francisco Demo	
09/30/74	09:01	1024:00	Transit to Coos Bay, OR	
10/02/74	10:21	1034:21	Transit to Seattle, WA	
10/07/74	00:51	1035:11	HUDAP tests	
10/08/74	00:22	1035:33	HUDAP tests	
10/10/74	--------	1035:33	*Ship in drydock	(113)
	Ship in drydock remainder of 1974			

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01/30/75	--------	1035:33	Ship undocked for CVA-64	
02/03/75	--------	1035:33	*Ship in drydock	(43)
03/17/75	--------	1035:33	Ship undocked; RAV terminated	
03/19/75	01:02	1036:35	Post RAV checkout	
03/20/75	00:50	1037:25	Post RAV checkout	
03/21/75	02:24	1039:49	Post RAV checkout	
03/22/75	02:22	1042:11	HUDAP tests	
03/24/75	02:35	1044:46	HUDAP tests	
03/26/75	04:17	1049:03	AHV-6 radar height sensor tests	
03/27/75	02:04	1051:07	Calmwater speed & power tests	
03/28/75	01:31	1052:38	Calmwater speed & power tests	
03/29/75	05:16	1057:54	HUDAP tests	
03/31/75	03:08	1061:02	Coast Guard crew training	
04/01/75	03:00	1064:02	Radar height sensor tests	
04/02/75	01:09	1065:11	Coast Guard crew training	
04/03/75	--------	1065:11	LT Bianco relieves LT Orvis as OIC	
04/04/75	--------	1065:11	LT Gehring, USCG, relieves LT Bianco	
04/04/75		1065:11	Coast Guard takes over ship	
04/04/75	07:50	1073:01	Transit to Astoria, OR	
04/05/75	07:04	1080:05	Transit to Crescent City, CA	

04/06/75	02:33	1082:38	Transit to San Francisco. CA	
04/09/75	00:49	1083:27	Fisheries patrol; lube oil casualty	
04/13/75	00: 16	1083:43	Machinery checkout	
04/16/75	03:53	1087:36	Marine environment patrol	
04/17/75		1087:36	Hullborne check of disconnect coupling	
04/18/75	08: 17	1095:53	Fisheries patrol; Soviet fishing fleet	
04/24/75	08:54	1104:47	Fisheries patrol	
04/25/75	04:00	1108:47	Fisheries patrol; SAR exercise	
O-i/26/75	00: 27	1109:14	Fisheries patrol; transmission casualty	
05/05/75		1109:14	Ship returned to Navy at Alameda. CA	
05/05/75		1109:04	LT Bianco relieves LT Gehring, USCG	
05/27/75		1109"4	Navy begins transmission repair	
06102175		1109:04	Transmission repairs completed	
06/03/75	--------	1109:04	Conducted spin tests	
06/04/75	01:05	1110:19	Machinery checkout	
06/05/75	01:32	1111:51	Calmwater speed & power trials	
06/06/75	02:51	1114:42	Roughwater trials	
06/07/75	00:35	1115:17	Independent ship exercises (ISE)	
06/10/75	00:25	1115:42	ISE	
06/11/75	00: 36	1116:18	ISE	
06/12/75	00:53	1117:11	Calmwater speed & power trials	
06/15/75	06:42	1123:53	Transit to Crescent City, CA	
06/16/75	07:35	1131:28	Transit to Astoria, OR	
06/17/75	06:48	1138:16	Transit to PSNS	
06/ 181'5	01:06	1139:22	Joint operations with PEGASUS, (PHM- 1)	
06/25/75	00:36	1139:58	Demo, RADM Zech, COM-13, and Rep. Hughes	
06/25/75	00:36	1140:34	Demo, NATO SWG-6	
06/26/75	01:35	1142:09	Dependents cruise	
07/03/75		1142:09	*Ship in drydock	(30)
081011'5		1142:09	Ship undocked for CVA-64	
08/05/75		1142:09	*Ship in drydock	(30)
09103175		1142:09	Ship undocked	
09/06/75	00:51	1143:00	Post RAV checkout	
09/09/75	00:22	1143:22	PHM-1 support	
09/11175	05:47	1149:09	PHM- 1 support	
09/16/75	00:35	1149:44	PHM- 1 support	
09/17/75	00: 29	1150:13	Trouble-shooting transmission problem	
09/19/75	00: 35	1150:48	Trouble-shooting transmission problem	
09/24/75	03:11	1153:59	Vented propeller tests	
09/26/75	02:05	1156:04	Vented prop tests; prop shaft failure	
09/29/75		1156:04	*Ship in drydock	(5)
10/03/75	-------	1156:04	Ship undocked	
10/06/75	00: 54	1156:58	Demo, CAPT K. A. Low, RN	
10/08/75	03:17	1160:15	Complete vented propeller tests	
10/10/75	02:25	1162:40	Flap effectiveness test	
10/15/75	00:43	1163:23	Underway replenishment trials	
10/23/75	01:13	1164:36	VIP demo	
10/24/75	01:52	1166:28	Hydrodynamic tests	

10/30/75	00:36	1167:04	VIP demo	
10/31/75	00:17	1167:21	Forward strut steering evaluation	
11/03/75	01:52	1169:13	Transit to Port Angeles,WA	
11/04/75	04:53	1174:06	Roughwater trials	
11/05/75	03:36	1177:42	Roughwater trials	
11/06/75	04:24	1182:06	Roughwater trials	
11/07/75	05:02	1187:08	Interrupt trials; transit to PSNS	
11/10/75	01:31	1188:39	Transit to Port Angeles	
11/13/75	02:00	1190:39	Transit to PSNS	
11/14/75	00:18	1190:57	Refuel at Manchester	
11/17/75	00:51	1191:48	VIP demo	
12/01/75	01:44	1193:32	Transit to Port Angeles	
12/02/75	01:48	1195:20	Roughwater trials	
12/04/75	--------	1195:20	Transit to PSNS; HUDAP removed	
12/10/75	00:25	1195:45	Checkout	
12/11/75	02:06	1197:51	Foil cavitation tests; evaluate TANCAV	
12/12/75	01:35	1199:26	Foil cavitation tests; evaluate TANCAV	
12/16/75	-------	1200:26	*Ship in drydock	(31)

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01/16/76	--------	1200:26	Ship undocked	
01/19/76	01:31	1201:57	Checkout and run measured mile	
01/20/76	02:32	1204:29	Foil cavitation tests	
01/21/76	00:14	1204:43	VIP demo	
01/23/76	03:39	1208:22	Transit PSNS to Vancouver, B. C.	
01/26/76	04:25	1212:47	Return to PSNS	
01/27/76	00:56	1213:43	Run measured mile	
02/11/76	00:40	1214:23	Engine checkout	
02/18/76	00:50	1215:13	VIP demo	
03/01/76	--------	1215:13	*Ship in drydock	(9)
03/10/76	00:49	1216:02	Ship undocked	
03/12/76	00:55	1216:57	Carbo-blast turbines	
03/16/76	00:33	1217:30	Refuel	
04/09/76	01:11	1218:41	Cavitation tests	
04/12/76	00:24	1219:05	Transit to Todd shipyard, Seattle	
04/13/76	00:59	1220:04	Demo for RADM Bill Barnes, BuShips,	
04/14/76	01:51	1221:55	Cavitation tests; transit to Pier 91	
04/16/76	03:21	1225:16	Complete forward foil cavitation tests	
04/27/76	01:40	1226:56	Demos for Navy League	
04/29/76	02:36	1229:32	Radar speed tests	
04/30/76	02:54	1232:26	Tact Navig & Collis Avoid Video syst test	
05/03/76	01:23	1233:49	TANCAV tests	
05/04/76	00:52	1234:41	TANCAV tests	
05/21/76	01:56	1236:37	TANCAV tests	
06/04/76	01:15	1237:52	Transit to Everett, WA	
06/05/76	01:26	1239:18	VIP demos	
06/06/76	01:09	1240:27	Transit to Bremerton	
06/10/76	00:32	1240:59	Engineering checkout	
06/17/76	00:42	1241:42	VIP demo; joint ops with PLAINVIEW	

07/16/76	--------	1241:49	*Ship in drydock	(5)
07/30/76	00:31	1242:20	Ship undocked; checkout runs	
08/02/76	00:36	1242:25	Refuel	
08/03/76	00:37	1243:01	Systems check	
08/06/76	00: 18	1243:19	Refuel	
08/09/76	00:47	1244:06	VIP demo; check doppler velocity log	
08/10/76	01:06	1245:12	Tests of NADC speed log	
08/11/76	03:57	1249:09	Tests of NADC speed log	
08/12/76	01:15	1250:24	Tests of NADC speed log	
08/13/76	00:55	1251:19	Tests of NADC speed log	
08/14/76	00:33	1251:52	Tests of NADC speed log	
08/17/76	--------	1251:52	*Ship in drydock	(41)
09/27/76	--------	------------	Ship undocked for CVA-63	
09/28/76	--------	1251:52	*Ship in drydock	(204)
	Ship in drydock remainder of 1976			

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04/20/77	--------	1251:52	Ship undocked	
04/22/77	00:35	1252:27	Machinery checkout	
04/28/77	00:58	1253:25	Machinery checkout	
05/06/77	01:59	1255:24	Tow dummy thin-line array	
05/09/77	01:39	1257:03	Tow dummy thin-line array	
05/10/77	00:38	1257:41	Refuel	
05/11/77	07:44	1265:25	Tow thin-line array in roughwater	
05/19/77	01:55	1267:20	Transit to Victoria, B. C.	
05/20/77	04:45	1272:05	Round trip Victoria to Keyport	
05/22/77	02:21	1274:26	Transit Victoria to PSNS	
05/24/77	01:14	1275:40	VIP demo and refuel	
05/26/77	02:06	1277:46	Debris avoidance trial	
07/01/77	--------		Moored at Port Orchard for Open House	
07/05/77	--------		*Ship in drydock; pod repair	(9)
07/14/77	--------	------------	Ship undocked	
07/15/77	00: 11	1277:57	Starboard aft prop lost on takeoff	
07/19/77	04:47	1282:44	Tests of high speed log	
07/21/77	01:21	1284:05	Transit to Pier 91; Israeli demo	
07/22/77	01:33	1285:38	Pressure signature test with AGEH-1	
07/26/77	04:46	1290:24	Roughwater trials	
07/29/77	03:00	1293:24	Pressure signature test with AGEH-1	
08/02/77	--------	1293:24	*Ship in drydock	(23)
08/25/77	--------	------------	Ship undocked	
08/31/77	00: 17	1293:41	Ox trial	
09/02/77	00:07	1293:48	Ox trial	
09/02/77	--------	1293:48	*Ship in drydock; VDS installed	(102)
12/13/77	--------	------------	Ship undocked (weight 124.7 long tons)	
12/14/77	01:43	1295:31	Transmission checkout	
12/20/77	00:32	1296:03	Check effect of 5-ton VDS on fantail	
1212 1/77	05:05	1301:08	Transit PSNS to Tatoosh to Port Angeles	
12/22/77	00: 59	1302:07	Transit Port Angeles to PSNS	
12/29/77	--------	1302:07	LCDR Slocum relieves LT Bianco as OIC	

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01/09/78	01:23	1303:30	ISE to Pier 91	
01/12/78	00:25	1303:55	Transit to Keyport	
01/16/78	--------	1303:55	*Ship in drydock	(3)
01/19/78	--------	1303:55	Ship undocked	
02/02/78	00: 56	1304:51	HYTOW VDS trials	
02/09/78	01:46	1306:37	Engine check and speed calibration	
02/28/78	--------	1306:37	Hullborne transit to Keyport with barge	
03/01/78	00:34	1307:11	Transit to VDS operating area	
03/02/78	00:37	1307:48	Transit to operating area	
03/03/78	00:57	1308:45	Foilborne VDS trials	
03/08/78	--------	1308:45	Return to PSNS hullborne with barge	
03/14/78	--------	1308:45	CNO msg directs inactivation by 09/30/78	
03/15/78	--------	1308:45	*Ship in drydock	(20)
04/04/78	--------	1308:45	Ship undocked	
04/06/78	00:33	1309: 18	Machinery checkout	
04/13/78	00:02	1309:20	Machinery checkout	
04/14/78	01:05	1310:25	Refuel; carbo-blast engines	
04/15/78	01:03	1311:28	Dependents cruise	
04/25/78	01:25	1312:53	Engineering drill; carbo-blast engines	
04/27/78	01:44	1314:37	Demo for RADM Keener	
05/03/78	00:48	1315:25	Demo for RADM Briggs	
05/05/78	01:02	1316:27	Demo for CNO with JETFOIL	
05/11/78	01:57	1318:24	Vip demo; dual operations with AGEH	
05/12/78	00:32	1318:56	Refuel at Manchester	
05/24/78	01:23	1320:19	VIP demo; speed log check	
05/25/78	00: 10	1320:29	Machinery check; abort dual operations	
06/09/78	01:14	1321:43	Turbine check	
06/ 15178	00:23	1322:06	Refuel	
06/ 16178	03:44	1325:50	Pressure signature tests	
06/19/78	00:45	1326:35	Refuel; transit to Pier 91	
06/20/78	05:05	1331:40	Pressure signature tests with JETFOIL	
06/21/78	00:23	1332:03	Refuel to stay heavy	
06/26/78	03:43	1335:46	Pressure signature tests with AGEH	
06/27/78	01:58	1337:44	Pressure signature tests	
06/29/78	--------	1337:44	*Ship in drydock	(19)
07/18/78	00:30	1338: 14	Ship undocked; engineering checkout	
07/19/78	00:27	1338:41	Machinery check	
07/20/78	00:43	1339:24	Demo for ADM Whittle, CNM	
07/31/78	--------	1339:24	Transit to Keyport hullborne	
08/01/78	00: 52	1340:16	VDS trials	
08/02/78	01:21	1341:37	Demos at SEAFAIR	
08/03/78	00:46	1342:23	Refuel at Manchester; VDS trials	
08/07/78	00:31	1342: 54	Transit to Bremerton	
08/08/78	00:39	1343:33	VIP demo	
08/15/78	00:43	1344: 16	VIP demo and refuel	
08/17/78	00: 18	1344:34	AHV-20, radar height sensor trials	
08/25/78	--------	1344:34	ENCS McDowell relieves LCDR Slocum	
08/29/78	--------	1344:34	*Ship in drpdock	(398)

09/30/78	--------	1344:34	Transfer crew to COM-13 pending inactiv.	
10/16/78	--------	1344:34	QMC Lovelace relieves ENCS McDowell	
10/25/78	--------	1344:34	CNO cancels inactivation	
10/31/78	--------	1344134	Crew returned to duty on ship	
12/14/78	---- -	1344334	Composite flap installed	

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Ship in drydock most of 1979

06/07/79	--------	1344:34	LCDR Givens relieves QMC Lovelace as OIC	
10/01/79	--------	1344:34	Ship undocked	
10/03/79	02:28	1347:02	Post RAV checks; evaluate composite flap	
10/04/79	00:31	1347:33	Post RAV checks; vibration survey	
10/05/79	02:06	1349:39	Port foilborne transmission failure	
10/11/79	--------	1349:39	*Ship in drydock	(6)
10/17/79	--------	1349:39	Ship undocked	
10/18/79	--------	1349:39	Test Depressor-Towed Acoustic Syst (DTAS)	
10/21/79	-- - -	1349:39	Hullborne transit to Port Angeles	
10/22/79	--------	1349:39	Hullborne check of DTAS at Port Angeles	
10/24/79	--------	1349:39	Transit to Nanaimo, B.C., Wharf C	
10/25/79	--------	1349:39	DTAS MK 30 exercise at Nanoose Range	
10/29/79	--------	1349:39	DTAS MK 30 exercise at Nanoose Range	
1 0/3 1179	--------	1349:39	DTAS trials; Straits of Juan de Fuca	
11/02/79	--- --	1349:39	DTAS trials; Straits of Juan de Fuca	
11/04/79	--------	1349:39	Transit to Ranch Point, B.C.	
11/05/79	--------	1349:39	DTAS noise tests at full cable scope	
11/06/79	--------	1349:39	Hullborne transit to PSNS	
11/08/79	--------	134939	Stbd transmission vibration survey	
11/09/79	--------	1349:39	*Ship in drpdock	(66)

Ship in drydock remainder of 1979

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01/14/80	--------	1349:39	Ship undocked	
01/16/80	--------	1349:39	Hullborne tow trials; Coast Guard sled	
01/22/80	--------	1349:39	Hullborne tow trials; Coast Guard sled	
01/23/80		1349:39	Towing trials	
01/24/80		1349:39	Local operations	
01/25/80		1349:39	Hullborne tow trials; Coast Guard sled	
02/01/80		1349:39	Refuel at Manchester	
02/04/80		1349:39	* Ship in drydock; transm. overhaul(16 1)	
07/15/80		1349:39	Ship undocked	
07/18/80	02: 13	1351:52	Post RAV checkout	
07 /21/80	04:13	1356:05	Post RAV checkout; composite flap	
07122180	00:39	1356:44	Post RAV checkout	
07/23/80	01 :07	1357:51	*Docked and undocked to change seal	(1)
07/24/80	01:46	1359:37	Transit to Nanoose, B.C.	
0'125180	--------	1359:37	DTAS hydro-mechanical check; Nanoose	
0'126180		1359:37	DTAS self-noise tests; Jervis Inlet	
0'128180		1359:37	DTAS self-noise tests; Jervis Inlet	
07/29/80		1359:37	DTAS self-noise tests; Jervis Inlet	
07/30/80		1359:37	DTAS self-noise tests; Nanoose	

07/31/80	--------	1359:37	DTAS self-noise tests; Nanoose	
08/02/80	--------	1359:37	DTAS trials at Nanoose	
08/04/80	--------	1359:37	Sonar target tests at Nanoose	
08/05/80	--------	1359:37	Sonar target tests at Nanoose	
08/06/80	--------	1359:37	Sonar target tests at Nanoose	
08/07/80	--------	1359:37	Cable trim and self-noise test, Nanoose	
08/08/80	--------	1359:37	Turbine self-noise test; prop failure	
08/09/80	--------	1359:37	Transit to PSNS hullborne	
08/15/80	00:30	1360:07	Turb. check; demo, RADM Williams, COM-13	
08/21/80	00:21	1360:28	Refuel and make pre-transit checks	
08/22/80	02:29	1362:57	Began trip to SOCAL; prop shaft failure	
08/23/80	--------	1362:57	*Ship in drydock; cancel SOCAL deploy	(2)
08/25/80	--------	1362:57	Ship undocked	
09/04/80	--------	1362:57	Hullborne vibrations test	
09/09/80	--------	1362:57	Transit PSNS to Carr Inlet hullborne	
09/10/80	--------	1362:57	Hullborne acoustic tests at Carr Inlet	
09/11/80	--------	1362:57	Transit Carr Inlet to PSNS hullborne	
09/15/80	--------	1362:57	Local DTAS tests	
09/17/80	--------	1362:57	Calibrate ring-vented prop air feed	
09/18/80	--------	1362:57	DTAS self-noise test with vented prop	
09/19/80	--------	1362:57	Transit to Manchester to refuel	
09/22/80	--------	1362:57	Transit to Ranch Point for DTAS trials	
09/23/80	--------	1362:57	DTAS trials aborted; returned PSNS	
09/26/80	--------	1362:57	*Ship in drydock	**(339)**

Ship in drydock remainder of 1980

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01/01/81	--------	1362:57	Ship remains in drydock	
05/29/81	--------	------------	Completed overhaul of outdrive	
06/29/81	--------	------------	LCDR Mulhall relieves LCDR Givens as OIC	
07/28/81	--------	------------	Completed overhaul of ships generator	
08/04/81	--------		Completed overhaul of stbd tramsmission	
08/06/81	--------	------------	Completed overhaul of port transmission	
08/31/81	--------	------------	Ship undocked with HYTOW installed	
09/08/81	--------		Hullborne checks; stbd prop vibration	
09/09/81		------------	*Ship in drydock	(2)
09/11/81	--------	1362:57	Ship undocked	
09/14/81	01:33	1364:30	Post RAV checkout	
09/15/81	00:49	1365: 19	Post RAV checkout; refuel	
09/16/81	02:52	1368: 11	Complete post RAV checkout	
09/18/81	00:50	1369:01	ISE	
09/21/81		136901	*Ship drydocked; props balanced	(18)
10/09/81	--------	136901	Ship undocked	
10/22/81	02:07	1371:08	Transit to Keyport, WA	
10/23/81	00:49	1371:57	HYTOW tests hullborne; refuel	
10/26/81	00:48	137245	HYTOW tests	
10/27/81	01:09	1373:54	HYTOW tests	
10/28/81	01:00	1374:54	HYTOW tests	

10/30/81	01:24	1376:18	HYTOW tests	
11/03/81	01:03	1377:21	HYTOW tests	
11/04/81	00:55	1378: 16	HYTOW tests	
11/06/81	00:58	1379:14	HYTOW tests; 36 knot straight runs	
11/10/81	02:29	1381:43	HYTOW tests; 40.6 knots	
1 l/l 1/81	01:12	1382:55	HYTOW tests foilborne	
11/12/81	02:01	1384:56	HYTOW tests foilborne	
11/15/81	02:43	1387:39	Transit to Esquimalt, B. C.	
11/18/81	03:32	1391:11	Transit to Port Angeles; RADM Hughes RCN	
11/19/81	00:16	1391:27	Test aborted; saltwater in transmission	
11/20/81	04:00	1395:27	Transit to PSNS	
11/20/81	--------	1395:27	*Ship drydocked; remove VDS gear	(59)
12/03/81	--------	1395:27	Began HYPAM installation	
	Ship in drydock remainder of 198 1			

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01/12/82	--------	1395:27	HYPAM boom installed	
01/13/82	--------	------------	Began tests of HYPAM hydraulic system	
01/15/82	--------	------------	Completed HYPAM installation	
01/18/82	--------	1395:27	Ship undocked	
01/19/82	01:14	1396:41	Demo for CAPT B. Tibbetts, COM DTNSRDC	
01/25/82	01:58	1398:39	HYPAM foilborne handling trials	
01/28/82	01:47	1400:26	Transit to Everett, WA; HYPAM trials	
01/29/82	01:23	1401:49	HYPAM trials	
02/01/82	01:30	1403: 19	HYPAM trials	
02/02/82	01:58	1405: 17	HYPAM trials	
02/03/82	04:15	1409:32	HYPAM trials	
02/04/82	02:34	1412:06	HYPAM trials	
02/05/82	04:04	1416:10	HYPAM trials	
02/08/82	....	------------	Inport Everett; repair emergency gener.	
02/09/82	00:27	14 16:37	HY PAM trials	
02/10/82	02:04	1418:41	Transit to Bremerton	
02/17/82	02:39	1421:21	Baseline characterization	
02/22/82	....	------------	*Ship in drydock; remove HYPAM gear	(91)
04/12/82	--------	------------	Commodore Ricketts visits ship	
04/30/82	--------	------------	Replaced diesel emergency generator	
05/24/82	--------	1421:21	Ship undocked	
05/28/82	--------	------------	Underway crew training	
06/02/82	01:51	1423:12	Post RAV checkout; crew training	
06/03/82	00:54	1424:06	Outdrive checkout; crew training	
06/04/82	01:21	1425:27	Autopilot checkout; crew training	
06/07/82	01:02	1426:29	Autopilot checkout; crew training	
06/08/82	06:57	1433:26	Transit to Astoria, OR	
06/09/82	02:00	1435:58	Transit to Portland for Rose Festival	
06/14/82	02:00	1437:58	Transit to Astoria, OR	
06/15/82	07:08	1445:06	Transit to Bremerton	
06/29/82	01:47	1446:53	Machinery vibration checkout	
07/01/82	--------	1446:53	Transit to Port Orchard hullborne	

07/06/82	01:55	1448:48	Dependents cruise	
07/16/82	--------	1448:48	*Ship in drydock; installed HYTOW	(92)
09/16/82	--------	1448:48	Ship undocked	
09/30/82	--------	------------	Dr. Alan Powell, TD DTNSRDC, visits	
10/19/82	--------	------------	Installed new disconnect couplings	
10/20/82	02:04	1450:52	Transit to Torpedo station, Keyport, WA	
10/21/82	--------	1450:52	Hullborne HYTOW VDS trials	
10/22/82	00:08	1451:00	Port turbine fuel line failure	
10/25/82	--------	1451:00	Hullborne VDS trials	
10/27/82	--------	1451:00	Hullborne VDS trials	
10/29/82	--------	1451:00	Hullborne VDS trials	
11/03/82	01:43	1452:43	Returned to Bremerton	
11/08/82	01:31	1454:14	Foilborne HYTOW trials	
11/09/82	01:22	1455:36	Foilborne HYTOW trials	
11/11/82	02:05	1457:41	Foilborne HYTOW trials	
11/12/82	01:01	1458:42	Foilborne HYTOW trials	
11/15/82	01:47	1460:29	Foilborne HYTOW trials	
11/17/82	01:56	1462:25	Foilborne HYTOW trials	
11/18/82	00:49	1463:14	Foilborne HYTOW trials	
11/19/82	00:38	1463:52	Foilborne HYTOW trials	
12/03/82	00:52	1464:44	Crew training: VIP cruise	
12/07/82	03:03	1467:47	Crew training	
12/15/82	01:02	1468:49	Sonar checkout	

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01/05/83	02:42	1471:31	Independent steaming exercises(ISE)	
01/11/83	01:47	1473:18	ISE; Commodore Lewin embarked	
01/13/83	--------	------------	Westinghouse repairing VDS	
01/20/83	01:02	1474:20	ISE	
01/23/83	02:12	1476:32	Transit to Esquimalt; Project HYTOW	
01/27/83	02:46	1479:18	Transit to Nanoose with RADM Edwards,CF	
01/28/83	00:18	1479:36	HYTOW tests; transmission leak	
01/29/83	03:47	1483:23	Transit to PSNS	
02/01/83	--------	1483:23	*Ship in drydock; repair port transm.	(7)
02/08/83	--------	1483:23	Ship undocked	
02/09/83	00:53	1484:18	Foilborne checkout	
02/14/83	--------	1484:18	*Ship in drydock; repair stbd transm.	(9)
02/23/83	01:04	1485:22	Ship undocked; Foilborne checkout	
02/28/83	01:03	1486:25	ISE	
03/07/83	00:44	1487:09	ISE	
03/16/83	00:33	1487:42	ISE	
03/24/83	01:53	1489:35	ISE	
04/04/83	02:10	1491:45	Transit to Esquimalt B. C.	
04/07/83	03:14	1494:59	VDS trials, Nanaimo	
04/08/83	01:56	1496:55	VDS trials	
04/11/83	00:49	1497:44	VDS trials	
04/12/83	04:03	1501:47	Return to PSNS	
04/18/83	02:52	1504:39	Complete VDS trials	
04/19/83	01:40	1506:19	ISE	

04/20/83	--------	--------	Began removal of VDS	
04/21/83	--------	--------	Removed starboard power turbine	
04/22/83	--------	--------	Replaced stbd turbine with PGH-2 turbine	
04/23/83	--------	--------	Checked out stbd turbine	
04/26/83	01:50	1508:09	ISE	
04/27/83	00:31	1508:40	Refuel at Manchester	
04/28/83	08:30	1517:10	Transit to Newport, OR	
05/01/83	10:19	1527:29	Transit to PSNS; continuous FB record	
05/03/83	00:42	1528:01	Refuel	
05/05/83	00:46	1528:47	ISE	
05/10/83	01:30	1529:35	VIP demo	
05/12/83	--------	--------	LCDR Dunaway relieves LCDR Mulhall as OIC	
05/13/83	00:26	1530:01	ISE	
05/17/83	--------	1530:01	*Ship in drydock, Pier 7	(385)
	Ship in drydock remainder of 1983			
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01/27/84	--------	1530:01	Completed repairs of forward strut	
06/06/84	--------	1530:01	Ship undocked	
06/16/84	00:53	1530:54	Foilborne test off Vashon island	
06/19/84	--------	--------	All BQR-15 equipment aboard	
06/20/84	01:11	1532:05	Hullborne and foilborne checkout	
06/21/84	03:16	1535:21	EM log calibration	
06/23/84	03:40	1539:01	Transit to Nanoose Range	
06/24/84	01:41	1540:42	Began BQR-15 trials off Texada Island	
06/26/84	01:21	1542:03	BQR-15 trials	
06/27/84	01:32	1543:35	BQR-15 trials	
06/28/84	02:44	1546:19	BQR-15 trials	
06/29/84	00:40	1546:59	BQR-15 trials completed	
06/30/84	--------	1546:59	Hullborne transit, Nanoose to Nanaimo	
07/01/84	--------	1546:59	Hullborne transit to Bremerton	
07/02/84	--------	--------	BQR-15 equipment removed	
07/06/84	00:39	1547:38	Checkout of transmissions	
07/10/84	01:45	1549:23	Demo for Boeing guests	
07/11/84	03:03	1552:26	Crew training	
07/14/84	--------	1552:26	Refuel	
07/20/84	--------	1552:26	*Ship in drydock; transm. repair	(24)
08/01/84	--------	--------	Removed stbd transmission	
08/08/84	--------	--------	Stbd transmission reinstalled	
08/13/84	00:49	1553:15	Ship undocked; foilborne checkout	
08/14/84	01:20	1554:35	Transit to Whidbey Island	
08/15/84	00:29	1555:04	ALR-66 radar trials	
08/16/84	01:36	1556:40	ALR-66 radar trials	
08/18/84	02:00	1558:40	Transit to Bremerton	
08/20/84	03:18	1561:58	ISE	
08/22/84	00:10	1562:08	Refuel at Manchester	
08/23/84	--------	1562:08	*Ship in drydock	(5)
08/28/84	02:24	1564:32	Ship undocked; foilborne checkout	

08/29/84	01:56	1566:28	VIP demo; height sensor check
08/30/84	03:43	1570:11	Forward-looking height sensor test
08/31/84	01:33	1571:44	Demo for KING-5 TV News
09/12/84	01:33	1573:17	ISE
09/13/84	01:49	1575:06	Demo for Bremerton Press
09/14/84	01:01	1576:07	Vibration measurements
09/21/84	--------	------------	Telex extending deact. date to 12/01/84
10/01/84	00:15	1576:22	ISE
10/02/84	-------	------------	Put BQR-15 winch aboard
10/04/84	00:50	1577:12	Slow flight exercise
10/09/84	02:15	1579:27	Transit to Port Angeles
10/10/84	02:30	1581: 57	Begin 2nd BQR-1 j trials
10/11/84	06:50	1588:47	BQR- 15 trials
10/12/84	03:05	1591:52	BQR- 15 trials
10/13/84	03:24	1595:16	BQR- 1 j trials
10/15/84	06:22	1601:38	BQR- 15 trials
10/16/84	05:43	1607:21	Complete BQR- 15 trials
10/17/84	---- .	------------	Offload BQR- 15 equipment
10/24/84	00: 19	1607:40	
10/26/84	--------	------------	QMCM W. C. Wylie relieves LCDR Dunaway
10/30/84	05:56	1613:36	Test forward-looking radar height sensor
11/15/84	00:36	1614:12	

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01/23/85	Ship turned over to Boeing to operate with civilian crew.		
01/28/85	00: 15	1614:27	Transit to Boeing Renton
02/22/85	00:06	1614:33	
03/13/85	00:47	1615:20	Underway to operate machinery
03/20/85	-------	------------	RADM Bill Walsh, OP-32, visits ship
03/26/85	00:47	1616:07	Underway to operate machinery
04/04/85			Underway to operate machinery
04/10/85			Transit to Pier 90 Seattle
04/14/85			Transit to Ranch Point; BQR-15 trials
04/15/85			BQR- 15 trials
04/16/85			BQR-1 5 trials
04/17/85			BQR- 15 trials
04/18/85			Returned to Pier 90, Seattle
O-i/22/85			Transit Pier 90 to Boeing Renton
05/14/85	00:47		Underway to operate machinery
05/30/85	00:47		Underway to operate machinery
06/07/85			Recorded vibration data foilborne
06/20/85			Recorded vibration data foilborne
09/12/85			Underway to use Digital Data Acqs. Sys.
12/05/85			Underway to train new crew members
12/31/85	--------	1635:49	

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APPENDIX C

HIGH POINT Foilborne Time

YEAR	TOTAL YEARLY HRS:MIN	TOTAL ACCUM HRS:MIN
1963	05:27	05:27
1964	47:54	53:21
1965	0	53:21
1966	37:47	91:08
1967	91:59	183:07
1968	163:44	346:51
1969	122:08	468:59
1070	67:39	536:38
1971	186:15	723:53
1972	0	723:53
1973	95:38	819:31
1974	216:02	1035:33
1975	164:53	1200:26
1976	51:26	1251:52
1977	51:15	1302:07
1978	42:27	1344:34
1970	5:05	1349:39
1980	13:18	1362:57
1981	32:30	1395:27
1982	72:33	1468:49
1983	61:12	1530:01
1984	84:11	1614: 12
1985	21:37	1635:49

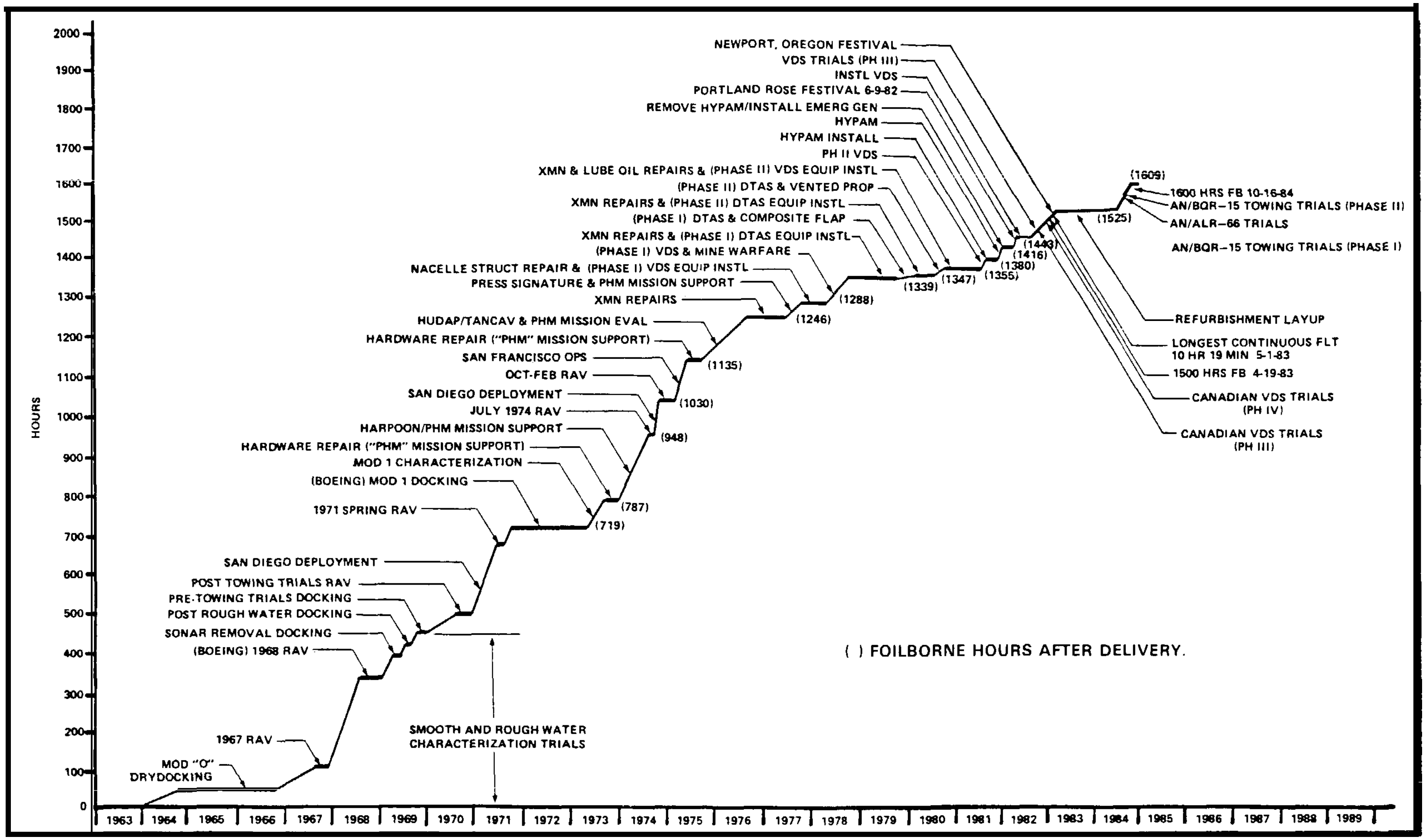

Figure 127. PCH-1 Foilborne Time and Major Milestones

APPENDIX D

Officers-in-Charge

OFFICERS-IN-CHARGE
HYDROFOIL SPECIAL TRAILS UNIT

OIC	DATE ASSIGNED
LCDR Karl M. Duff	10 NOV 1966
LCDR Henry Schmidt, Jr.	23 JUL 1970
LCDR Robert Eric Nystrom	04 OCT 1973
LCDR Louis C. Tedeschi	17 JUN 1976
CAPT Ross E. Sugg	19 JUN 1980
LCDR Wm. Michael Dunaway	30 JUN 1983 (Acting)
CDR F. Duane Duff	21 OCT 1983

OFFICERS-IN-CHARGE
HIGH POINT (PCH-1)

OIC	DATE ASSIGNED
LCDR Henry G. Billerbeck	09 MAR 1963
LT Steven W. McGanka	28 JUL 1965
LT Hugh A. Burkons	17 JUL 1967
LT James H. Ball	24 FEB 1969
LT Joel H. Roberts	24 JUN 1970
LT James W. Orvis	15 AUG 1973

LT Ralph D. Bianco	03 APR 1975
LCDR W. Scott Slocum	29 DEC 1977
EKCS Charles A. McDowell	25 AUG 1978
QMC Ronald W. Lovelace	16 OCT 1978
LCDR Joel D. Givens	07 JUN 1979
LCDR Daniel G. Mulhall	29 JUN 1981
LCDR Wm. Michael Dunaway	12 MAY 1983
QMCM W. C. Wylie	26 OCT 1984

OFFICERS-IN-CHARGE PLAINVIEW (AGEH- 1)

OIC	DATE ASSIGNED
LT Hugh A. Burkons	26 APR 1966
LT Stephen J. Duich	10 JUL 1967
LT William J. Erickson	09 JUL 1970
LT Edmund W. Woollen	12 JUL 1973
LT Frank W. Hudson, Jr.*	27 MAR 1975
LT Victor W. Ackley	24 MAR 1978

*Promoted to LCDR 24 MAR 19-X

HYDROFOIL PROGRAM OFFICERS

PROGRAM OFFICER	DATE ASSIGNED
LT George P. Moeckel	01 MAY 1966
LCDR Garrett M. Dyer	01 NOV 1967
LT Gilbert B. Perry	20 NOV 1968
LT Charles R. Rabel	07 MAY 197 I
LT Joel H. Roberts*	21 SEP 1973
LCDR Rex B. Fitch	01 AUG 1974
LCDR Wm. C. Stolgitis* *	17 MAR 1977

*Became PXO PHM- 1 0 1 JUL 1974

* *Transferred without relief

APPENDIX E

Advanced Development Objective ADO 46-06XR1 (Rev. 0 l-06-65)

AMPLIFYING DATA

THE OPERATIONAL NEED

a. **Threat.** The advent of the nuclear submarine and the modern high speed motor gunboat, the potential of satellite surveillance, and the increase in anti-surface weapon effectiveness, have emphasized the need for increased speed and seaworthiness in surface ships. Mobility, minimum reaction time, and the timely execution of missions have become increasingly important. Only incremental improvement in these characteristics have been attainable in the past 50 years using conventional hull forms.

b. **Current Operational Capability.** Destroyers are capable of 30 to 35 knots, motor gunboats of 30 to 40 knots. and fast patrol boats of 40 to 50 knots, but these speeds are not possible under adverse sea conditions. In reasonably heavy seas even the destroyer is forced to reduce speed significantly. The fast patrol boat: is particularly sensitive to sea conditions. Major hydrofoil development to date has primarily used surface piercing hydrofoils. The H.S. DENISON (80 tons), funded by the Maritime Administration, has made speeds of 60 knots in sea state 3. DENISON's surface piercing foils have built in wave following tendencies similar to displacement ships and produce a rough ride in high seas.

c. **Capability Under Development.** Two large hydrofoil craft are under construction for the U.S. Navy. The Submarine-Chaser Hydrofoil, PCH- 1, was authorized in the FY 60 Shipbuilding and Conversion Program and commenced trials in 1963. The PCH is being modified to correct specific deficiencies as a result of trials and is expected to complete in late 1965. The hydrofoil ship AGEH, of the FY 62 SCN Program, will be completed in late 1965. Both of these craft have submerged foils which are not greatly affected by surface waves and troughs up to design sea states and provide a relatively smooth ride. Significant characteristics of these craft are tabulated below:

	PCH	AGEH
Length Overall, Feet	115	212
Displacement , Tons	110	320
Foilborne Speed, Knots	45	50
Sea State Capability	5	5

In addition to the craft noted above, two Hydrofoil Gunboats (PGH) are included in the FY 65 SCN Program. Approximate hull characteristics are: LOA 80 Feet; beam 22 Feet; displacement 57 Tons; foilborne speed 48 Knots. The Marine Corps is evaluating two 15-Ton hydrofoil amphibians.

DEFINITION OF THE DEVELOPMENT

Development of hydrofoils must be coordinated with previous efforts in this field to achieve a creditable mission-oriented goal. There are many theories on the ability of large hydrofoil craft to perform in the open ocean, but no actual experience in operating in heavy seas; therefore. designs have been guided by present knowledge of displacement ships, seaplanes, and planing craft. Data required to determine the capability of various hydrofoil configurations to survive in heavy seas must be obtained by operating in the open ocean under varying conditions of weather in both the foil and hull borne modes. The objective of this development is to establish actual at sea environment tests, demonstrate the ability of PCH and AGEH to perform these tests, and provide information upon which to base a decision whether or not to proceed into engineering development of mission-oriented hydrofoil craft

a. Development Description

To achieve the objective of this development, a two-phase program is required.

(1) **Phase I.** A comprehensive test plan must be developed covering all conditions expected to be encountered in an open ocean environment. The two craft are to be operated in sea states 1 through 6 through their full range of speed, nominally O-50 knots. These tests must determine the ability of the craft to operate hull borne, take off, operate foil borne, and land at all sea states in the above range. Emergency ditching operations should be included. During this phase, it is expected that design deficiencies will be encountered which will require modifications to the test craft and retesting. This phase is expected to provide. through actual demonstrations, answers to such questions as: What are suitable rnaterials for foils and the hull? What is the optimum hull design that will perform satisfactorily while hull borne and during takeoff, and withstand impact loads when ditched? What are the best control systems for submerged foil craft? What is the best propulsion and power transmission? At the completion of Phase I, PCH and AGEH will have demonstrated the technical feasibility of large submerged foil craft in unrestricted operations up to sea state 6.

(2) Phase II. Assuming satisfactory progress and continued confidence in Phase I, planning and evaluation of specific missions for hydrofoils will be accomplished during this phase. Data obtained in Phase I will significantly affect the planning for Phase II, therefore, initiation of this phase should be based on a clearly defined decision point during Phase I. During this phase additional modifications may be required and experimental hardware developed.

acquired, and installed to support mission evaluations listed in para 2(b) below. At the completion of Phase II, all prerequisites necessary to support initiation of a Project Definition Phase should be fulfilled to permit engineering development of a specific mission-oriented craft.

(3) Analysis of Tests. A complete report analyzing the results of these two phases is to be submitted. The report should submit conclusions and recommendations for future hydrofoil programs. The report(s) may take the form of Proposed Technical Approaches for follow-on effort, if such action is indicated.

b. **Development Concept.**

The performance capabilities of hydrofoil vehicles for their applicability to specific navy missions have been the subject of numerous research studies. The following concepts require at-sea simulation:

(1) **Fast Patrol Craft.** As a fast patrol craft, it must be capable of operating offensively and defensively against high speed small craft; supporting amphibious operations against high speed boat attacks; conducting intelligence, reconnaissance, surveillance, and covert operations; supporting air and surface surveillance and interdiction operations against intelligence collection efforts and subversive smuggling and infiltration. A demonstration of platform stability for effective offensive and defensive weapons is required.

(2) Antisubmarine Warfare. Analyses indicate hydrofoil craft would be effective and economical in ASW screening operations in rough seas, area search operations, and hunter-killer operations. The capability of the hydrofoil to tow an underwater body simulating sonar at 40-50 knots with self noise at a low enough level to permit acceptable sonar performance must be demonstrated to validate the analyses.

(3) High Speed Minesweeper. An integral part of the advanced elements of an Amphibious Landing Force is the minesweeping unit. If large force compositions cannot be used in the mission, a hydrofoil minesweeper compares favorably with conventional MSO/MSC's. The capability of hydrofoils to tow simulated minesweeping gear should be determined and the analysis of this mission verified.

c. Performance Constraints.

(1) This project. shall be limited to the minimum experimental effort consistent with the stated objective. It shall not extend to engineering of refinements representative of those required for service use which might be suitable for inclusion in any follow-on engineering development. In addition, this project shall not include effort directed toward significant extension of the speed range of hydrofoil craft to that premised on increased state of the art advanced in supercavitating foils for example. This is not intended to preclude a suitable level of effort directed toward such an objective within the exploratory development program with a view toward a follow-on advanced development objective.

(2) Effort related to sensors, communications, and weapon systems will be limited to assimilation of work authorized under other projects and vital to this advanced development objective. This does not preclude acquisition of minimum suitable experimental equipment to determine hydrofoil towing capability if proposed and approved under Phase II.

d. Related Foreign Requirements or Developments.

The Royal Canadian Navy has a 180-ton ASW hydrofoil with surface piercing foils under development. This ship is to be completed and ready for sea trials in May 1966. An important element for this craft is the development of a Foilborne VDS body scheduled for evaluation in 1968. Close liaison has been maintained between the Canadian and U.S. Navies during the development of this craft, An Information Exchange Program with the UK and Canada is being formulated to cover hydrofoils.

EVALUATION AND REVIEW

Analyses to date have revealed a high potential effectiveness for hydrofoils in ASW. patrol boat, and minesweeping missions. However, the verification of this effectiveness cannot be achieved until experimental open ocean tests have been conducted.

GENERAL

In any instance where the attainment of a particular specification threateas the orderly progress or early realization of the ‘objective of the development, the developing agency will immediately advise the Chief of Naval Operations and will make appropriate alternative remedial recommendations. Upon receipt of such information and recommendations, the CNO will make decisions as to further courses of action including whether or not to proceed to full system development if appropriate.

APPENDIX **F**

Hydrofoil Special Trials Unit Charter and Operating Plan

I. INTRODUCTION

A HYDROFOIL SPECIAL TRIALS UNIT has been established as an element of the HYDROFOIL DEVELOPMENT OFFICE of the David Taylor Model Basin. The initial purpose of the Unit is to provide a Navy activity to conduct extensive trials of hydrofoil craft HIGH POINT (PCH-1) and PLAINVIEW (AGEH-1) in accordance with Technical Development Plan S46-06X for Hydrofoil Craft dated November 1965.

The mission of the Unit is three-fold:

1. To test assigned craft, evaluate systems performance, identify design deficiencies, and accomplish appropriate modifications necessary to achieve reliable and acceptable craft performance.

2. To obtain test data for correlation with model tests and computer predictions and establish criteria for design of future craft.

3. To demonstrate technical feasibility, financial acceptability, and military usefulness of hydrofoils in various naval missions.

It is anticipated that HYSTU will provide both the nucleus and operational experience for later expansion to permit similar development and evaluation of other advanced surface ship types. It should be noted, however, that this may require a later relocation of the Unit. Recommendations for establishment of an Advanced Surface Craft Special Trials Unit are currently in preparation by Naval Ship Systems Command Headquarters.

II. ORGANIZATION

In the interest of economy and the need for early implementation of hydrofoil craft special trials, the Unit will be staffed with the minimum number of military and civilian personnel considered necessary to accomplish the assigned mission.

The Officer-in-Charge of the Trials Unit is responsible to the Commanding Officer and Director of the Model Basin for all military matters and to the Manager of the Hydrofoil Development Project Office for all technical matters pertaining *to* the operation of the Unit. He will have authority to commit funds and make decisions within the framework of the approved RDT&E Program for special trials, and will perform the following functions:

a. Planning and direction of all special trials of assigned craft.

b. Coordination of logistics support, overhaul, and maintenance of assigned craft.

c. Recommendation and coordination of redesigns, modifications, and repairs of assigned craft.

d. Supervision of all contracts for contractor engineering and technical support of the trials program.

e. Supervision of all facilities and personnel within the direct cognizance of the Trials Unit.

III. SUPPORT

Since it is considered. neither desirable nor prudent to provide a complete capability to perform all functions of the Unit within its own internal organization, extensive support must be obtained from other naval and industrial activities. In consideration of such factors as location of the PCH-1 and AGEH-1 and their prime contractors, and the availability of a suitable test environment and extensive naval and industrial support facilities, it is proposed to establish the Trials Unit as a tenant activity of the Puget Sound Naval Shipyard, Bremerton, Washington. Operational control of craft assigned to the Unit will be by the Commandant, 13th Naval District, and technical and administrative control of the craft will be provided by the Model Basin through the Officer-in-Charge of the Unit. In addition, the Model Basin will have command and primary support of the Trials Unit. Support will be provided by these activities as well as by Supervisor of Shipbuilding, Seattle; Industrial Manager, 13th Naval District; and private contractors, in accordance with the guidelines set forth below.

Base Support

PSNS will supply the necessary base facilities including pier space and pier facilities for berthing of assigned craft; parking space and facilities for mobile support vans; building space for offices and a small machine shop; and storage space for spare parts, equipment, and materials. The Shipyard will also provide vehicles for transportation of personnel and equipment in the Bremerton area; quarters and messing facilities for military personnel as required; supply services for procurement of parts and materials; and reproduction services requested by the OIC of the Trials Unit. The Shipyard will designate a representative to provide direct liaison with the Unit on all matters relating to such base support requirements.

The OIC of the Trials Unit will be responsible to the host activity, PSNS, and the Taylor Model Basin for the physical security of all facilities directly under control of the Unit.

Operational Support

The Officer-in-Charge of each craft assigned to the Special Trials Unit will report to the Commandant, 13th Naval District, for operational control and will be responsible to COM-1 3 for the physical security of their craft, The OIC of the Trials Unit will be responsible for technical control of each craft.

COM- 13 will coordinate efforts in support of all craft operations including those of base components involved in logistics support. COM-13 will issue operation orders for the craft in accordance with the schedules and plans of the Trials Unit. The overall scheduling and technical direction of craft trials will be performed by the OIC of the Unit and he will keep COM- 13 and PSNS informed of all appropriate matters regarding schedules and plans.

The OIC of each test craft will arrange for test area assignments and movement of their craft to and from the test area assigned by COM- 13. Arrangements for support craft required in and around the test area will be initiated by the OIC of the Unit.

The OIC of each test craft will clear, with COM-I 3, all visits to U.S. ports outside the Puget Sound area. COM- 13 will plan and provide for logistics support outside the Puget Sound area as requested by the OIC of the Trials Unit.

The Bremerton Naval Hospital will provide a corpsman qualified for independent duty to travel with test craft during operations.

Administrative Support

Although a limited number of administrative and clerical personnel will be provided within the Trials Unit, a major portion of needed administrative support must be provided by other activities.

In general, the David Taylor Model Basin will provide all personnel services necessary for civilian personnel assigned to the Trials Unit with assistance of PSNS as required. The official personnel records of civilian employees will be maintained at the Model Basin. In those cases where it would be impractical for an employee to obtain a personnel service directly from the Model Basin, arrangements will be made to provide this service locally. All civilian personnel of the Unit will be appointed by the Model Basin and their applications will be processed in accordance with existing procedures. New applicants from the Bremerton or Seattle area will be given physical examinations and sworn in locally.

PSNS will assist with such matters as counseling, housing or quarters, emergency leave, and hours-of-work problems, and will provide counsel in regard to disciplinary problems.

Military personnel billets for the Trials Unit will be assigned under the allowance of the Taylor Model Basin.

PSNS will provide administrative services necessary for military personnel of the Trials Unit and test craft assigned to the Unit. Such services will include maintenance of personnel records. pay accounts. and leave records.

PSNS will also provide additional clerical services which may be required and which are not within the capabilities of Unit personnel.

The Bremerton Naval Hospital will maintain health records and provide sick call, consultation, and hospital services for military personnel of the Trials Unit and test craft assigned to the Unit.

Industrial Support

The developmental nature of test craft assigned to the Unit and the need for rapid and flexible response in effecting minor repairs and modifications to maximize craft time-on-the-line makes it essential to provide a small machine shop capability directly under the control of the Trials Unit. The shop will be funded by the Unit and will be located in space adjacent to the ship berthing area. It will be outfitted either by direct purchase, lease, or loan of equipment by the Shipyard. Th.e shop will be staffed by a Test Mechanic and an Experimental Machinist who will be civilian employees of the Trials Unit.

It is expected that most requirements for normal upkeep, and minor repairs and alterations to test craft will be within the capabilities of the Trials Unit shop and crews assigned to the craft. Performance of such work that is beyond the capabilities of the Trials Unit shop will be requested and funded through the normal procedures of the Shipyard, or by recourse to private contractors.

Routine test craft overhaul availabilities will be scheduled by the Trials Unit through COM-13 in accordance with Navy policy for similar requests. The OIC of the Unit will be responsible for obtaining estimates of cost and time for such work from PSNS or private contractors and will submit recommendations and estimates to the Hydrofoil Development Project Office for approval.

The OIC of the Trials Unit will approve and arrange for emergency repairs which may be required while test craft are outside the Puget Sound area. Such actions will be in conformance with policies and procedures established by COM- 13.

Major repairs, redesign, and modifications to the test craft will be accomplished in the Naval Shipyard or by private contractors through the Industrial Manager, 13th Naval District. INDMAN- 13 will negotiate, award, and monitor any such contracts with private contractors, in coordination with the OIC of the Trials Unit.

Since a substantial proportion of the required industrial support will be obtained from PSNS, the Shipyard will designate a project engineer to provide direct liaison between the OIC of the Trials Unit and the various departments of the Shipyard.

Technical Support

The OIC of the Trials Unit is responsible for all data acquisition in accordance with instrumentation and trials plans approved by the Manager of the Hydrofoil Development Project Office. He will be assisted in the performance of this function by an engineer and an instrumentation technician on the staff of the Unit, and by technical specialists on the staff of the Project Office, TMB technical trials personnel, and contractors.

Contracts for engineering services in connection with special trials will be initiated through the appropriate contract section of NAVSHIPSYSCOM Headquarters and, when assigned, such contracts will be administered by SUPSHIP, Seattle.

Additional engineering, design, and other technical support required by the Trials Unit will be obtained from PSNS and funded by the OIC of the UNIT.

The maintenance, repair, and upkeep of technical equipment (e.g. special trials instrumentation and gear) will be the responsibility of the Unit.

Funding

The Trials Unit will operate within the general financial policy applicable to the Taylor Model Basin, a NIF activity. It will be a sub-cost center under the Technical Director of the Model Basin and the Hydrofoil Development Project Office.

The Hydrofoil Project Office will provide information on request to the Administrative Assistant to the TMB Technical Director for incorporation in quarterly operating and annual funding budgets of the Model Basin, Job 'orders issued to HYSTU will constitute the authority for expenditure of funds. The OIC of the Unit will be responsible for controlling funds allocated to a job order.

The Trials Unit will request industrial support from the Shipyard and other naval activities using a NAVCOMPT Form 140. Accepted copies of each Form 140 will be sent directly to the Model Basin by the performing activity for obligation of funds. Also, all billings for work performed will be sent directly to the Model Basin.

INDMAN- 13 and PSNS will provide procurement services for the Trials Unit. All procurements initiated by the Unit will be charged to the end use Model Basin accounting data. Copies of all procurement documents will be sent to TMB at the time of their issuance. All bills will be paid by the appropriate Disbursing Officer.

The Trials Unit will draw office supplies and other materials from the Shipyard Shop Store and the Navy Supply System. The Unit will send a NAVCOMPT Form 140 to the Shipyard to finance such purchases.

The Trials Unit will prepare travel requests in accordance with Model Basin travel policy. Travel requests approved by the OIC will be sent to the Shipyard Comptroller Department which will prepare the travel orders and arrange for the necessary transportation requests. Model Basin funds will be cited on all travel orders issued for the Unit. At the time of issuance, the Comptroller will send two copies of each travel order to the Model Basin so that funds can be obligated. Upon completion of travel, I'nit personnel will submit claims to the Shipyard Comptroller for payment.

The OIC of the Unit will prepare a NAVCOMPT Form 140 and send funds quarterly to the Shipyard to cover the costs of tenant services required. Accepted copies of each Form 140 will be sent to the Model Basin by the Shipyard.

The Trials Unit payroll will be prepared by the Shipyard as a tenant service. Payroll changes will be submitted to the Shipyard by the Model Basin Personnel Department. Official military payroll records will be maintained by the Shipyard.

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APPENDIX G

Plainview (AGEH- 1)

As noted earlier, in December 1960, the Bureau of Ships had issued a circular of requirements for a hydrofoil research ship designated the AGEH- 1. It was to be a 50-knot experimental oceangoing ship with provision for future conversion to achieve speeds up to 90 knots. This was to be accomplished by addition of two more gas turbines and a supercavitating strut/foil system. Its purpose was to provide criteria for design of future Navy hydrofoil ships and to explore the utility of such ships for antisubmarine warfare and other mission applications.

Proposals were submitted by a number of contractors. Grumman Aircraft Engineering Corporation (now named Grumman Aerospace Corporation) was selected as the contractor based on their submission which consisted of two different concepts. One had fixed foils which could be retracted only nith a crane at dockside. The other had a fully self-contained foil retraction system. The fully-retractable design was selected and, on 26 October 1961, Grumman was awarded a cost-type contract for the guidance design of AGEH- 1. There was a provision in the contract whereby, if the Navy did not like Grumman's estimate of the cost of detail design and construction. they had the option to go out for bids in a new competition. The Grumman team included Newport News Shipbuilding Corporation and the General Electric Company. Grumman was designated the Program Manager and principal designer and it was proposed that they build the foils and install the transmission. Newport News was to be involved in the design of the shipboard systems and the hull and would be the hull builder and outfitter. General Electric had the responsibility for the propulsion system.

The guidance design took about one year. The preliminary design and weight estimates were submitted and approved in February 1962. The contract drawings and final draft of the specifications were signed off by RADM James, Chief of BuShips, on 9 October 1962. Grumman's estimate for detail design and construction was about S 17M. Since the Navy had budgeted $ 12M for the buy. they exercised the option to recompete the procurement. Additional bids were received, all of which were in the neighborhood of $17M, except for the bid of Puget Sound Bridge And Drydock Co. in Seattle, WA. (Later to become Lockheed Shipbuilding And Construction Co.). They bid :a shade under $12M and, on 9 July 1963, were a-warded a fixed-price contract for detail design and construction. The contract for this 320-ton advanced hydrofoil, the largest ever constructed, was only seven pages long. (The actual cost of the ship, including changes, was close to 32 1M.)

Major subcontractors to Lockheed included W. C. Nickum & Sons for engineering and detail design, Rucker for the design of the hydraulic system, General Electric for the design and construction of the hullborne and foilborne transmissions, Hamilton Standard for the automatic control system, and Lockheed California for design and construction of the strut/foil system.

The keel was laid on 8 May 1964 and the ship was launched on 28 June 1965. It was christened PLAINVIEW in honor of Plainview, NY and TX. The sponsor was Mrs. John T. Hayward, wife of VADM J. T. Hayward, USN (ret), former President of the Naval War College. The Prospective Officer In Charge was LT Hugh Burkons. He was later transferred to become OIC of HIGH POINT. He was relieved by LT Stephen J. Duich just before PLAINVIEW got underway for the first time on 4 August 1967. The ship made its first foilborne flight of 1 1-1/2 minutes on 2 1 March 1968 but, it was nearly a year later, on 3 February 1969, when it began Preliminary Acceptance Trials. On 1 March 1969, the Navy reluctantly took delivery and assigned the ship to HYSTU for administrative and technical control. This was nearly 3-1/2 years later than the orginally projected delivery date. Much of this delay was due to 3 major strikes during the construction period. PLAINVIEW was far from problem free at time of delivery. It seemed clear, however, that the Navy's best course of action was to undertake its own program of deficiency correction if the ship was ever to become fully operational.

Final Contract Trials were begun on 2 1 January 1970 and, on 2 March 1970, the Navy accepted the ship. On 9 July 1970. LCDR Stephen J. Duich was relieved by LT Wm. J. Erickson as OIC.

PLAINVIEW's characteristics are given in Table 6. Figure (128) shows the ship with foils retracted and Figure (129) shows the ship foilborne. Figure (130) is a cutaway view which was published in the December 1968 issue of Popular Mechanics magazine and is reprinted with permission.

As can well be appreciated, PLAINVIEW's assignment to HYSTU was a considerable additional burden on the Unit, particularly since there were many problems and deficiencies to overcome. This was to be expected, however, with a first-of-a-kind, one-of-a-kind, sophisticated and complex system. Fortunately, at the time of PLAINVIEW'S delivery, the problems with HIGH POINT had become much more manageable and the focus of attention could be directed more to the big ship during this early period.

For four years after delivery of PLAINVIEW, the story of trials and tribulations was a repeat of the early problems with HIGH POINT. Finally, on 16 May 1974, what was to be a two-year overhaul and modification effort, was begun at Todd Shipyard in Seattle. This included the following major items:

- A new hydraulic system with all welded piping.
- Disassembly and refurbishment of the main struts and foils.
- A new incidence control system.
- A new r-ail strut of HY-130 steel, built by Grumman.
- The Hydrofoil Universal Digital Autopilot, taken from PCH.
- A radar height sensor in place of the sonic unit.

TABLE 6

PLAINVIEW CHARACTERISTICS	
Foil Configuration	Airplane
Length Overall	212 Feet
Extreme Beam, Foils Down	70.8 Feet
Full Load Draft Hullborne	
Foils Up	6.4 Feet
Foils Down	25.0 Feet
Full Load Displacement	320 Long Tons
Hullborne Propulsion	
(2) Packard Diesels	1200 Shaft HP
(2) Thrust Producers	5-Bladed Subcavitating Propellers
Foilborne Propulsion	
(2) GE, LM-1500 Turbines	28,000 Shaft HP Continuous
(2) Thrust Producers	4-Bladed TI Super-cavitating Propellers
Maximum Hullborne Speed	15 Knots
Calm Water Takeoff Speed	33 Knots
Maximum Foilborne Speed, SS O-5	50 + Knots
Maximum Normal Turn Rate	6.0 Deg/Sec
Minimum Turn Radius (At 40 Knots)	215 Yards
Foil/Strut Material	HY-80/ 100 Steel (Coated)
Foil Control Incidence	(22 Deg/Sec)

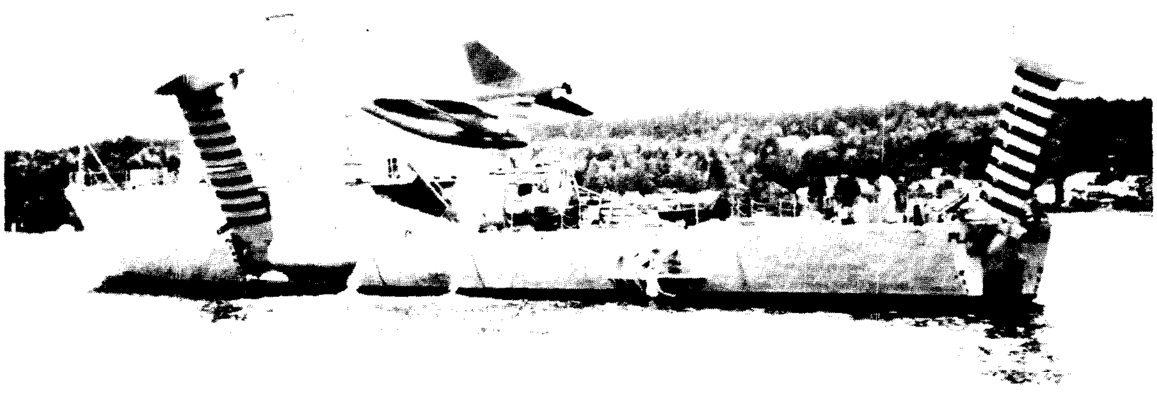


Figure 128. PLAINVIEW with Foils Retracted

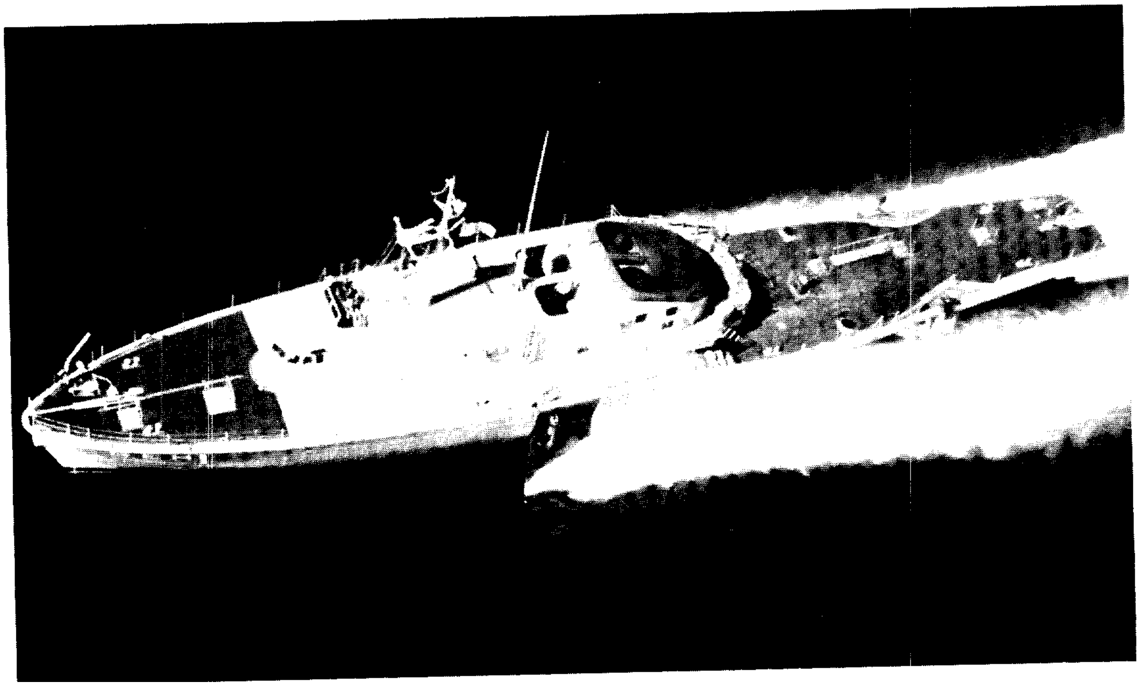
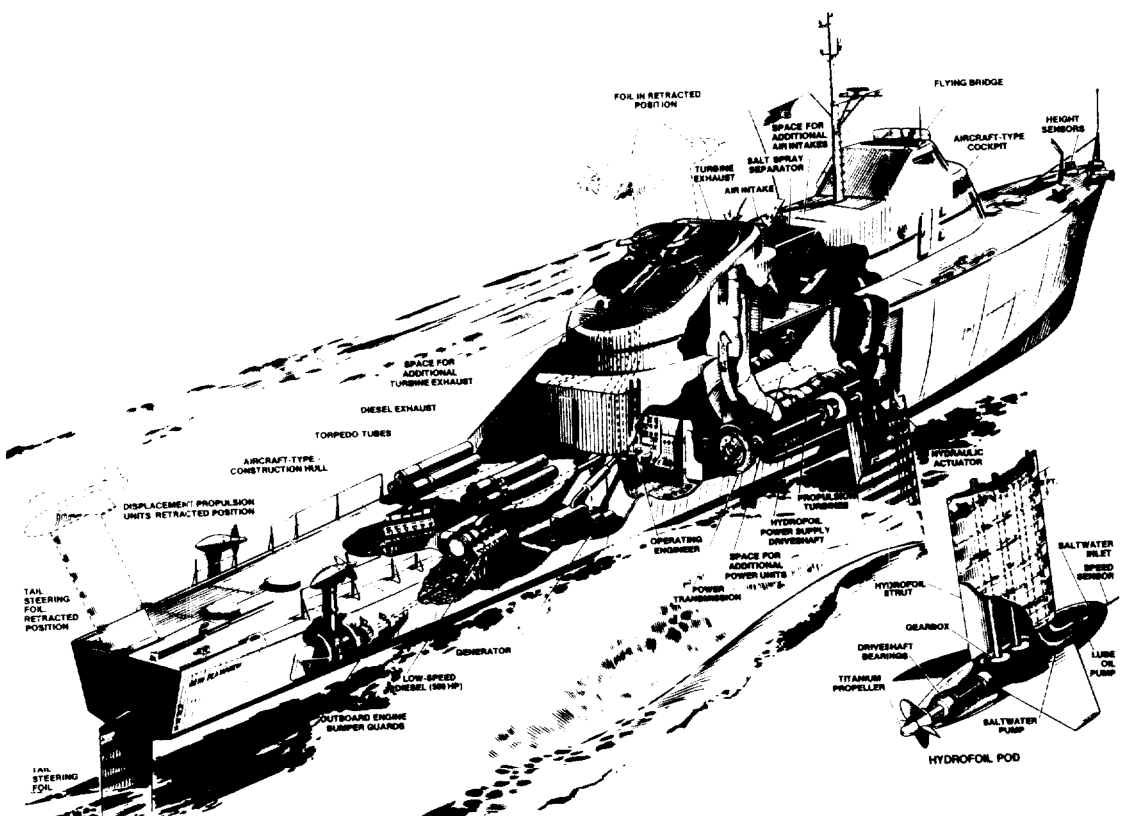


Figure 129. PLAINVIEW Foilborne



Courtesty Popular Mechanics

Figure 130. Cut-Away View of PAINVIEW

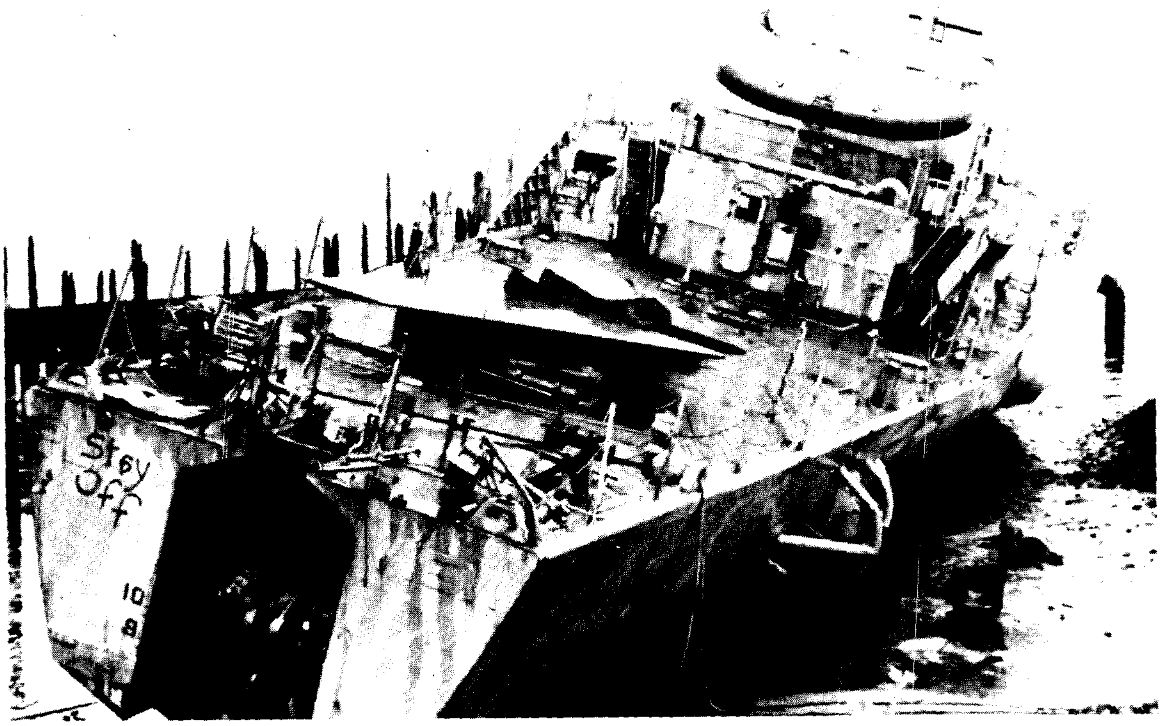


Figure 13 1. PLAINVIEW Abandoned on a Mud Flat Near Astoria, OR

Unfortunately, soon after returning to the trials program with significantly increased availability. PLAINVIEW fell victim to the Congressional budget knife. She made her last foilborne flight on 17 July 1978, ending with a total of 268 foilborne hours and without ever being tested to the limits of her rough water capability, The ship was officially inactivated on 22 September 1978 and towed to the inactive fleet at Bremerton. In May of 1979, the hull, without the struts and foils,gas turbines, and other special equipment, was sold to a private party for the sum of $128.000. It was understood that it was to be converted for use as a fishing boat. This was either unsuccessful or was never attempted. The final indignity for this once-proud and beautiful ship can be seen in Figure (13 1) which shows it resting on a mud flat near Astoria, Oregon.

The story of PLAINVIEW is told in much more detail in a paper entitled “A Ship Whose Time Has Come--And Gone”, written by Bob Johnston and Bill O'Neill, Reference 90.

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APPENDIX H

197 1 Socal Deployment Visitors List

DATE	NAME	ORGANIZATION	LOCATION
05 JAN	Dr. Wm. E. Cummins	NSRDC	Bremerton, WA
	Pete Edmondo	NSRDL, Annapolis	to Astoria, OR
	Jack B. Hadler	NSRDC	
	George R. Stuntz, Jr.	NSRDC	
	LCDR H. Schmidt, Jr.	HYSTU	
06 JAN	Pete Edmondo	NSRDL, Annapolis	Astoria, OR to
	LCDR H. Schmidt, Jr.	HYSTU	Crescent City, CA
07 JAN	Pete Edmondo	NSRDL, Annapolis	Crescent City to
	LCDR H. Schmidt, Jr.	HYSTU	San Francisco
08 JAN	RADM W. Groverman	COMWESSEAFRON	San Francisco, CA
	CAPT McDonald	CO USS CORAL SEA	
	CAPT Wade	USCG	
	CDR Newberg	USCG	
	LT Jacobson	PAO 12th Nav. Dist.	
	CDR Chamberlain	12th Nav. District	
	LCDR Miller	12th Nav. District	

11 JAN	Pete Edmondo	NSRDL, Annapolis	San Francisco to
	Gabor Dobay	NSRDC	Port Hueneme, CA
	Jerry Feldman	NSRDC	
	Ray Wermter	NSRDC	
	LCDR H. Schmidt, Jr.	HYSTU	

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13 JAN	CAPT G. C. Foltz	IUW G-l NAVSTA LGB	Long Beach, CA
	LT(jg) Jackson	IUW G-l NAVSTA LGB	
	LCDR M. R. Greer	IUW G-l NAVSTA LGB	
	CDR McLemore	IUW G-l NAVSTA LGB	
	ET- 1 Werner	IUW G-l NAVSTA LGB	
	ETR-3 Krause	IUW G-l NAVSTA LGB	
	LT Yates	IUW G-l NAVSTA LGB	
	ETR-3 Warren	IUW G-l NAVSTA LGB	
	E. York	Boeing Parafoil Gp.	
	0. E. Fowler	Boeing Parafoil Gp.	
	D. H. Holz	Boeing Parafoil Gp.	
	W. G. Tank	Boeing Parafoil Gp.	
	L. C. Logie	Boeing Parafoil Gp.	

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14 JAN	CAPT Lebreton	C/S MINPAC	Long Beach, CA
	CAPT Lilly	COMCRUDESFLOT 7	
	CAPT Chiswell, USCG	COM CG 11	
	LT Larabee, USCG	CG PAO	
	CAPT Casserly	COMMINFLOT 3	
	LCDR Fields	CO MINERON 11	
	LT Semple	C/S MINERON 11	
	CAPT Pierce., USCG	OPS 1 lth CG Dist	
	CAPT Altor	COMDESRON 19	
	CAPT Grouse	COMSERVRON 1	
	LCDR Modern	X0 SERVRON 1	
	CAPT Merrick	COMPHIBRON 7	
	CDR Miller	C/S PHIBRON 7	
	LT Chas. Rabel	NELC	
	CDR Mossman	OPS PHIBRON 7	
	CAPT Bailey	COMDESRON 13	
	PHC Quisenberry	Combat Camera Gp	
	PH1 Tomes	Combat Camera Gp	
	Dale Beresford	NELC	

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15 JAN	Ed Cherry	NELC	Long Beach to
	Charles Miller	NELC	San Diego, CA

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18 JAN	CAPT Jenks	PHIBPAC	San Diego, CA
	LCDR Lamb	PHIBPAC	
	LCDR Knapp	COS DIV 32	
	LCDR Susag	USS BAUER (DE 1025)	

	LT Weisgerber	USS BAUER (DE 1025)	
	LT R. Martin	USS CHEHALIS (PG 94)	
	LT Westerman	USNR San Diego	
	LT(jg) D.A.Houser	USS BAYA (AGSS 318)	
	LT(jg) R.Cooper	OIC FLAGSTAFF (PGH I)	
	Myles J. Sheehy	NELC Code 230	
	BMCM Brietenstein	USS FLAGSTAFF (PGH 1)	

x*************

27 JAN	G. Minard	NSRDC	San Diego, CA
	Dave Washburn	NE LC	
	LT(jg) R.Cooper	OIC FLAGSTAFF (PGH 1)	
	PHC Quesenberry	Combat Camera Gp	

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28 JAN	Prince Juan de Carlos	Prince of Spain	San Diego, CA
	Sr Jaime Arguelles	Spanish Ambassador	
	Sr Ricardo D .Hochleitner	Undersec Minis. of Ed.& Sci.	
	Brig. Gen. Carlos Dolz	Spanish Air Force	
	Sr M. de Mondejar	Chief of Household	
	CAPT A. de las Heras	Military Aide	
	Col. A. Armada	Personal High Secretary	
	Sr F. de la Mcrena	1 st Secre., Embass. of Spain	
	Emil Mosbacher, Jr.	Ch Protocol Off., US State Dept.	
	W. R. Codus	Asst Ch of Protocol. US	
	R. Passwaters	US State Department	

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29 JAN	Dr. Joel S.Lawson, Jr.	Dir of Navy Labs	San Diego, CA
	Dr. C.E.Bergman	Tech Dir NELC	
	CAPT C. A. L. Swanson	OPNAV Code 00K1	
	John Giblin	NAVSHIPS Code 033	
	CDR W. C. Filkins	NAVMAT Code 037B	
	Bob Hubbard	Boeing Marine Systems	
	Jim Mason	HYSTU	
	EN1 W. Reddick	USS BAYA (AGSS 318)	
	ENC C. Smith	USS BAYA (AGSS 318)	
	EN1 S. Bagwell	USS BAYA (AGSS 318)	
	PH1 B. Leslie	Combat Camera tip	
	G. S. Anderson	NELC	
	LCDR Hank Schmidt, Jr.	OIC HYSTCJ	

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02 FEB	CAPT Bob Ripley	OPNAV Code 03	San Diego. CA
	Wm. M. Ellsworth	NSRDC	
	James L. Schuler	NAVSHIPS Code 03	
	LCDR W. F. Hicks	NAVSHIPS	
	LCDR Dave L. Greene	NAVSHIPS	
	Robt. J. Johnston	Grumman	
	John J. Gifford	NSRDC	

	Tom Rosling	NAVORD	
	Jim Mason	HYSTU	
	J. Hood	NELC	
	R. Wall	Seaworld	
	W. Teal	NSRDL, Panama City	
	J. Christoff	NSRDL, Panama City	
	Dave Forbes	NUC	
	E. Swentsen	Westinghouse	
	E. Sapporetti	Honeywell	
	W. Gregg	Night Visability Lab	
	D. Forney	NUC	
	J. Ferrer	NUC	
	E. Floren	NUC	

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03 FEB	Jim Mason	HYSTU	San Diego, CA
	W. Teal	NSRDL, Panama City	
	J. Cristoff	NSRDL, Panama City	
	LT Chuck Rabel	NELC	
	Dave Forbes	NUC	
	C. Forney	NUC	
	J. Ferrer	NUC	
	E. Floren	NUC	
	E. Saporretti	Honeywell	
	E. Swentsen	Westinghouse	

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04 FEB	VADM N. C. Johnson	COMPHIBPAC	San Diego, CA
	RADM J. B. Davis	COMPHIBTRAPAC	
	CAPT F. E. Smith	PHIBPAC	
	CAPT O'Drain	PHIBPAC	
	LCDR Darling	OIC BSU-1	
	LCDR J. Lamb	PHIBPAC	
	LCDR D. R. Eastman	PHIBPAC	
	MAJ Murphy	US Army	
	LT Barnes	BSU- 1	
	LT Thomas	BSU- 1	
	LT(jg) R. Cooper	OIC FLAGSTAFF (PGH 1)	
	LT(jg) T. McDermott	PHIBTRAPAC	
	PH2 Grant	PHIBPAC Photo Gp	
	LT Chuck Rabel	NELC	

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08 FEB	Cal McMahon	NELC	San Diego, CA
	W. Putnam	NELC	
	R. Eastley	NELC	

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12 FEB	RADM J. L. Butts	COMCARDIV- 1	San Diego, CA
	CAPT K. A. Burrouws	CARDIV- 1	
	LT A. A. Chasey	CARDIV- 1	

	COM NUC
CAPT Charles Bishop	Tech Dir NUC
Dr. Gene Cooper	NUC
Eldon Dunn	NUC
Dr. Dan Andrews	NUC
G. Anderson	NUC
A. Schlosser	NUC
L. Gray	NUC
LCDR C. Farrel	CO TUCUMCARI (PGH-2)
LT Richard Stedd	NAVSEC
Howard Chatterton	COM NELC
CAPT M. D. VanOrden	SUBFLOT- 1
CAPT Clark	SUBFLOT- 1
CAPT Clifford	SUBFLOT-1
R. VanOrden	USNR
CAPT B. Towle	NUC
Dr. Tom Lang	

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San Diego, CA

		COMFIRSTFLT
16 FEB	VADM Ray Peet	FIRSTFLT
	CAPT W. F. Foster	FIRSTFLT
	CAPT D. Clark	FIRSTFLT
	CDR F. Hannegan	FIRSTFLT
	LCDR A. Hayworth	USMC
	COL F. Kubitz	COMASWGRU-3
	RADM J. C. Longino	ASWGRU-3
	CAPT F. C. Gilmore	ASWGRU-3
	LCDR N. C. Lord	CO USS TICONDEROGA (CVA-14)
	CAPT E. Boyd	COM NELC
	CAPT M. D. VanOrden	

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