HIGH - SPEED VESSELS
Future Developments Conference

FUTURE TRENDS IN HIGH SPEED VESSELS

by

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Introduction

Fast ferries have been with us for over 40 years, the early craft being mainly surface piercing hydrofoils and hovercraft. The modern catamaran passenger ferry first appeared in Norway 30 years ago and the market continues to be dominated by this hull form. Early vessels qualified to be called fast ferries if they exceeded 25 knots with a goal of achieving, perhaps, 30 knots. Speeds quickly rose to 30 knots, but 40 knots seemed to present a natural barrier. Throughout the 70's and 80's most new passenger ferries were built for speeds in the range 35-40 knots. The 90's have brought a resurgence in the quest for higher speeds with the title "Fastest Ferry in the World" changing hands several times a year! Previously unheard of speeds are now being seriously contemplated and as the Millennium approaches, there is a real acceptance by operators that radical changes are possible and desirable.

What are the market forces driving recent rapid increases in top speeds and where will we see this trend going during the next 10 years? The reasons for the gradual increase in ferry top speeds may be some of the following:

- Simply that it is now possible; the long track record of over 1000 vessels built for what are now regarded as relatively modest top speeds in the region of 35 knots, has indicated that fast ferries are safe and very much in demand. This solid base of an established industry has encouraged leading operators to pursue higher speeds.

- A strong existing market has encouraged manufacturers, particularly for machinery and propulsors to produce ever more compact and efficient packages capable of delivery the power to weight ratios needed to push speeds up. This is particularly evident in the recent widespread application of gas turbines, to passenger and Ro-pax vessels.

- Vessels are general getting bigger as the technology matures. The economic top speed of larger ferries is higher than for smaller vessels.

- Fast ferries are being used on ever longer routes. The optimum speed on a longer route will always be higher than on a shorter route and certain very long routes can only be undertaken in a fast ferry if speeds can be increased.

- Fast ferries are trying to compete with other forms of transport, notably short haul aircraft.

Whether the above or other reasons are the driving forces the result is clear - dramatically increased ferry top speeds and a steady increase in vessel size. Large vessels moving at very high speeds raise further issues of safety, environmental impact, comfort and powering which must be carefully addressed as the industry progresses into the next century (Figure 1).

Passenger Ferries

The passenger ferry market is dominated by catamarans. Catamaran development started in Norway, where the West Coast is so difficult for land transport that movement of people by sea was a practical and unavoidable necessity from the earliest times. In the 1960's, the Norwegian Westermoen Hydrofoil Company was busily engaged in producing hydrofoils and monohulls and similar vessels were being built in Italy by Rodriquez. Then in 1970, Westermoen evolved the catamaran as a vessel which could give high speeds, coupled with stability, good seakeeping and simplicity. Since 1960, vessel sizes and speeds have steadily increased (Figure 2). Today, 650 catamaran vessels have been built and annual deliveries have stabilised at around 40 vessels per year. Total high speed passenger vessels of all hull forms now operating exceed 1300 (Figure 3). The fastest passenger-only carrying vessel in the world is the Patricia Olivia II, owned by South-American operator Buquebus and built by Derecktor Shipyards in New York state to a design from Nigel Gee and Associates Ltd. Figure 4 shows the vessel on trials in December 1998, when it achieved a maximum speed of 57 knots and a fully loaded speed of 53 knots. The speeds were achieved safely and comfortably and with noise levels in the main passenger saloon of around 70dB(A). The vessel is in daily service on the River Plate between Argentina and Uruguay. This high top speed will certainly be eclipsed in the near future by vessels exceeding 60 knots as operators demand higher speeds on longer haul routes to compete with local airlines. Nigel Gee and Associates Ltd has evolved a new hull form to meet these ever increasing speed challenges. The Pentamaran (reference 1) is a long slender monohull stabilised by sponsons port and starboard. The vessel is essentially a single catamaran hull stabilised by the low drag slender sponsons. The hull form solves the problem of the high wave-making drag encountered by shorter, fatter monohulls and significantly reduces the frictional drag suffered by twin hull catamarans. A particular variant of this hull form is the ultra high speed passenger vessel and one of these has been developed for SeaConn of the United States (Figure 5). This vessel is designed to carry commuters from Long island Sound into Manhattan at a top speed of 70 knots and a cruising speed of 65 knots. Tank tests have established the feasibility of achieving this economically and comfortably. Other passenger vessel projects include a 75 knots, 500 passenger vessel and it is hoped that construction on both these projects will begin in the coming months.

Where will these development go in the future? If a 75 knot ship is at the design stage, why not 100 knots? The idea of a 100 knot vessel carrying passengers, cars or even freight is regarded by many as nothing short of madness. “It’s not safe”; “it’s not necessary;” “it’s not possible”: these are the responses that normally greet request or suggestions from ship owners and shipyards for proposals for such vessels. But isn’t it true that only 10 years ago, the suggestion that there would be 40 knot ferries carrying not only passengers but also cars would have been treated with derision, and 5 years ago the suggestion that car ferries would have top speeds exceeding 60 knots would surely have been disbelieved. However, as we know in 1999 the 60 knot car ferry is a reality, and some 50 other car ferries are capable of speeds in excess of 40 knots. As this decade comes to a close, enquiries from owners for passenger and car ferries capable of speeds between 75 and 100 knots are increasing in frequency. The technology for such ferries certainly exists and the limiting factors will be safety, economy and comfort. The author believes that these potential limits will certainly not stop developments and that 70-75 knot ferries will be in operation early in the next Millennium and speeds up to 100 knots during the next decade. Beyond 100 knots becomes more difficult to forecast, since at these speeds the possibilities for aerodynamic lift is such that “marine” vessels will undoubtedly be lifted far enough out of the water/air interface to be considered as true marine/aero hybrids. As speeds approach 100 knots designers will have to pay far more attention to the aerodynamics of the structures they are designing. Aerodynamic drag and noise will become very important and designs will have to be routinely wind tunnel tested. The possibilities for aerodynamic lift at these speeds are significant and multi-hull vessels operating at 100 knots will undoubtedly be able to benefit from surface effect and will probably become a hybrid between a semi-planing multi-hull and a low flying wing-in-ground (WIG) effect machine. Such vessels will have most of the benefits of the low drag of a WIG vessel but with the advantage of being able to use marine propulsion and having the enhanced control ability implied by having elements permanently in the water (Figure 6).

Car and Passenger Ferries

Very fast car ferries have been with us since 30 years ago when British Hovercraft Corporation introduced 50 knot SRN4’s onto the English Channel. Although, still in operation, high manufacturing costs have limited further applications of this technology. The modern car and passenger ferry was introduced by International Catamarans in 1990, and this proved so successful that there are now in excess of 100 large fast car carrying vessels in operation and a large number on order. Sizes and speeds of vessels have steadily increased since 1990 (Figure 7) such that we now have very large examples in operation including the Stena 1500 in Europe and the Catamaran Ferries International ferry here in British Columbia. Speeds have increased to a staggering 60 knots achieved by Luciano Frederico L operated by Buquebus. Recent vessel deliveries (Figure 8) indicate that there is strong and continuing market for fast vehicle and passenger ferries. There is currently a market for 30 vessels per year having an average value of US$50 million representing a total annual sales potential of US$1.5 billion. 90% of these vessels are currently built by only 6 shipyards, mainly in Australia and Europe, but recently joined by Catamaran Ferries International in Canada. It is likely that more shipyards will enter this market, once it has been shown that market demand will continue and vessel specifications have been established. One thing seems certain - the market for this type of vessel will continue to increase, for the very strong reason that these high speed Ro-pax vessels are actually cheaper to operate than their conventional counterparts. This is because vessel purchase costs for a given work capacity are lower than for conventional vessels and crew costs are a fraction of those for the larger slower vessels with their high hotel and catering requirements. Whilst it is true that fuel costs are very much higher for fast vessels the total operational costs are still lower. This, coupled with the fact that an operator may be able to charge a small premium for the high speed transit makes high speed ferries much more profitable than their slower steel predecessors. Figure 9 shows the issues which are likely to dominate further expansion of the fast car ferry market. Whilst nearly 1000 Ro-pax vessels world wide could be replaced with fast car ferries operators are resistant to the new technology because of concerns over materials, machinery and safety. Designs which can address these fears are likely to be the more successful in the coming decade. Figure 10 summarises the requirements for future vessels. One of several solutions to this design problem is the Pentamaran car ferry. The very high efficiency of this hull form allows this vessel to be built in steel and propelled by medium speed diesels and still compete with lightweight aluminium catamarans and monohulls propelled by high speed diesels or perhaps gas turbines (Figure 11 and 12). Transport efficiency of this vessel compared with current catamarans and monohulls is shown in Figure 13.

Such a vessel can undertake relatively long voyages at high speed. A recent design study examined the carriage of cars and passengers from Scotland directly to the European continent thus bypassing the congested English motorway network. The route length is approximately 400 miles (Figure 14) and this can be achieved in 10 hours at a cruising speed of 40 knots. Vessels of this type would certainly have to meet the requirements of the IMO High Speed Craft Code which preclude the use of closed cabin accommodation. Passengers would have to be accommodated in aircraft style seating. The question arises as to whether the travelling public will be prepared to spend 10 hours, on day or overnight crossings with only a seat (albeit a very comfortable one) and not a bunk and cabin. There is an obvious parallel with air travel where passengers are prepared to spend up to 13 hours in one cramped seat and usually with very little ability to move significantly from that seat and with absolutely no alternative locations for eating or entertainment. The future fast car/passenger ferry will be weight limited and not volume limited and so passenger accommodation can and will be very spacious. All passengers can be offered at least “Club Class” seat spacing and the ability to move to restaurants, bars or promenade decks at will.

Will it possible to maintain speed comfortably on such long haul routes? Examination of the route shown in Figure 14 has indicated that at a sustained speed of 40 knots is easily possible (Figure 15) and that comfort standards comparable with highway luxury coaches can be achieved on almost all occasions (Figure16). The author believes this “Jumbo” super ferry will become a reality early in the next decade. Up to 1000 passengers and accompanying vehicles, or perhaps light freight can be transported over relatively long distances at rates which are extremely competitive with short haul aircraft. Many routes in the Americas, Europe and the Far East could be serviced by such a craft.

Fast Freighters

During the last 10 years, marine technical published literature has been full of proposals and predictions for future fast freight vessels and services. Recent conferences on fast freight transportation by sea underline the wide interest in this subject (reference 2). However, to date no significant new fast freight operation has been established. Whilst there is a general perception of market demand for fast freight services, it has proved difficult to define this market except in the most general terms. It is likely that the market will be led by the supply side at least in the short term. The argument from the design and build community is that coastal and short sea freight routes could be served by modifications of existing high speed car and passenger ferries. An existing car and passenger design modified by the removal of passenger saloons and car decks (and all their safety and comfort features) could provide a good platform for carriage of pure freight. Many such freight proposals have been offered to the operator market but as yet none have entered service. The reason for this is that the economic factors in the fast car market are very different from those in the short sea freight market. Firstly, platform costs for the small freight carrier are greater than their simple slow conventional counterparts which is the opposite of the situation with the fast car ferries, and secondly although fuel costs are up crew costs remain approximately constant. These vessels are therefore more costly than conventional freight vessels in a business where freight rates are extremely low (Figure 17). Freight rates for containerised or palletised cargo are only a fraction of those chargeable to passengers/cars and their occupants. For short sea freight, rates would need to rise by a factor of between 2 and 3 for a 40-45 knot vessel to be economically viable. It has been argued this sort of raised freight rate could be justified on the basis of the higher speed offered and the very high cost of air freight at about 10 x existing sea freight. It is considered this argument is not sound since current short sea freight is being carried at speeds of approximately 15-20 knots and air freight at 450-500 knots. The increase in speed of the sea freight to 40 knots represents only 4% of the speed increase by sending cargo by air freight and it, therefore, seems unlikely that a 200-300% in freight rate could be justified.

International container operator Norasia of Switzerland has determined a set of requirements for a high speed freighter which could trade profitably within current freight rate structures. Figure 18 shows these requirements compared with current fast freighter proposals. It can be seen that a transport efficiency 3-4 times that offered by current designs is required and a fuel cost efficiency of 6-10 times that currently proposed.

To meet Norasia's requirements, Nigel Gee and Associates Ltd have produced designs in the 20-30 knot region and also in the 40 knot range. Figure 19 shows the first of a new series of 10 super feeder/fast liner container ships building for Norasia in Germany and China. The first 5 ships are in operation and the first of class completed its maiden voyage from Zebrugge in Belgium to Montreal in Canada at a record speed for the route, averaging 26.15 knots. This speed qualified the vessel for the Blue Riband of the North Atlantic/Canadian route. By early 2000, 10 of these vessels will be in operation in the Atlantic and the Pacific, and further faster vessels based on the same hull form are planned. These vessels work profitably within existing freight rates.

To exceed 30 knots with a substantial size vessel a quantum reduction in resistance is required when compared to conventional monohull forms. Nigel Gee and Associates Ltd have proposed a Pentamaran ship (Figure 20) which can carry 12000 tonnes of containerised cargo at 40 knots economically. The economics were achieved in part because the vessel can use medium speed diesel engines burning low cost heavy fuel. Comparison between the PEBOS concept and the fast ship Atlantic monohull is shown in Figure 21. Fuel costs per tonne of cargo carried are approximately one sixth of those of Fastship and construction costs for this vessel have been estimated by European shipyards as approximately US$75 million which is one third of the published cost of Fastship.

Looking even further ahead, operators are demanding even higher speeds for specialised cargoes. Vehicles, electronics, pharmaceuticals, Fedex packages etc would all benefit from a higher speed freight service. Halter Marine commissioned Nigel Gee and Associates Ltd to examine the possibility of a 60 knot, 4000 tonne transatlantic freighter and a rendering of this vessel is shown in Figure 22. There are obvious applications for this type of craft for military sealift commands both in America and Europe.

Summary

In the current fast vessel market demand and finance are available for significant advances over a wide range of vessel sizes. The challenge to the design and build community is to produce economic, safe and comfortable vessels which can meet these market requirements. Figure 23 summarises the requirements and the possible solutions.

Precise predictions are always dangerous. In 1960 a long and illustrious future for hydrofoils and hovercraft was predicted. In the 80's a speed limit of 40 knots was widely accepted. More recently the widespread introduction of gas turbines to marine vehicles was believed very unlikely. All of these predictions have been proved wrong and it would be a brave person who would try and pick precise solutions for the next 10 years. One thing, however, seems certain; the demand for higher speed vessels carrying more payload on longer routes will increase and the winners will be those who can achieve this with economy, safety and comfort.

References

Ref. 1. The Pentamaran, a new hull concept for fast freight and car ferry applications N.Gee et al. 13th Fast Ferry International Conference, Singapore, 1997.

Ref. 2. The Economically Viable Fast Freight, Nigel Gee R.I.N.A. Conference on Fast Freight Transportation by Sea, London, 1998.

Figure 1. - Future Design Trends in High Speed Vessels

Issues :

- Speed
- Size
- Safety
- Environmental
- Comfort
- Powering

Figure 2.- Passenger Vessel Size & Speed

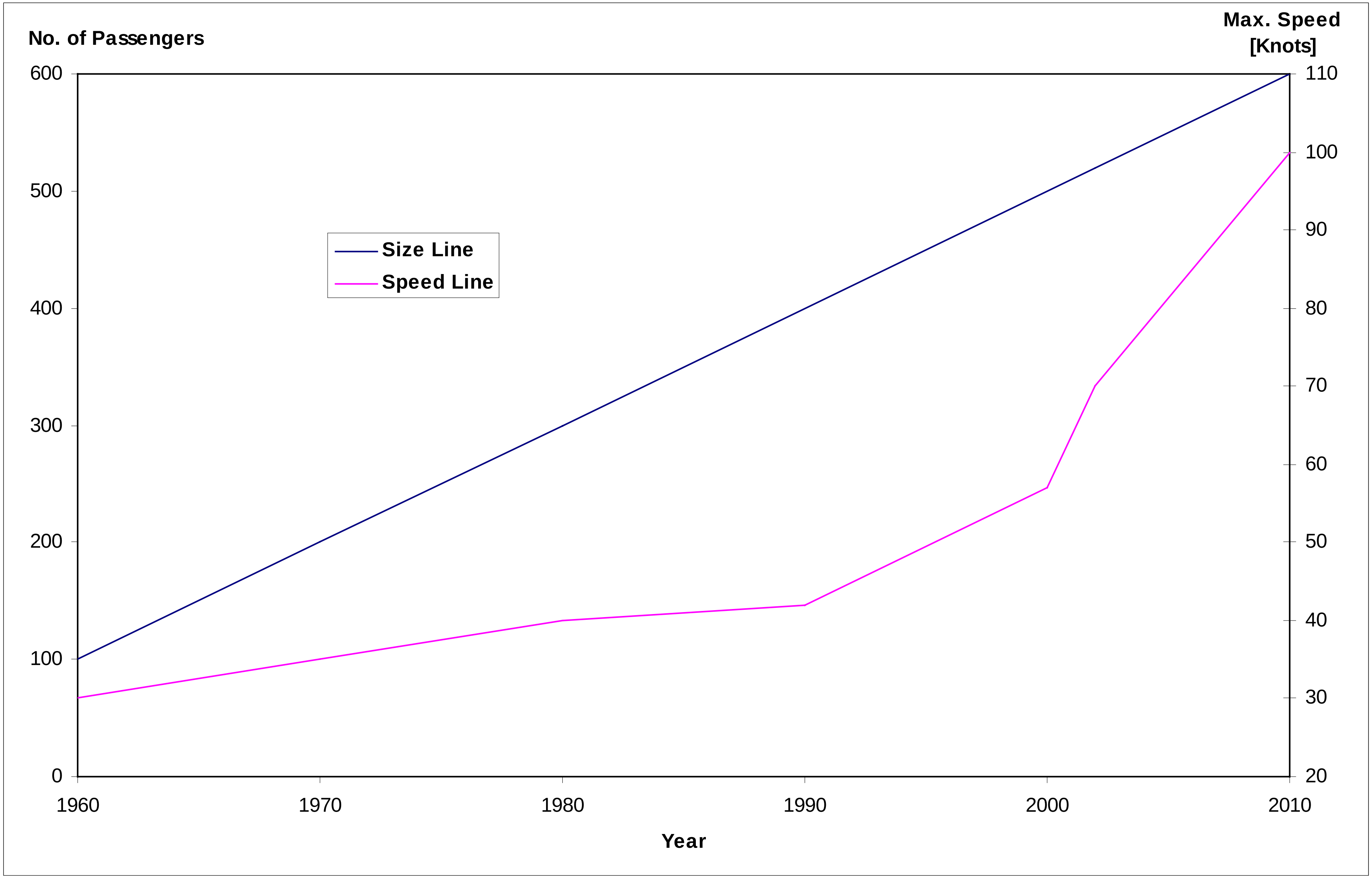

Figure 3.- Passenger Vessels in Service 1999

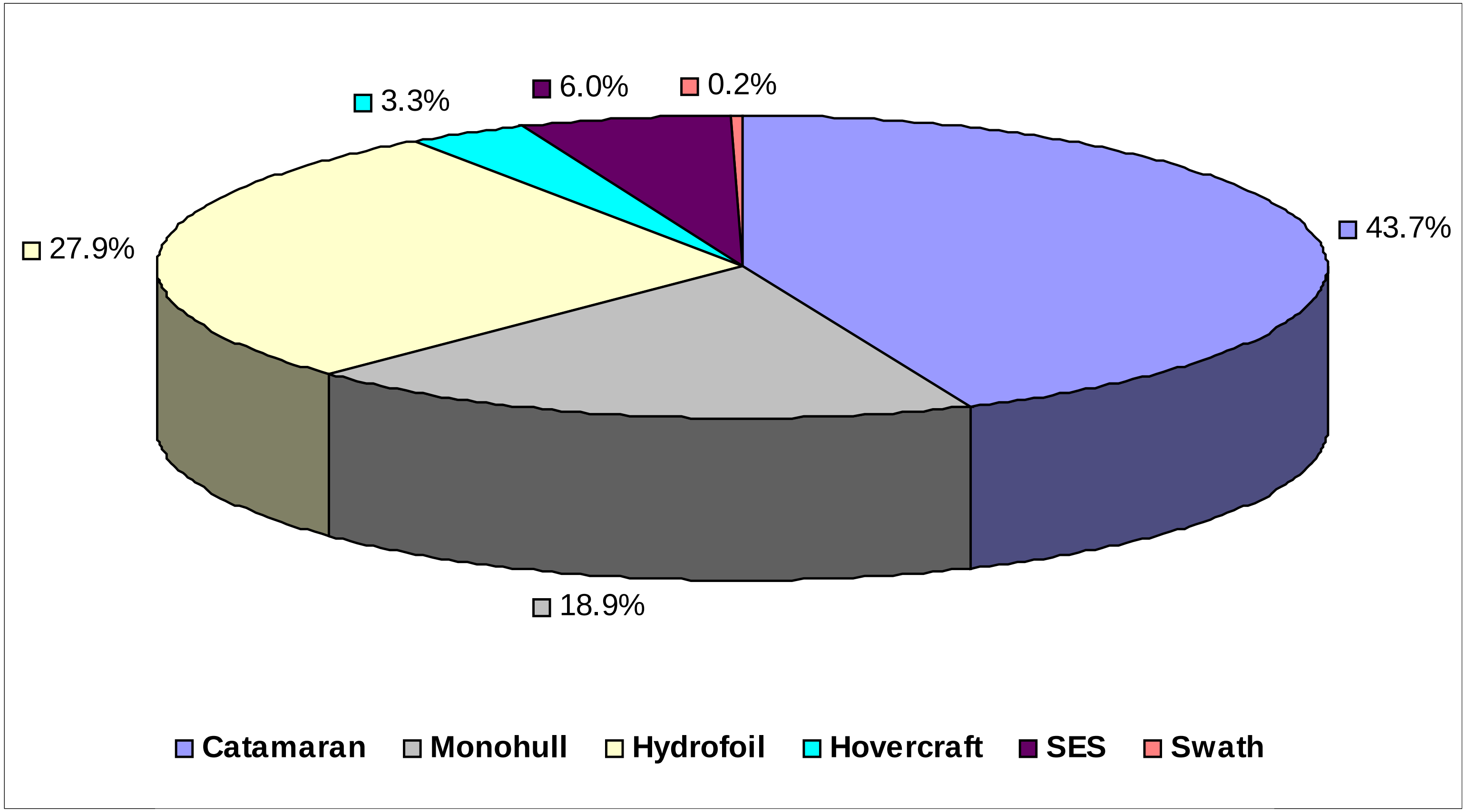

Figure 4.- Patricia Olivia II
During Sea Trials at 55 Knots

Figure 5.- Pentamaran Passenger Vessel

Figure 6.- Speed Boundaries for Waterborne & Air Crafts

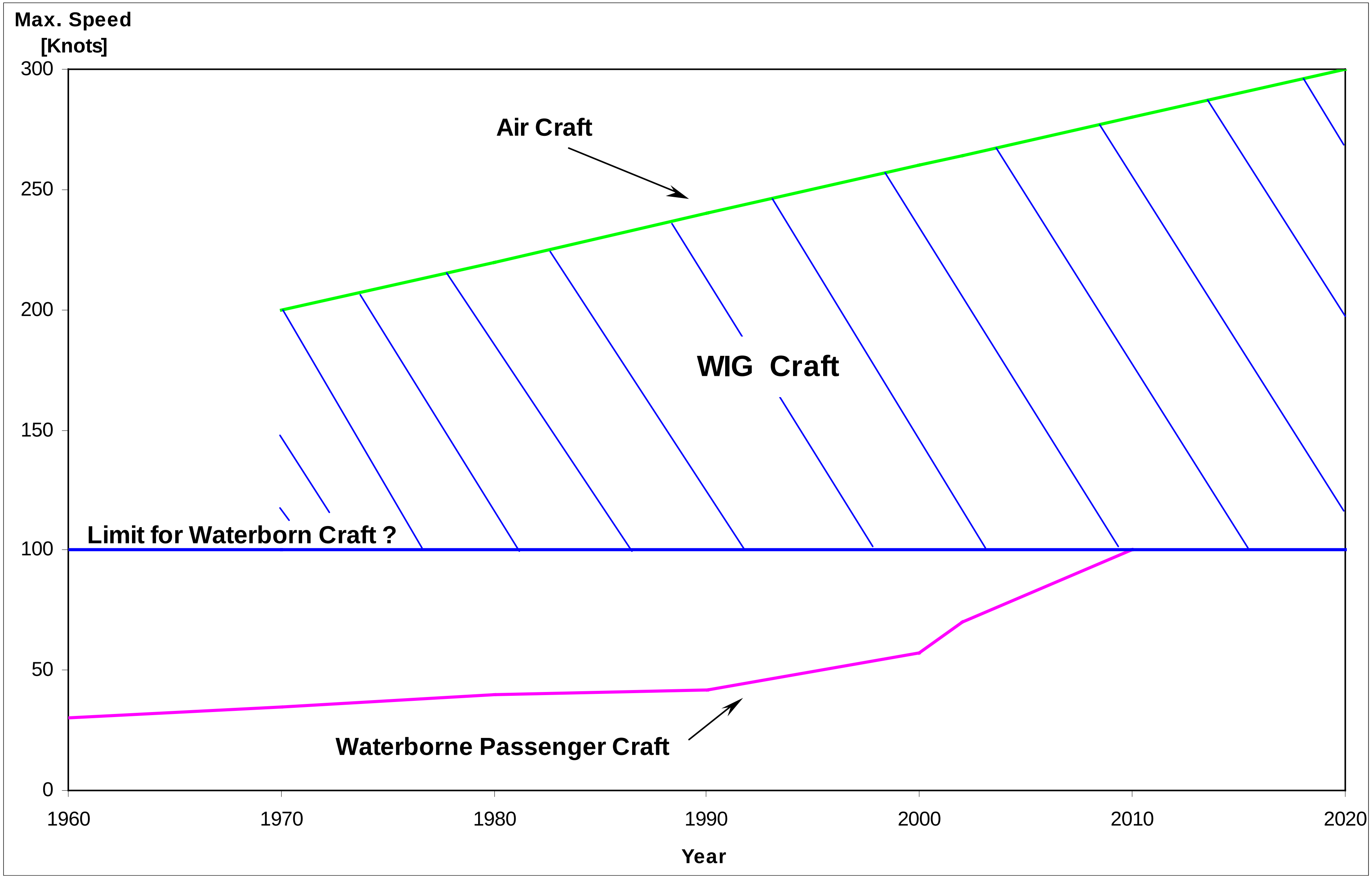

Figure 7.- Fast Car Ferry Size & Speed

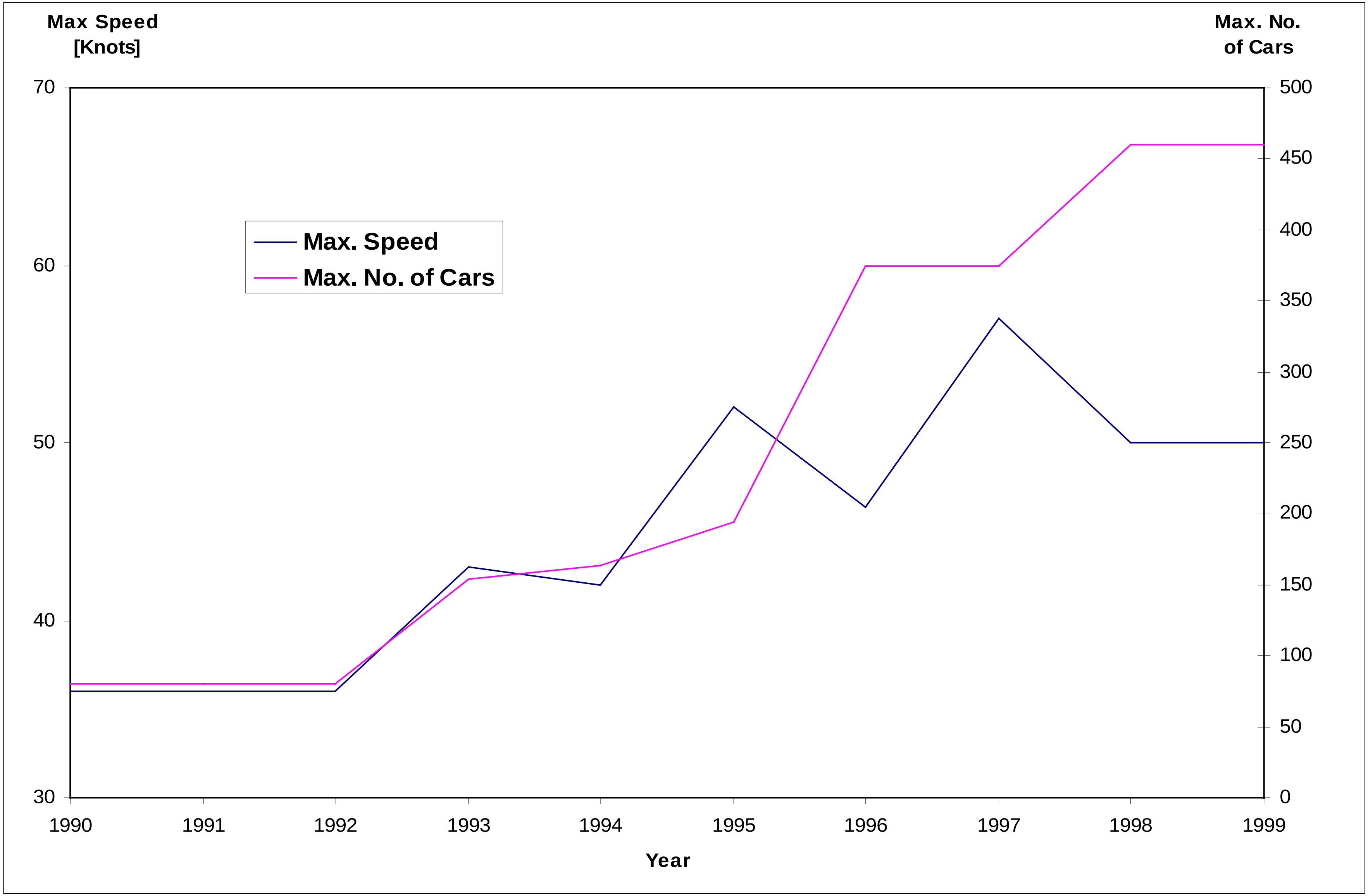

Figure 8.- No. of Fast Car Ferries Entering Service 1990 - 1999

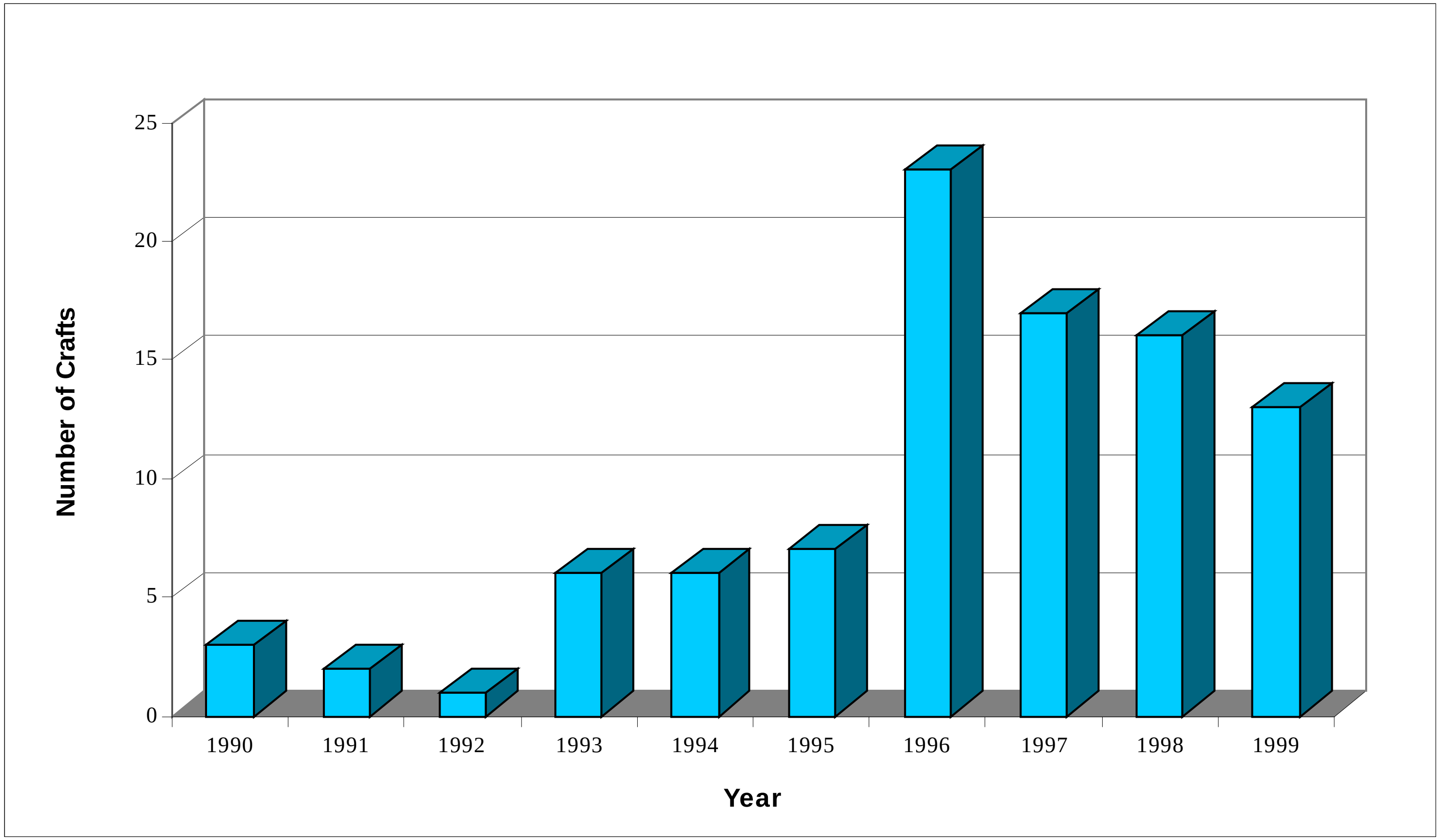

Figure 9.- Future Car Ferries - Design Issues

WHY NOT 100% CONVERSION TO FAST VESSELS ?

MARKET RESISTANCE DUE TO:

- UNCONVENTIONAL PRIME MOVERS — **HIGH SPEED DIESELS, GAS TURBINES**

  ISSUES: RELIABILITY
  MAINTAINABILITY
  MAINTENANCE COST
  FUEL COST

- UNCONVENTIONAL MATERIALS — **ALUMINIUM, COMPOSITES**

  ISSUES: COST
  DURABILITY (IMPACT / FATIGUE)
  REPAIRABILITY

- SPEED, NAVIGATION, SAFETY ISSUES.

Figure 10.- Market Requirement for Future High Speed Car Ferries

MARKET RESISTANCE ISSUE	CONVENTIONAL FERRY	CURRENT FAST FERRY	PENTAMARAN FERRY
PRIME MOVER	MEDIUM SPEED DIESEL	HIGH SPEED DIESEL OR GAS TURBINE	MEDIUM SPEED DIESEL
HULL MATERIAL	STEEL	ALUMINIUM	STEEL
SPEED	20 KNOTS	40 KNOTS	40 KNOTS

Figure 11.- Pentamaran Car Ferry General Arrangement

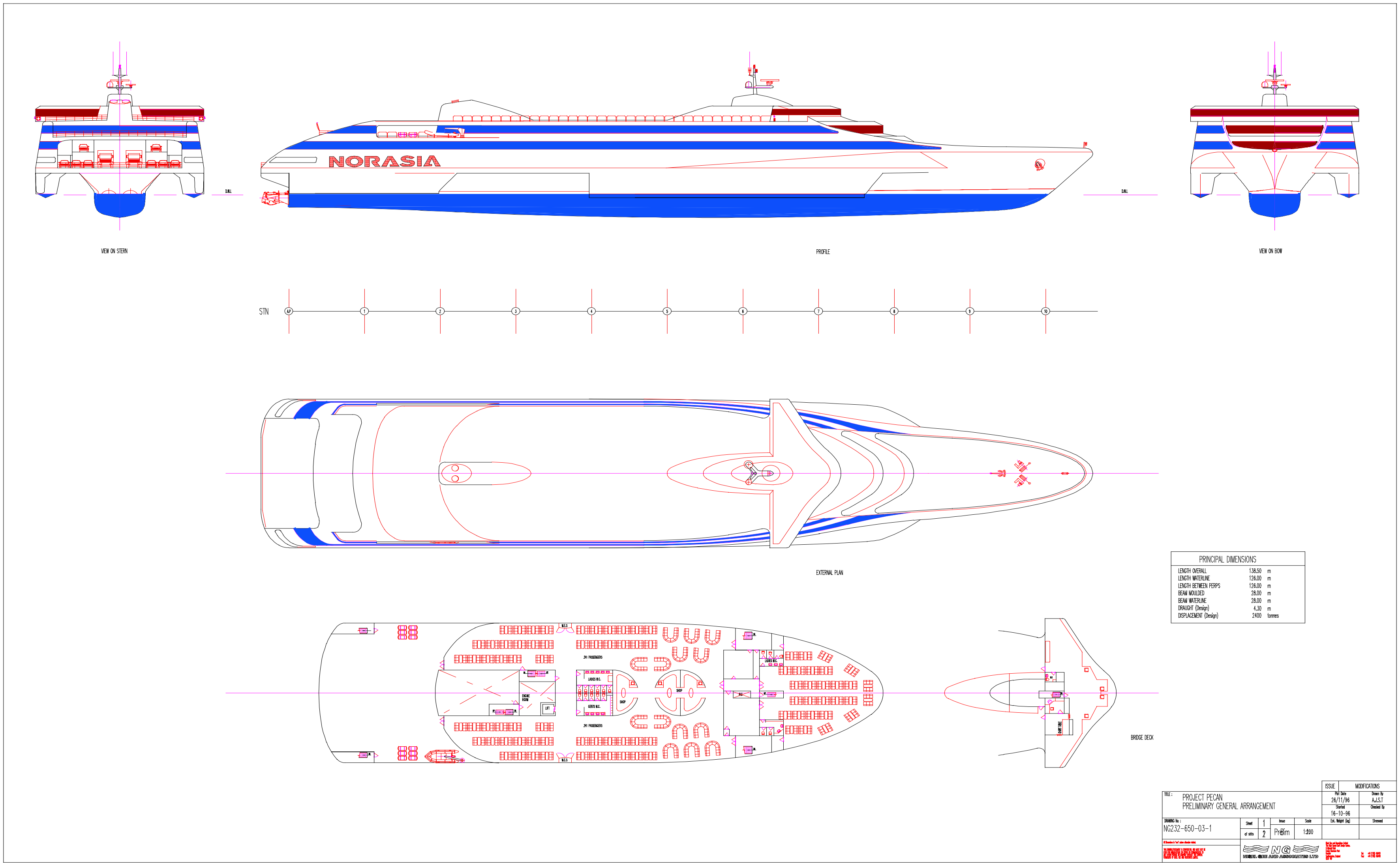

Figure 12.- Pentamaran Car Ferry Computer Image

Figure 13.- Car Ferry Transport Efficiency

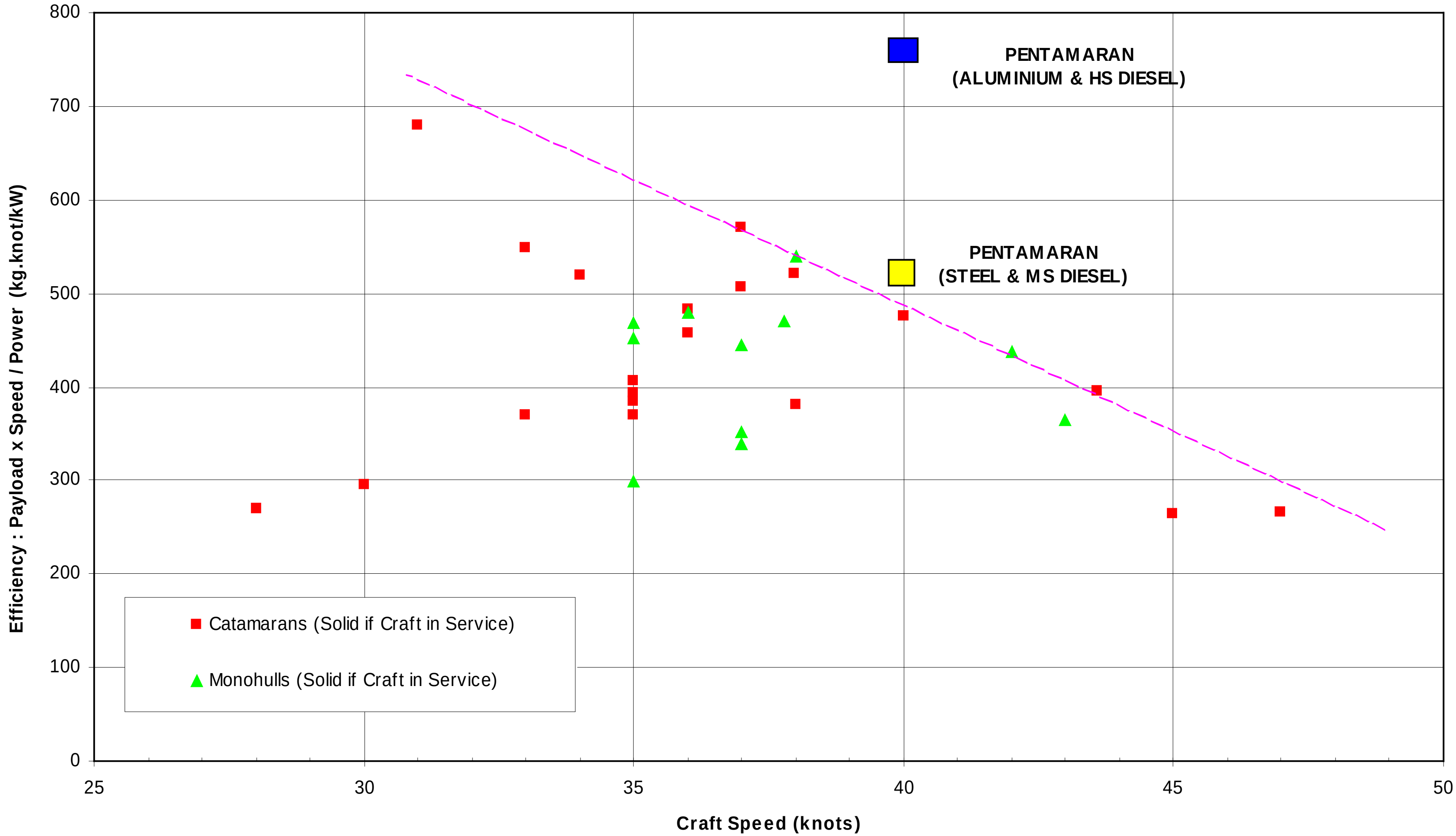

Figure 14.- European Car Ferry Route

PROPOSED ROUTE

Positions Weather Stations Shown. Recorded wave data has been used in speed analysis.

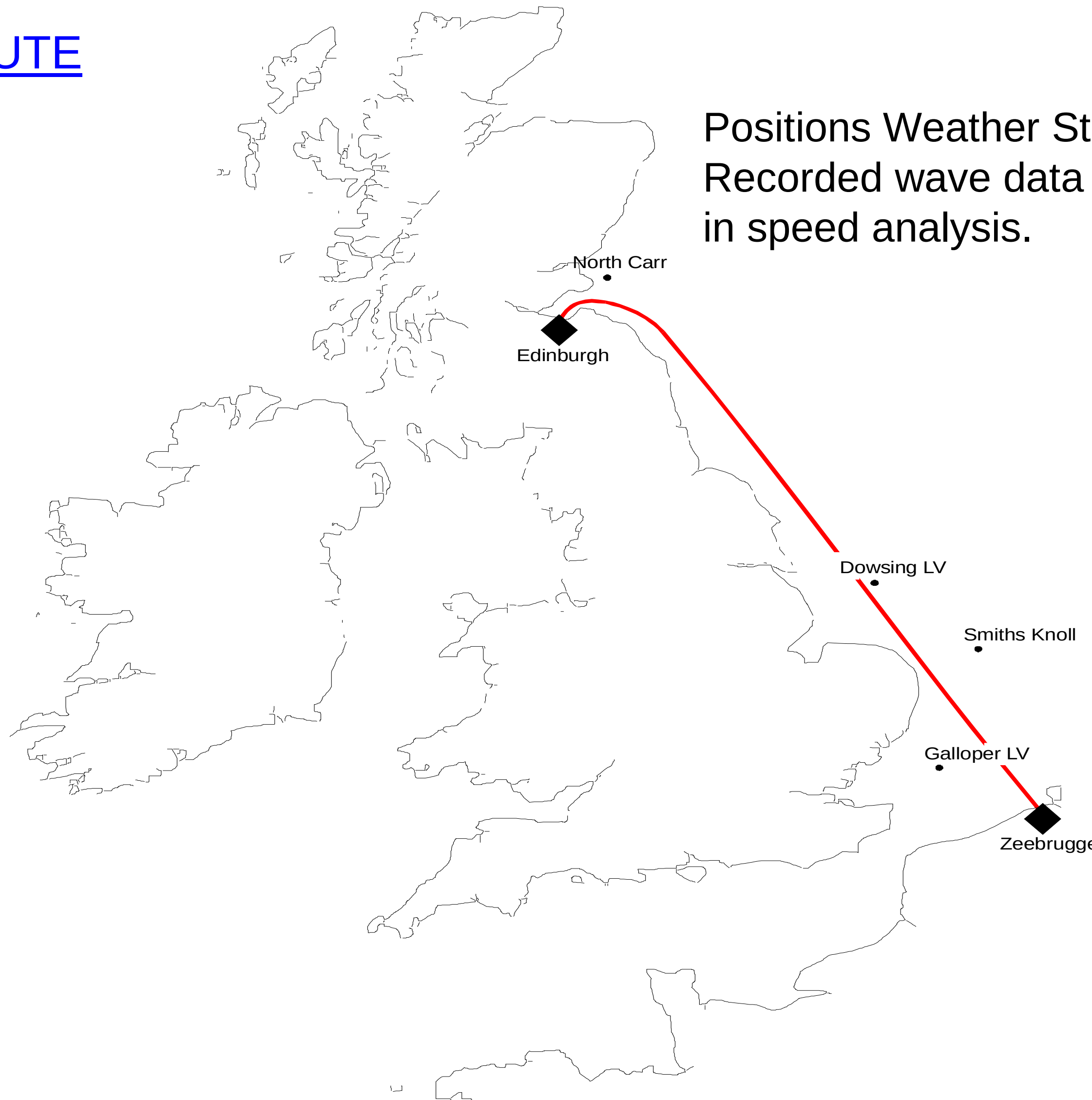

Figure 15.- European Car Ferry Route - Sustained Speed

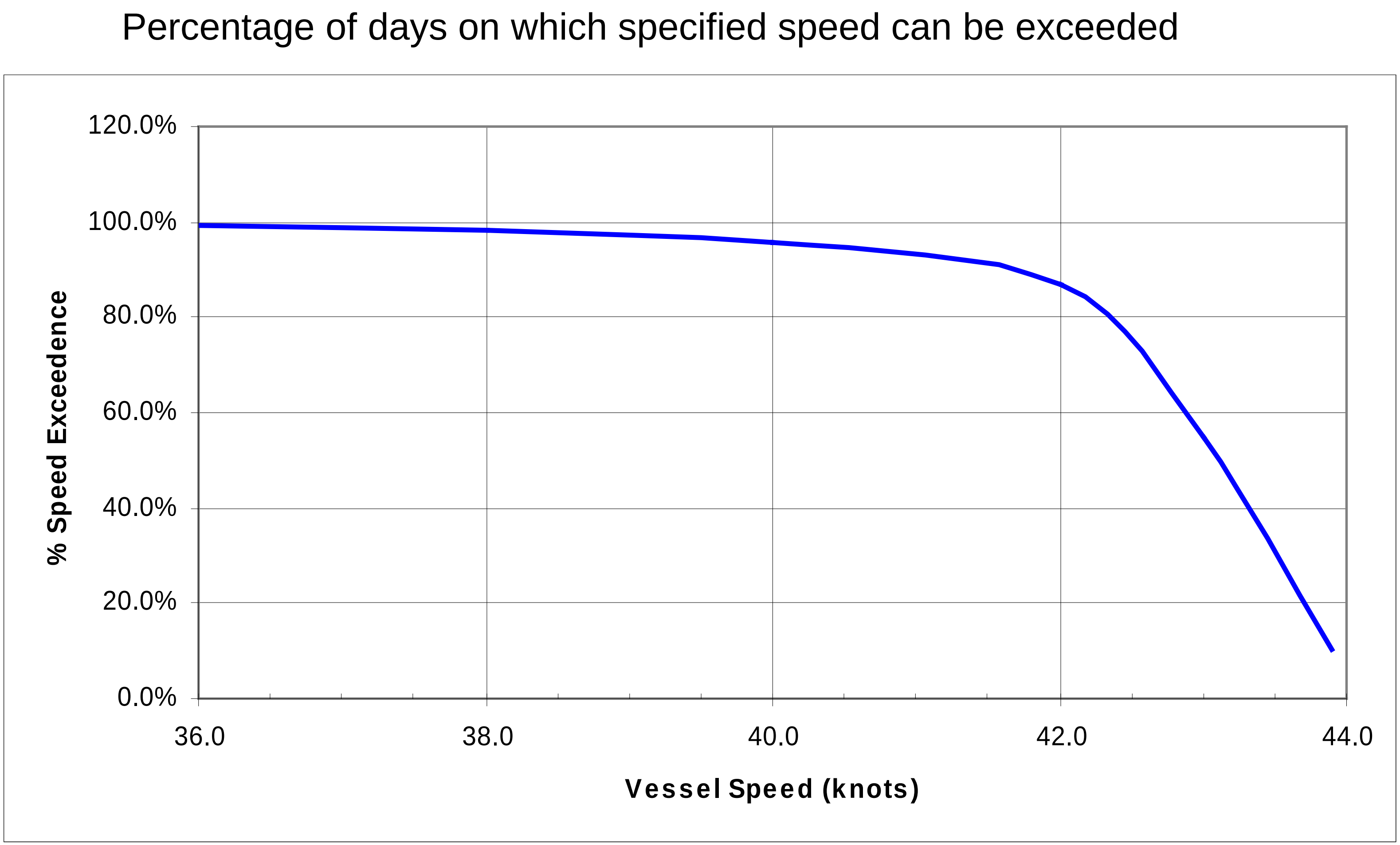

Figure 16.- European Car Ferry Route - Comfort

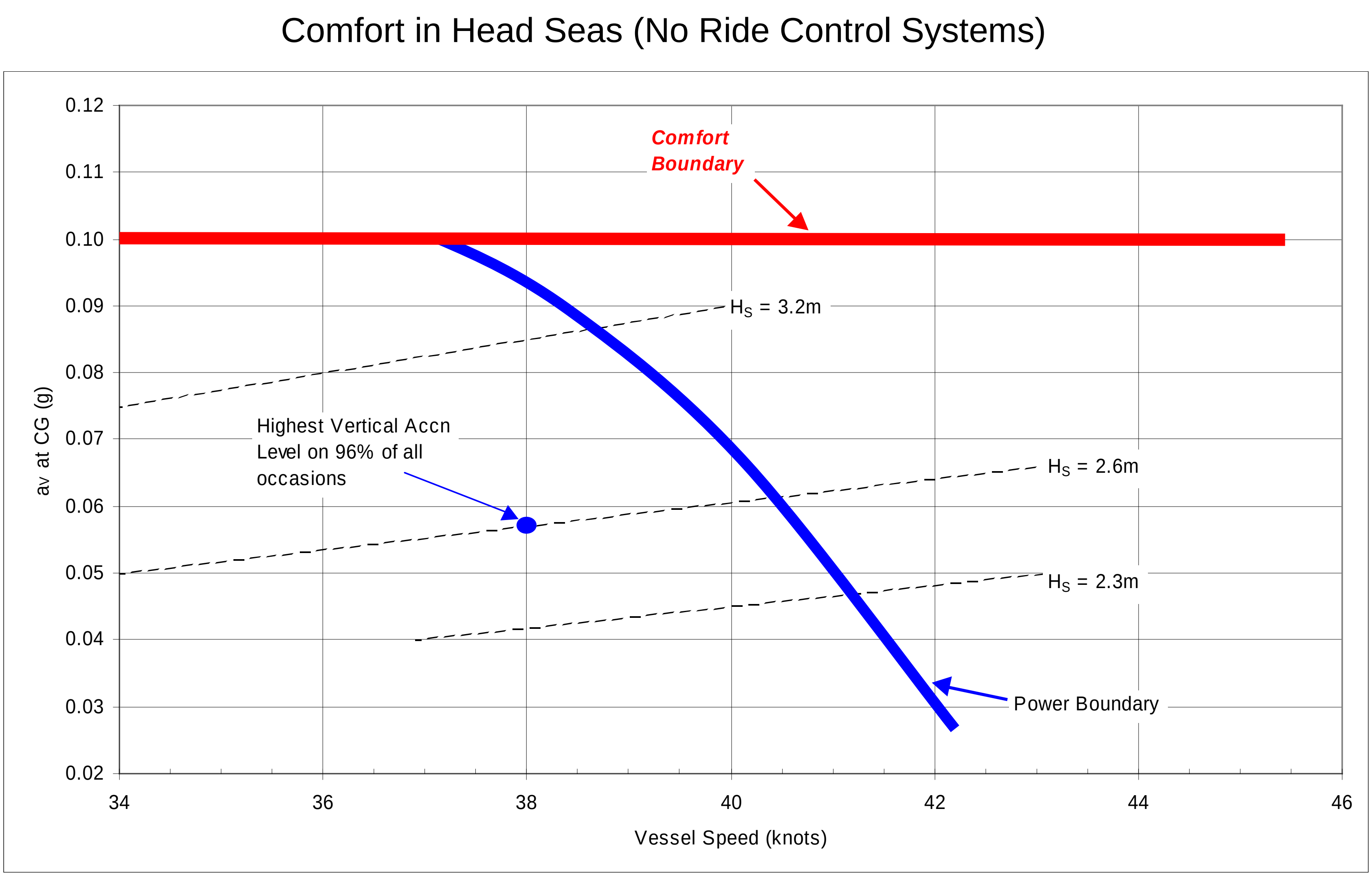

Figure 17.- Freight Rates

ROUTING	TEU	FEU
Europe - Asia	$350	$550
Asia - Europe	$1000	$2000
Europe - Middle East	$800	$1400
North Europe - Montreal	$350	-
Montreal - North Europe	$450	-

Figure 18.- High Speed Freighter Requirements

Vessel	Length m	Payload tonnes	Speed knots	Power MW	Transport Efficiency	Fuel Cost Efficiency
Fast Monohull	125	465	38	33.9	521	6.9
Fast Catamaran	95	855	33	32.4	871	10.0
TSL 'A127'	127	1000	50	87.4	572	8.35
FASTSHIP Mk II	236	9760	37.5	223.8	1635	19.6
Economic Ship Requirement (NORASIA 1999)	?	10,0000.0	40.0	100.0	4,000.0	100.0

$$\text{Transport Efficiency} = \frac{\text{Payload} \times \text{Speed}}{\text{Power}}$$

$$\text{Fuel Cost Efficiency} = \frac{\text{Payload} \times \text{Speed}}{\text{Fuel Cost per 100 n.m.}}$$

Figure 19.- NORASIA Super Feeder in Service

Figure 20.- Pentamaran Container Ship

Figure 21.- Pentamaran -vs- Fast Ship

COST FACTORS

	PENTAMARAN	FAST SHIP	RATIO IN FAVOUR OF THE PENTAMARAN
SHIP	$75 MILLION	$220 MILLION	2.9
FUEL	$1640	$7200	4.4
PAYLOAD	12,800 TONNES	9900 TONNES	1.3
CREW	20	20	1

Figure 22.- Transatlantic Ultra High Speed Freighter

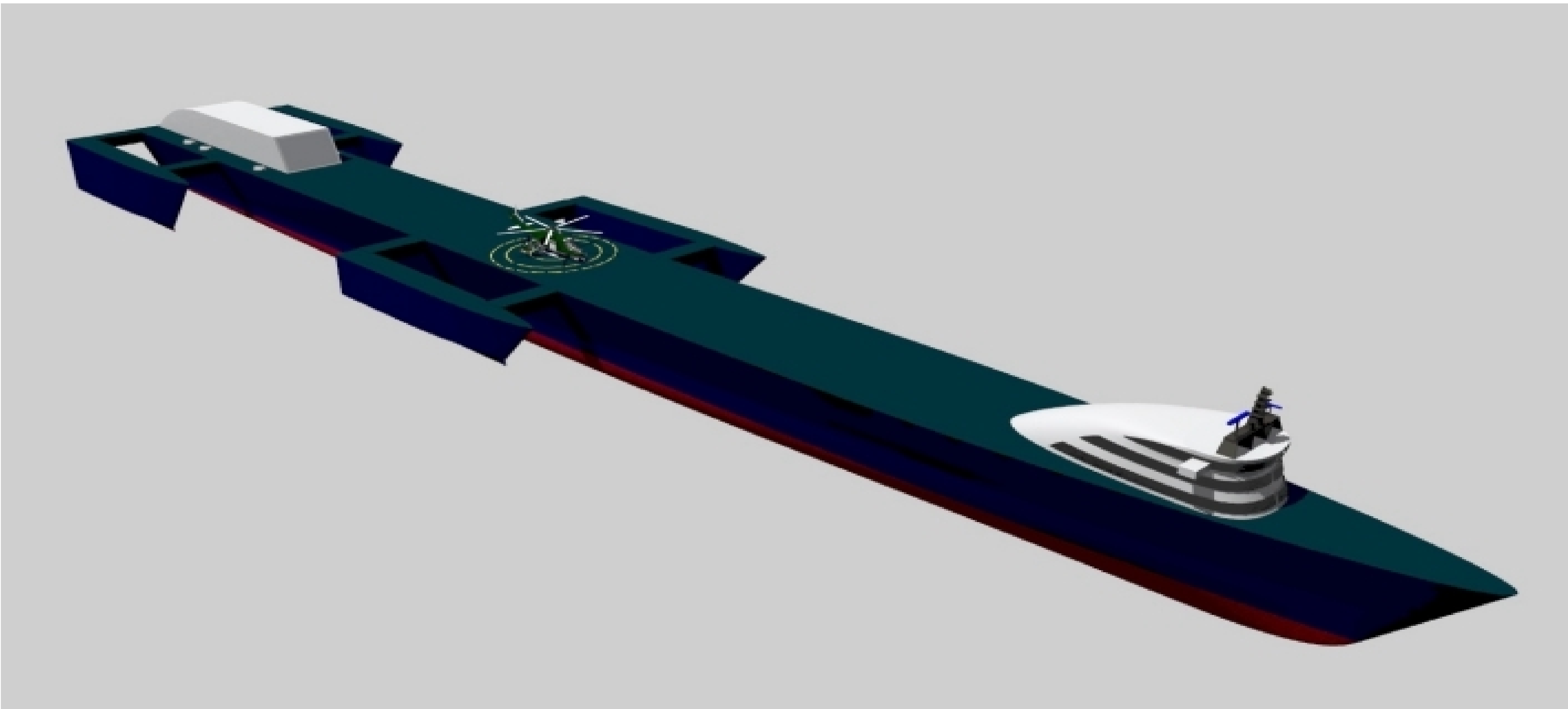

Figure 23. - Future Market Requirements and Possible Solutions

VESSEL TYPE	MARKET REQUIREMENT 2000-2010	POSSIBLE SOLUTIONS
PASSENGER FERRIES	70-100 KNOTS	TRI/PENTA - MARAN
		WIG
	500 + PASSENGERS	WAT
CAR FERRIES	50-60 KNOTS	CATAMARANS
	300-400 CARS	MONOHULLS
	30-50 TRUCKS	TRI/PENTA-MARAN
FAST FREIGHTERS	30-60 KNOTS	SLENDER MONOHULLS
	3000-10000 TONNES PAYLOAD	FASTSHIP
	3000-10000 MILES RANGE	PENTAMARANS