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HYDROGRAPHIC SURVEY CATAMARAN FOR THE PORT OF LIVERPOOL

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ABSTRACT

This article discusses the reasons for choosing a twin hull vessel for port surveys, describes briefly the vessel subsequently built and comments on her performance.

INTRODUCTION

The Mersey Docks and Harbour Company operates a fleet of vessels engaged in buoyage, hydrographic surveying and dredging work in and adjacent to the port of Liverpool. As part of a fleet renewal/replacement programme spanning 5 years, it was decided to replace two existing survey craft with one vessel. A study was carried out into the work requirements of the proposed new vessel, from which a design was commissioned, followed by tank testing of a model and subsequent building.

DESIGN STUDY

Existing vessels

The proposed new vessel was to replace two existing survey craft – one, a 25 metre steel hulled vessel built in 1949 with a permanent crew of 7 men, the other,

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a 12 m G.R.P. launch built in 1970 as a combined harbour patrol/survey launch with a crew of 4 men. One or two Surveyors were carried on each vessel in addition to the crew.

The larger vessel was engaged exclusively in surveying the seaward approaches to the port up to 18 miles from base, and the smaller vessel generally surveying in the River Mersey up to 6 miles from base in conjunction with two other 12 m wooden launches which were to be retained. All survey vessels operate on a day work basis.

The larger vessel was expensive to crew and maintain and was not sufficiently manœuvrable for large scale surveys off tidal berths and in the confined areas of the River Mersey.

The requirement for the smaller launch to carry out harbour patrol work no longer existed and, at slow speeds, she had not proved to be entirely satisfactory for carrying out hydrographic surveys.

Proposed new vessel

By replacing two vessels with one, considerable financial benefits would result from reduced payroll and maintenance costs. The new vessel would be required to carry out the combined duties of the other two.

Typical duties of new vessel

1. Hydrographic surveys up to 5 hours' duration in coastal waters and sea approach channels, with a maximum distance of 18 miles from base to survey area.
2. Hydrographic surveys up to 2 1/2 hours' duration in river, with a maximum distance of 6 miles from base to survey area.
3. Hydrological observations of up to 13 hours at anchor.
4. "First-aid" navigational buoy maintenance, i.e. re-lighting or changing gas bottles, involving lying alongside first class buoys for up to one hour.
5. Estimated annual work requirement 180 days.

Design Priorities

Based on the duties which were to be performed, the following priorities were established for the "ideal" type of vessel :

1. Stable and manœuvrable at slow speeds with good seakeeping.
2. Large combined wheelhouse and chartroom with excellent all round visibility and upward vision when working close to quays and jetties at low water (tidal range maximum 10.5 metres).
3. Minimum squat and draught commensurate with size of vessel.
4. Economical to crew, maintain and operate.

5. Robust hull and decks for buoy maintenance.
6. Maximum deck space for hydrological and buoy work.
7. Day-work crew accommodation above deck to modern standards.
8. Mechanical lifting capability for hydrological and buoy work.
9. Displacement not to exceed 60 tonnes to enable vessel to be lifted by Company's own crane during re-fits.

Acceptable Design

In considering the duties and design priorities, the first decision made was that a steel hulled vessel of 12 knots was required. To provide the deckspace and crew accommodation above deck, a conventional (i.e. single hull) vessel would need to be about 20 metres in length. A vessel of this size would have exceeded the limitation on displacement (60 tonnes) and its manœuvrability in close quarter situations at slow speed was questionable although the possibility of a bow thruster was considered.

A twin-hulled vessel, however, would be capable of providing ample deck space and accommodation on a length of about 16 metres with a displacement of about 40 tonnes. Slow speed manœuvrability would be good, due to the wide spacing of the twin screws.

The differences between a single hull and a twin-hulled vessel in terms of building, operation and performance are so great that it was decided to obtain as much information as possible on power driven catamarans before making a firm decision.

A number of technical reports [1], [2], [3] were studied and from these the following facts emerged :

Advantages of catamaran hull :

1. Excellent transverse stability;
2. Good directional stability;
3. Good sea-keeping characteristics;
4. Good slow-speed manœuvrability;
5. Large deck area in relation to displacement;
6. Improved living and working conditions due to enlarged accommodation space above deck.

Disadvantages of catamaran hull :

1. Limited design experience;
2. Lack of space below deck;
3. Highly sensitive to weight, which generally excludes catamarans from cargo-carrying roles.

The advantages given in the various reports matched, very closely, the design priorities. As a further check, a number of organizations known to operate power driven catamarans were contacted and favourable comments were received from all on the performance of their vessels. Also, a number of twin-hulled vessels were visited to evaluate performance.

The main problem was the design and it was considered that this could be done only by a naval architect specialising in power driven multi-hull vessels of this size.

The other disadvantages would not apply to a vessel with un-manned engine rooms and no requirement to carry heavy loads.

Taking all the various factors into account, it was decided to commission a specialist naval architect to design a steel, power-driven catamaran with the following basic features :

Length	16.0 m
Beam	6.5 m
Draught	1.75 m
Maximum speed	12 knots
Main duties	hydrographic surveying in coastal waters in conditions up to Beaufort Force 5
Secondary duties	minor maintenance of navigational buoys on station.

The design was to incorporate fully dimensioned builder's plans to enable boat builders to submit competitive tenders.

Final Catamaran Design

The final, accepted design was an assymetric catamaran with round-bilge hull form. Each hull was subdivided into five watertight compartments, the largest being the engine room which was to accommodate a 265 B.H.P. engine (one in each hull). A steel deck spanned the two hulls and an ingenious lightweight, steel-panelled wheelhouse and deckhouse was designed above deck level. Complete all-round visibility was achieved in the wheelhouse.

The spacing of the hulls was arranged so that a 3 m diameter navigational buoy could be "docked" between the bows and a reverse sheer increased the forward freeboard to enable work to be carried out on a buoy lantern from deck level. The naval architect suggested an unusual feature which was, in some respects, experimental. It was proposed to fit a horizontal, stabilising foil which would span between the skegs aft, at a depth of about 1.6 m below the water line. The purpose of the foil was to reduce squat and to assist in reducing pitching motion.

Model tests

A contract to build the designed catamaran was placed, after competitive tender, with a local builder subject to satisfactory model tests being carried out. A scale model was duly tested at the National Physical Laboratory, Teddington, U.K. The tests indicated that the designed catamaran would be capable of performing the required speed with the designed engines. The model was tested both with and without the foil. At full speed, with foil fitted, the hull resistance was about 14% less than without the foil. Also, the foil reduced the squat at full speed from 4° stern trim to 3/4° stern trim. Following the successful model test, construction commenced and was carried out mainly under cover. Each hull was constructed separately – the final connection between the hulls was carried out on the launching slipway. The wheelhouse/deckhouse was pre-fabricated in one unit before being lifted on board.

DESCRIPTION OF CATAMARAN

The new vessel was handed over on 26th May, 1981, having been named *H.M. Denham* after the first Marine Surveyor appointed by the port authority in Liverpool in 1833 [4].

The main features of *H.M. Denham* are as follows :

Length	16.0 m
Beam	6.5 m
Draught	1.9 m
Displacement	39 tons
Gross Tonnage	32.71 tons
Net Register Tonnage	19.72 tons

Propulsion : 2×265 BHP Rolls Royce diesels. Twin screw.
Fuel capacity : 2,000 litres.
Electrical power : 2×10 kW air-cooled diesels providing 240 V A.C. in addition to 24 V D.C. battery power.
Hydraulic windlass/winch.
Portable davit for suspending instruments overside.
Deck strengthened to take hydraulic crane of 1 tonne S.W.L.
Dual steering – hand wheel and power hydraulic tiller.

Survey Equipment

A Kelvin Hughes MS 48 echo sounder was fitted, with a pair of transducers in each hull. The hull is cut in way of each transducer which is housed inside an integral watertight unit. A changeover switch is fitted adjacent to the recorder, which allows a choice of either port or starboard transducer.

The positioning of echo sounder transducers is critical in any survey vessel because of possible turbulence or aeration causing loss of signal. The position of the transducers in *H.M. Denham* was chosen after careful consideration by the Naval Architect, the echo sounder manufacturers and the owners. The particular problem with a twin-hulled vessel is the turbulence created between the hulls at the point where the two inboard bow-waves meet. The designed hull shape was finalised to bring this point as far aft as possible – the inboard bows are, therefore, slightly concave on the waterline. The transducers are fitted $0.37 \times$ length from forward on the outboard side of each keel. This position has given excellent results at all speeds and in all operational weather conditions. The transducers are very close to the outboard side of each hull, allowing the "bar-check" to be carried out using a disc instead of a bar. There are no external openings or projections on the hulls forward of the transducers and all welds throughout are ground off to give the hulls a smooth finish.

Motorola Mini-Ranger III position fixing system is fitted, incorporating multi-user capability. The transmit/receive unit is mounted above the wheelhouse, to

FIG. 1. – *H.M. Denham* survey catamaran.

starboard, 1 metre horizontally from the echo sounder transducer. The Mini-Ranger III system has been in use in Liverpool since 1978.

A Hewlett Packard desk-top calculator – HP 9815A – is fitted in addition to a four-colour plotter – HP 9872A. When interfaced to the Mini-Ranger III, these provide on line track-plotting facilities and may also be used to plot sextant re-section fixes.

All survey instruments are mounted on the large chart table in such a manner that the Surveyor may operate them from a central, seated position. The calculator and plotter are fitted in a recess which can be covered over when they are not required, thus providing a large, flat chart table for conventional plotting.

Navigational Equipment

The usual range of navigational equipment is fitted : magnetic compass, Decca 090 Radar, navigation and survey lights, etc. The steering position is on the centreline with all instruments accessible by the helmsman from a seated position.

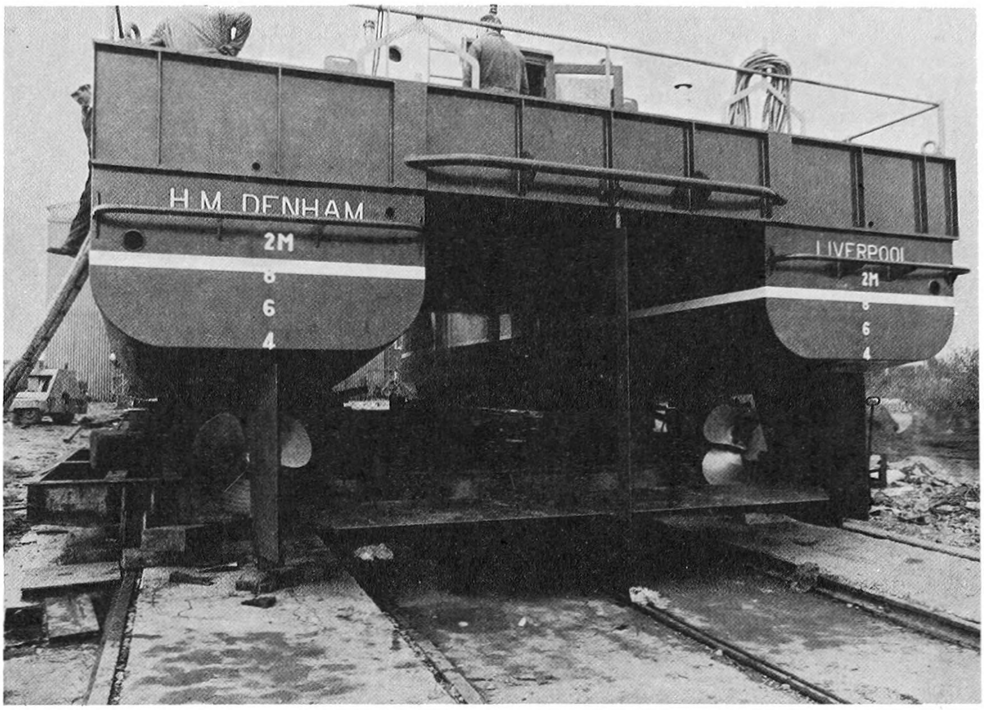

FIG. 2. – Stern : showing horizontal foil.

FIG. 3. – *H.M. Denham* preparing to "dock" a navigational buoy between the bows

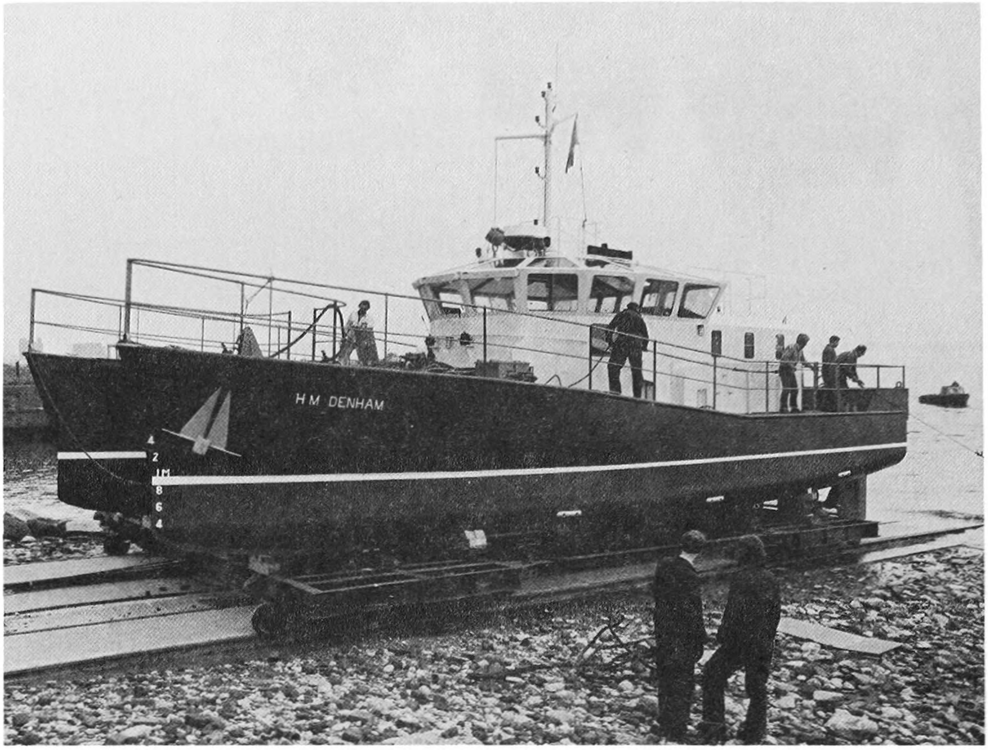

FIG. 4. – *H.M. Denham* prior to launching.

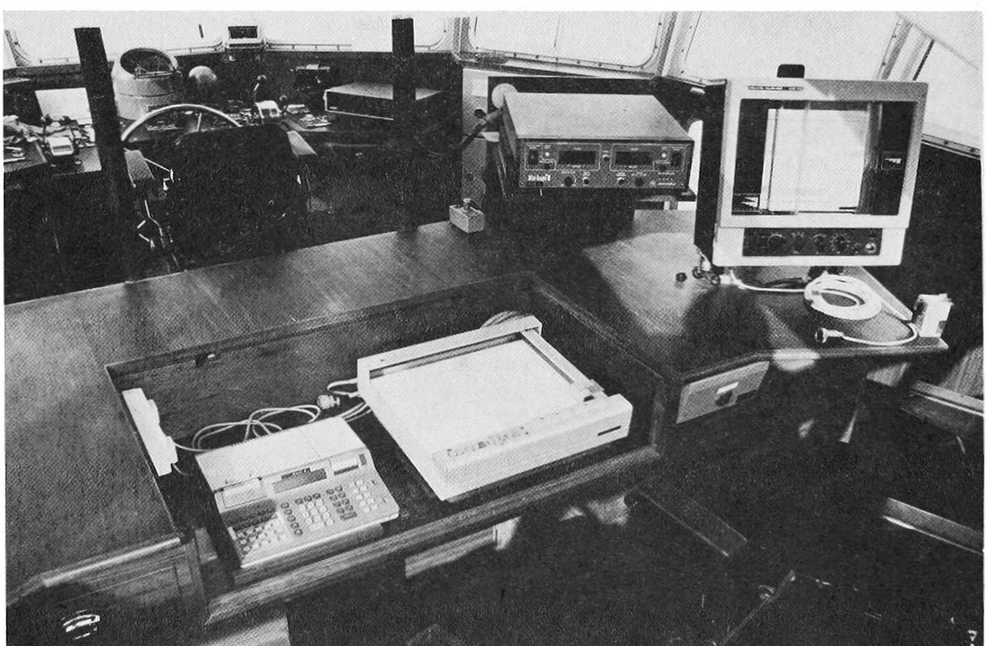

FIG. 5. – *H.M. Denham* wheelhouse/chartroom showing survey instruments.

Crew

H.M. Denham, when engaged on surveying duties, is manned by a crew of four plus either one or two surveyors depending on the type of survey.

On non-surveying duties a crew of three may be used.

Accommodation

The messroom is abaft the wheelhouse at a lower level and can seat six persons in comfort. Adjoining the messroom is a fully equipped galley with cooking facilities, refrigerator, locker, etc.

On the same level as the messroom is a toilet and shower compartment.

Access to the engine and fuel tank compartments in each hull is available from the messroom.

Store-rooms and generator compartments

Each hull has a large storeroom forward of the engine room with access from the deck via a hatch. The echo sounder transducers are located in these rooms.

The aft compartment in each hull houses a 10 kW air-cooled diesel generator with access via a deck hatch. The port generator also drives the hydraulic pump for the windlass.

Special Features

The specification for the hull construction included strengthening to sustain a "point" grounding, i.e. port stem and starboard stern or vice versa and also the ability to be beached without damaging propellers or rudders.

Lifting eyes have been incorporated on main beams forward and aft to facilitate lifting out of the water without "belly bands".

Trolling gear is fitted to both main engine gear boxes which allows very slow propellor revolutions from fixed engine revolutions if required.

PERFORMANCE

The catamaran has met all the requirements specified and has satisfied the owners in all respects.

Stability and manœuvrability are excellent. The transverse GM under normal operating conditions is 19.0 metres with positive stability up to an angle of heel of 85°.

At full speed the turning circle using rudders only is 2.5 times length and a 360° turn is achieved in 50 seconds.

At full speed the catamaran can be stopped, relative to the ground, in 9 seconds using full astern power with a head reach of just over a ship's length.

The catamaran is very easy to steer on a fixed course and even when operating on one propeller only it requires no more than 2° helm to maintain course.

The motion in a seaway tends to be small and jerky, because of the high metacentre, but not uncomfortable. The catamaran has carried out surveys in sea conditions which could not have been acceptable to a conventional launch of the same length but, as expected, Beaufort force 5 conditions are the upper limit for precise surveys.

CONCLUSION

The twin-hull concept for a port hydrographic survey launch has proved to be justified for the duties and conditions outlined above.

The advantages of wide deck space, increased manœuvrability and stability have been fully exploited to provide a versatile survey craft equipped with spacious, comfortable working and accommodation areas.

Acknowledgements

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[2] FRY, E.D. & GRAUL, T. (1972): Design and application of modern, high speed catamarans.

[3] Royal Institute of Naval Architects (1969): Twin hull ships. Transactions, Vol. III, No. 4.

[4] DAWSON, L.S.: Memoirs of Hydrography. Lt. H.M. Denham was employed from 1833 to 1839 as Marine Surveyor by the Liverpool Dock Trustees and established systematic surveys and a comprehensive buoyage system. He returned to service with the British Admiralty and carried out numerous hydrographic surveys in many parts of the world. He reached the rank of Admiral and was knighted for his survey of the Fiji Islands.