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Cover photo: *Two Boeing hydrofoils on sea trials in Puget Sound in late 1981. In the foreground, PHM-4* Aquila, *one of a class of six being built for the US Navy. In the background,* Bima Samudera 1, *an only slightly modified* Jetfoil *929–115 purchased by the Indonesian government for evaluation in both military and commercial roles. These and other military hydrofoils are described in detail in an article beginning on page 155.*

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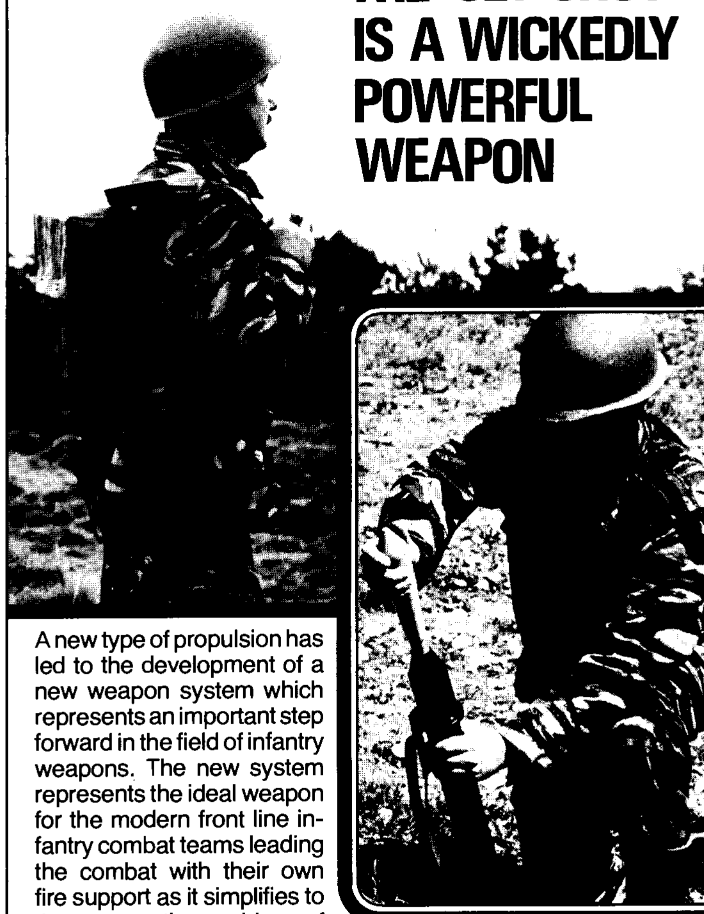

A new type of propulsion has led to the development of a new weapon system which represents an important step forward in the field of infantry weapons. The new system represents the ideal weapon for the modern front line infantry combat teams leading the combat with their own fire support as it simplifies to the utmost the problem of logistics and maintenance, while ensuring maximum efficiency and greatest probability of hitting the objective.
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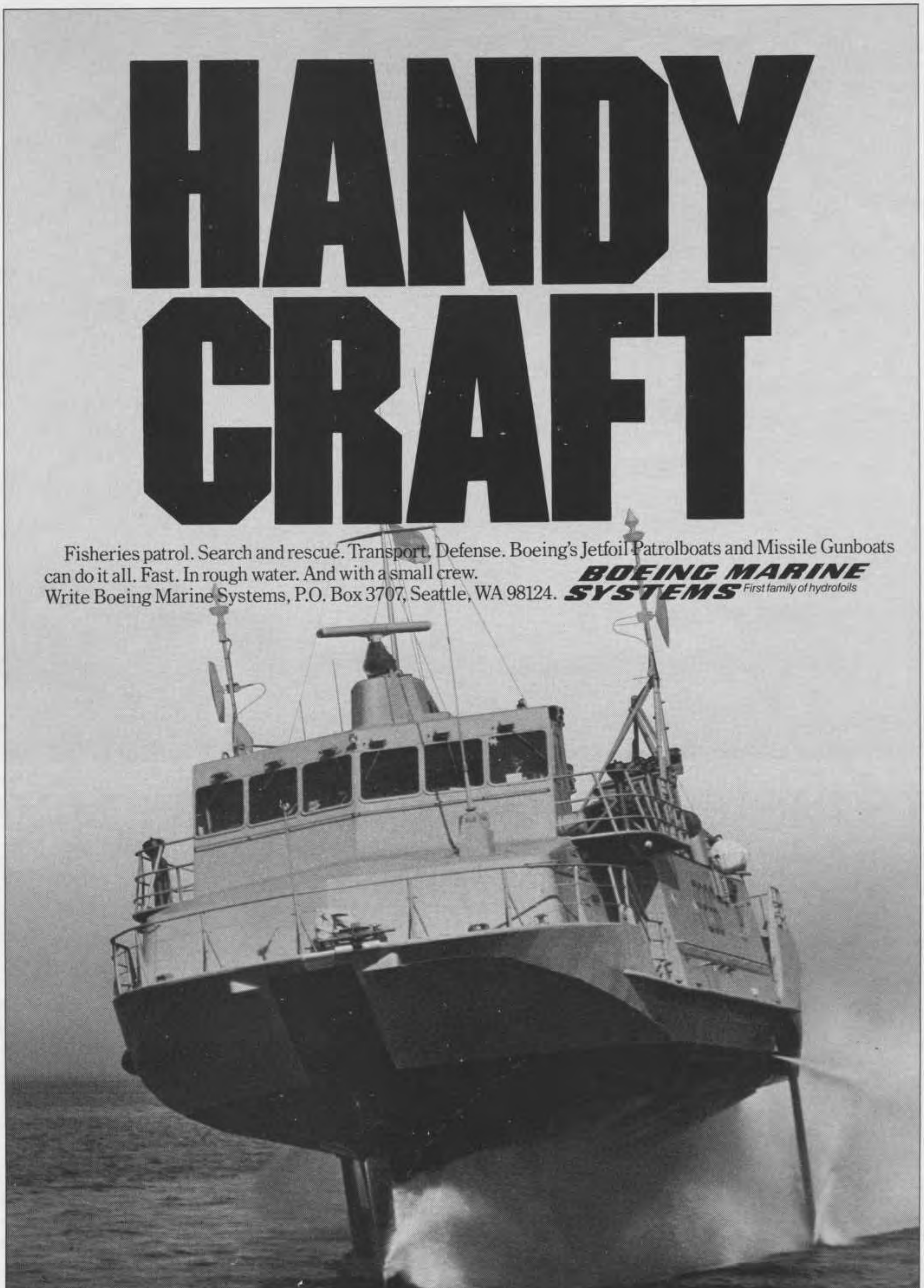
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Western Military Hydrofoils Come of Age

by Alan Blunden[*]

In a few weeks' time, two hydrofoils will leave the US Navy's Bremerton Shipyard in Washington State on the first stage of a positioning journey to Key West, Florida. There, they will join the lead Patrol Hydrofoil Missile (PHM) ship, USS *Pegasus*, which has been based at Key West since August 1980. When the three further PHMs now being fitted out arrive next winter, the US Navy's first hydrofoil squadron will be complete.

After more than two decades of development, the hydrofoil is beginning to make the transition from prototype to operational vessel. The Italian navy is introducing seven patrol hydrofoils, the first of a planned fleet for the Israeli navy was launched last summer, both the Royal Navy and the Indonesian government have purchased a Boeing *Jetfoil* for evaluation purposes and several other countries have hydrofoil programs.

The role of the US Navy in the building of these vessels has been crucial. Investigation of the potential of hydrofoils began in the United States during the mid-1950s. One of the Navy's requirements was for a weapon platform capable of operating on the open sea, and it was soon decided that the fully submerged foil concept showed the most promise. Because the entire surface of the foil remains submerged, this arrangement, unlike the surface-piercing foil, is inherently unstable. Consequently, it has to be linked to some form of automatic control system which maintains the foils at a pre-set depth and stabilises the craft.

The US Navy ordered its first large hydrofoil, PCH-1 *High Point*, from Boeing in 1960. Like all the Navy's subsequent hydrofoil craft, this had a gas-turbine propulsion installation for foilborne operations and a diesel engine for lower-speed, hullborne running. *High Point* was officially handed over in 1963 and has since been used to evaluate possible weapons and ASW equipment. In 1973-74 two *Harpoon* missiles were successfully fired while it was travelling at 40kt. A second, considerably bigger hydrofoil, AGEH-1 *Plainview*, was launched by Grumman in 1965, but faults in the hydraulic systems and other problems delayed Navy trials for five years. However, three *Sea Sparrow* missiles were fired during rough-weather trials in 1972.

Operational military designs

A move towards an operational design was made in 1966 when two Patrol Gunboat Hydrofoils were ordered, PGH-1 *Flagstaff* from Grumman and PGH-2 *Tucumcari* from Boeing. Both were delivered in 1968

▲ PHM-3 *Taurus* on sea trials in 1981. Being built by Boeing Marine Systems for the US Navy, this class of hydrofoils will form a six-ship squadron later in 1982, initially based at Key West, Florida. The PHM squadron's support infrastructure is designed for mobile basing, however, the most likely theatre of operations for the squadron being the Mediterranean.

and shipped the following year to Viet-Nam for six months of combat evaluation. *Flagstaff* was also used in a series of trials, in the United States, to determine this type of craft's ability to withstand underwater explosions. It successfully survived these tests and was transferred to the US Coast Guard in 1976. *Tucumcari*, the first hydrofoil to have the now familiar combination of fully submerged canard foils, automatic control system and waterjet propulsion, operated with both the Pacific Fleet Amphibious Command and the Atlantic amphibious forces. During 1971, when it was deployed to Europe, the craft joined the Sixth Fleet in the Mediterranean and made demonstration visits to several NATO countries.

Improved versions of the two PGH designs have since gone into series production overseas. A derivative of the Boeing craft (the *Sparviero* class) has been built in Italy and the *Flagstaff* MkII program is progressing steadily (the lead craft was due to be delivered by Grumman to the Israeli navy in late 1981 / early 1982 and a second craft is under construction at Haifa). The US Navy, though, felt that it needed a larger hydrofoil, and in 1970 the 11 countries represented in the NATO Naval Armament Group decided that a 140t vessel based on the *Tucumcari* should be built.

When it became clear that a different design would be needed to satisfy the operational requirement for a fast patrol hydrofoil carrying surface-to-surface missiles, the United States embarked on the PHM program. Then, shortly after Boeing was awarded a preliminary contract for work on two pre-production vessels in 1971, a formal agreement on joint development of the PHM by the United States, Italy and West Germany was finally arrived at.

The PHM program

In 1973, a $42.6 million design and development contract was given to Boeing. At that time, it was planned that the first two craft would be followed by 28 production vessels. But by the end of 1974, there had been two major setbacks. Increasing costs caused the suspension of all work on the second PHM and Italy revealed that it would not be ordering any craft. In the United States, the program came under increasingly critical scrutiny, culminating in a decision by the Carter administration to restrict it to just the prototype plus the spares necessary to keep this craft operational. At the beginning of 1977, West Germany also decided not to take delivery of any PHMs but, a few months later, Congress guaranteed the future of the project by approving a $272.7 million contract for the construction of five further vessels.

During this period, PHM-1 *Pegasus* was engaged in manufacturer's and acceptance trials. Displacing 235t, the craft is armed with eight *Harpoon* missiles, a Mk75 76mm rapid-fire gun, a Mk94 surveillance and weapon-control system

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(Mk92 in PHM-2 onwards), chaff launchers and an ECM system.

The vessel was commissionned as USS *Pegasus* in July 1977, the first hydrofoil to be officially designated a United States Ship. Assigned to the Pacific Fleet, it was based in San Diego, California. During the next two years, *Pegasus* took part in six exercises. One of these, in Hawaii, involved two 3,000n.m. journeys.

Although fitted out for a crew of 21 and a five-day patrol, several missions lasting between seven and nine days and one of 11 days have been completed. Refuelling has been carried out successfully at speeds of over 15kt in conditions up to sea state 6. Using ESM, radar or third-party targetting, simulated missile attacks have been made on major targets at both short and over-the-horizon ranges. On one exercise, eight simulated *Harpoon* firings were made against six US Navy ships at ranges of 11 and 23n.m. Because these ships had insufficient position information on the *Pegasus*, the attacking hydrofoil was not engaged in return. It has also proved difficult to see the hydrofoil from the air. If attacked, the hydrofoil has its 76mm gun and associated fire-control system, stated to be accurate against air targets up to 3,750-6,000m away, with which to defend itself.

Now transferred to the Atlantic Fleet, *Pegasus* is operating out of Key West, Florida. The first of the production vessels, PHM-3 *Taurus*, was commissioned in October. It has since been joined at the Bremerton Shipyard on Puget sound by PHM-4 *Aquila* and PHM-5 *Aries*. PHM-6 *Gemini* was scheduled to be launched at Boeing Marine Systems' Renton facility in December 1981, and the final craft, PHM-2 *Hercules*, on which work had been suspended, will go into the water in April 1982.

Externally, the production PHMs are virtually identical to the prototype, *Pegasus*. The hull is an all-welded structure of aluminium alloy with most of the machinery housed in three watertight compartments aft. The inverted-T forward foil and full-width aft foil are manufactured from stainless steel. Both retract to reduce draught during hullborne operations. Thirty-two percent of the dynamic lift is provided by the bow foil and 68% by the aft foil.

Height sensors, gyros and accelerometers feed information about vessel motion to a computer. This then automatically adjusts flaps on the trailing edges of the foils, through electrohydraulic servo actuators. The forward and aft flaps provide pitch variation and height control, the aft flaps are used for roll control and changes in direction. The combination of the automatic control system and steerable bow strut permits the PHM to bank smoothly into turns of up to six degrees a second.

The General Electric LM2500 was chosen as the main (foilborne) powerplant because of a desire to standardise the gas turbines used by the US Navy. It had the advantage of already having been selected for the DD-963 *Spruance* and FFG-7 *Oliver Hazard Perry* classes. One difference on the production PHMs is that the unit is rated at 12,700kW (17,000shp) rather than the 12,100kW (16,200shp) of the prototype. But this still leaves considerable growth potential as it should be possible, with a redesigned gearbox, to take 22,400kW (30,000shp) from the LM2500.

As on *Pegasus*, the engine drives an Aerojet two-stage waterjet through two sets of reduction gears. The foilborne system is also identical, two MTU 8V331TC80

◄ The Italian navy hydrofoil *Nibbio*, one of seven (including the prototype, *Sparviero*) to be ordered. The design of the light (62.5t), compact (23m) craft was derived from that of Boeing's *Tucumcari*, forerunner of the US Navy's PHM class.

▼ A spectacular crash stop by PHM-4 *Aquila* during high-speed tests in Puget Sound in November 1981.

► After Grumman's *Flagstaff* lost the US Navy's PHM competition to Boeing's *Pegasus*, Grumman developed as a private venture a larger version of its entrant, *Flagstaff* MkII. First customer is Israel which was due to take delivery of the first craft (the *Shimrit*) in late 1981 or early 1982 and is building a second (the *Livnit*) at Israel Shipyards in Haifa. Photo shows the *Shimrit* just after its launch in Florida in May 1981. The craft will be armed with two *Gabriel* missiles, four longer-range *Harpoon* missiles and an Emerson *Emerlec* twin 30mm gun mount. Note the 1.32m-diameter controllable-pitch propeller visible at the tip of the aft strut, this type of propulsion making it necessary, however, to have a mechanical transmission running down the strut (Boeing has avoided this problem by adopting water-jet propulsion). The large radome houses the antenna of the Elta search radar, while the smaller, rotating radome above it accommodates a fire-control radar.

US Navy trials vessels

	PCH-1 *High Point*	AGEH-1 *Plainview*	PGH-1 *Flagstaff*	PGH-2 *Tucumcari*
Length overall (m)	35.28	64.61	22.20	22.71
Beam overall (m)	9.14	12.31	6.50	8.61
Max displacement (t)	127.2	290.0	67.5	57.5
Max speed (kt)	50	50+	–	45+
Cruising speed (kt)	30–40	42	40+	–
Speed hullborne (kt)	8	8	7	–

Production vessels

	Pegasus class (PHM)	*Sparviero* class	*Flagstaff* MkII	*Jetfoil* 929–115
Length overall (m)	40.50	22.95	25.62	27.40
Beam overall (m)	8.60	7.00	7.32	9.50
Draught (m):				
foilborne	2.70	0.80	1.70	1.40–2.00
hullborne	7.10	4.33	4.83	5.20
foils retracted	1.90	1.81	1.45	1.80
Max displacement (t)	241.3	60.5	100	117
Max speed (kt)	50+	50	50+	50
Cruising speed (kt)	40+	44	42	43
Speed hullborne (kt)	11	7	10	5–15
Range (n.m.):				
foilborne	600+	400	1,000+	600+
hullborne	1,800+	1,000	3,300+	1,500+

600kW (800hp) diesels each powering an Aerojet waterjet with steering and reversing nozzles. Electrical power is supplied by two AirResearch ME831-800 gas turbines and 250kVA/400Hz/450V Westinghouse generators.

Design modifications

A few detail alterations have been made in the equipment and crew areas of the production PHMs but the major changes are structural. After *Pegasus* was launched, Boeing Marine Systems examined various ways in which the design could be simplified to shorten building time, reduce the amount of welding involved and improve the quality of the finished vessel. The result is that the hulls of the production boats have 49% fewer individual parts and are approximately 9% lighter. It also proved possible to reduce the total length of welds by 59% and increase the use of mechanical welding techniques by 720%.

One problem encountered during early operations with *Pegasus* was cracks, mainly the result of metal fatigue, appearing on the skins of the foils. The struts and foils of the production PHMs are less complex but, because their strength and fatigue characteristics have had to be upgraded, they are heavier.

The equipment and weapon systems on the first four production vessels will be similar to that on board *Pegasus*. The final PHM, though, will be delivered without armament and used, initially, as a trials craft. Some of the improvements incorporated in the production craft will be retrofitted on *Pegasus*.

PHM deployment

It was intended that the squadron would have the use of the LST *Wood County*, specially converted for the purpose, to provide complete support facilities, but this was one victim of the budget cuts that was not reinstated in the program. The six PHMs were then to be based in Norfolk, Virginia, but the Navy decided that, since the squadron was supposed to have a rapid-deployment capability, it should not be located in an area where good support facilities already existed ashore. Key West was therefore selected as the home port. All support there and on deployment will be supplied by a mobile group of 130 men working out of 73 shelters. When the PHMs are deployed, they will either transit in forma-

tion, refuelling at sea, be towed or be carried aboard ship. Boeing Marine Systems points out that, with three underway refuellings, the PHMs could travel from Massachusetts to the United Kingdom, at an average speed of 30kt, in 4.2 days. Refuelling four times, it would be possible to cross from Norfolk to Cadiz in 4.6 days.

The first deployment, probably involving two PHMs, will take place in 1983. It is likely that this will be to the Mediterranean. The area has been described as the "most logical place for the initial deployment" by Admiral John D. Johnson. "If you look at the Mediterranean geography," he has said, "and lay out the radii of capability of the PHM, you will find that we can cover the Mediterranean quite adequately from about two or three selected bases. We would want to have a fairly long initial deployment to prove the sustainability of the PHM."

The PHMs could be used either as part of a battle group or, with surveillance aircraft, in a choke-point control force. Other possible applications include convoy support duties, mine countermeasures and anti-submarine warfare. Whatever the task, it is likely that the vessels will operate in pairs.

The Italian program

Although the US Navy's PHMs are currently the focus of attention, the first NATO navy to order operational hydrofoils was Italy. As in the United States, several years elapsed between the delivery of the lead ship and the launching of the first follow-on craft. The Italian navy had been impressed by *Tucumcari* and was interested in a derivative with an advanced weapon fit.

An order for a prototype, to be built in Italy, was placed in 1970. This craft, the *Sparviero*, was completed four years later. Not unexpectedly, the fully submerged canard foils and automatic control system are very similar to those of *Tucumcari*. At speeds of 42kt in head seas at sea state 4, these limit the maximum vertical acceleration to 0.25g RMS, the maximum roll angle to 2½° and the maximum angle of pitch to 2°.

Sparviero is built of aluminium alloy, welded in the hull and riveted in the superstructure. The foilborne propulsion system consists of a single Rolls-Royce *Proteus* gas turbine, rated at 3,400kW (4,500shp), driving a waterjet with a capacity of 106,000 litres (28,000 US gall) a minute. During trials, it was demonstrated that *Sparviero* could "take off" in sea state 4 in bow and head seas, and in higher sea states in a following sea. In sea state 5, for example, the hydrofoil has maintained a speed of over 36kt.

For hullborne running, *Sparviero* has a steerable, retractable propeller driven by a General Motors 6V53 diesel. The electrical system is based on two 110kW (150hp) gas turbines. Two fixed and eight folding berths are provided for the crew. Armament comprises a 76mm OTO Melara gun and two *Otomat* missiles. Manning levels depend on the mission. For peacetime patrol duties, the crew totals five, increasing to a maximum of ten under battle conditions. The men are drawn from two officers, two weapon specialists, two communications specialists, two chief engineers and two seamen.

Surface-piercing hydrofoils

The country usually associated with the widespread use of passenger hydrofoils, the USSR, has also introduced a variety of military hydrofoil vessels. Most of the designs in service with the Soviet navy, however, are modified versions of the *Osa* FPB hull with a bow-mounted surface-piercing foil. This configuration was first seen on the P8 torpedo hydrofoils, now withdrawn, and has subsequently been used on two recent designs.

Both the *Turya*-class fast torpedo craft and the more recent *Matka*-class missile craft (for photo, see *IDR* No. 5/80, p. 655) are based on the welded-steel hull of the *Osa* class. Three 3,750kW (5,000hp) diesels give the 200t hydrofoils a maximum speed of 40-45kt. As well as increasing the speed by some 15-20kt, the bow foil produces a more stable weapon platform. The only purpose-built hydrofoils thought to be in service in the Soviet navy are 25 vessels of the *Pchela* class, a development of a passenger ferry design. Also using surface-piercing foils, these are operated on frontier patrol duties by the KGB.

Currently being evaluated by the Soviet navy, though, are two much larger hydrofoils, both of which are believed to be fitted with a surface-piercing bow foil and fully submerged aft foil. The 330t *Sarancha* is a fast strike craft with a maximum speed of over 50t. The prototype is fitted out with four launchers for SS-N-9 missiles, a twin SA-N-4 launcher and a 30mm Gatling mount. An even bigger hydrofoil, the 400t *Babochka*, is capable of similar speeds. Its armament comprises two quadruple launchers for ASW torpedoes and two 30mm Gatling mounts.

The People's Republic of China has also produced hydrofoils by adding a bow foil to an existing FPB hull design. More than 140 of the resulting *Hu Chwan* class of fast torpedo boats are thought to be in service in China, and craft have been supplied to Albania, Pakistan and Tanzania. Several were also shipped to Romania, where the design was put into production in the early 1970s.

In the West, two companies have dominated the market for surface-piercing hydrofoils, which have enjoyed not inconsiderable success as high-speed ferries. Both firms have produced proposals for military craft, based on established hulls.

Supramar Hydrofoils, the consultants whose PT.20 and PT.50 vessels, licence-built in Italy, Norway and Japan, pioneered the introduction of hydrofoils in the late 1950s and early 1960s, have designs ranging from 31t to 180t displacement. All have cruising speeds of about 40kt and ranges foilborne of 300-400n.m.

Cantiere Navale Rodriguez, which has built almost 150 surface-piercing hydrofoil ferries in Messina (Italy) over the past 25 years, is now marketing a range of naval vessels. The smallest of these is the M100, a coastal-patrol hydrofoil able to carry a 4t payload at 38kt. Other designs would be fitted with an electronic stabilisation system developed by Rodriguez and Hamilton Standard. These include the 54t M150, the 65t MRHS150, the 85t M300 and the 125t M600. Travelling at 35-40kt, the craft could carry payloads of between eight and 21t.

An electronic seakeeping-augmentation system (SAS) has been fitted on the larger Rodriguez hydrofoils for several years. During trials with an SAS-equipped RHS160 commercial ferry, which has an identical hull to that of the proposed M300, a helicopter successfully landed on the roof of the upper passenger saloon, and took off again, while the craft was foilborne (see *IDR* No. 5/78, p. 772). The SAS consists of a computer, a gyro, an accelerometer and four position transducers. The computer analyses information from the sensors and sends the relevant control impulses to control servo-valves which activate flaps on the vessel's W-shaped foils.

In November 1977, the Royal Navy conducted a series of trials with an RHS160 in the waters around the Channel Islands. When foilborne at 33kt in sea state 6, the RMS values of pitch and roll in the cabins of the SAS-equipped vessel were of the order of one to two degrees. This was better than the comparative data available, produced by a stabilised 400t ship cruising at 20kt in sea state 5.

But surface-piercing hydrofoils have yet to be ordered in any numbers for naval duties in the West. The availability of larger craft, though, may change this situation. Prominent amongst such proposals is the M600. Based on the hull and foil system of the RHS200, the largest passenger hydrofoil currently in production, this could be fitted out with a 7 × 11m helicopter pad on the aft deck. The 125t craft could carry a payload of 21t. Maximum speed from two MTU 16V652TB81 2,020kW (2,750 metric hp) diesels driving two variable-pitch propellers would be 39kt. At a cruising speed of 36kt, the range would be 650n.m. One option available is an additional engine, an Avco Lycoming TF25 gas turbine, powering a waterjet unit. This would boost the maximum speed to 45kt.

In 1976 the Italian navy ordered another six hydrofoils from Cantieri Navali Riuniti. The first of these, the *Nibbio*, was completed at the beginning of 1980, and the entire fleet was scheduled to be delivered by the end of last year. Modifications include the adoption of a water-injection system on the *Proteus* gas turbine. When required, for take-off in hot / overload conditions or to maintain foilborne operation in marginal seas, for instance, this system can be used to boost the output of the gas turbine by an additional 370kW (500shp).

The *Nibbio* and subsequent hydrofoils of the class also have a more streamlined superstructure with additional space, different waterjet intakes, a new design of waterjet pump and rationalised control and electrical systems. Some of the changes have already been introduced on *Sparviero*.

To support the hydrofoils, a mobile logistic-support unit has been designed and built. This consists of a support-crew car, diesel-generator unit, electric and hydraulic-power distribution module, electrical and mechanical-workshop module, secretarial-office module and spare-part storage module. The unit is designed to support two hydrofoils at any one time, carrying out routine maintenance and general repairs.

Grumman's Flagstaff MkII

Following the experience gained from *Flagstaff*, Grumman Aerospace produced proposals for a derivative, the *Flagstaff* MkII. This has more installed power, a longer hull, a modified foil system, a new automatic control system and a new foilborne-propulsion transmission. The first craft, ordered by the Israeli navy, was launched in the United States last summer. A second is under construction at Haifa. A decision from the Israeli navy on how many of the class will be built under licence in Israel will depend on the results of evaluation trials with the first two, named *Shimrit* and *Livrit*, respectively. The hull is of welded aluminium alloy and, as on *Flagstaff*, the foil arrangement consists of two inverted-T foils forward and a single inverted-T foil aft. All three are machined from solid forged aluminium. The supporting welded-steel struts are retractable and the aft one rotates through ±5° for steering.

The main engine, an Allison 501KF gas turbine rated at 4,000kW (5,400shp), drives a variable-pitch, four-bladed stainless-steel propeller through a Z-drive transmission. Hullborne power is provided by two 75kW (100hp) diesels and retractable propeller outdrives. Two Pratt & Whitney ST6 gas turbines supply the auxiliary power. The Israeli craft will be crewed by about 15 men, but there will be no berthing and only the minimum of messing facilities. The weapon fit comprises two *Gabriel* missiles, four longer-range *Harpoon* missiles (or any other combination of the two, with the same weight) and an Emerson *Emerlec* twin 30mm mount.

◄ The Messina shipyard Rodriguez (also known as Navaltecnica) has built almost 150 hydrofoil ferries with surface-piercing foils rather than the fully submerged foils of the Boeing and Grumman craft. The largest hydrofoil to be built at Messina is the RHS200, the first of which (photo) entered service in 1981. Rodriguez has for some time been proposing a range of military designs based on its commercial craft, the largest of which, the M600, is based on the RHS200.

Military Jetfoils

Two other countries, the United Kingdom and Indonesia, have decided to evaluate the potential of the hydrofoil by putting a Boeing *Jetfoil* into service. The first to be commissioned, by the Royal Navy in June 1980, was HMS *Speedy*. The order followed trials with a standard passenger *Jetfoil* at Rosyth and Portsmouth and the submission of a report by Boeing Marine Systems, at the request of the Royal Navy, on the suitability of the vessel for fishery protection duties in the North Sea.

The report concluded that continuous foilborne operation would be possible in the North Sea for 90% of the year and in the North Atlantic, off the coast of Scotland, for more than 80% of the year. During the winter months, it was estimated, the figures would fall to 85% and 72%, respectively. It was anticipated that a cruising speed of 43kt could be maintained for 85% of foilborne time, 40kt for 93% and 38kt for approximately 96%.

HMS *Speedy* is essentially a commercial *Jetfoil* 929-115 with a modified superstructure and propulsion system. The upper passenger saloon aft of the bridge has been removed to provide a deck measuring 4.9×7.3m. This is fitted out with two davits carrying Avon *Searider* rigid-hulled inflatables for use as boarding boats. In addition to the two normal Allison 501K20A 2,800kW (3,750shp) gas turbines and Rocketdyne R20 waterjets, the hydrofoil has a secondary propulsion system of two General Motors 8V92TI diesels rated at 410kW (550bhp) each. These power the waterjets during hullborne operations at up to 15kt.

The usual crew is made up of four officers and 13 ratings. HMS *Speedy* has a communications room, commanding officer's cabin, officers' cabin, wardroom, senior and junior ratings' cabins, ratings' mess and galley. Equipment includes a Decca CANE computer-aided navigation system with automatic plotter, Decca Navigator, radar, depth recorder, VHF / UHF transceiver and HF direction finder. No armament is fitted.

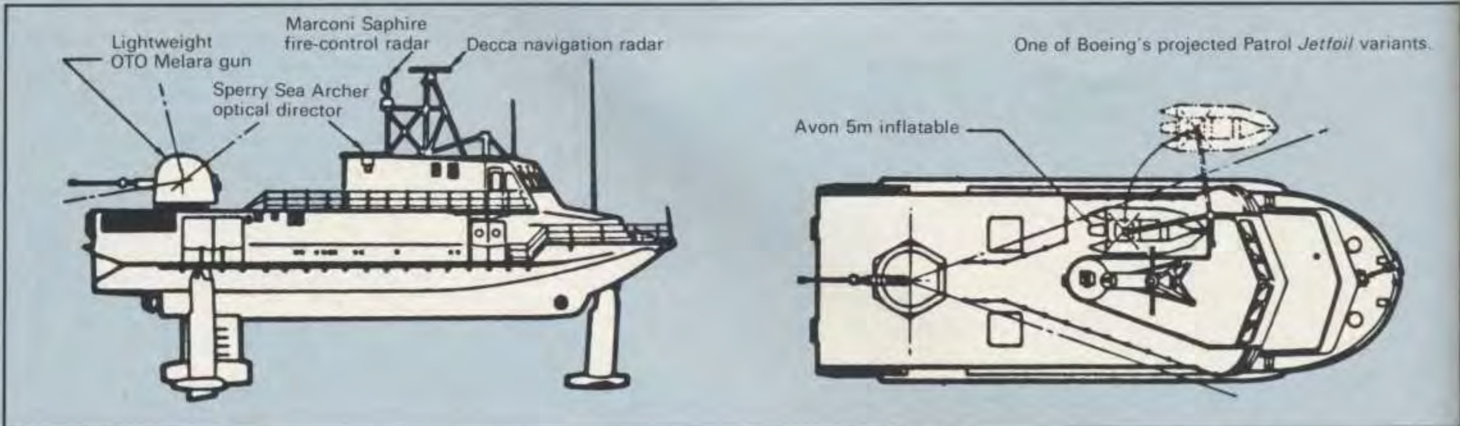
Initial evaluation has concentrated on the protection of offshore fisheries and oil / gas installations. After a working-up period at Portsmouth, the vessel was allocated to the Fishery Protection Squadron. It has since operated in the North Sea, South-West Approaches and Irish Sea. Towards the end of 1980, it was based in Kiel for a short trials period in the Baltic on behalf of the German Navy.

The Boeing *Jetfoil* 929-115 recently delivered to Indonesia, *Bima Samudera* I, is virtually a standard commercial hydrofoil. Ordered by the Ministry of Research and Technology, it is to be operated by the Agency for the Development and Application of Technology. The craft is likely to be first used on customs patrols in the South China Sea. To increase endurance on this and other evaluations, *Bima Samudera* I has the increased fuel capacity of the projected Patrol *Jetfoil* range. (Boeing Marine Systems has developed designs for several Patrol *Jetfoil* variants, some of them featuring redesigned superstructures. These could be fitted out to carry a small helicopter, boarding boats, containers, an OTO Melara 76mm gun or missile launchers.)

▼ The HYD-7, a Boeing Marine Systems proposal for a future generation of large hydrofoils.

The French hydrofoil program

Another country understood to be considering the purchase of a *Jetfoil* last year was France. The version involved would have a modified propulsion system with a propeller replacing the waterjet, but an order does not appear to have been placed. The French navy has been investigating the use of hydrofoils for some 15 years. One design produced by the Direction Technique des Constructions Navales is the 185t *Saphyr* (see *IDR* No.1/81, pp.101-102).



One of Boeing's projected Patrol *Jetfoil* variants.

Designed to be powered by two Allison 570KA 5,350kW (7,170shp) gas turbines, each driving a pod-mounted propeller, *Saphyr* would have a maximum speed of over 50kt. At a cruising speed of 40kt, a range of 740n.m. would be achievable. Using a hullborne propulsion system based on two diesel-powered Z-drive Schottel units, the *Saphyr* could travel up to 2,400n.m. at 10kt. Armament could include four *Exocet* surface-to-surface missiles.

Swiss hydrofoil designs

Supramar Hydrofoils, a Swiss-based company more normally associated with surface-piercing foil systems, has also released preliminary details of two military designs with fully submerged foils. The largest, the Supramar MT250, would displace 250t and have a maximum speed of 60kt. A Rolls-Royce 18,500kW (25,000shp) *Olympus* gas turbine driving a Rocketdyne *Powerjet* 46 waterjet would give a range of 400n.m. at a cruising speed of 55kt. Two MTU diesels driving propellers would increase the range, at 13kt, to 1,800n.m. Supramar's other design, the 85t MT80, would have similar ranges. Maximum speed from a Rolls-Royce *Proteus* driving either a waterjet or a propeller would be 53kt.

Proposals for the future

The US Navy, too, is interested in larger hydrofoils, and both Boeing Marine Systems and Grumman Aerospace have completed design studies for vessels of up to 1,500t. A Destroyer Escort Hydrofoil proposed by Boeing would be able to carry out open-ocean missions and cross the Atlantic without refuelling. A similar-sized Ocean Hydrofoil Combattant from Grumman would have a range foilborne of some 3,000n.m., a maximum speed of more than 50kt and be capable of maintaining foilborne operations in sea state 6. Another Grumman proposal to the US Navy, the HYD-2, would displace 2,400t and could carry two LAMPS helicopters. The total installed power of the primary propulsion system would be 64,000kW (86,000shp) and, as with other large-scale hydrofoil designs, one of the major development problems would be to design a compact, lightweight drive capable of transmitting this power.

A project which may be closer to realisation is the Extended Performance Hydrofoil. For the past two years, the David Taylor Naval Ship R&D Center has been investigating the possibility of increasing the range of hydrofoils by fitting a long, slender buoyancy/fuel tank beneath the foil system. Approximately 50% of the total foilborne lift would be supplied by the tank, permitting a lower foilborne cruise speed without a large reduction in possible maximum speed.

Model tests have indicated that a buoyancy/fuel tank should increase endurance at speeds of 10-20kt by 25-100%, reduce efficient foilborne speeds by 5kt and, particularly on bigger hydrofoils, increase foilborne endurance significantly. An additional benefit, because the vessel would be less weight-sensitive, is an increase in payload.

Trials with a full-size vessel have now been programmed. The US Navy's first large hydrofoil, PCH-1 *High Point*, is to return to the Bremerton Shipyard for the installation of a buoyancy/fuel tank. Next year, at a maximum displacement increased from 131 to 200t, it will be put through a series of hullborne and foilborne trials in conditions up to sea state 5. ++

▼ The Royal Navy's HMS *Speedy*, a Boeing *Jetfoil* fitted out by Vosper Thornycroft with a Decca CANE navigation system, an auxiliary diesel propulsion installation and two Avon *Searider* semi-rigid inflatables for evaluation as an offshore patrol vessel. The Indonesian government has also recently ordered a *Jetfoil* for evaluation purposes (see cover photo).