International Hydrofoil Society

50th Anniversary

Virtual Conference and Celebration

October 2020

U.S. Navy Patrol Hydrofoil - Missile (PHM) Program Retrospective



Mark R. Bebar markbebar@juno.com

Vice-President, International Hydrofoil Society

www.foils.org

IHS 50th Anniversary Celebration

October 2020

Outline

- Program Beginnings
- PHM-1 Lead Ship Production
- PHM Design
- Program Evolution
- Follow Ship Construction
- Squadron Operations
- Decommissioning – July 1993
- USS Aries (PHM-5) Museum – Gasconade, Missouri, USA

PHM Beginnings - 1

- First U.S. Navy ship program to complete all aspects of design, construction, technical evaluation and independent operational evaluation as required by U.S. DoD "fly-before-buy" policies.

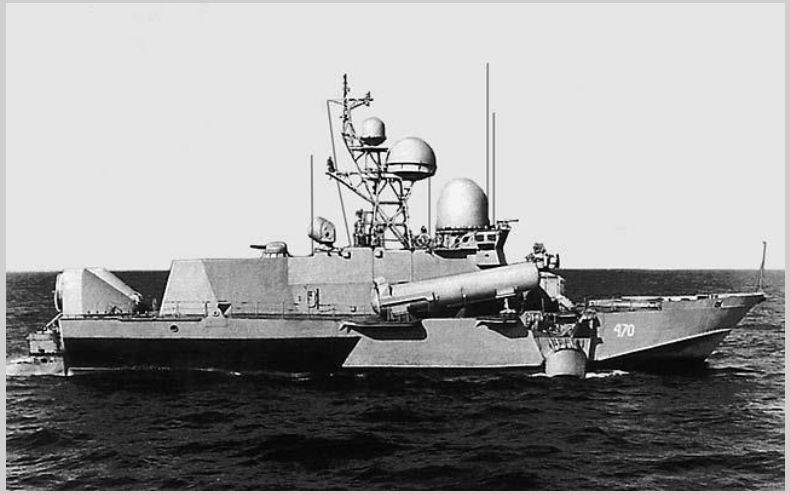
- Extensive pre-delivery test and evaluation on PHM-1, including problem resolution and corrective actions, accounted for more than 2.5 years from launch to delivery.

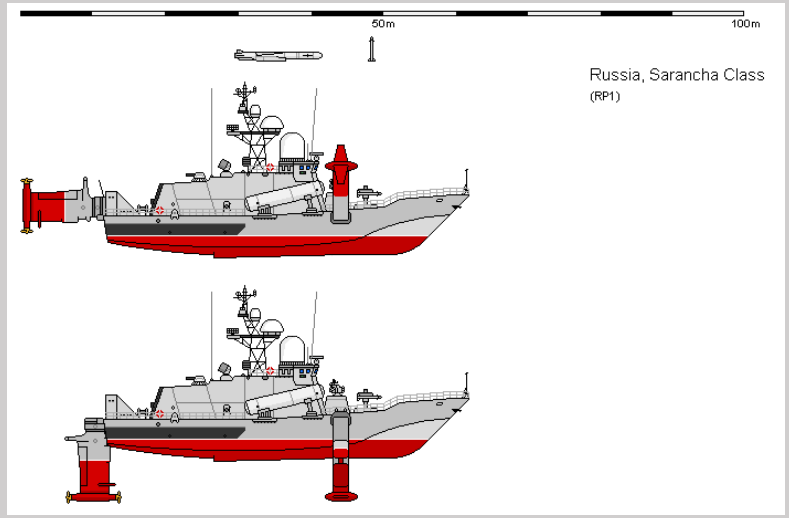
PHM Beginnings - 2

- Need for relatively small, fast ships to counter Soviet/Warsaw Pact missile boats like Soviet hydrofoil *SARANCHA* identified by NATO in the late 1970's.

- NATO analysis led to agreement among the US, West Germany and Italy in 1972 for design, development and acquisition of the NATO PHM .

- Program strongly supported by Admiral Elmo Zumwalt, U.S. Navy Chief of Naval Operations (CNO). PHM would play a major role in his "high-low mix" vision for the U.S. Navy's shipbuilding program.





PHM Beginnings - 3

NATO-agreed basic operational characteristics for PHM

- Displacement: 250 Metric Tons
- Length: 132.9 ft
- Beam: 28.2 ft (hull) 47.5 ft. (foils)
- Propulsion: 1- LM-2500 gas turbine w/waterjet pump (foilborne)
  2- MTU diesels w/waterjet pumps (hullborne)
- Crew: 4 Officers / 19 Enlisted
- Foilborne Speed : 40+ knots/Sea State 0; 40 knots/Sea State 5
- Hullborne Speed : 11 knots/Sea State 0
- Range: 750 nautical miles foilborne/1200 nautical miles hullborne
- Draft: 7.5 ft (foils raised) / 23ft (foils lowered)

PHM Beginnings - 4

- Two NATO production variants (Germany and Italy) were to be very similar with primary differences in combat suites and certain internal arrangements.
- US Variant to be outfitted with US Harpoon surface-to-surface missile, mounted aft.
- German Variant would mount French Exocet missiles in a similar configuration, as shown in the lower figure.





PHM Beginnings - 5

- Initial plan: 30 PHMs, reduced to 25 in 1974, then to 6 in 1975.
- Italy announced in 1974 that they would not enter PHM production but would continue to participate in design and development.
- Germany remained a full partner in development as well but deferred any production decision until the US decision would be made.

PHM-1
USS Pegasus

- Built by Boeing Marine Systems (BMS), Seattle, Washington
- Launched: June 1974
- First foilborne flight: February 1975
- Commissioned: July 1977
- Operational: July 1977 – July 1993
- Decommissioned: July 1993







PHM-1 Production

- PHM-1 began the most extensive technical and operational evaluation (TECHEVAL/ OPEVAL) of any US Navy ship at that time.



- PHM-1 shown here successfully launching a HARPOON missile in Sea State 3.





USS PEGASUS Launching



USS PEGASUS on Cradle

PHM-1 Launch
Renton, Washington - June 1974

PHM Class Characteristics

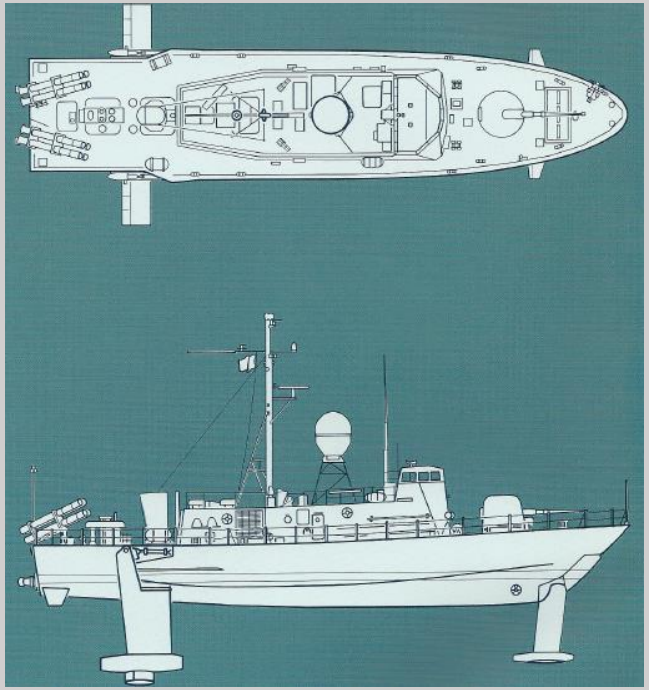
Pegasus Class—General Characteristics and Principal Subsystems

Dimensions	Length overall, foils down	40.5 meters
	Beam, main deck	8.6 meters
	Overall aft foil span	14.5 meters
	Draft, foils up	1.9 meters
	Draft, foils down	7.1 meters
	Height of bridge, hullborne	6.8 meters
	Height of bridge, foilborne	11.1 meters
	Full-load displacement	241.3 metric tons
Foilborne propulsion	1 General Electric LM2500 gas turbine engine 1 Aerojet Liquid Rocket Company waterjet propulsor	
Foilborne speed	In excess of 40 knots	
Hullborne propulsion	2 Motoren-und Turbinen-Union (MTU) 8V331TC81 diesel engines 2 Aerojet Liquid Rocket Company waterjet propulsors with nozzle steering and reverser assemblies	
Hullborne speed (diesels only)	11 knots	

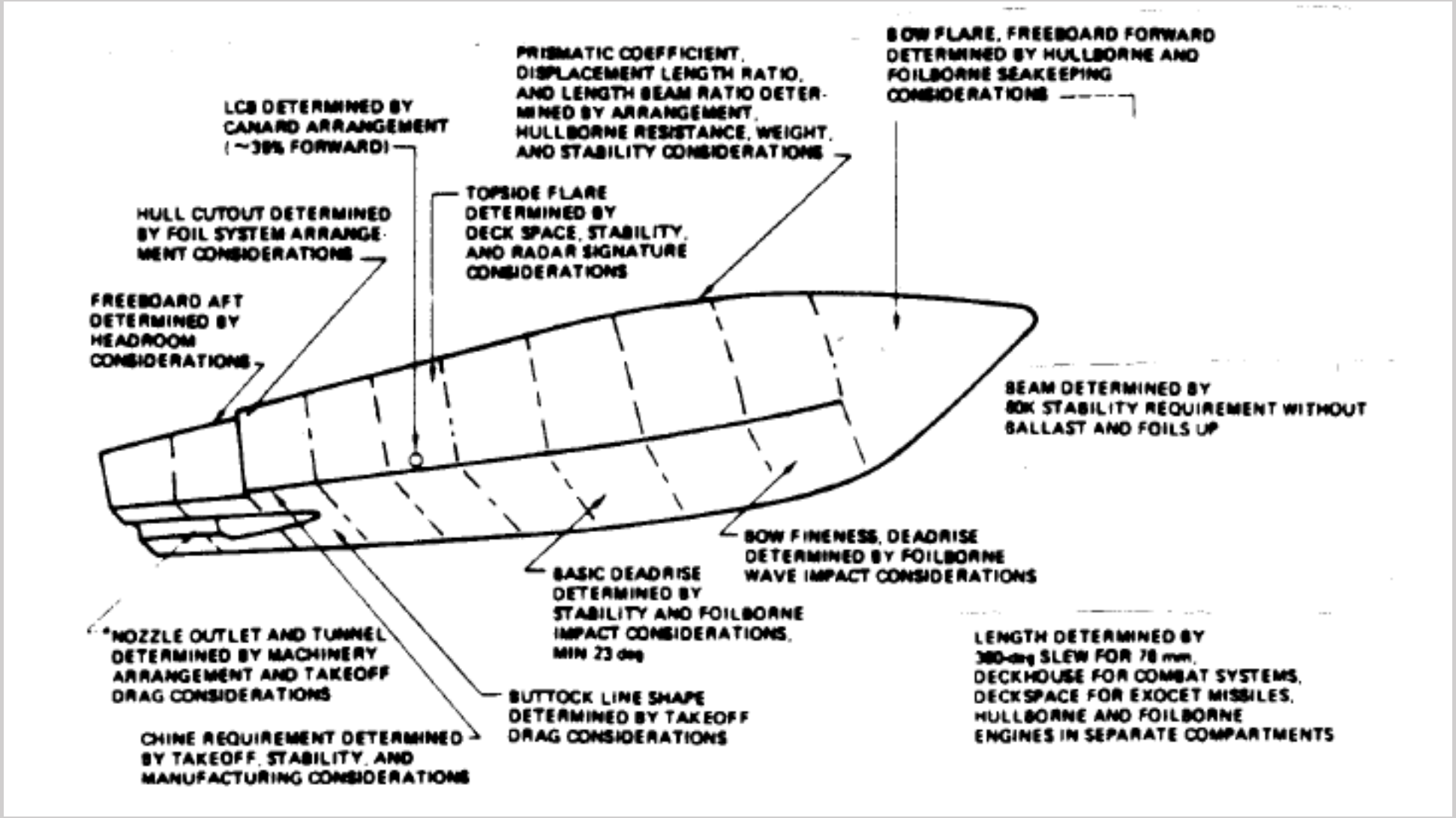
Electrical	2 AiResearch ME831-800 gas turbine engines, each driving a 450V ac, 250-kVA (200 kW), 400-Hz, 3-phase generator
Fuel	Diesel oil per MIL-F-16884 (NATO F-76) or JP-5 per MIL-T-5624 (NATO F-44).
Hull	Welded 5456 aluminum
Foils and struts	Welded 17-4PH corrosion-resistant steel
Accommodations	24 berths
Complement	23 officers and enlisted men
Provisions	5 days (nominal)
Total Payload*	36.3 metric tons
Mission Load**	87.9 metric tons

*Includes payload portion of Command Surveillance, Armament, and Military Loads.

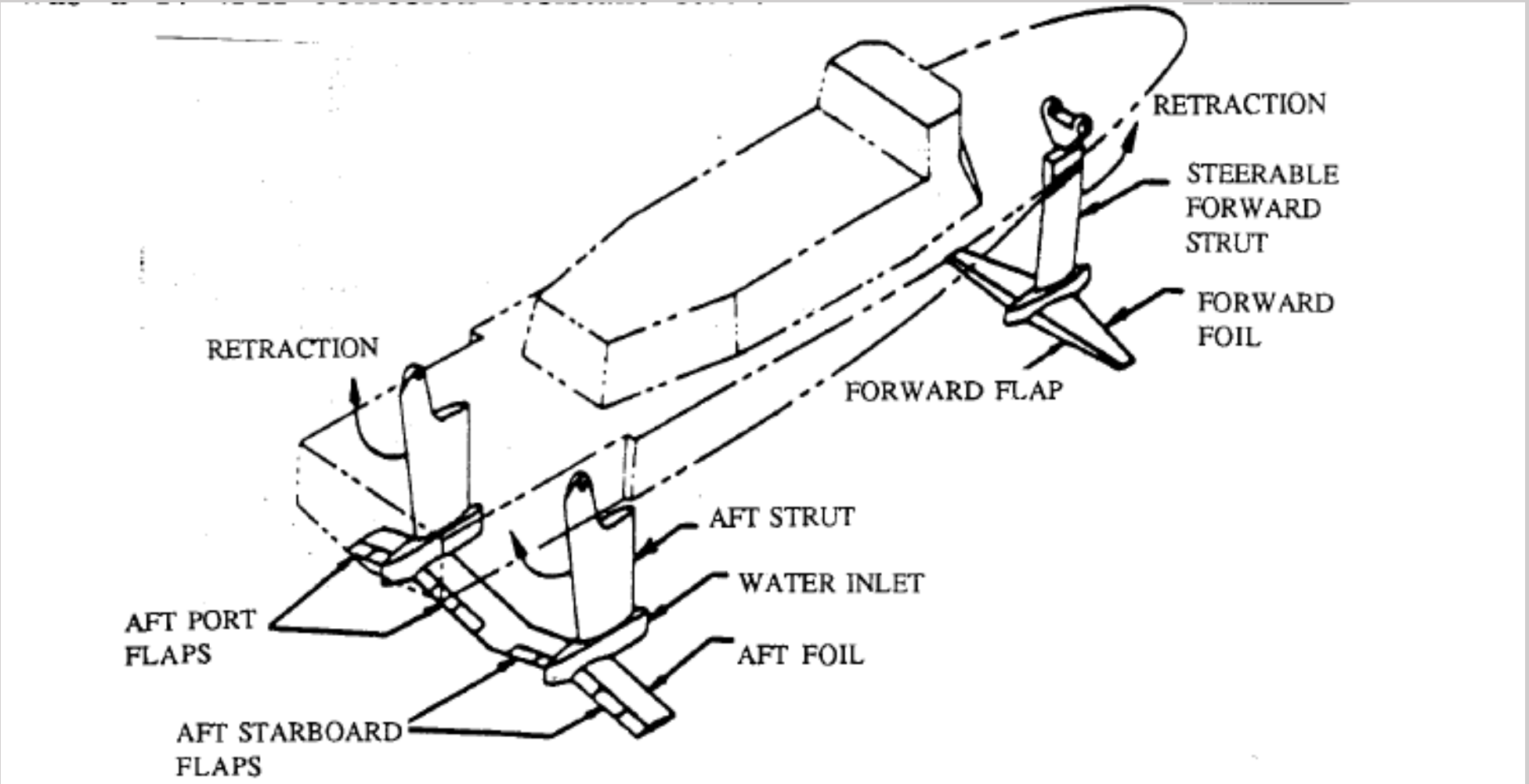
**Includes Total Payload plus crew, provisions, water, and fuel.



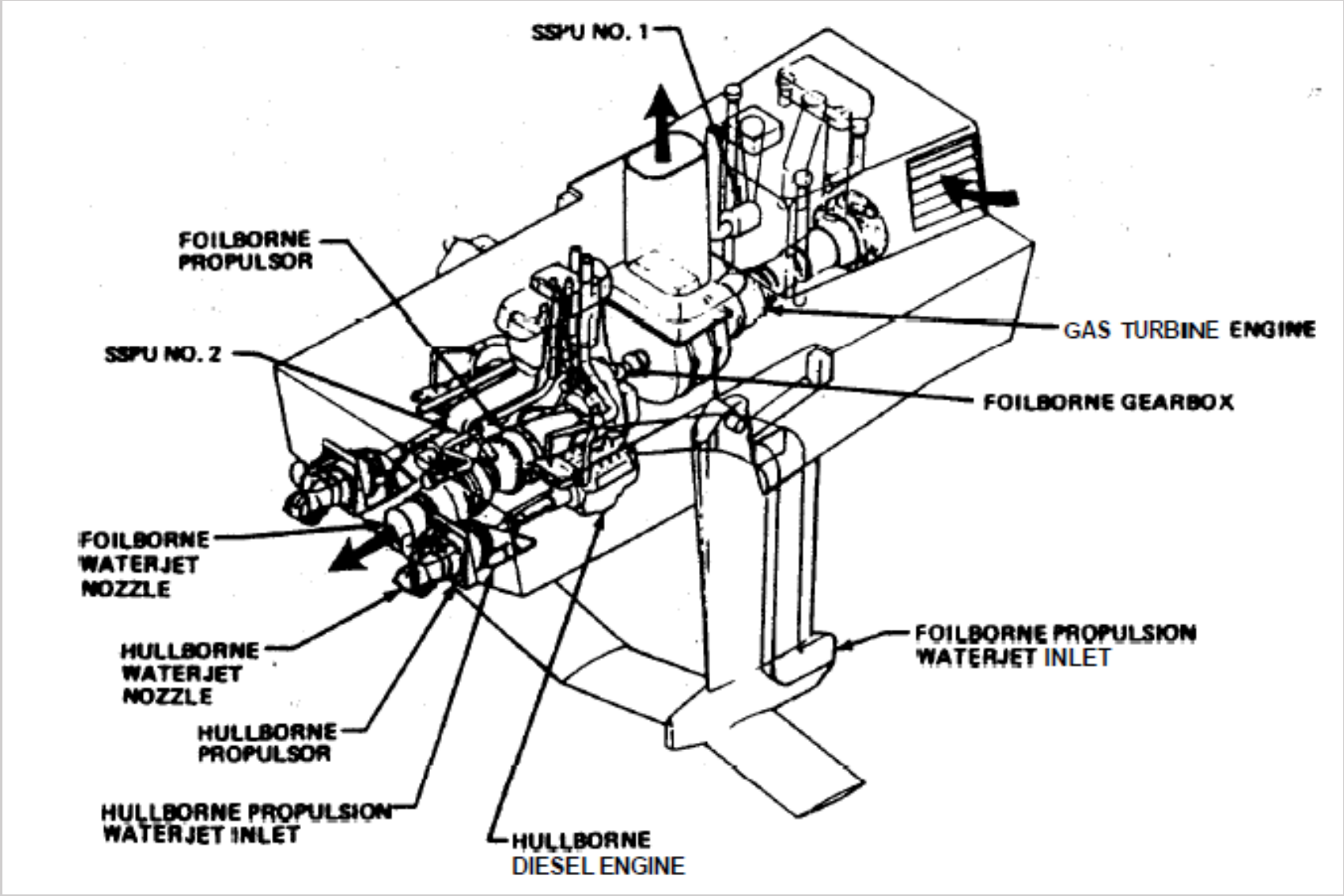
PHM – Hullform Design Considerations



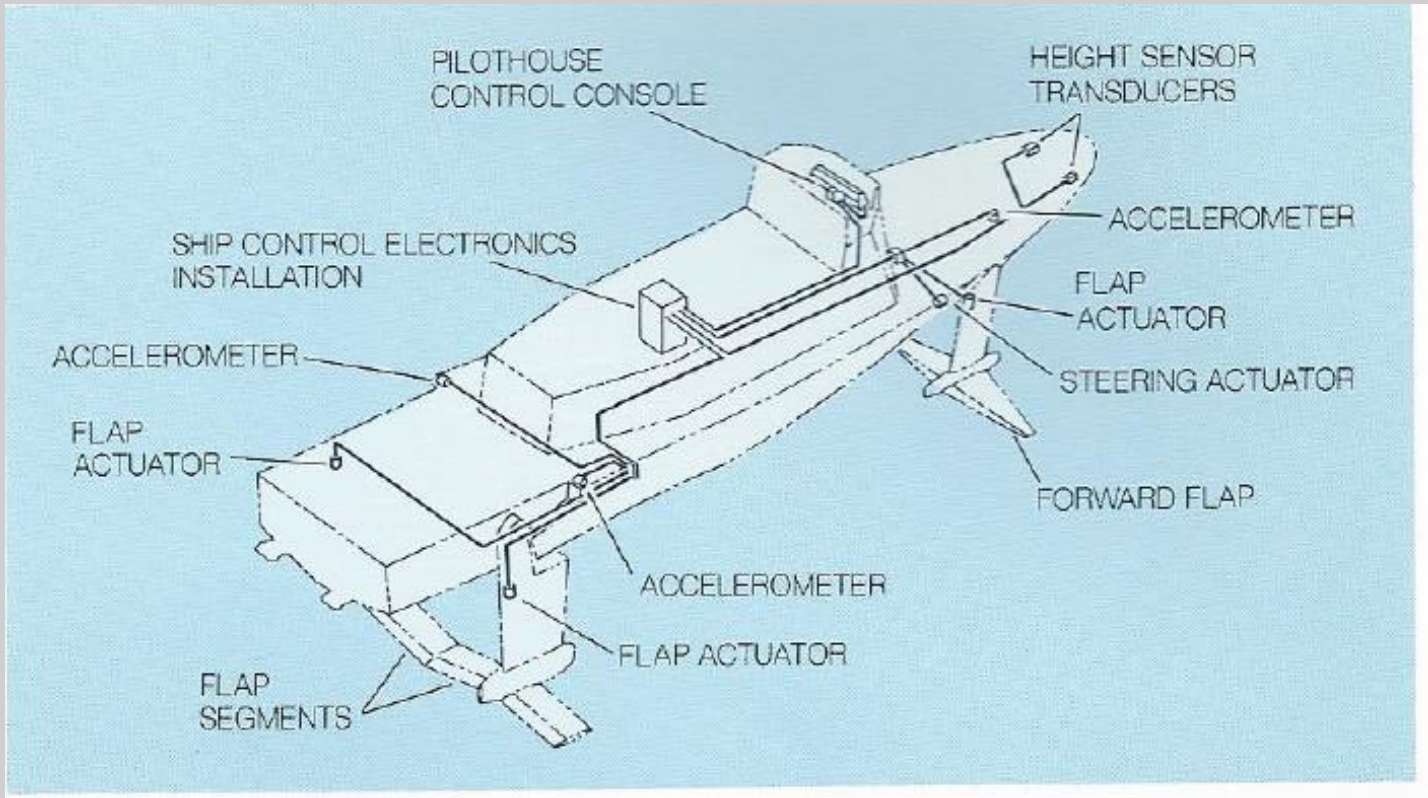
PHM – Foil System Configuration



PHM – Propulsion System Arrangement



PHM Automatic Control System (ACS)





The automatic control system (ACS) provides continuous computerized dynamic control of the ship during takeoff, landing, and all foilborne operations. The only inputs required are mode selection, foil depth setting, foilborne throttle setting, and steering.

PHM – Program Evolution

- At completion of OPEVAL (summer 1976) PHM-1 had traveled over 25,000 miles (40,000 km), essentially once around the world.

- In 1975 the U. S. Navy program was reduced to 6 ships; *PEGASUS*, plus four ships for which funding had been appropriated in 1975, plus completion of *HERCULES* (appropriated in 1976).

- In May 1977, two months before the Congress reinstated the program, the German Navy announced its decision not to procure PHMs, effectively ending the NATO aspect of the program. Germany maintained that their decision was based on unit cost.

- Germany later built conventional fast patrol boats (S-143 Class).

PHM – Program Evolution (2)

- OPEVAL identified significant technical issues on PHM-1
- Boeing/Navy design modifications incorporated in PHM-3 Series follow ships (built to a detailed specification approved by the Navy).
- Major design areas:
  - Hull structural producibility
  - Strut and foil system: fatigue life, hydrodynamic performance and producibility
  - Foilborne gearbox and waterjet pump
  - 400 Hz to 60 Hz static frequency converters
- Design modifications added about 6 metric tons to Full Load Displacement and required uprating LM-2500 gas turbine, foilborne waterjet pump, foilborne gearbox and refinement of foil system structural design.

PHM-3 Series Follow Ships

- *USS HERCULES PHM-2*: Commissioned July 1982



- *USS TAURUS PHM-3*: Commissioned Oct 1981



PHM-3 Series Follow Ships (2)

- *USS AQUILA PHM-4*:
  Commissioned Dec 1981



- *USS ARIES PHM-5*:
  Commissioned Apr 1982



PHM-3 Series Follow Ships (3)

- *USS GEMINI PHM-6*: Commissioned June 1982



PHM Squadron Operations (1)

- *PEGASUS* home-ported initially at Little Creek, Virginia in 1979, awaiting arrival of sister ships.
- 1980: PHM-1 homeport shifted to Key West Florida so she could participate in the US Navy's contribution to the "War on Drugs" while awaiting delivery of PHMs 2-6.
- Production ships and the shore-based, but transportable PHM Mobile Logistic Support Group (MLSG) were delivered to Key West over the next three years, with the full squadron (PHMRON TWO) constituted in Spring 1983.







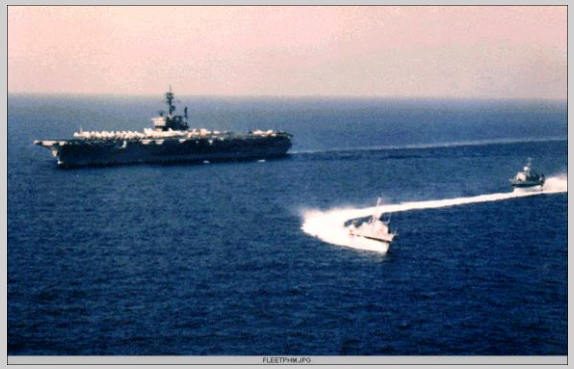
PHM Squadron Operations (2)

PHM Operations

- WAR - Grenada
- Battle Group Workups
  - Usually "Orange Force"
- Port Visits
  - East Coast/Carib/GOM Ports
- Developed Fast Ship Tactics
  - With USN and Foreign Navies
- Trial Deployments

Counter Drug OPS

- 3% of Navy Ships Accounted for 30% of Navy-assisted "Busts"
- 225,000 Lb MJ, 12,000 Lb Cocaine
  - Street Value $1.2 Billion
- Received 22 Unit Awards from USCG
- PHM is: "Superior Platform, . . . The Most Effective Surface Asset . . ." (in Many Counter Drug Scenarios)
  -- Commander USCG District 7 (AUG '92)







PHM Squadron Operations (3)

Why Was the PHM So Effective?

SPEED

- Could Cover Larger Areas in Shorter time
- Faster Turnaround Between Station and "Home Plate"
- Could Intercept Other High Speed Craft

SUSTAINED HIGH SPEED IN SEA STATE

- Speed Advantage Not Degraded in Bad Weather
- Tailchases Can Succeed, Even Against Faster Ships

PHM Squadron Decommissioning – July 1993

- Despite the remarkable contribution these ships made to U.S. national objectives , the Navy decided in June 1993 to decommission them., citing their expense to operate.

- Since PHM operating costs were very modest – about 1/3 the cost/ship of the FFG-7 Class), PHM advocates believe the 6 PHMs were sacrificed early in the post-cold war naval drawdown to avoid loss of an equal number of larger, more capable ships.



USS Aries (PHM-5) Museum - Gasconade, Missouri

- Website: http://www.ussaries.org/

- USS Aries Hydrofoil Memorial, Inc., is a non-profit organization created for the preservation, and rehabilitation of the only remaining Patrol Hydrofoil Missile (PHM) Ship and is a member of the Historic Naval Ships Association and the International Hydrofoil Society.



- The Aries is quite complete and utilizing the original MTU diesels, she is capable of getting underway hullborne. The museum's goal is to return her to flying condition.

- Over the years the museum's mission has expanded to include other hydrofoils, both military and civilian, domestic and international. The fleet of hydrofoils has grown to over 7 , including , many of which have been restored to flying condition. This includes the 1960's era Boeing-built *LITTLE SQUIRT* test craft.

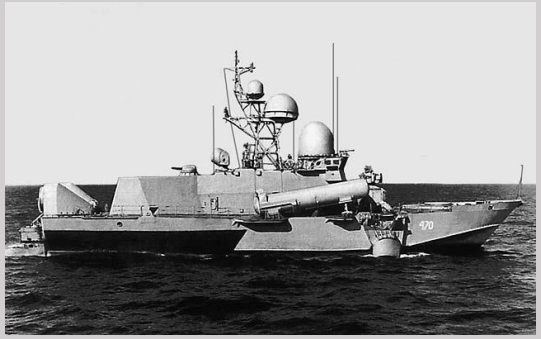
Backup Slides

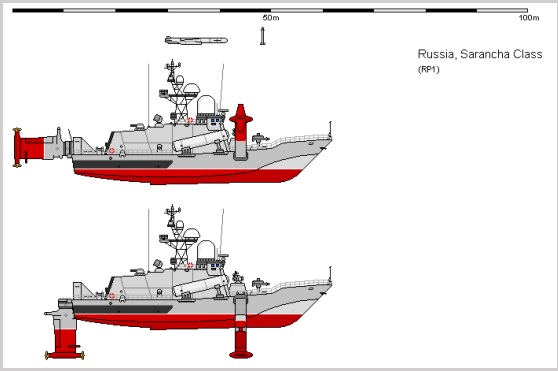


Soviet *Sarancha* Class Hydrofoil

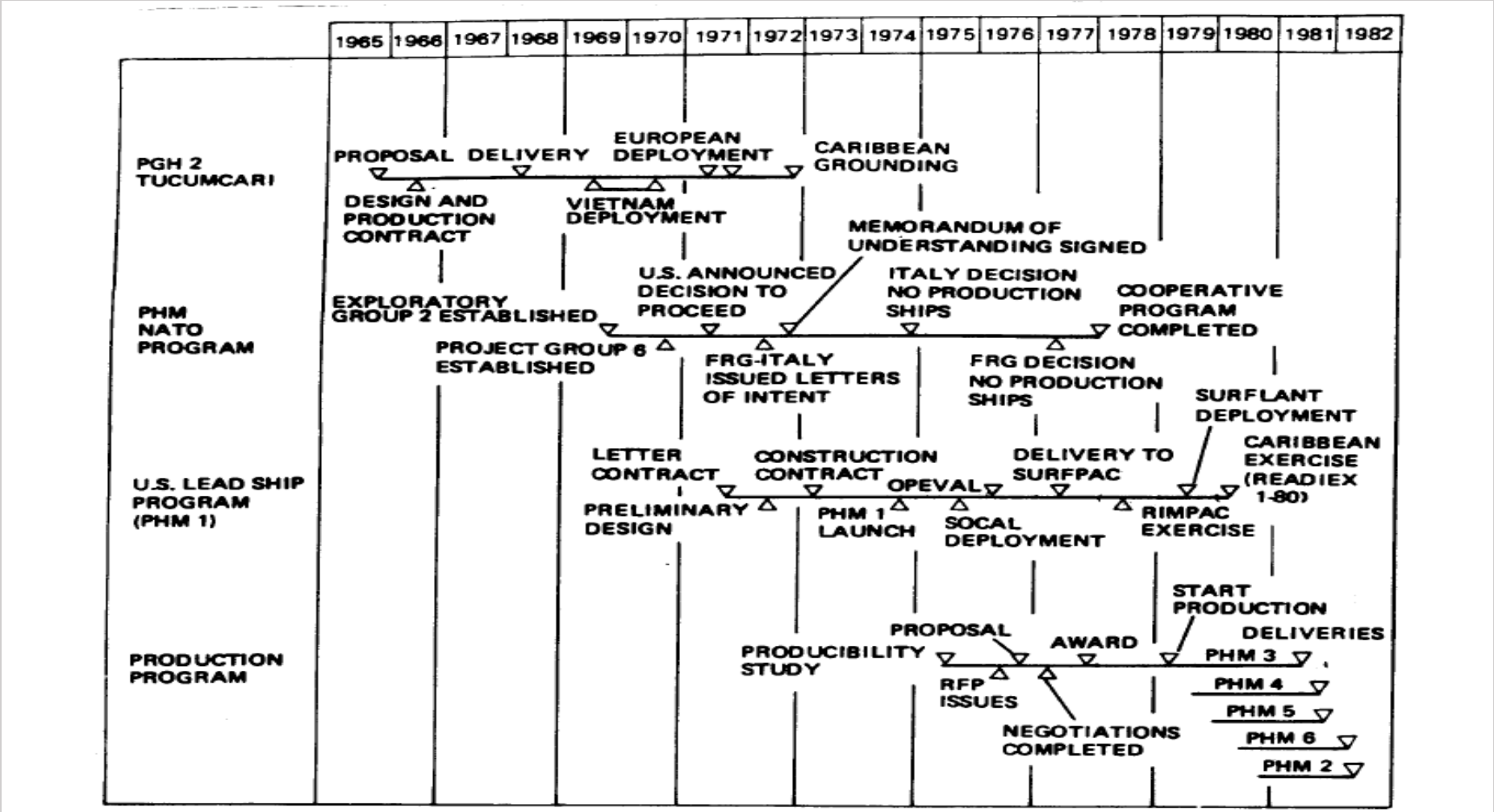
(Built: 1973 / In commission: 1977-1990)

General characteristics	
Type:	**hydrofoil missile boat**
Displacement:	**280 tons standard, 320 tons full load**
Length:	**53.6 meters**
Beam:	**31.31 meters**
Draught:	**2.6 meters (7.3 meters/oils extended)**
Propulsion:	**4 shafts , 2 gas turbines (30,000 hp) and 2 diesels**
Speed (calm water):	**58 knots (107 km/h)**
Range:	**700 nautical miles (1,300 km)**





PHM – Program Evolution



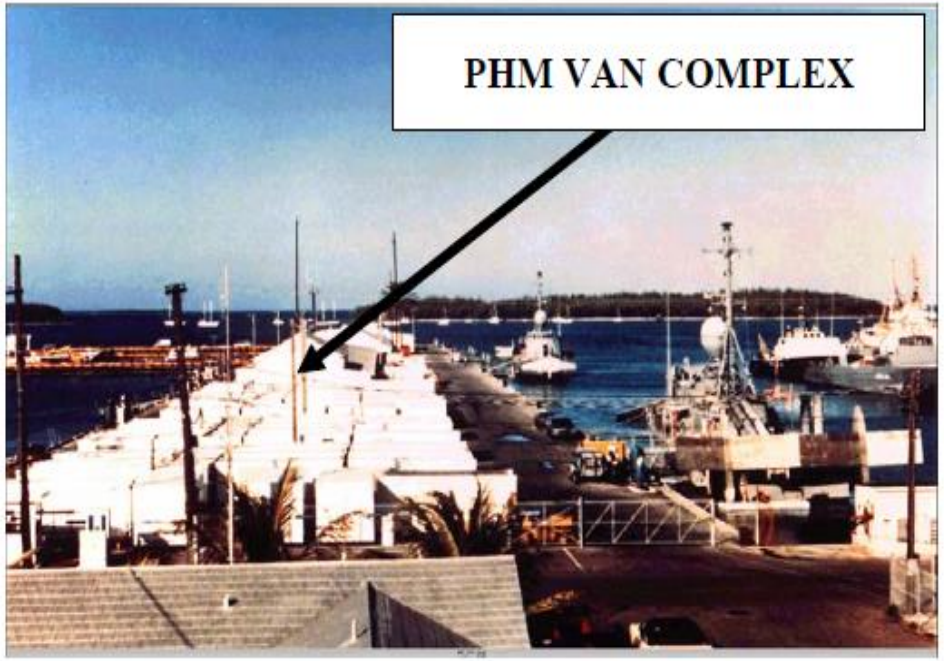
Major Events Leading to the Operational PHM Squadron

NATO PHM MILESTONES

- Nov 72: NATO PHM Program Office and Steering Committee Formed (US, FRG and Italy)
- Contract Let to Boeing Marine Systems for Two Lead PHMs
- Nov 74 PEGASUS (PHM-1) Launched
- 1975: Funds to Build PHM 3-6 Appropriated.
- 1976/1977: Funds to Complete PHM 2 Appropriated

PHM Squadron Logistic Support

PHM Logistic Support



PHM Logistic Concept

- Ships Manned Only To Operator Level (Port & Stbd Watch Sections)
- Clerical, Personnel , Supply, Disbursing, Inport Berthing/ Messing, Training And All O/I Level Maintenance Except Daily PMS, Performed Off-Ship By PHM Mobile Logistic Support Group (MLSG)
- 4 Officers/150 Enlisted
- Housed in Transportable Complex of 70 8'x 8' x 20' ISO Vans
- PHM Unique Parts Control (63% of COSAL), Expanded Planning Yard and ISEA, "Privatized" Under Contract to Builder (Boeing)

German Navy Type 143 Fast Attack Craft

Displacement:	**398 long tons (404 t)**
Length:	57.80 m (189 ft 8 in)
Beam:	7.80 m (25 ft 7 in)
Draught:	2.60 m (8 ft 6 in)
Propulsion:	4 shafts, 4 MTU 16V 956 TB91 diesels 17,700 hp (13.2 MW)
Speed:	40 knots (74 km/h; 46 mph)
Range:	1,300 nmi (2,400 km; 1,500 mi) at 30 knots (56 km/h; 35 mph)
Complement:	40

The German Navy retired the class in 2005 and sold the boats off to Tunisia and Ghana.

Source: https://en.wikipedia.org/wiki/Albatros-class_fast_attack_craft



Italian *Sparviero*-Class Hydrofoil Patrol Boat



Displacement:	**60.6 tons full load**
Length:	22.95 m (75 ft 4 in) 24.56 m (80 ft 7 in) (hydrofoils retracted)
Beam:	7.01 m (23 ft 0 in)
	1.87 m (6 ft 2 in) 1.45 m (4 ft 9 in) (on foils at speed)
Speed:	**93 km/h (50 kn)**
Range:	740 km (400 nmi) at 45 kn (83 km/h) 1,940 km (1,050 nmi) at 8 knots (15 km/h)
Complement:	10 (2 officers)

Source: https://military.wikia.org/wiki/Sparviero-class_patrol_boat

Presenter – Mark Bebar



- B.S. , Naval Architecture and Marine Engineering – Webb Institute of Naval Architecture (1970)
- M.S., Ocean Engineering – Massachusetts Institute of Technology (1973)
- U.S. Navy Department (1970 – 2003) – Naval Ship Engineering Center (NAVSEC) and Naval Sea Systems Command
- **PHM Concept Studies/PHM-3 Series Design Integration Manager (1971 – 1972, 1975 - 1978)**
- Preliminary/Contract Design: AO-177 Fleet Oiler (1973 – 1974), ARS-50 Salvage Ship (1979-1981)
- High Speed Sealift Action Officer Group Coordinator (2010-2014)
- Force Architecture/Ship Concept Studies Support – Navy Warfare Development Command and CNO Strategic Studies Group: 1998 – 2002
- Chairman – NATO Naval Group 6 on Ship Design: 1996 – 2002
- Computer Sciences Corp (CSC) and CACI – Professional Adviser (2003 – present)