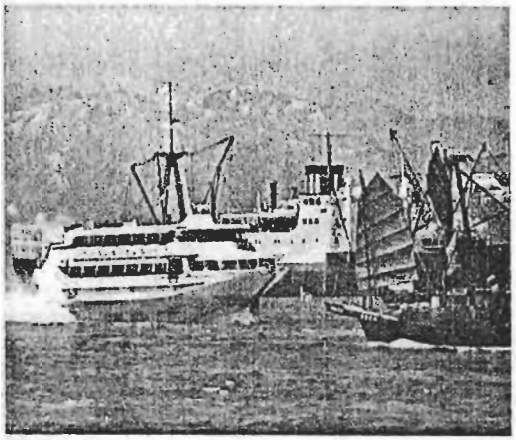
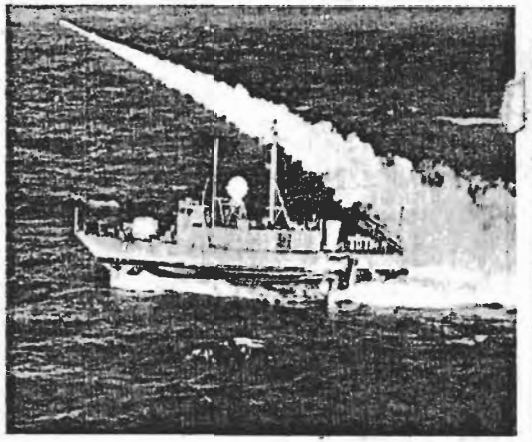
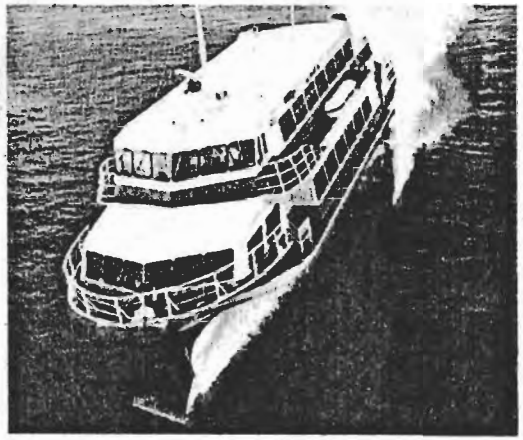
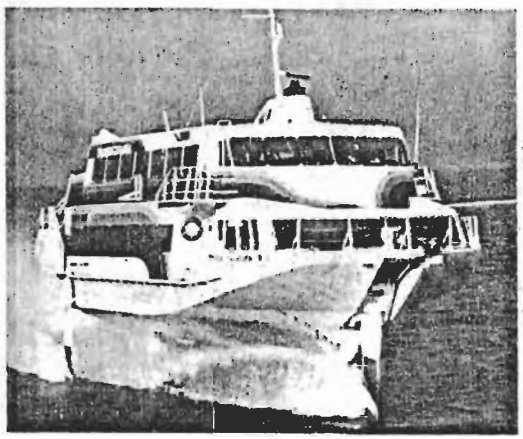
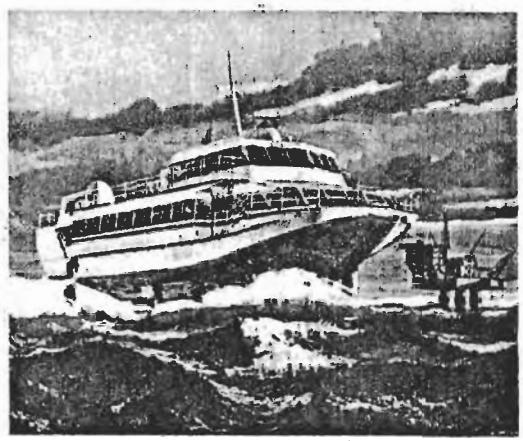
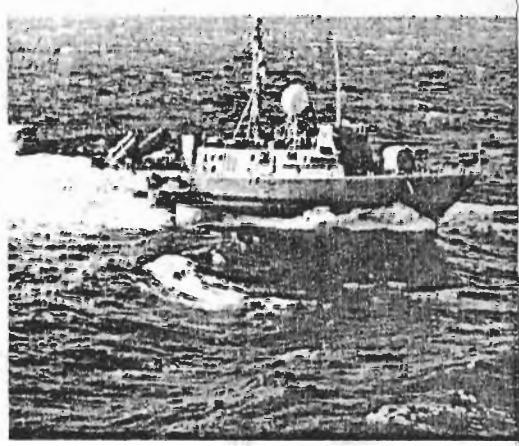
First family of hydrofoils . . .

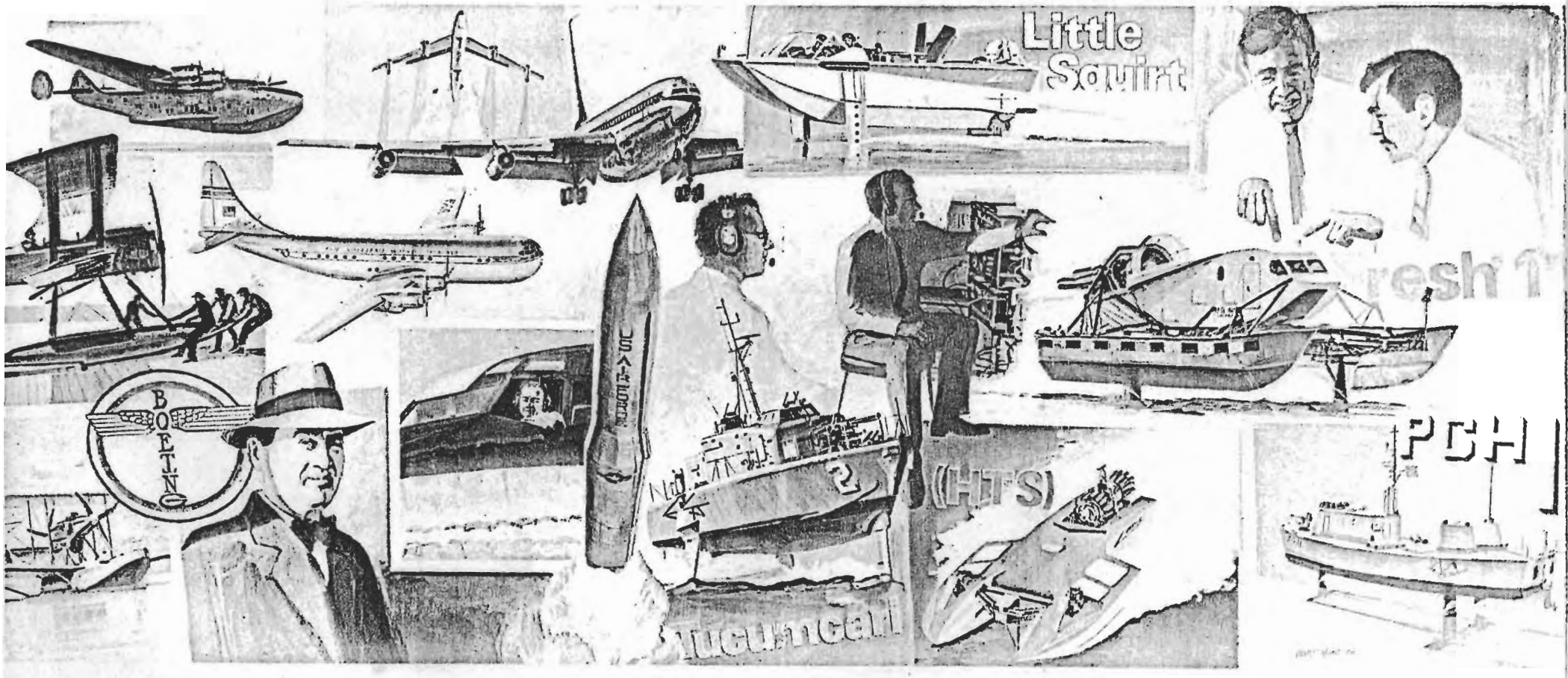






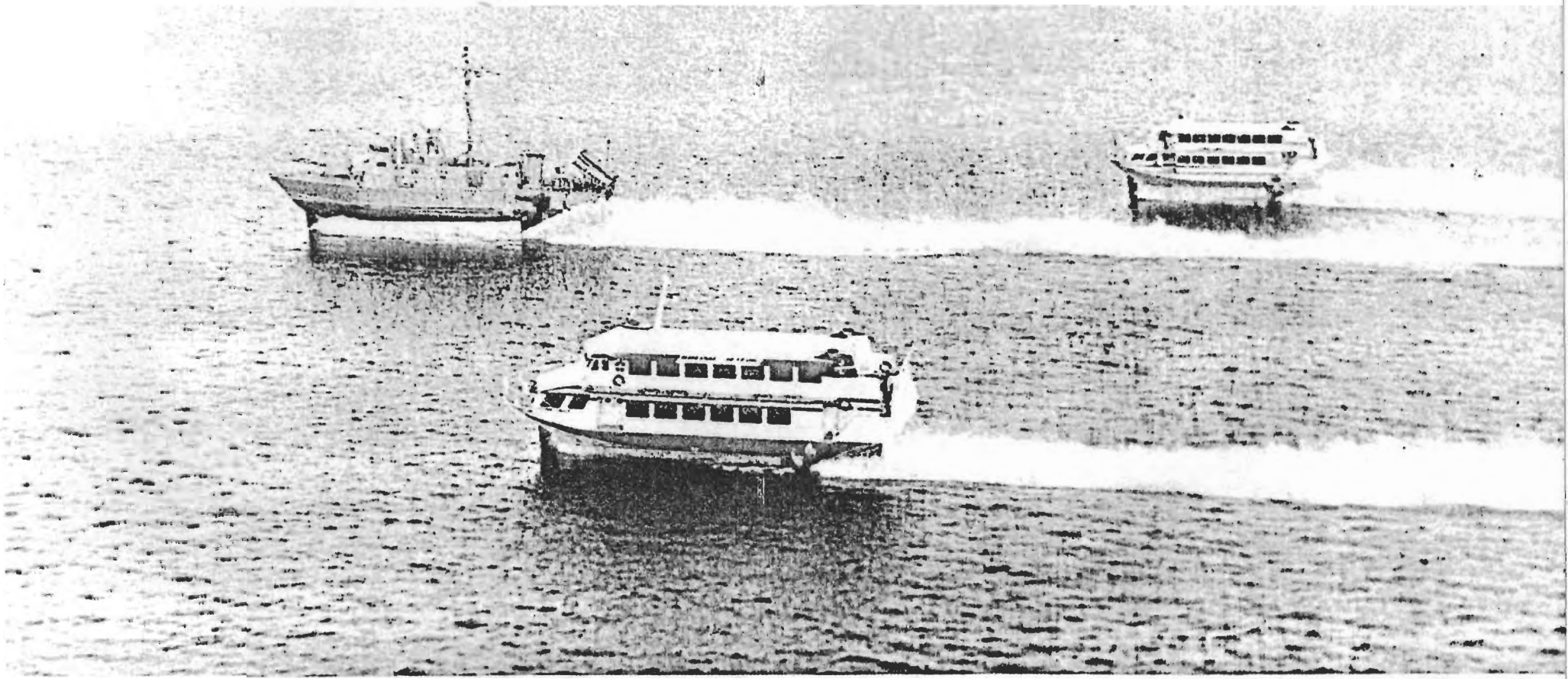
Boeing Marine Systems

HISTORICAL BACK GROUND
OF THE PHM


Little
Squirt
BOEING
(HTS)
PBH

INTRODUCTION

It was inevitable that Boeing's interest in aerodynamics would lead to interest in hydrodynamics. Its earliest products were seaplanes and the company itself is located on Puget Sound, an arm of the Pacific Ocean.



Boeing hydrofoils have inherited much from modern aircraft and missile technology – and through extensive testing and operation have proven superiority over both conventional and other hydrofoil vessels as a means of water transportation.

This brochure describes the capabilities of Boeing Marine Systems (BMS) in providing the most advanced form of water transportation in the world.

BOEING HYDROFOIL HISTORY

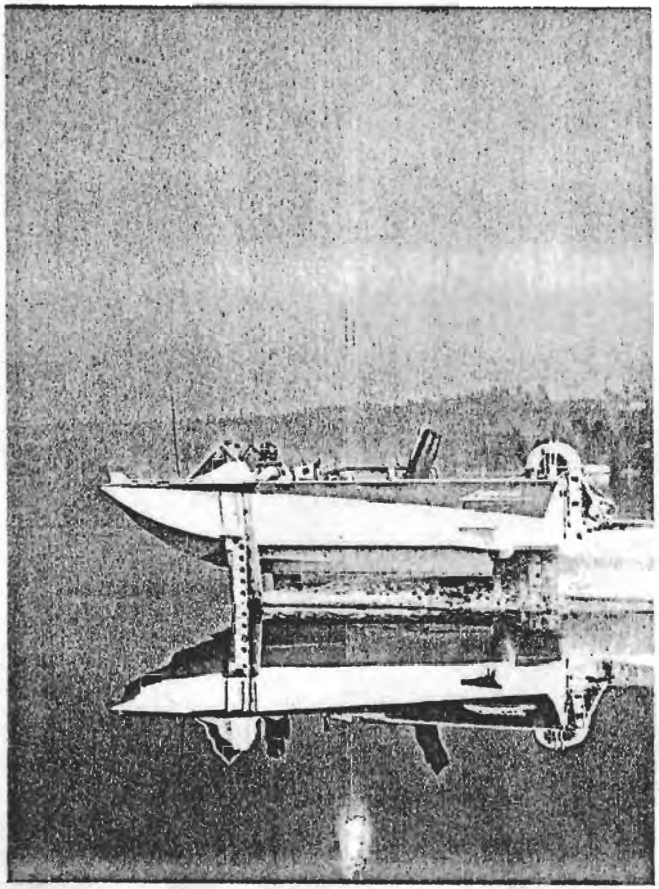
Hydrodynamic Test System (HTS) 1960

Early research began in 1959, and in 1960 Boeing built this hydroplane test craft principally of mahogany plywood. Nicknamed Aqua-Jet, the lobster-shaped craft had two prows, each with a cockpit and instrument compartment. The open center was used like a wind tunnel for preliminary

hydrodynamic testing. In addition to foils, the craft was used for antisubmarine warfare testing.

Little Squirt 1962

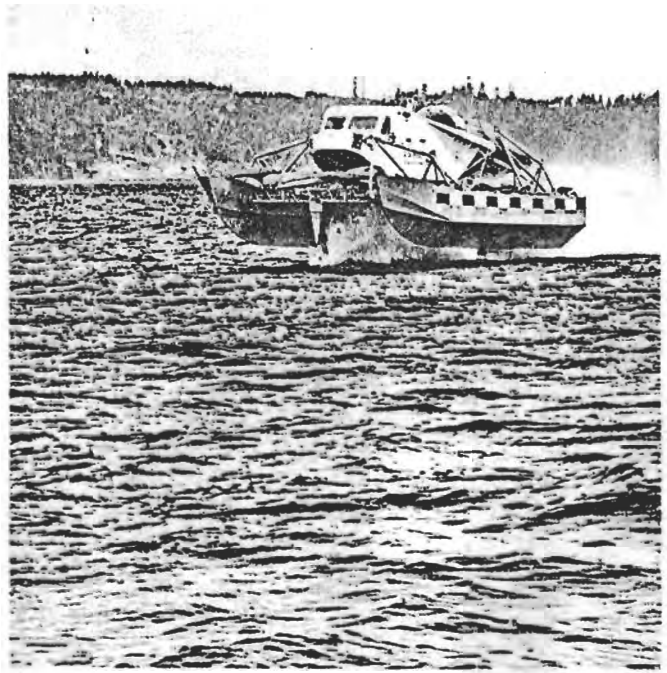
Little Squirt was built in 1962 as a company-sponsored research program. It was built to prove the feasibility of waterjet propulsion now used on all Boeing hydrofoils. It was used in the development of a number of systems, including the automatic control system and the trailing-edge



concept as a method of hydrodynamic control. The acoustic altimeter, mounted on the bow, and flap controls have been used on all subsequent Boeing hydrofoils. Little Squirt also demonstrated a 50-knot capability for hydrofoils.

Fresh I 1963

This Foil Research, Experimental, Supercavitating Hydrofoil (FRESH I), completed in 1963 under U.S. Navy contract, still holds the hydrofoil speed record of 84 knots. Its greatest contribution was in the field of stability and control, where it demonstrated the importance of directional and



roll stability. It was tested in two configurations – one foil forward, two foils aft (canard) and two foils forward, one aft (conventional airplane). Propulsion was by a single-aircraft turbofan. Its unique design allowed large variations in foil location and arrangement and the testing of a wide variety of foil configurations and automatic controls.

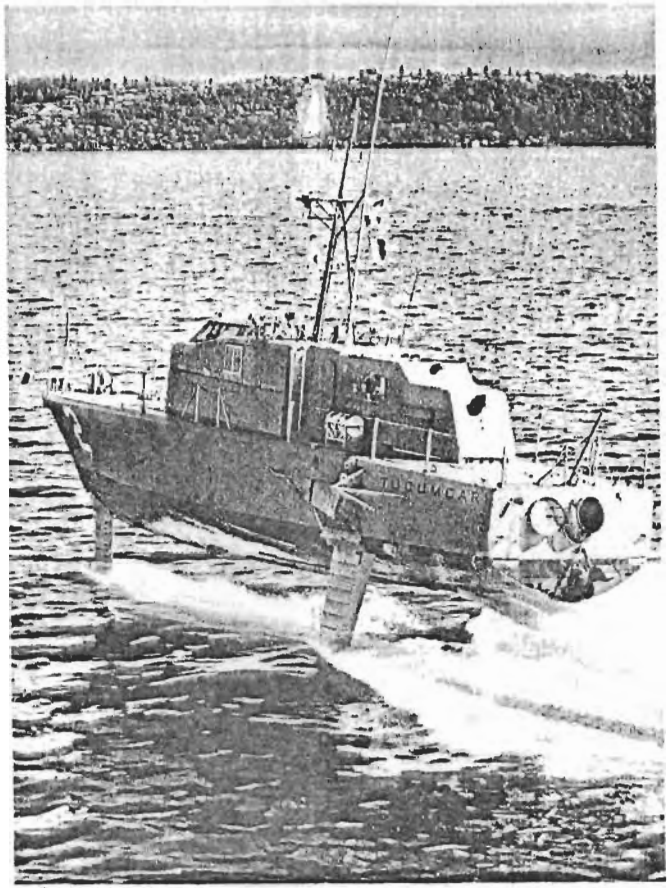
High Point 1963

The patrol craft PCH-1 High Point was the first military hydrofoil to be built by The Boeing Company for the U.S. Navy. Its design, by the U.S. Navy Bureau of Ships, was based on the successful demonstration of the fully submerged, automatically controlled foil of the small

experimental craft Sea Legs. Boeing won the construction award for High Point in 1960 and the ship was delivered in 1963. PCH-1 has a unique propeller drive system powered by two Rolls-Royce Proteus marine turbines. Foil and propulsion systems were revised during overhaul in 1973 to provide a steerable forward strut and anhedral configuration (foils canted downward from center to tip) of the aft foil.

Tucumcari 1967

PGH-2 was the Navy's designation for Tucumcari, the first Navy hydrofoil to use waterjet propulsion rather than propellers. Tucumcari employed the first anhedral foil configuration and was the first hydrofoil equipped with a steerable forward strut. The construction contract was awarded in 1965 and



Tucumcari was completed in 1967. As a result of trials in the United States, European demonstrations and evaluation during service in Vietnam, the features of Tucumcari were chosen as requirements for the NATO hydrofoil program and the patrol hydrofoil missileship (PHM).

Swordfish 1973

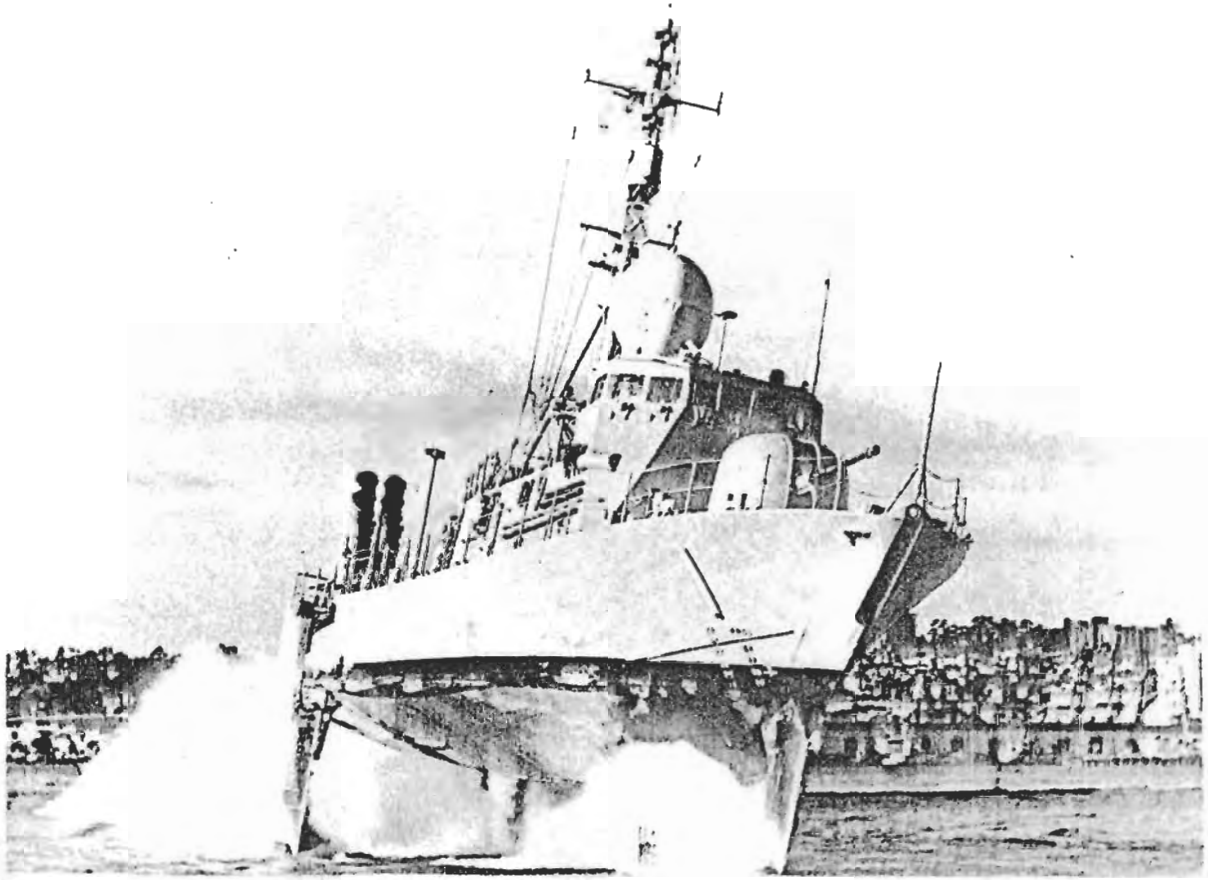
Swordfish, the first derivative of Tucumcari, was built by the Italian firm, Alinavi, under license from Boeing. Launched in May 1973, it retains the principal features such as fully submerged foils, automatic control system and waterjet propulsion.

Additional 60-ton Swordfish class hydrofoils are under construction in Italy.

;trol Hydrofoil ...ssileship (PHM) 1971

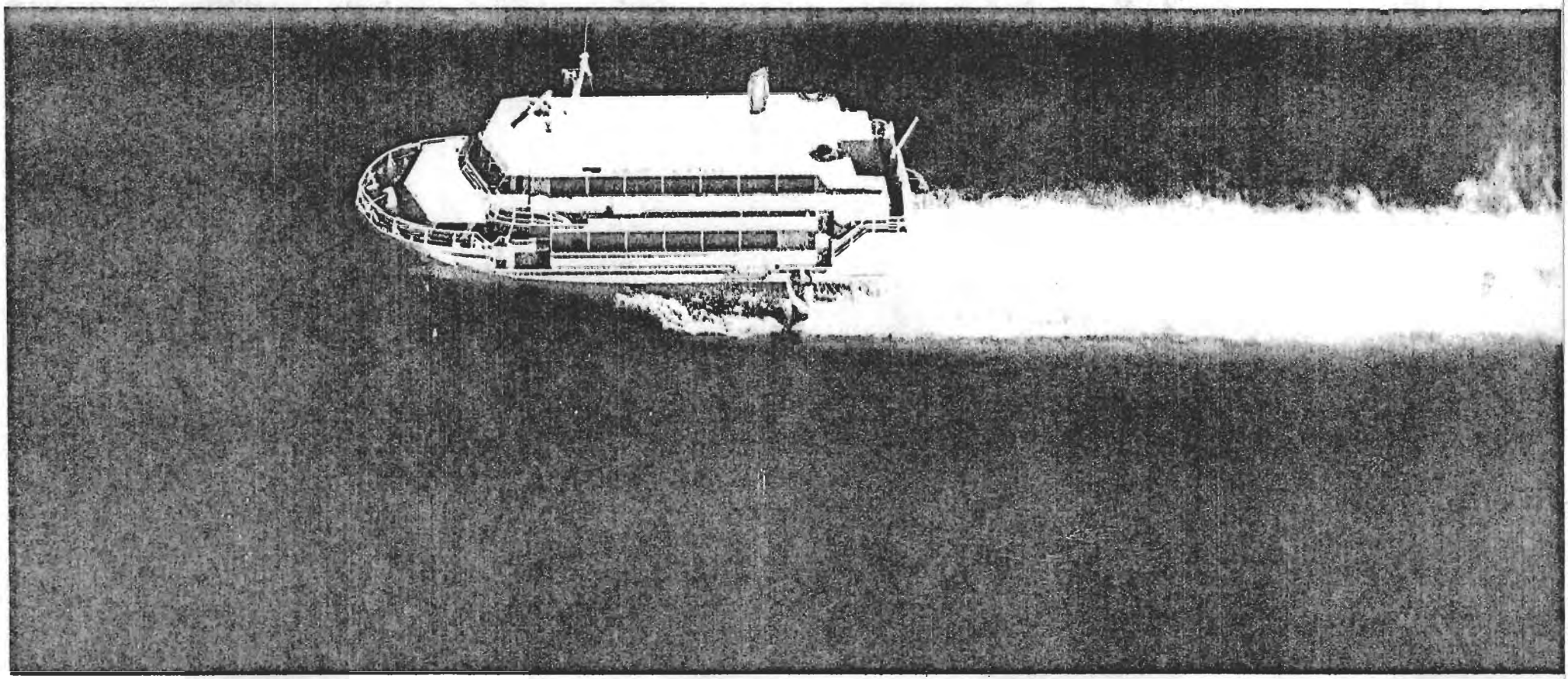
eing was awarded a contract in 1971 for design d construction of the PHM leadship Pegasus, as new type of missile carrying ship to meet NATO quirements. Pegasus was launched in November 74, and, following extensive successful test and aluation by the U.S. Navy, was commissioned in July 1977, as the first operational hydrofoil in the Navy fleet.

In October 1977 BMS was awarded a contract to build five additional PHMs for delivery in 1982. High fire rates of the PHM's eight Harpoons and 76-mm gun, great speed and maneuverability, ability to provide a stable platform in heavy seas, and small radar cross section, give it unique advantages in survivability and attack capability. With a crew of 21 on a PHM and total squadron personnel fewer than that of a destroyer, the risk to men and material is at a minimum.

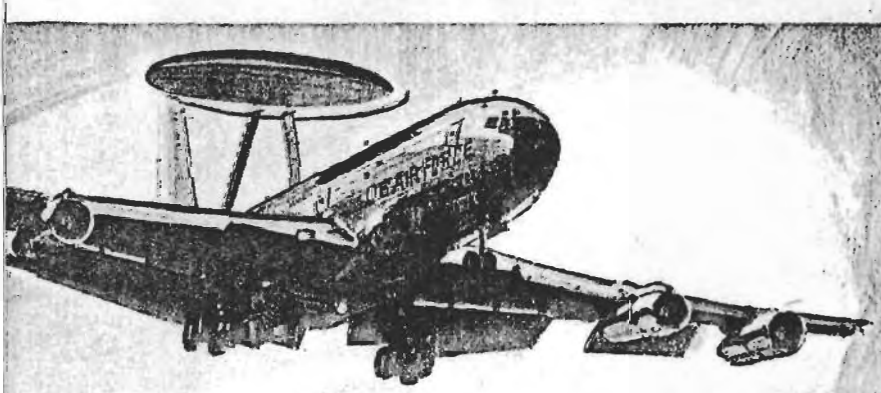


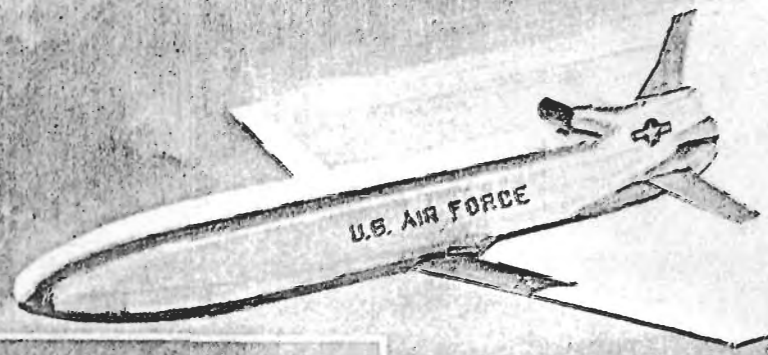
Jetfoil 19

Based on the technical experience gained in past projects and on an evaluation of the potential market, Boeing initiated the Jetfoil program in September 1972. The first Jetfoil, Model 929-100, flew in July 1974. Almost a year of test and evaluation was performed before the first commercial Jetfoil service was begun in April 1975 by Far East Hydrofoil Company of Hong Kong. A new improved Jetfoil, Model 929-115, was launched in June 1978. This current model features major economic improvements in payload, range and reliability.



BMS AND THE BOEING COMPANY





CHAIRMAN
AND
CHIEF EXECUTIVE

PRESIDENT

PRESIDENT
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DIVISION

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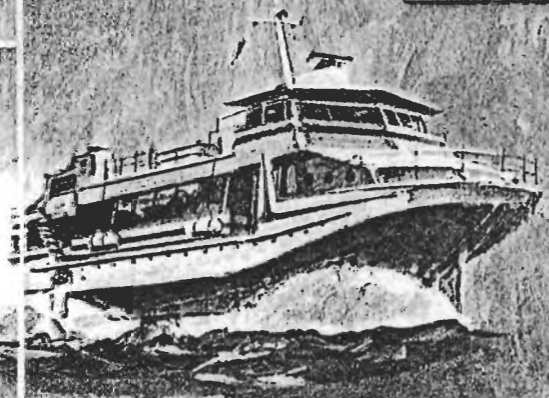
AIRPLANE COMPANY



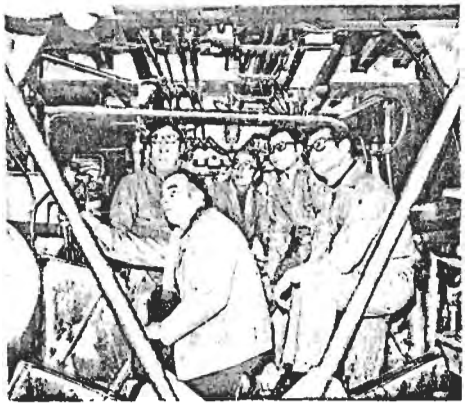
BMS Engineering

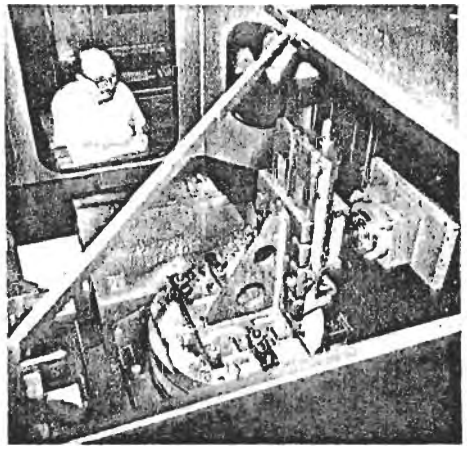
BMS Engineering consolidates all activity under one manager reporting directly to the vice president-general manager. Supported by the technical resources of the entire company, this arrangement provides efficiency, direct project management, and rigid cost control and

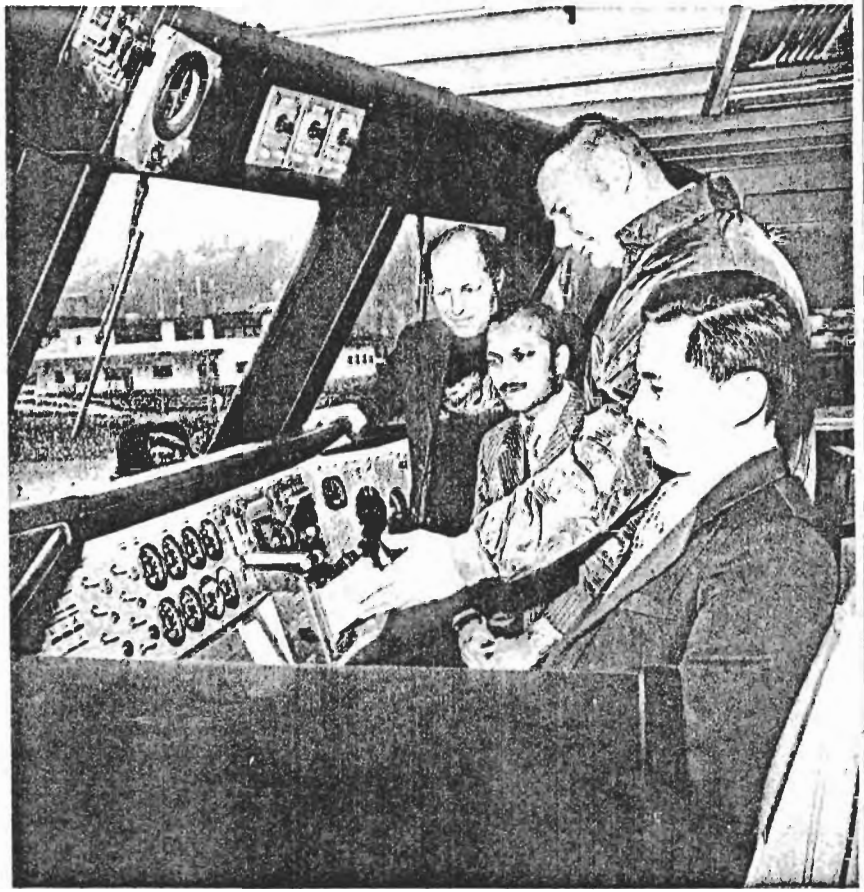
accountability. Engineering is functionally divided into PHM and Jetfoil project engineering, technical staff, ship system testing, and research and development. The organization is augmented by Boeing technical experts from virtually all fields, with access to full laboratory support.

BMS Product Support

The Product Support organization provides a comprehensive program of customer assistance during introduction and operation to attain maximum efficient product utilization. This is accomplished by a program that covers training, facilities planning, supplies, tools and parts. Following this, the operation is monitored by an on-site Boeing representative



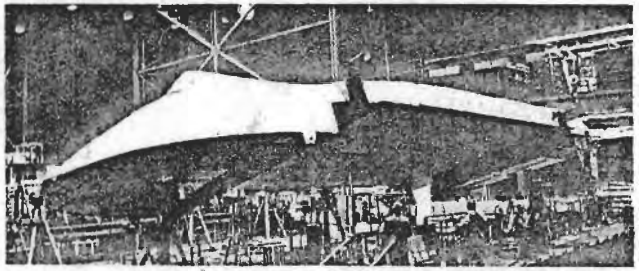


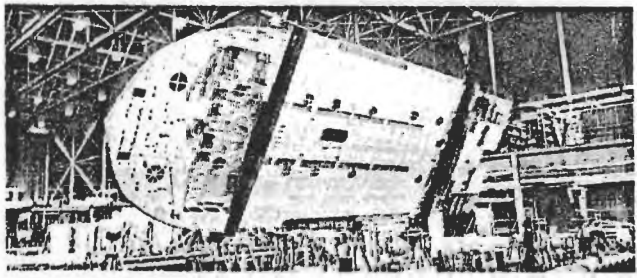


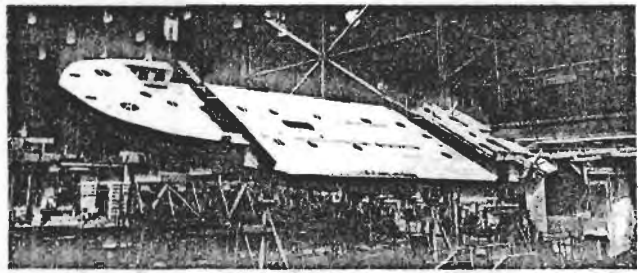
with direct communications to Boeing. Based on these communications, operation, maintenance and hardware improvement concepts are provided to further enhance the operation. The total support program is backed by The Boeing Company, which stands ready to provide additional services such as repair teams, technical assistance and rapid parts shipment as required.

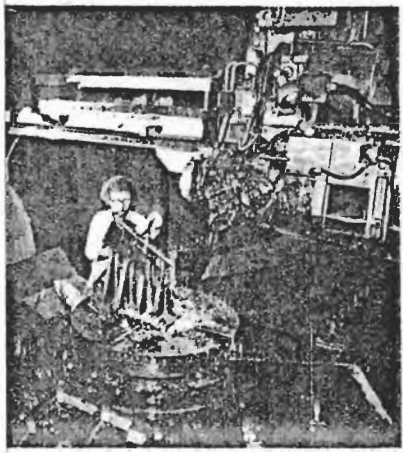
BMS Manufac hg

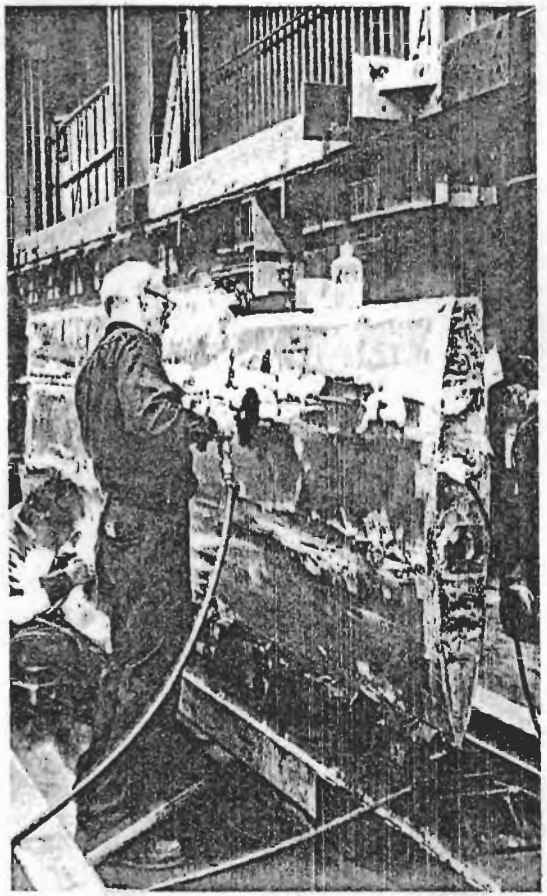
BMS manufacturing capabilities cover the full range of assembly and fabrication techniques required for advanced marine vehicle systems. Facilities, equipment and tooling requirements are analyzed to establish the most efficient production methods, consistent with cost and schedule. To ensure quality, a combination of scientific, technical and operational skills make up the quality control team. Surveillance at all levels of production assure dimensional tolerances within specifications, accurate materials and processes control, and realistic tests of component performance. In addition, some of the most sophisticated aircraft manufacturing facilities in the world, with specialized facilities and personnel in the Puget Sound area and elsewhere are used when appropriate. This combination ensures delivery of marine systems products of highest quality at lowest cost.

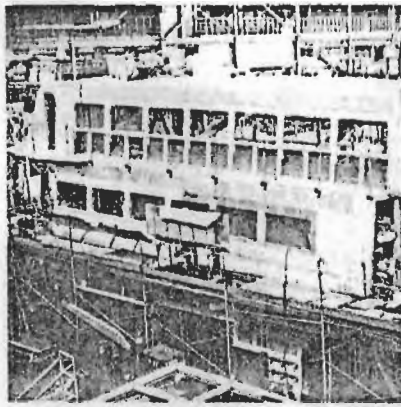


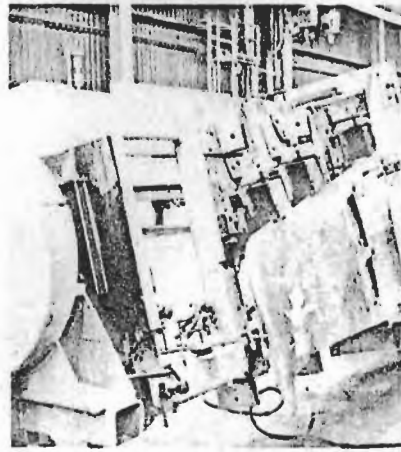


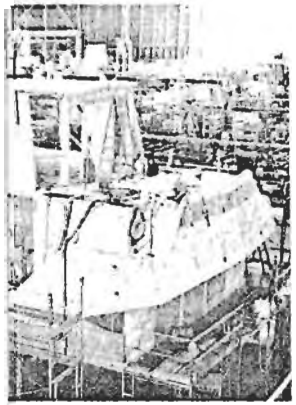


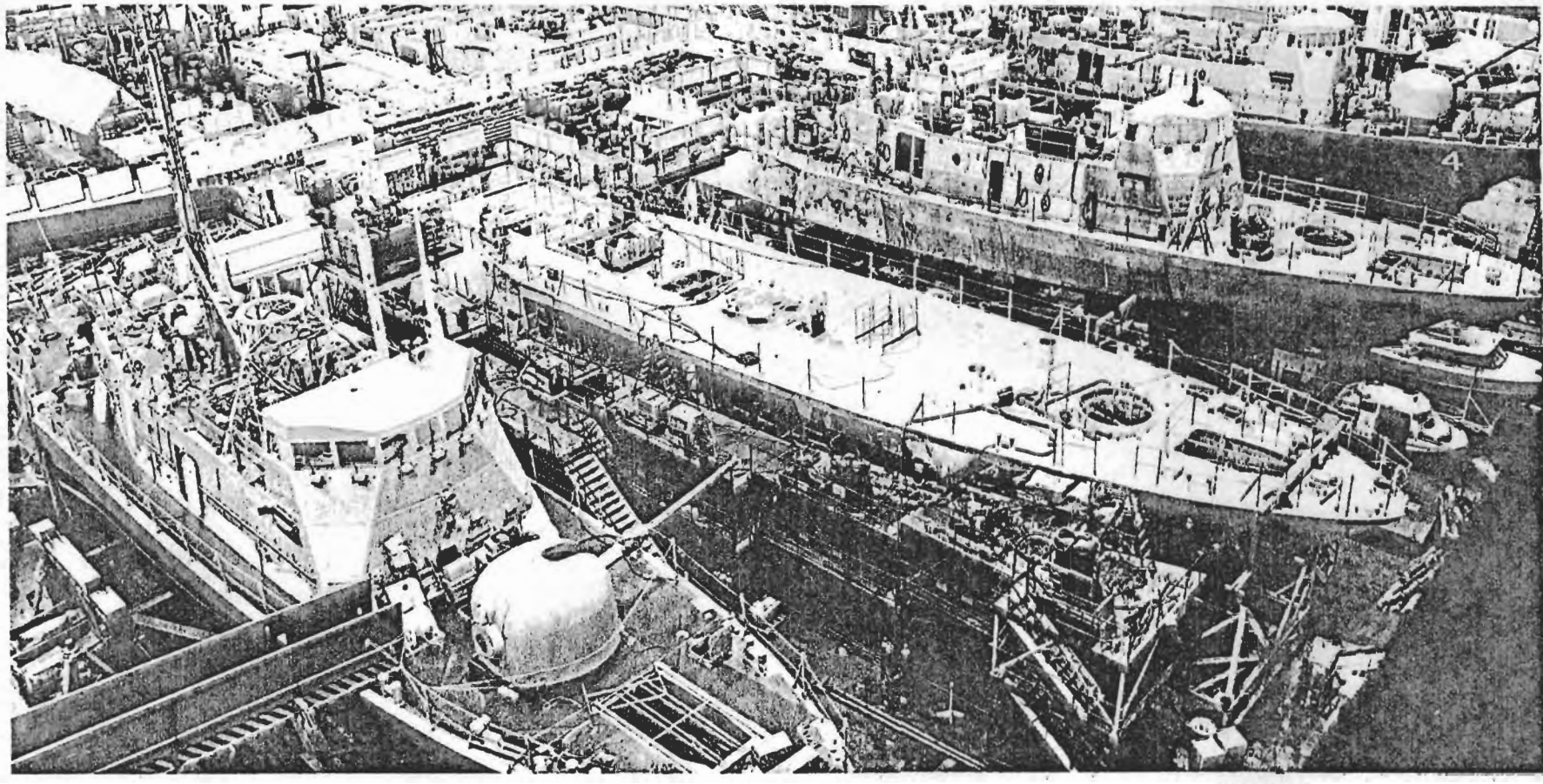






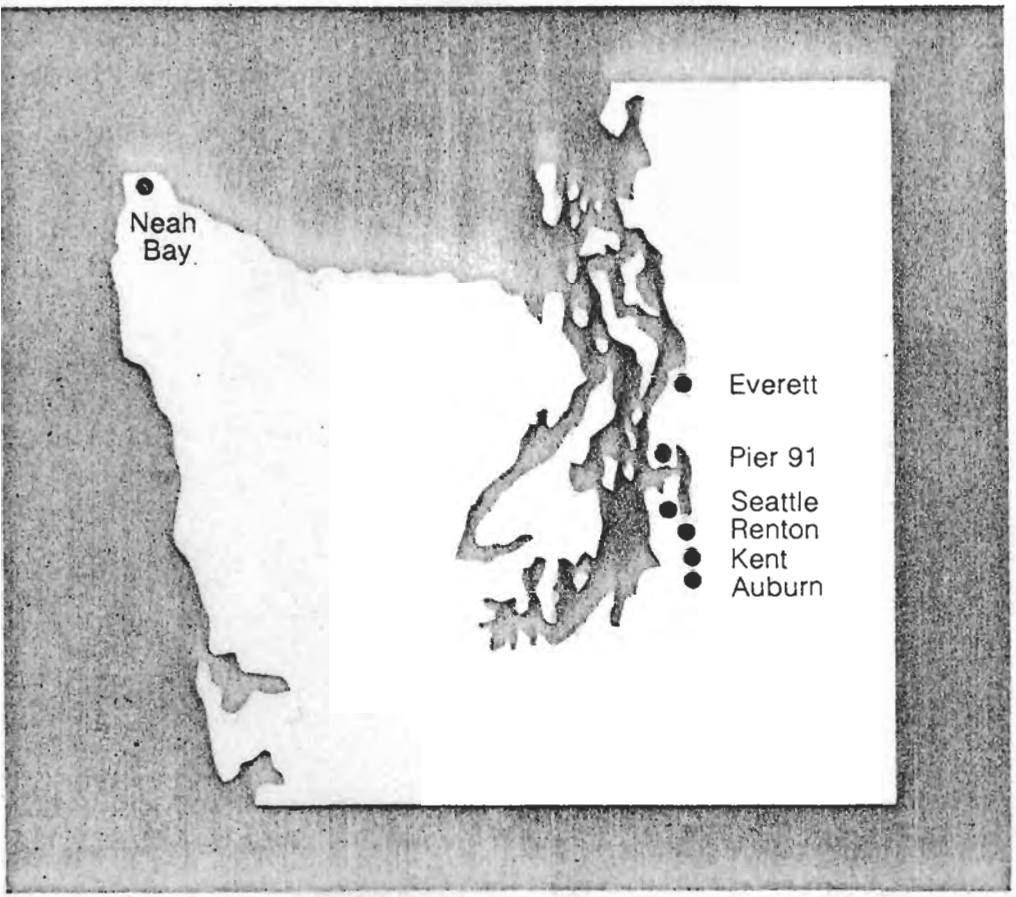






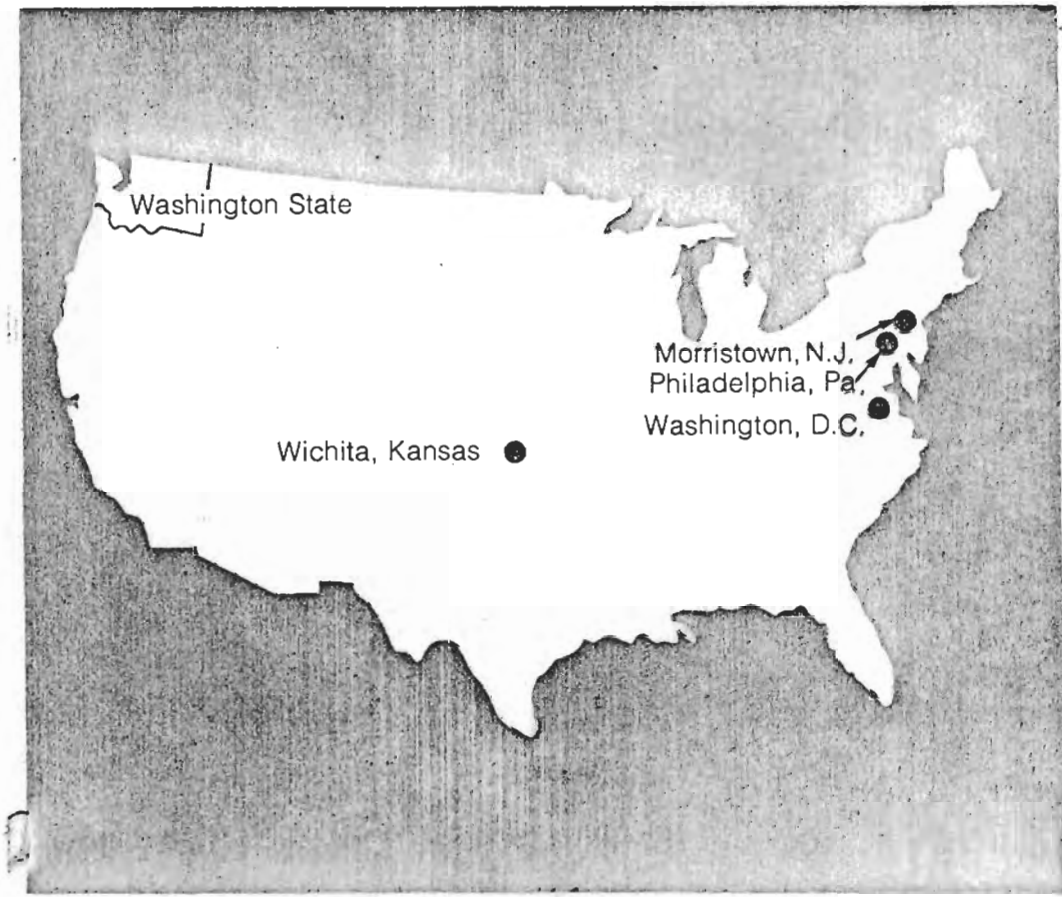
BMS FACILITIES

The Boeing Company in Washington State



Seattle – Headquarters/Aerospace and BMS
Renton – 707/727/737/757 and BMS
Kent – Aerospace
Auburn – Fabrication
Everett – 747/767/777
Neah Bay/Pier 91 – BMS

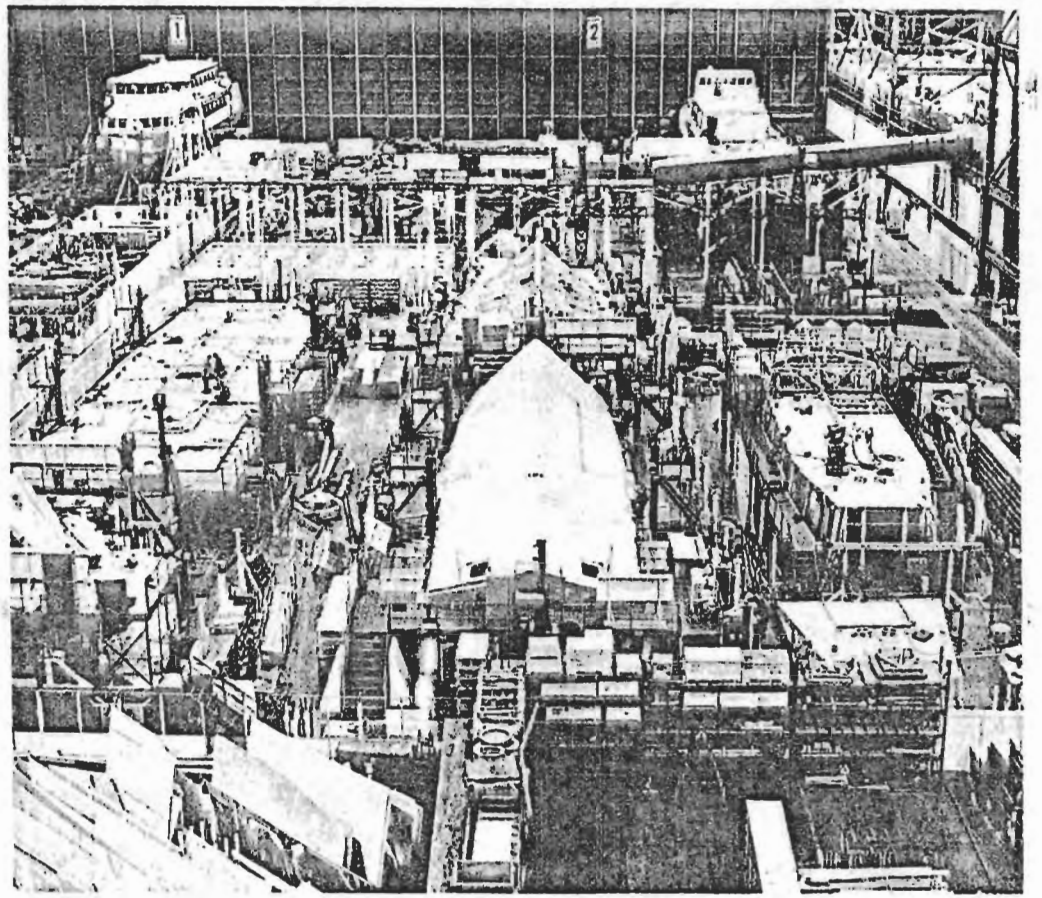
The Boeing Company Nationwide



Philadelphia – Helicopters
Wichita – Airplane Components and Modification
Morristown – Computer Services

Renton

Boeing hydrofoils are assembled in Renton, Washington in a large building adjacent to the 707/727/737/757 jet airplane line. One of the cleanest ship building facilities in the world, the factory uses an assembly line approach for cost effectiveness and quality control.

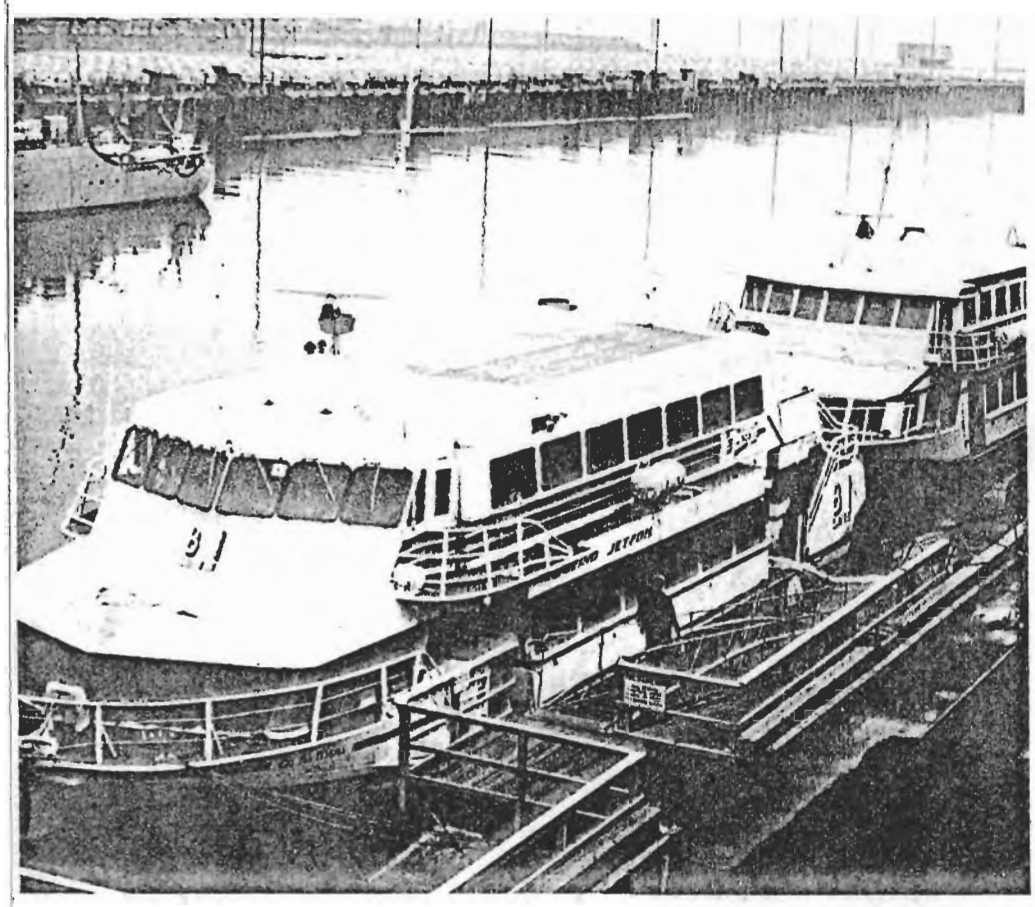


Auburn

The Boeing Company has an extensive manufacturing center in Auburn, Washington, which supports all Boeing products. This center is utilized to fabricate complex hydrofoil parts such as struts and foils. Here some of the largest most sophisticated equipment is used to produce the exacting tolerances required for advanced marine vehicles.

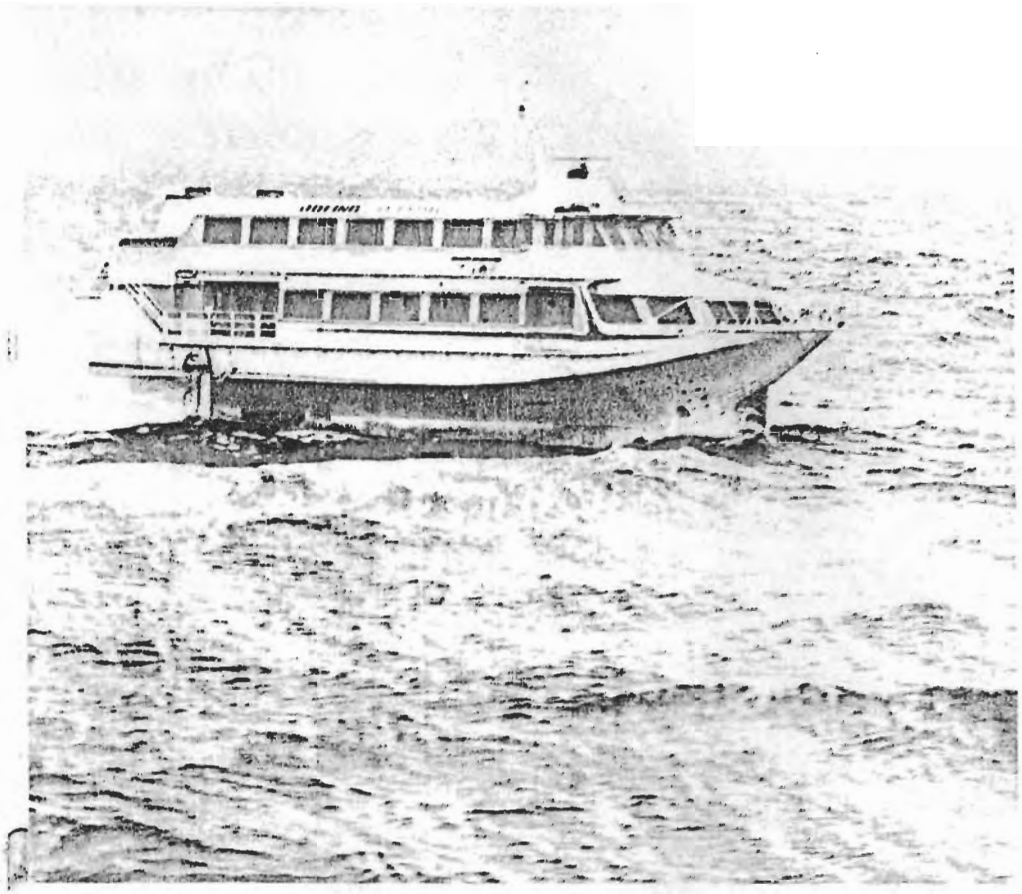
Pier 91

BMS maintains a testing facility at Pier 91 in Seattle. Here development and production test programs are monitored and hydrofoils are prepared for delivery. Pier 91 is located on Puget Sound, with easy access to the Pacific Ocean for testing.



Neah Bay

A facility is maintained at Neah Bay on the northwesterly tip of Washington. Here rough water tests are conducted in the Pacific Ocean where seas can reach sea state 5.



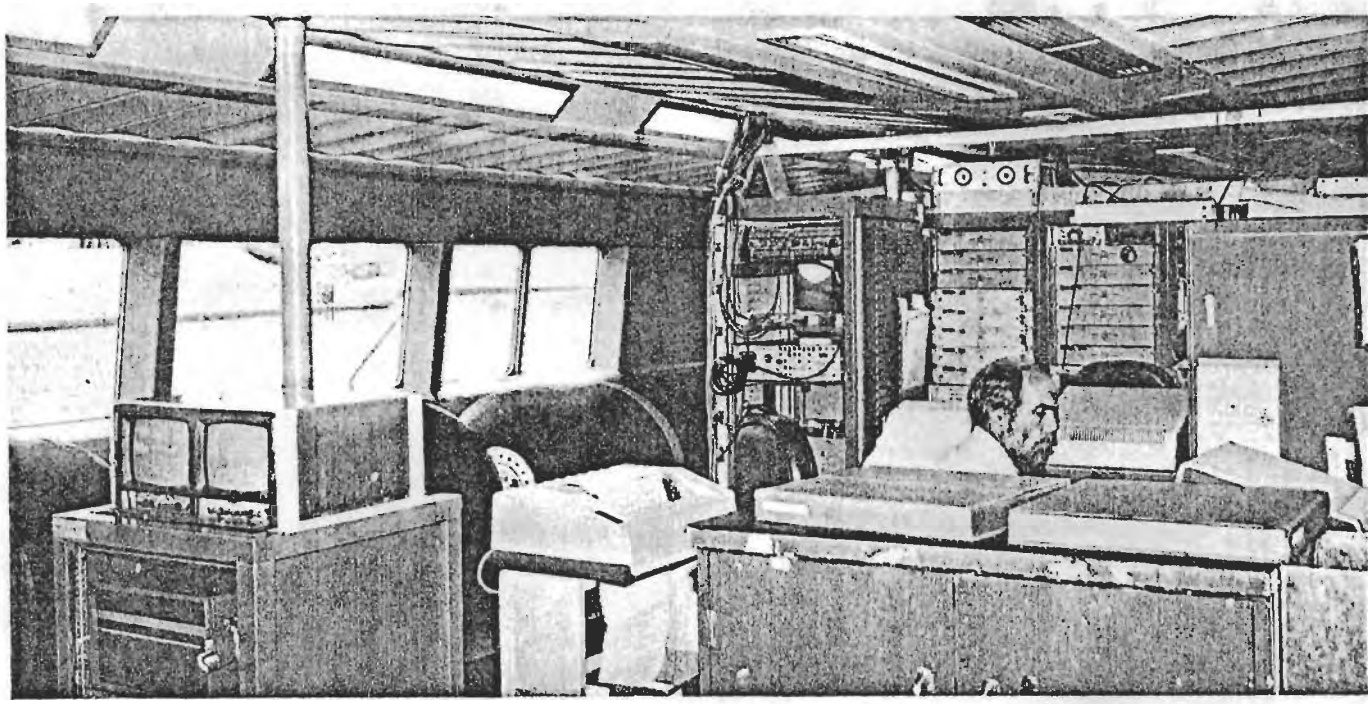
BMS TEST PROGRAMS

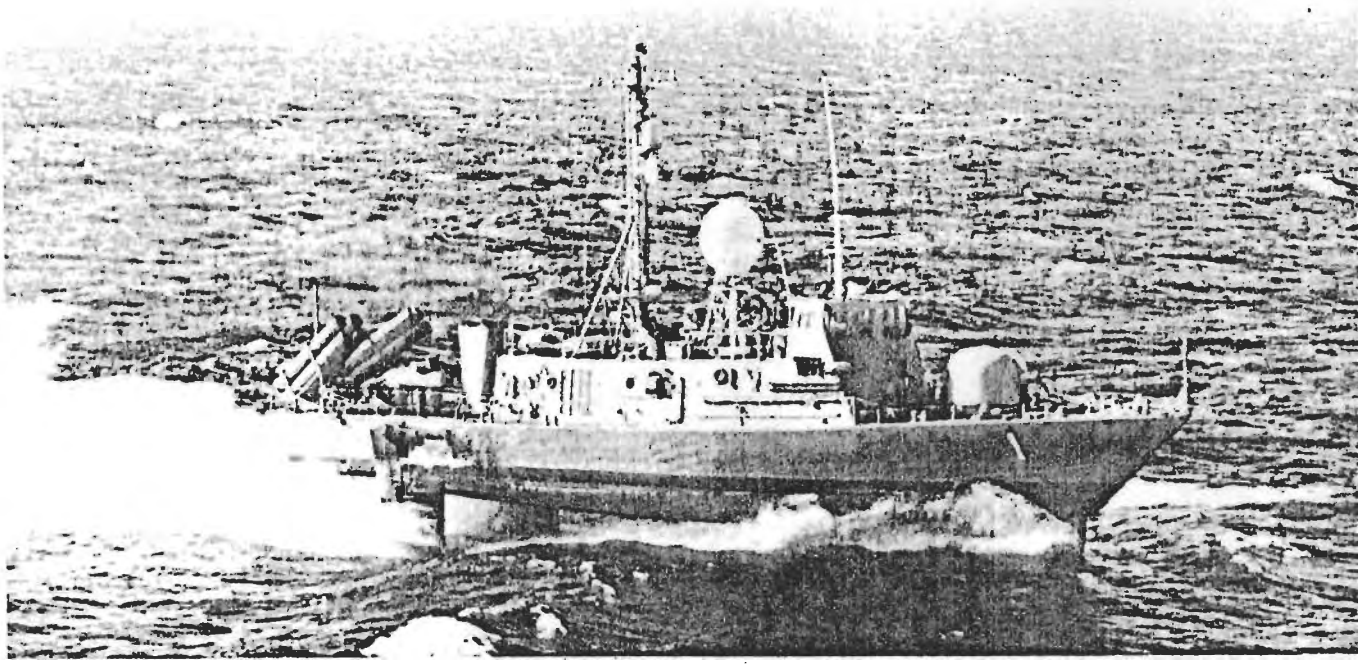
Boeing Testing Philosophy

In order to ensure that its products meet the highest levels of safety, performance and comfort, The Boeing Company conducts extensive tests prior to delivery. This philosophy is continued with the Boeing hydrofoil and is carried out during the initial basic design, later design modifications and with each Jetfoil and PHM delivered.

Initial Test Program

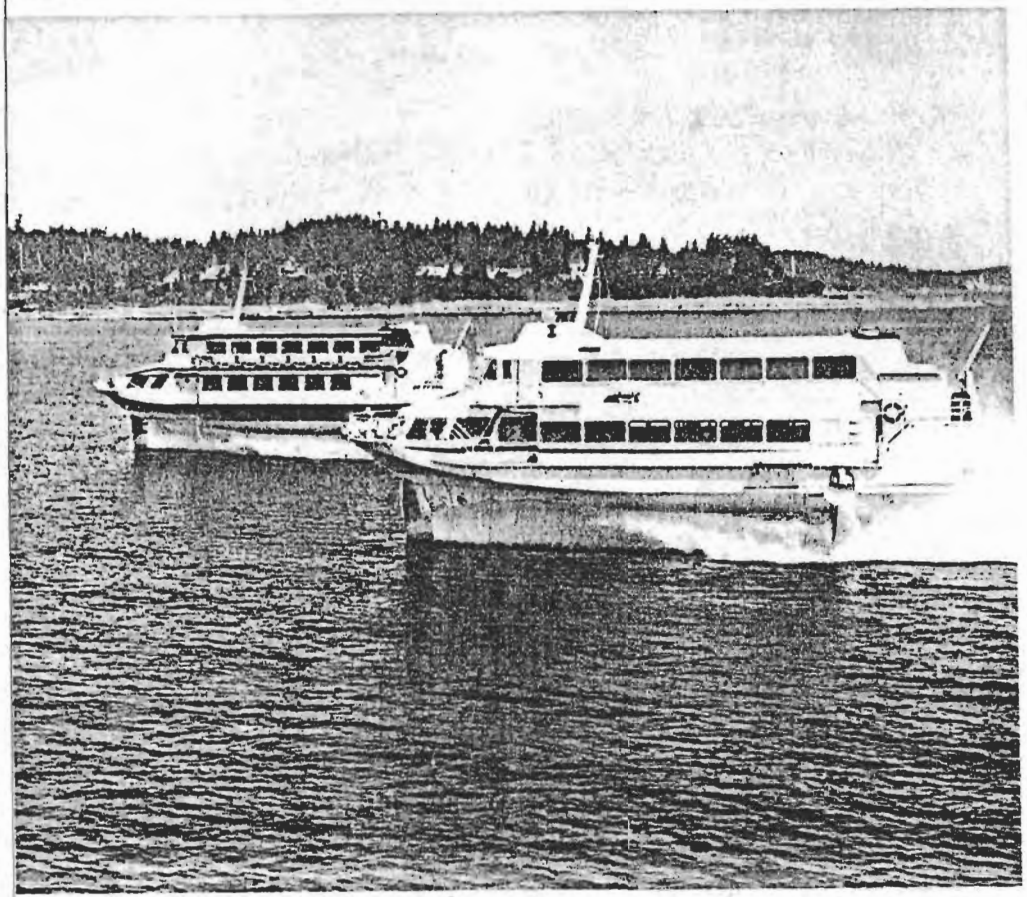
More than 2,500 hours of testing were accomplished on the Model 929-100 Jetfoil and PHM-1, including critical rough water trials, certification trials, customer demonstrations and builders trials for various regulatory agencies. Extensive testing is conducted to determine how each craft behaves relative to its design objectives including simulation of all possible failures and resulting craft motion.





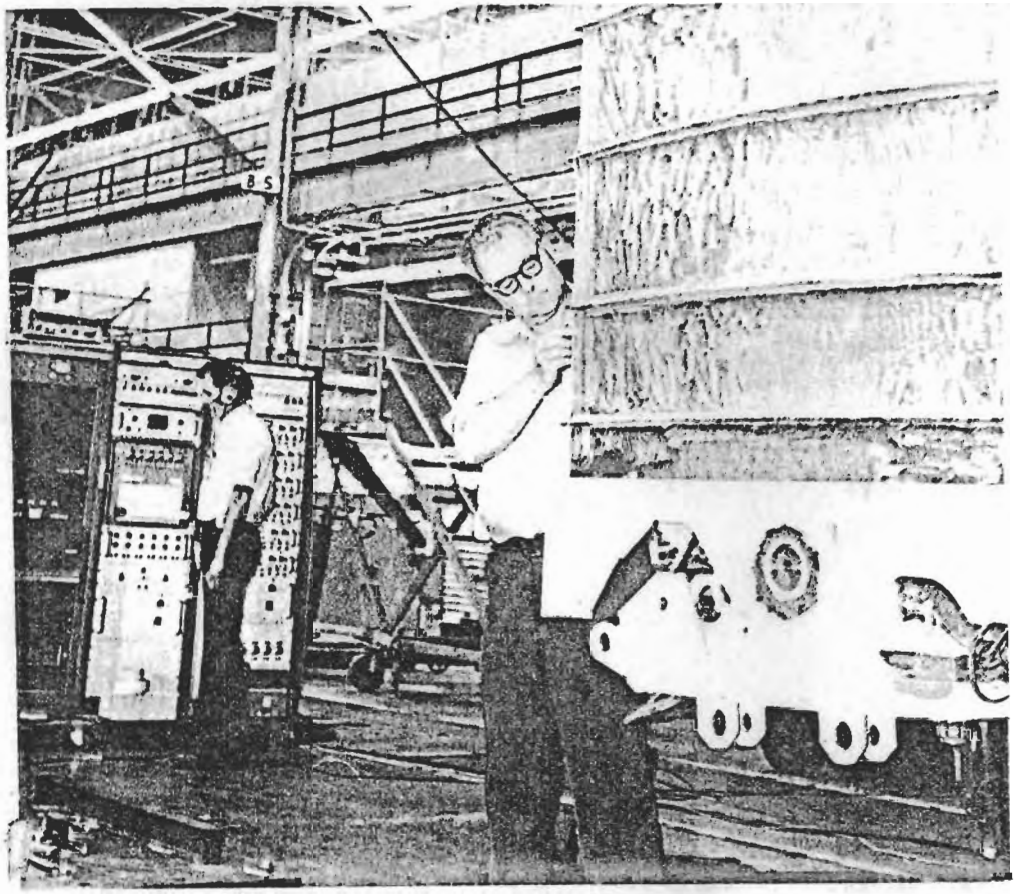
Model 929-115 Tests

Extensive testing on the first of the new Model 929-115 Jetfoils was conducted in 1978. The 250-hour program utilized an onboard computerized test-data retrieval system to evaluate performance. Specific areas tested included hydrodynamic effects of a new shaped forward foil, changes in strut and foil systems, and complete evaluation of changes designed to increase payload and improve maintainability.



Production Testing

Prior to acceptance by regulatory agencies and the customer, each hydrofoil undergoes a significant amount of production testing. This includes a complete dockside and underway check of all operating systems and evaluation of performance variables such as speed, takeoff capability, maneuverability, fuel consumption and ship weights. These are conducted for every hydrofoil delivered.



Jetfoil Model 929-115

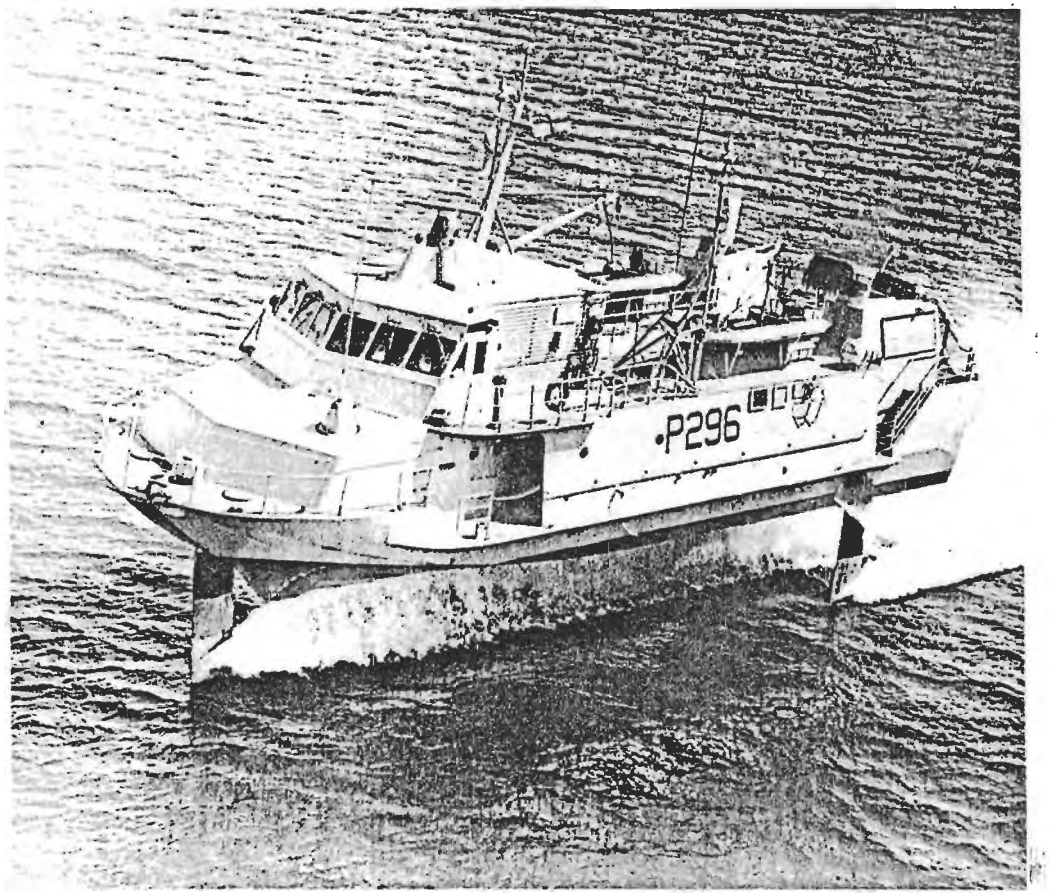
Speed:	Hullborne – 6-20 knots (11-37 km/h) Foilborne – 43 knots (80 km/h)
Displacement:	115 long tons
Length: (foils down)	90 feet (27.4 meters)
Width:	30 feet (9.1 meters)
Mean Draft:	
Hullborne – (foils up)	6 feet (1.9 meters)
Hullborne – (foils down)	17 feet (5.2 meters)
Foilborne – (nominal)	4.5 to 6.5 feet (1.4 to 2.0 meters)
Propulsion:	two Allison 501-K20A turbines with two Rocketdyne R-20 waterjet pumps
Capacity:	200-350 passengers depending upon customer requirements
Standard Crew:	2 officers; 4 cabin attendants

Patrol Hydrofoil Missileship

Length:	132.8 feet (40.5 meters)
Width:	28.2 feet (8.6 meters)
Displacement:	237.5 long tons (241.3 metric tons)
Speed:	
Hullborne –	11 knots (12.6 mph – 20.4 km/h)
Foilborne –	in excess of 40 knots (46 mph – 74 km/h)
Draft:	
Hullborne –	(foils up) 6.2 feet (1.9 meters)
Hullborne –	(foils down) 23.2 feet (7.1 meters)
Foilborne –	(nominal) 8.8 feet (2.7 meters)
Range:	
Hullborne –	in excess of 1200 nmi (2223.0 km)
Foilborne –	in excess of 600 nmi (1111.5 km) (can be refueled underway)
Propulsion:	
Hullborne –	two Mercedes-Benz 8V331 diesels with 2 Aerojet waterjets
Foilborne –	one GE LM 2500 gas turbine with one Aerojet waterjet
Crew:	21
Armament:	eight harpoon missiles, 76 mm rapid fire gun, rapid-bloom offboard chaff system and MK-92 gunfire control system; weight and space reserves for expansion to ASW or AAW missions

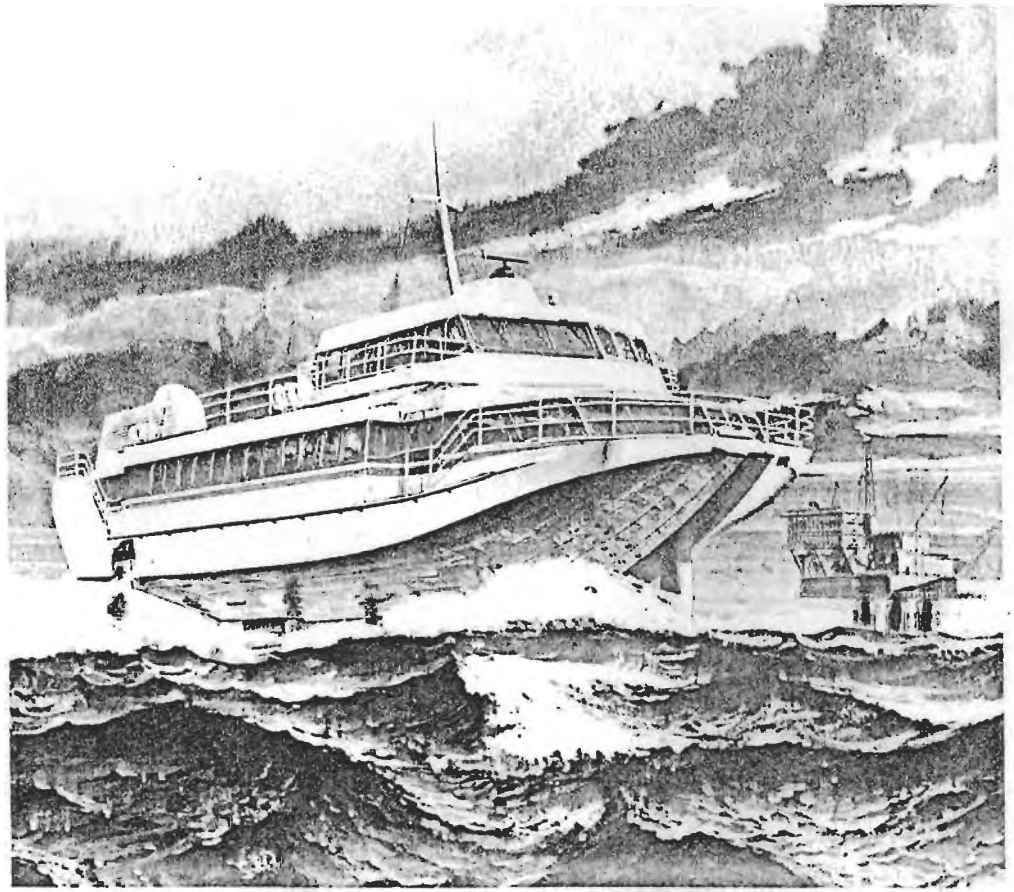
Patrol Jetfoil

Basic specifications for Jetfoil derivatives such as this Fisheries Patrol Vessel are the same as for the Jetfoil. Superstructure may be changed and diesel engines and extra fuel tanks added to provide more on-station and range capability. Derivatives are available for various civil, military, and paramiltary roles.



Offshore Jetfoil

A derivative of the 929-115 Jetfoil, the Offshore Oil Jetfoil offers efficient crew and equipment transfer and new approaches to some special problems: security, emergency, evacuation, fire, oil-spill containment.



Future Hydrofoils

BMS is working on a blueprint for larger hydrofoils of the future. Preliminary design reviews prove the technical feasibility of hydrofoils in excess of 2,000 tons. Given a viable future market, these large multipurpose hydrofoils will be available for both military and commercial applications.