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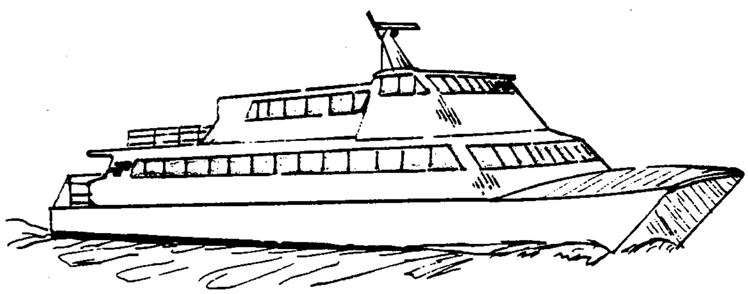

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1983

DEVELOPMENT OF A SERIES OF FAST CATAMARANS IN AUSTRALIA

SUMMARY

Over the past seven years a series of fast catamaran craft have been developed in Australia. The majority of the vessels have been used in passenger ferry service, but two oil field utility vessels have recently been delivered and projects are currently underway adapting the designs for use in other roles. This paper traces the development of the vessels historically with digression to examine special design features of the catamaran type.

Twenty-one of the vessels are now in service in Australia, New Zealand, The Peoples Republic of China, and Thailand. This paper will also review adaptations made to the basic design concept to meet special requirements of each of the services operated.

HISTORY

In 1975 a shipping accident in Hobart severed the Tasman Bridge which links the city's Eastern and Western shores. The alternative road access between the two communities was hopelessly inadequate and involved a detour of at least 30 miles.

There was an obvious need for expanded ferry services and both Government and Private organisations moved to supply the need. Existing vessels were converted to ferry service and in very quick time two additional ferries were built. Generally these craft were conventional monohull steel vessels capable of carrying 150 to 300 passengers at about 10 knots.

It was envisaged that the bridge would take 2-3 years to repair and in the interim the situation was a ferry operator's dream. However one company looked to the future and decided there were long range prospects to maintain ferry services after the bridge had been restored. Obviously the prospect would be better with a more modern design concept giving greater speed and passenger comfort.

The company chartered a rigid side wall hovercraft and put it into service. The passenger response was excellent even though a premium had to be charged on the prevailing fare. Despite this the vessel was not an economic success. It was plagued by mechanical problems and proved incapable of operating a reliable service.

It was felt there had to be a better way and an extensive study of alternative high performance craft was undertaken. The outstanding characteristic of the craft investigated was their mechanical complexity and high initial cost. While such characteristics might be accepted on high density routes where back up craft and advanced technical support were available these conditions were not met in Hobart.

Attention was concentrated on a simple catamaran design and the ferry operators joined naval architecture interests in a close working relationship to develop the concept. A preliminary lines plan was drawn, a model was made, and a tank testing programme was undertaken at Sydney University. The results were most encouraging.

STRUCTURAL DESIGN

With an apparently promising hull form the next step was the structural design. For simplicity of construction it was decided the hull should be of welded steel. Scantlings were taken out using conventional classification rules but were judged to be too heavy. Tank testing had been undertaken at varying displacements and the penalty of excess weight was obvious.

It had been decided that the vessel would be built under survey by the Navigation and Survey Authority of Tasmania and appropriately they were consulted to determine minimum structural requirements. They indicated willingness to accept structural design based on Det Norske Veritas Tentative Rules for the Construction and Classification of Light Craft. It was noted that the rules specifically excluded multi hull craft but it was believed the rules could be safely applied to each individual hull and the bridging load subsequently superimposed.

From the beginning the ferry operators had insisted on what, at that time, was a highly novel feature - they wanted the superstructure built as a separate unit and mounted on anti-vibration mountings. This was hoped to isolate vibration and minimise noise in the passenger compartment. With this system adopted it was decided not to rely on any assistance from the superstructure in joining the two hulls. Further, the superstructure floor could be strengthened to accept water impact loads and a significant overall weight saving made by eliminating structure between the hulls under the superstructure. The hulls were joined by short structures forward and aft of the cabin. This produced a simplified bridging design concept in that each end of each hull was considered cantilevered from the adjacent hull.

Much time and effort was devoted to the selection of the superstructure mounts. Finally it was decided to use approximately a dozen air bag type anti-vibration mountings in conjunction with rubber buffers for horizontal location. Subsequently these mountings proved to be most effective but posed a problem due to their large horizontal and vertical deflections under load. Furthermore, the vessel's crews never seemed to get around to maintaining air pressures in the bags. After the first 4 vessels the bags were superseded by solid rubber mountings. When sufficiently soft rubber has been used these mounts have given lower cabin noise levels than the air bags.

Noise levels for the 22m vessel "Reef Link" are typical. At full speed (28k) the following values have been obtained:

In main cabin directly over engines	77 dB
In main cabins remote from engines	75 dB
In wheelhouse	65 dB
On open upper deck	70 dB (approx)
On open lower deck aft	95 dB
In engine room	108 dB

With the superstructure insulated from the hull by the resilient mountings it was a logical decision to adopt an aluminium superstructure.

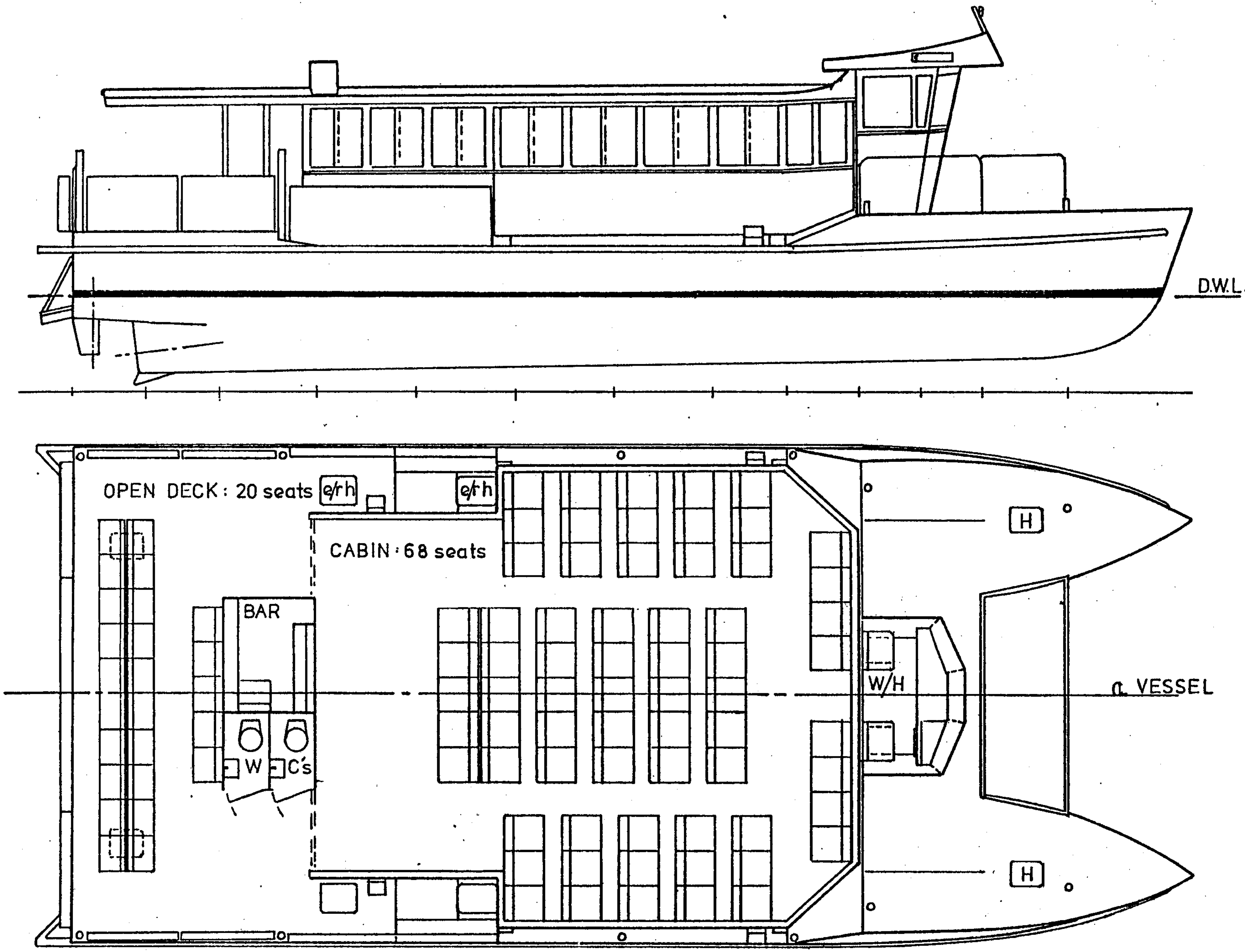
Apart from the twin hulls and resiliently mounted superstructure the design concept was very conventional and allowed quite standard machinery and systems to be used for propulsion, steering, pumping etc. The only proviso was that weight had to be carefully controlled.

"JEREMIAH RYAN"

At this stage the ferry operators found the courage to proceed with construction of the vessel, subsequently named "Jeremiah Ryan". A general arrangement is shown in fig. 1.

Construction proceeded remarkably smoothly considering the novel characteristics of the vessel. Minor delays and aggravations occurred trying to find lighter ways of doing basically conventional jobs, but the only problem of any real significance was that time was rapidly running out. It became touch and go whether the vessel would be commissioned before the bridge was repaired and re-opened.

In the end the boat was completed three weeks before the bridge, and entered service amid much publicity. It was an outstanding success. The Catamaran was fast, comfortable, quiet, vibration free and most important, could be operated profitably at exactly the same fare structure as the conventional slow speed ferries. The only significant adverse criticism centered on appearance - the boat looked dreadful.



M.V. JEREMIAH RYAN

fig. 1

COMMUTER FERRY SERVICE

"Jeremiah Ryan" went into operation on the commuter ferry services in Hobart. The city business center lies within half a mile of the main shipping wharves. One of the wharves had been converted to a ferry terminal. On the other side of the Derwent River at Bellerive a ferry terminal had been built with a large carpark and a bus interchange. A similar but smaller terminal had also been built at Lindisfarne further up river. The ferry distance to Bellerive was about 2 miles and to Lindisfarne was about 3 miles.

When "Jeremiah Ryan" entered service she joined Government and Private ferries operating basically a "quick-on, quick-off" shuttle service.

Operation of the vessel allowed some interesting comparisons. Firstly, it ran alongside vessels having twice its passenger capacity at half its speed. It proved capable of halving every aspect of the bigger vessels' timetable. It loaded and unloaded passengers in half the time - it manouevered in half the time - its transit time was half that of the bigger vessels. Its fuel consumption per mile was a little higher than that of the conventional craft but being smaller it required one less crew. It offered commuters the enormous advantage of providing twice the frequency of service. In off peak hours a minimum frequency of sailing must be maintained as a public service. The fast ferry was able to replace two conventional vessels by making alternate trips on two different routes.

It has long been recognised that quick turn around is of utmost importance in shuttle type ferry services. This is highlighted by the results of investigation into the hydrofoil services operated on Sydney Harbour. These run from the city center at Circular Quay to Manly - a distance of approximately 6 nautical miles. Each hydrofoil operates on a 20 minute time slot. From the time lines are let go at one terminal to the time lines are on and gangway's down at the other end averages about 15 minutes. During peak loading times the traffic tends to be one way. Unloading time is approximately 2 minutes leaving a 3 minute buffer time. The hydrofoils carry a maximum of about 140 passengers and while flying average about 31 knots.

The vessels berth bow-in at finger piers and on leaving have to back out and turn. At Circular Quay the vessels have to transit a restricted speed zone before entering the main harbour.

As can be seen from Fig.1 "Jeremiah Ryan" was built with approximately 3 metre wide gangways right at the aft end of each side of the vessel. These allow two advantages:

1) They allow 2 traffic lanes to develope - one from the near side of the vessel to the forward end of the gangway - the other from the outer side, around the bar/toilet block to the aft end of the gangway. The vessel could, and did unload her full capacity of 145 passengers in less than 1 minute.

2) The stern is the "live" end of the vessel. Berthing approach is made about 1 metre clear and then the stern is "kicked in". A line is secured, the gangways lowered and passenger unloading commenced while the bow of the vessel is brought in, swinging on the line. There is no necessity to wait until the vessel is hard alongside as is required with midship gangways.

"Jeremiah Ryan" and the successive catamarans have all shown great acceleration. They have regularly been timed from a standing start to 20 knots in about 10 seconds. In practice this acceleration would throw many passengers off their feet but it does show that the vessels are not fettered by long take off times as with hydrofoils.

Returning to the hydrofoil timetable it can be demonstrated that the catamaran could save two minutes on the hydrofoil's time in the vicinity of terminals. This would allow the existing 31 knot service speed to be reduced to about 26 knots yet still maintain the same timetable. If for some reason only one minute could be saved in the terminal vicinity the service speed could be reduced to about 28 1/2 knots again still maintaining the original timetable.

The Sydney-Manly investigation has looked at operating the service with vessels having a carrying capacity of 250 passengers. Given environmental and service conditons this would require a catamaran ferry of approximately 24 metres length. Power and fuel consumption to obtain the above speed are given in the following table.

Service speed (knots)	Power (HP)	Fuel consumption (imp.gal/naut.mile)
31	2x1400	4.11
28.5	2x1150	3.67
26	2x950	3.33

It is interesting to note the power required for a 31 knot service speed. The existing hydrofoils on the service use virtually the same power (1350 horse power each side) to achieve the same service speed carrying less than 60% of the passengers carried by the catamaran.

COMMERCIAL DEVELOPMENT

Regrettably, but perhaps predictably, the Hobart ferry fairy tale had to end. The bridge reopened and commuters took to road transport by bus or private cars. Ferry services have never been able to compete with such alternative transport unless of course the alternative has been severely overcrowded. Hobart was no exception and ultimately patronage dropped too low. The ferry services were abandoned.

In the meantime much interest had been aroused by the catamaran and it wasn't long before a charter was arranged in North Queensland. Here the vessel operated trial services to a number of resort islands off the coast. Again the concept was a great success but "Jeremiah Ryan" proved to be a little too small for the services and the sea conditions experienced. "Jeremiah Ryan" ultimately returned to Hobart and now runs tourist and charter cruises.

While "Jeremiah Ryan" was not the ultimate boat it had proved the viability of the concept. In addition, the long delivery trips to and from Queensland had turned up an unexpected bonus. The vessel proved to be an exceptionally comfortable seaboat.

The potential of the catamarans was undoubtedly there and so a new company was formed to develope the commercial potential. This proved to be a most significant step in the technical development as the establishment of a specialist company made greater funding available for research, etc. It also facilitated experimentation with bizzare ideas, e.g., new rudder development, weight refinements, etc.

Initially orders came slowly and the first three years produced only three vessels. One for the tourist industry in Tasmania and two for the tourist industry in New Zealand. These craft were similar in having steel hulls of 18 to 19 metres length. Superstructures were all aluminium, still mounted on air bag type anti-vibration mountings. Speeds ranged from 22 - 28 knots and passenger capacities from 100 to 150 . Each craft was greeted with new enthusiasm by customers and owners alike and in New Zealand the second order came from the first customer returning for a repeat vessel.

"FITZROY"

In late 1980 work commenced on "Fitzroy", a 20 metre all aluminium vessel to work in the North Queensland tourist industry. "Fitzroy" subsequently proved to be almost as significant as the original "Jeremiah Ryan".

Firstly, being all aluminium she was significantly lighter than a comparable steel vessel. The reduction in lightship weight was approximately 8 tonnes which represented a saving of approximately 20 percent on the full load operating displacement. With the hull form used on these catamarans power is approximately proportional to weight. So the switch to aluminium yielded a reduction in fuel consumption of approximately 20 percent. Subsequently it was discovered the aluminium vessel could be built for the same or a lower price than a steel vessel of the same carrying capacity and speed. The aluminium cost is significantly more than the steel cost but there are worthwhile savings to be made in fabrication time and in painting time. Furthermore, the reduction in weight allows a reduction in installed power and the lower cost of engines, shafts, propellors, etc. makes up the balance.

"Fitzroy" was also significant in being specifically designed for offshore service. The earlier steel hull catamarans had all been designed for service within partially smooth water limits i.e. on bays, esturaries, in rivers, etc. "Fitzroy" was to operate up to fifty miles offshore making daily trips to a resort island with extension to the Great Barrier Reef on approximately three days per week. The principal changes for offshore service were generally increased freeboard, improved forward end fairing of bridging structure and increased deckhouse scantlings, window thicknesses, etc. Lifesaving appliances were also upgraded.

LIFTING RUDDERS

"Fitzroy's" final claim to fame lay in her rudder system. The second catamaran built had proved a little slower than anticipated. At one stage attention was focussed on the rudders and it was felt they may be creating undue drag. The vessel was taken into shallow water and the rudders and stocks were dropped out for retrieval at low tide. The vessel then ran trials without rudders and revealed an increase in speed of between one and one and a half knots. While this was not a large speed margin it did represent approximately 5 % difference in power and consequently fuel consumption. As such it was seen to be worthy of further investigation.

Over a period of about two years various alternative steering systems were examined. From the very first vessel all had featured an extention of the bottom plating beyond the transom to form a planing wedge or trim tab. This structure was approximately one metre long and was held in fixed position by brackets from the transom. It proved to be an ideal position to fit the Lifting Rudder system finally devised.

Each hull has a rudder set at a fixed angle from the centreline. The port rudder is set to steer the vessel to port and the starboard rudder to turn to starboard. When the boat is moving in a straight line, the rudders are held out of the water. To turn the boat, one rudder at a time is dipped into the water through a slot in it's trim tab. Rather than varying the rudder angle as on most boats, the rudder is raised and lowered, controlling steering by changing the area of the rudder under water. As each rudder only has to steer one way it is cambered accordingly for greater efficiency. This system is now in service on 10 catamarans and is being fitted to most new vessels.

TOURIST FERRIES

In June 1981 "Fitzroy" entered service in the tourist industry in Queensland. The operation is a little different to the commuter ferry. Firstly, while the commuter vessel may work up to 18 hours a day the tourist vessel seldom runs more than 6 hours a day. In many cases this allows somewhat higher engine ratings to be used.

Loading and unloading facilities differ considerably. A commuter ferry usually works to specially designed terminals and gangways are arranged to suit for rapid passenger movement. On the other hand many of the tourist ferries work to a number of wharves of different heights, etc. These conditions require versatile gangway arrangements which may slow passenger movement. Also time is less pressing in the tourist industry.

The appearance of the craft is of utmost importance. In many instances they appear prominently on promotional material. In other cases a more attractive vessel at the wharf will gain greater loads.

The layout of the tourist industry vessel requires adaptation to suit the requirements of the service operated. The majority of the vessels are required to provide fast, comfortable transport to a resort destination or on a sight seeing trip. Voyage times vary between three quarters of an hour and about two hours. Seating must be comfortable and furnishings must be attractive. Of prime importance refreshments and souvenirs must be available for sale on the voyage. Most operators provide complementary tea, coffee and biscuits and supplement their takings significantly by selling alcoholic beverages, souvenirs, confectionary, etc.

A large area of open deck is essential for the out door types though at 25 knots the wind tends to blow a lot of people inside.

Some of the vessels are now operating day trips to the Outer Barrier Reef. Sometimes, the destinations have no dry land and the vessel is a floating resort when it arrives there. Passengers swim, dive and undertake glassbottom boat tours to view the underwater coral. Interior facilities have to be modified to allow lunch to be served (usually a cold smorgasbord) and to provide tables and chairs to eat at. Because of the predominance of wet bodies in bathing suits, seats and furnishings are slightly different.

Provision must also be made for carrying a glassbottom boat. Typically this would be a flat bottomed alumininum vessel, 6 to 7 metres long. A lifting platform has been devised and is now fitted to the sterns of 6 of the catamarans. The platform runs on inclined tracks and can be lowered to approximately 200mm below the water level to allow the glassbottom boat to be floated on and off. The platform can be raised clear above the tunnel between the hulls to enable the boat to be carried safely in transit. In addition, the platform can be locked at an intermediate position for boarding the glassbottom boat or simply for use as a swimming platform.

"Spirit of Roylen" is a 29m Catamaran operating Outer Reef trips. Her general arrangement is given in Fig. 2 and particulars are given below.

Length overall		29.4m
Length waterline		25.5m
Beam overall (excl. fenders)		11.2m
Beam hull only		3.2m
Draft aft		1.8m
Hulls	all welded aluminium	
Superstructure	all welded aluminium	
Survey	Marine Board of Queensland	
	Restricted Offshore (Class 1C)	
	245 passengers	
Main Engines	2 x MWM diesels model TBD 604 V8	
	Gearboxes Z.F. BW255 2.05:1	
Power	2 x 830PS continuous	
	2 x 900PS intermittent	
Propellers	5 blade	
Rudders	Lifting rudders - 2 each hull	
Speed	light trials	27k
	loaded max	26k
	loaded cruising	24k

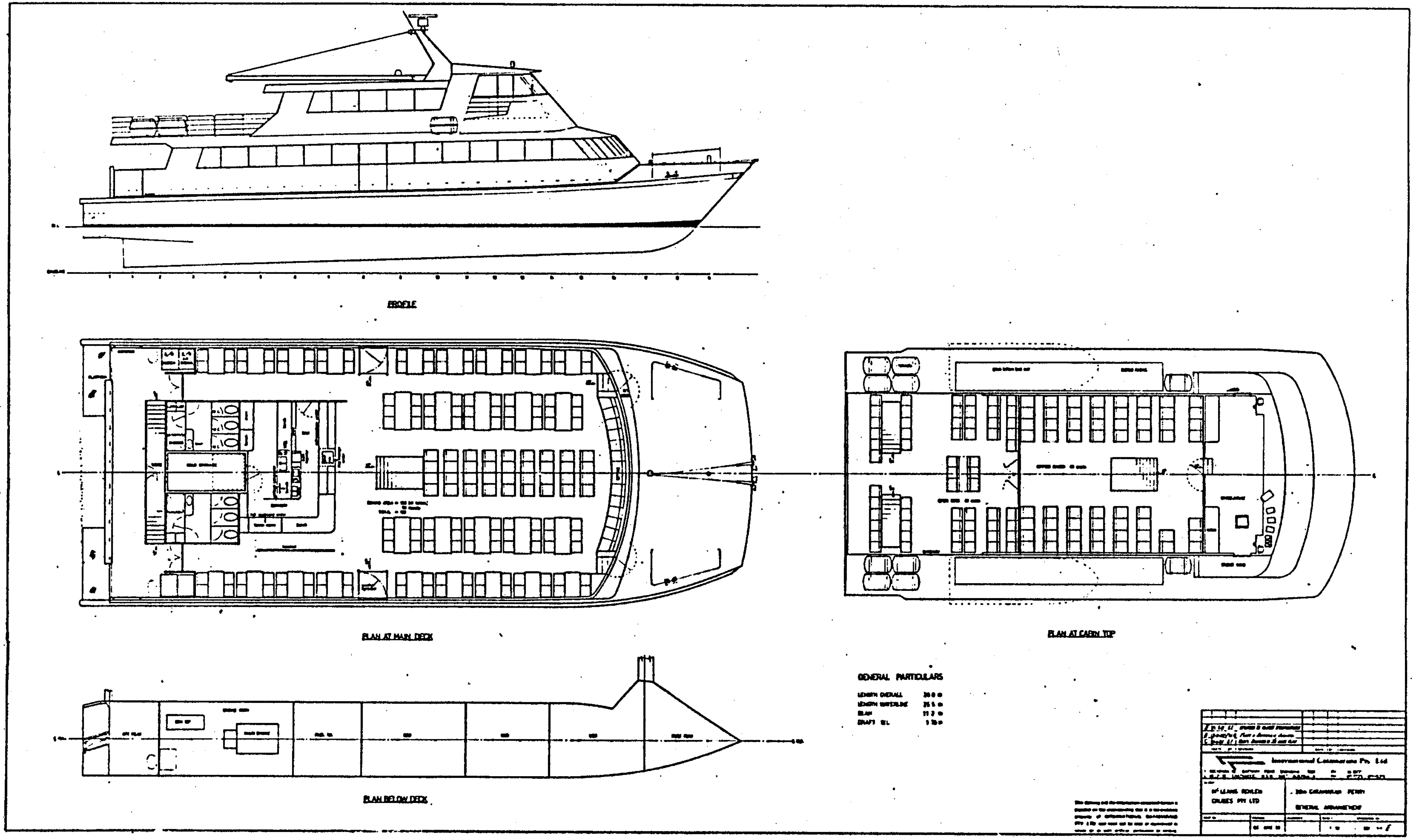

PROFILE
PLAN AT MAIN DECK
PLAN AT CABIN TOP
PLAN BELOW DECK
GENERAL PARTICULARS
International Catamarans Pty. Ltd
GENERAL ARRANGEMENT

fig. 2

FREIGHT CARRYING

Generally, the passenger vessels are the only means of carrying supplies to resort islands and small quantities of freight are carried on most trips. In this respect the catamaran has huge advantages over alternative craft. The catamaran's exceptional stability allows cargo to be carried on the highest structures of the vessel where loading and unloading access is best. In December 1981, a 20 metre catamaran, "Tangalooma" was delivered for service between Brisbane and Moreton Island. She provides an excellent example of adaptation of a basically standard vessel to carry resort supplies.

Racks are fitted each side on the main cabin roof to accommodate standard 46 inch square timber pallets. Supplies are delivered palletised or are so assembled at the owner's city terminal. The pallets are loaded direct on to the vessel by fork lift truck. The only drawback with this system is that the vessel must be turned around to load pallets on the opposite side. However, diesel fuel is also carried to the resort and it is common practice to balance palletised cargo on the port side with fuel loaded in the starboard hull. "Tangalooma" meets all stability requirements with 15 tonnes of freight carried on the upper deck cargo racks and her survey approves carriage of this cargo. In practise the owners try to schedule freight for trips when passenger loadings will be lower to avoid slowing the vessel down with the excess weight.

A logical extension of this concept is to lift off all or part of the passenger cabin and replace it with freight containers. This allows a major freight carrying activity when passenger loading is low. Of course, it presupposes the availability of heavy cranage at each end of the service for handling the modules and freight and this facility is not always available. The resiliently mounted superstructure particularly lends itself to this lift-on lift-off concept.

The first of the subject catamarans to employ this concept was "Trojan" which was commissioned in April 1983. "Trojan" is essentially a standard 20m catamaran but the superstructure roof has been removed immediately aft of the wheelhouse. The cabin floor has been strengthened and protected to form an open cargo deck extending over the after half of the vessel.

The vessel can carry up to 30 tonnes of cargo or a lesser quantity of cargo and up to 80 passengers in a cabin in the deckhouse. Alternatively a portable module can be fitted at the forward end of the cargo deck to accomodate up to 40 additional passengers.

SEAKEEPING

While only designed for sheltered water operations the first four vessels had performed more than creditably in bad weather conditions. The only real problems encountered were firstly, "Jeremiah Ryan" suffered from insufficient tunnel clearance in way of the bridging structures connecting the hulls and secondly, two of the early vessels lacked sufficient rigidity in the superstructure floors. When an occaisional wave hit the bottom of the superstructure the impact was transfered through to the passenger seats above causing some consternation. The height problem was readily rectified with a little more freeboard and modified foredeck and bridge configuration. It is impractical to raise the tunnel to avoid wave impact entirely. The increase in freeboard reduced the incidence of wave impact but also the superstructure floor was redesigned and strengthened to absorb localised shock loadings from wave slap.

"Fitzroy" and the subsequent catamarans have proved to be extremely good seaboats. This appears due to the following:
1) Displacement Hull.
These vessels feature an extremely fine, displacement form. This means they run in the water rather than on it and consequently do not follow the water surface over the waves and into the troughs in the same way that a surface supported hull would do.
2) Speed.
In all but extreme sea conditions ride is definitely better at high speed. With the fine hull form easing passage through waves the vessel's path largely averages out the wave contour.
3) Hull Spacing.
When moving diagonally to the seas the vessels benefit from an apparent lengthening effect. Essentially the length becomes that from one bow to the opposite stern. It is alway difficult to quantify the benefit of such phenomena but under such circumstances a 20 metre catamaran appears to match a 25 to 30 metre monohull.
4) Stability.
A catamaran's exceptional stability is traditionally assumed a disadvantage in terms of seakeeping. However experience has shown it reassures passengers by avoiding large rolling angles. The vessels' rolling motion becomes a little jerky under some conditions but all crews claim they very quickly become accustomed to it and are not adversely affected. Passengers obviously don't become experienced to the motion but no undue problems are caused.

Seakeeping ability is very difficult to measure and to a great degree depends on the sea conditions experienced. Generally the existing vessels are working reasonably close to the coast where a short sharp wind slop predominates. Under worst conditions this is superimposed on a longer swell. Typical bad weather in North Queensland waters is a 30 to 40 knot wind with about 2 metre significant wave height and the occasional 3 metre wave. Both the 20 and 22 metre vessels working in this area maintain their normal cruising speeds of 23 to 26 knots under these conditions. The following table gives a seakeeping assessment of the 20 and 22 metre craft in deep open water. In sheltered waters sea states will be lower and higher speeds can be achieved.

Windspeed 15 knots and Sea State 3

Up wind	Full speed
Across wind	Full speed
Down wind	Full speed

Windspeed 18 knots and Sea State 4

Up wind	Reduce to 20 knots or alter course
Across wind	Full speed
Down wind	Full speed

Windspeed 22 knots and Sea State 5

Up wind	Reduce to 15 knots or alter course
Across wind	Full speed
Down wind	Full speed

Windspeed 30 knots and Sea State 6

Up wind	Reduce to 12 knots
Across wind	Full speed
Down wind	Care must be taken not to surf too fast

Windspeed 40 knots and Sea State 7

Up wind	Reduce to below 10 knots
Across wind	Good speed can still be maintained
Down Wind	Good speed can still be maintained

Windspeed 50 knots and Sea State 8

Vessel perfectly seaworthy, speed restricted with regard to passenger comfort.

SIMPLICITY

One of the fundamental components in the design philosophy of these craft has been the need to maintain simplicity. Many of the existing and future craft operate in one or two boat situations remote from sophisticated support facilities. Any breakdown of complicated equipment will mean delay and loss of service until maintenance help arrives.

In many cases the general layout or machinery arrangement has been deliberately modified to avoid sophisticated solutions. As an example, the temptation to instal toilet spaces below deck has been strenuously avoided to escape the cost and unreliability of sullage pumping systems. Remember, if it is possible to avoid putting something (like a sullage pump) on a vessel three immediate benefits are gained:

1. It doesn't cost anything.
2. It doesn't weigh anything
3. It doesn't break down.

HULL FORM

Having traced the development of the craft through to the stage where propulsion and seakeeping characteristics have been proven successful, it is appropriate to review the hull form of the craft. The vessels feature an extremely fine waterline entry and an extremely deep V-hull form for the first two thirds of the length. At the stern the hulls flatten into a planing type afterbody to resist squat at high speed. If planing is defined as motion through water with the centre of gravity of the vessel raised above it's static position by dynamic forces, then, technically the vessels plane. Essentially however the hulls are exceptionally fine displacement form.

This hull design philosophy appears at variance with the vast majority of other high speed catamaran forms. It is intriguing to note that the adoption of a different hull form philosophy was caused by total ignorance of the extent of development of planing catamaran forms. Had knowledge of this development been available it is almost certain a planing form would have been chosen, with subsequent reduction in seakeeping and propulsive efficiency.

Much has been said and written on the relative merits of asymmetric and symmetric hull forms for catamarans. Regrettably funding has not been found to fully evaluate the two forms in tank tests.

It seems the basis of design of asymmetric planing catamarans is to take a comparitively slender mono hull planing form, split it down the centre and move the two halves apart. It stands to reason that the resistance must be greater than the mono hull due to the extra wetted surface on the inboard hull sides.

By comparison, the fine lined, symmetric, displacement catamaran appears to have significantly lower total resistance than the planing mono hull. As it bears the burden of the extra wetted surface of the inboard hull sides, the reduction of overall resistance must be due to lower residuary resistance. There does not appear to be any significant interaction between the two hulls at the speeds and hull spacings being used.

A further benefit in hull efficiency seems to be gained by continuation of the deep V-body amidships into a skeg at the aft end of the vessel. The skeg allows the engine to be installed lower in the vessel and gives either a larger propeller diameter or a flatter shaft angle. In addition the skeg accomodates a conventional sterntube, eliminating the drag of shaft brackets, exposed shafts, and bossings. The nett effect is a hull with virtually no appendage resistance and space for a very large diameter propeller. By selecting low propeller revolutions, a lightly loaded propeller can be designed, normally yielding open water propeller efficiencies in excess of 70%. There is an additional benefit in that the propellers can be designed cavitation free.

The nett worth of the hull form is illustrated by plotting it's characteristics on the following Fig 3.

WEIGHT OPTIMISATION

The first tank testing program demonstrated that resistance increases at least linearly with displacement. After the first few vessels had proven the general concept, it was decided to concentrate research and development on weight optimisation. A detailed weight estimate was prepared and examined item by item for possible savings. Traditionally weight saving effort is concentrated on hull structure and machinery. These had been closely scrutinized in the design of all the earlier catamarans, so effort was concentrated on minor structural elements and outfit, where significant savings were made.

Overall the lightship weight of a 20 metre vessel was reduced from an initial estimate of 32 tonnes to a current best of 26.5 tonnes. This represents a reduction in power (and fuel consumption) of about 15% at an average loading condition.

Cabin seats are an excellent example of the scope for weight saving. The first vessel built was fitted with seats having padded bases, padded back rests, and individual armrests. The seats weighed approx 15 kgs each. Later vessels have seats with the same overall dimensions, cushion depths, etc., yet the weight has been reduced to just below 5 kg each. The saving of 10 kg per seat on a 20 metre vessel with about 150 seats is significant.

FAST PASSENGER CRAFTS

ABOUT 200 PASSENGERS

POWER/CAPACITY/SPEED RATIO

Reproduced from "Hull forms and propulsion for Moderate capacity passenger vessels" presented at the IMTA seventh annual conference, November 1982, by S.A. Bertelsen.

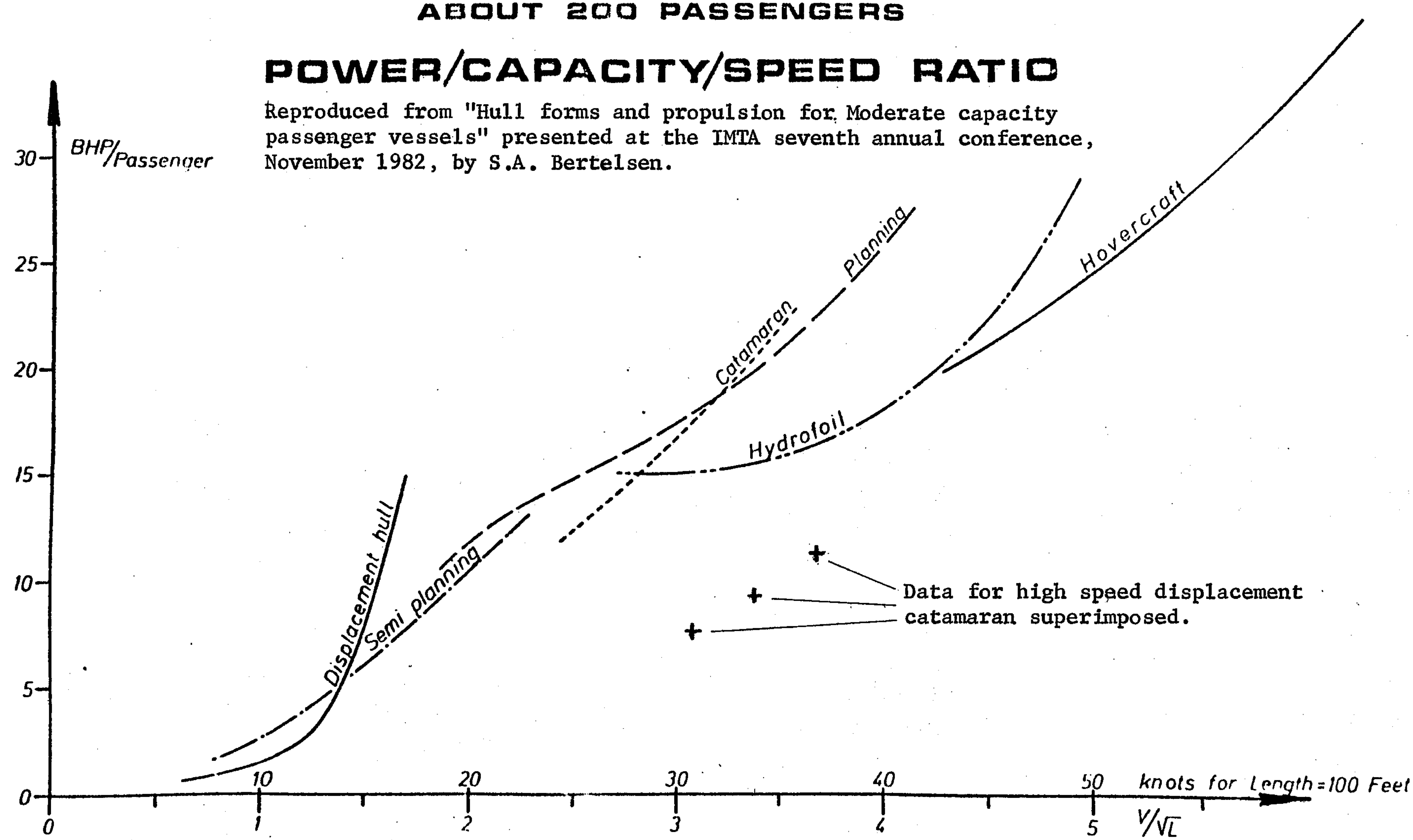


fig. 3

Unfortunatley not all weight saving schemes were successful. Some of the vessels had exhaust systems with an initial length of steel pipe and the remainder of the system in aluminium. Subsequently, experience showed that the transition had been made too close to the engine and quite a bit of exhaust system rebuilding had to be undertaken. Polycarbonate windows were used on some vessels but unfortunatley they have proved to have inadequate scratch resistance and their use has been discontinued.

OIL FIELD SERVICE

Late in 1982 an order was received for two fast utility vessels for service in an oil field in the Gulf of Thailand. These vessels have recently been completed and are about to enter service. Underwater hull shape is identical to that used by the 29m tourist ferry. However in most other respects there is little similarity between the oil field vessel and the tourist ferry. The general arrangement of the latest Oil Field vessel is shown in Fig 4. The principal differences are as follows:

1. Hull scantlings have been greatly increased - particularly at outboard topsides and decks.

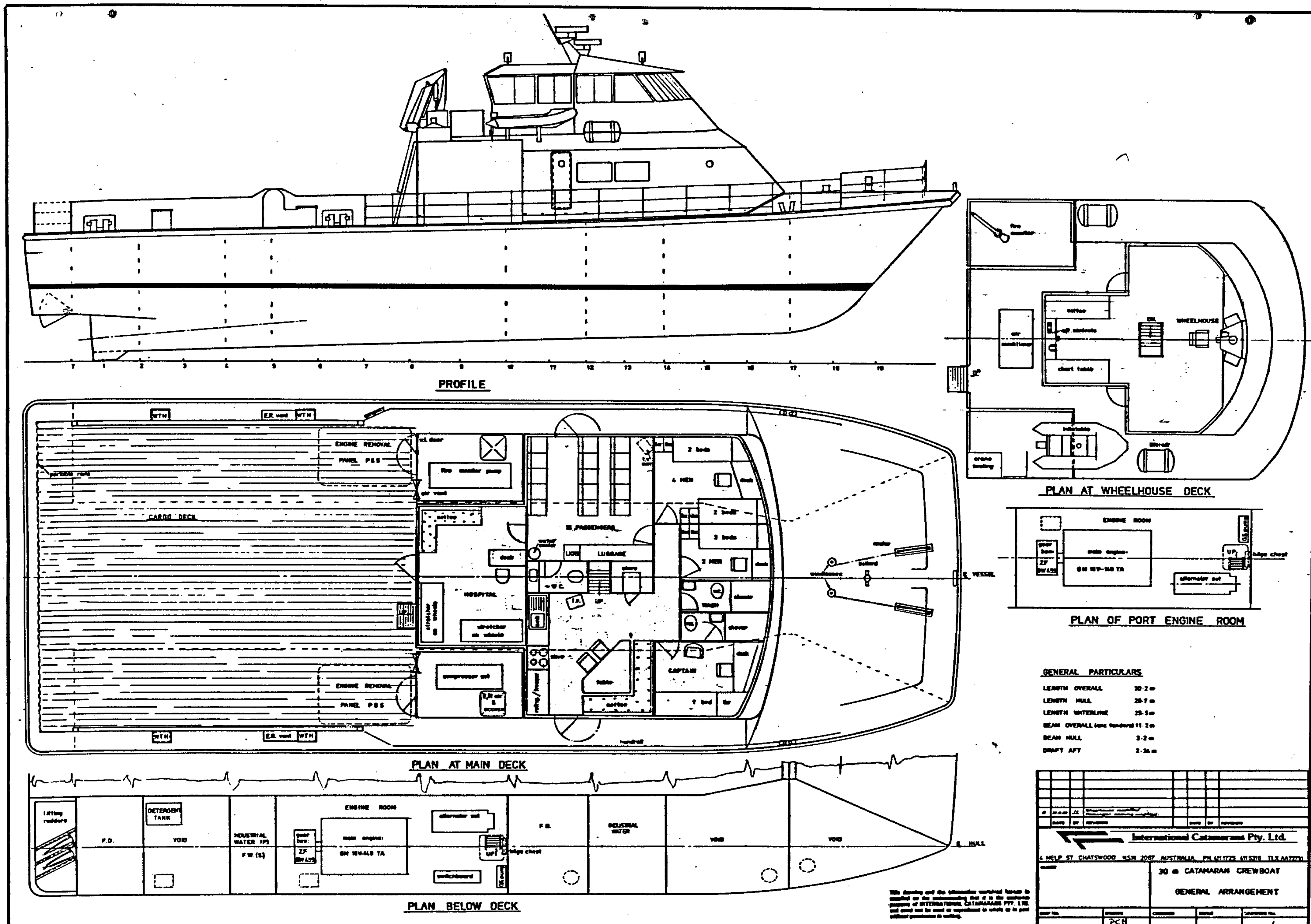
2. The after bridging structure has been completely re-designed. Where the ferry has one large I-beam on the transoms, the oil field vessel has ten smaller beams incorporated in the base of the cargo deck.

3. Deckhouse width has been reduced to allow a walk around side deck.

4. Freeboard has been increased to allow the vessels to operate at deeper displacement.

5. Fendering systems have been totally re-designed, unfortunately with massive weight increase.

As a result of these changes, lightship weight of the crewboat is some 30 to 40% greater than that of a comparable ferry. There is a tendency in the offshore oil industry to have every vessel capable of everything. This results in a lot of equipment being carried around and seldom used. It is believed a critical evaluation must be made before accepting the weight penalty of an additional capability on a fast boat. Because of the catamarans enormous stability (the total deadweight can be carried several metres above the main deck) close attention is being given to devising portable equipment to fulfill some capabilities.


PROFILE
PLAN AT MAIN DECK
PLAN BELOW DECK
PLAN AT WHEELHOUSE DECK
PLAN OF PORT ENGINE ROOM
WHEELHOUSE
chart table
settee
air conditioner
inflatable
liferaft
crane seating
CARGO DECK
ENGINE REMOVAL PANEL P&S
fire monitor pump
compressor set
HOSPITAL
stretcher on wheels
16 PASSENGERS
LUGGAGE
store
W.C.
UP
CAPTAIN
table
settee
2 beds
4 MEN
2 MEN
shower
desk
windlasses
bollard
anchor
℄ VESSEL
ENGINE ROOM
main engine:
GM 16V-149 TA
gear box
ZF BW 455
alternator set
bilge chest
switchboard
lifting rudders
F.O.
DETERGENT TANK
VOID
INDUSTRIAL WATER (P)
F.W. (S)
INDUSTRIAL WATER
℄ HULL
GENERAL PARTICULARS
LENGTH OVERALL 30·2 m
LENGTH HULL 28·7 m
LENGTH WATERLINE 25·5 m
BEAM OVERALL (exc fenders) 11·2 m
BEAM HULL 3·2 m
DRAFT AFT 2·34 m
International Catamarans Pty. Ltd.
4 HELP ST CHATSWOOD NSW 2067 AUSTRALIA PH 4111725 4115316 TLX AA72770
30 m CATAMARAN CREWBOAT
GENERAL ARRANGEMENT
1:50
697/1-1

As an example, provision of an external fire fighting capability can be examined. The first two catamaran oil field craft each carry a 230 tonne per hour fire pump, with independent diesel drive. A manually operated fire monitor is fitted, as are self cooling sprays, and 2000 litres of foam. The gross weight of the fire fighting installation (including foam) is approximately 5 tonnes.

As an alternative, it would be possible to provide a self contained fire fighting module which could be kept either in the oil field or at the base port and loaded on to the vessels cargo deck when required. The module would incorporate the fire pump with it's own engine - either diesel or gas turbine. The base of the module would contain fuel and foam tanks and a tower would be built over to support a monitor and cooling sprays. The module could be heavier than the permanent installation as it would only occasionally be carried, and consequently it's fire fighting capability could be very much higher.

FUTURE DEVELOPMENTS

Much work is being done on adapting the existing design concept to new uses. Propsals have been prepared for a number of small miltary craft. These include:

1. 29 metre, 42 knot patrol vessels
2. 22 metre, 36 knot fisheries patrol craft
3. 16 metre, 35 knot police launches
4. 15 metre, 40 knot customs vessels.

Interest has been shown in adapting the vessels to pleasure craft. A proposal has been completed for a 12 metre, 30 knot diesel powered express cruiser. A layout has been prepared and a propulsion study completed for a 25 metre, 50 knot super luxury express cruiser.

Further proposals have been prepared for fast fishing vessels, pilot vessels, and express container vessels.

Future effort will be devoted to extension of the existing design concept to larger vessels. Examination of the current size range (12 - 30 metres) has shown that larger vessels become proportionally lighter. While displacement varies with length cubed, it has been found, in crude terms, that lightship weight varies with length squared. Hence the larger vessel can either carry proportionally more deadweight or operate proportionally lighter. As speeds tend to be determined by scheduling or other operational requirements, larger vessels have the added advantage of working at lower speed/length ratios.

In the interest of simplicity, powering has been restricted to high speed diesel and structure has been limited to welded steel or aluminium. However it is recognised that major weight reductions are offered by the adoption of gas turbine engines, foam sandwich construction, carbon fibre reinforcement, etc. As development progresses these and other weight refinements will be evaluated.

WAVE PIERCING CATAMARAN

A further new project is commencement of development of the "Wave Piercing" catamaran. Initial work is being concentrated on a 60m version of this type designed to carry 300 passengers and 50-60 cars at a service speed of about 40 knots. The preliminary general arrangement of this vessel is shown in Fig 5.

The wave piercing catamaran is designed with very generous clearance between the superstructure and the water. The hulls are widely spaced and have minimal reserve buoyancy. They are designed to go through waves rather than up and over them. Obviously the amount and distribution of reserve buoyancy will be critical. A 1/7 scale prototype will be built soon to test and develope the concept.

The wave piercing catamaran has been conceived as a "Poor-mans's SWATH". It is not expected to quite match SWATH seakeeping abilities but is expected to have far lower resistance than the SWATH due to greatly reduced wetted surface. It will also be simpler due to elimination of the active fins required to control longitudinal trim and pitch on most SWATH proposals.

CATAMARAN PROGRESS

Inevitably the question arises "if catamarans are so good, why aren't there more of them around?"

The concept of the catamaran is not new. We believe the earliest boats were built by hollowing out logs. These craft were long and slender and presumably suffered from stability problems. It's now thousands of years since some smart soul took two hollow log vessels and tied them together with a couple of smaller logs for mutual support, to create the first catamaran.

The Polynesians were great catamaran builders and undertook some amazing voyages over a thousand years ago. We can only speculate why catamarans weren't used more by other races. Probably the greatest single problem has been structural. The rigging loads on sailing craft are very high and an essentially disjointed structure like the catamaran does not readily withstand those loads.

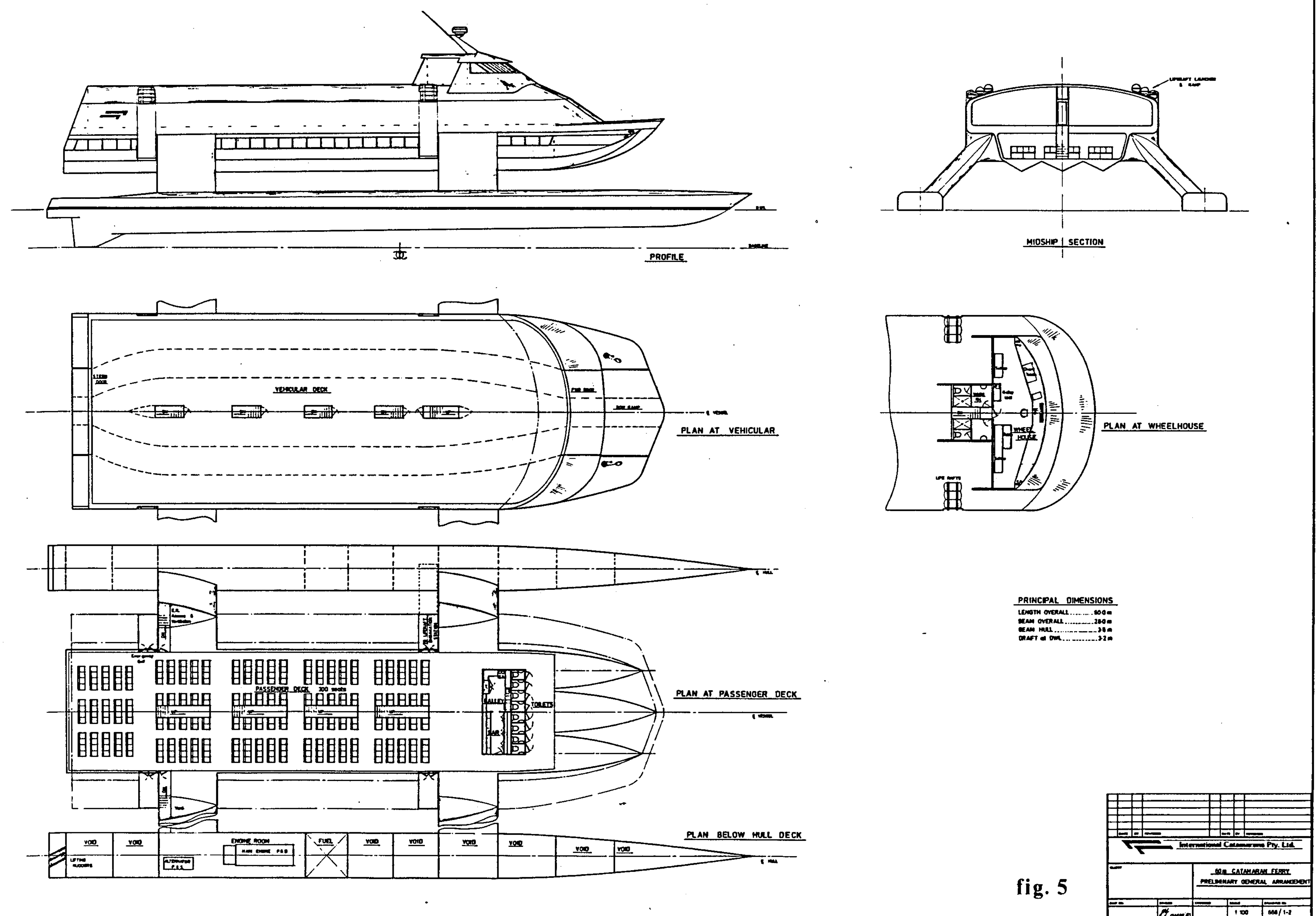

PROFILE
MIDSHIP | SECTION
LIFERAFT LAUNCHER & RAMP
VEHICULAR DECK
STERN DOOR
PLAN AT VEHICULAR
PLAN AT WHEELHOUSE
WHEEL HOUSE
LIFE RAFTS
PASSENGER DECK 300 seats
GALLEY
TOILETS
BAR
PLAN AT PASSENGER DECK
PLAN BELOW HULL DECK
VOID
ENGINE ROOM
FUEL
ALTERNATOR
LIFTING RUDDERS
PRINCIPAL DIMENSIONS
LENGTH OVERALL .... 60·0 m
BEAM OVERALL .... 28·0 m
BEAM HULL .... 3·8 m
DRAFT at DWL .... 3·2 m
International Catamarans Pty. Ltd.
60 m CATAMARAN FERRY
PRELIMINARY GENERAL ARRANGEMENT
1 100
668/1-2

fig. 5

Today we still read of sailing catamarans being lost due to structural failure. In the commercial world however, professional designers and survey authorities are quite capable of calculating the loads on powered craft and ensuring that adequate structures are designed. Quite apart from fast catamarans, in Australia there are a very large number of slow, powered catamarans in service or being built. Bridging structure failure is simply not a problem with these craft.

The structural and design techniques to safely bridge catamarans have probably not been available for much more than a hundred years. The marine industry has always been very traditional and it is only in the last few decades that any real lateral thinking and innovation has occured.

Unfortunately powered catamarans today still bear the stigma of structure and stability failures in sailing catamarans. Many people are unable to perceive the conceptual difference between sailing catamarans and powered catamarans. Yet the stigma of a yachting catastrophe does not reflect on mono hull ferries.

So it can be argued the technological advances and changes in marine industry attitudes necessary to allow catamaran development are all quite recent and indeed catamaran development is probably right on timetable.

CONCLUSION

The fast powered catamaran is now well established in ferry services. There are many different types of operations and we have touched on the way the catamaran must and can be modified to suit the special requirement of each service.

The developement process is now extending to encompass different uses for the basic concept as well as continuing with improvement of seakeeping and propulsive characteristics.

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APPENDIX - VESSELS BUILT

By September 1983 the following vessels have been completed in Hobart, Australia; Cairns, Australia; Whangarei, New Zealand; Hong Kong or Singapore.

Name	Length	Completed	Speed	Built
Jeremiah Ryan	18m	Sept. 1977	26k	Hobart
James Kelly	18m	June 1979	28k	Hobart
Tiger Lily	18m	Dec. 1979	22k	N. Z.
Tiger Lily II	19m	Jan. 1981	22k	N. Z.
Fitzroy	20m	June 1981	28k	Hobart
Tangalooma	20m	Dec. 1981	28k	Hobart
Amaroo	15m	Dec. 1981	12k	Hobart
Mingzhu Hu	21m	Jan. 1982	29k	H. K.
Yinzhou Hu	21m	March 1982	29k	H. K.
Green Islander	20m	June 1982	28k	Hobart
Green Island Express	22m	June 1982	29k	Cairns
Quicksilver	20m	Aug 1982	28k	Hobart
Liuhua Hu	21m	Sept. 1982	29k	H. K.
Telford Reef	22m	Oct. 1982	30k	Cairns
Spirit of Roylen	29m	Dec 1982	27k	Hobart
Magnetic Express	22m	March 1983	29k	Cairns
Trojan	20m	April 1983	30k	Hobart
Lijiang	21m	June 1983	29k	H. K.
Reef Link	22m	July 1983	29k	Cairns
Offshore Pioneer	29m	July 1983	32k	S'pore
Offshore Pride	29m	Sept. 1983	32k	S'pore

A further 7 vessels are under construction.