MARINE ENGINEERING AND RESEARCH INSTITUTE

TRANS TECH

2011

TECHNICAL PAPER ON:-

"HULL AND PROPELLER"

PRESENTED BY:-

Cdt. KOVID PARKASH (Bsc-194)

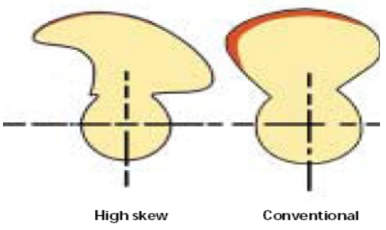
Cdt. VIVEK KUMAR (Bcs-167)

Cdt. AVADHESH KUMAR YADAV (Bsc-200

Acknowledgement

First of all we are very thankful to our Deputy Director, Mr. Rajeev prakash giving us this golden opportunity to put forth our views in form of such technical paper. We are also deeply indebted to TMI (I) for organizing such seminars.

Lastly, we express enough gratitude to our librarian for providing us with necessary library assistance and also internet facilities and in the end, Mr. A.N.S. Neti and our seniors for their constant motivation, help and guidance.



ABSTRACT

Hull and propeller are most valued part of ship without both in best condition we can not even imagine to go to sea and to sail there.

Our paper consists of environment friendly hull designs and ways to reduce propeller vibrations an increase propulsive efficiency. We are trying to throw light on some modern hull designs like pentamaran and its comparison to existing designs and some new propulsive technique including fixed pitch, azipod type, controllable pitch and contrarotating propeller.

PROPELLER

An actual marine propeller is made up of sections of helicoidal surfaces which act together 'screwing' through the water and transmits power by converting rotational motion into thrust for propulsion of a ship, or submarine through water, by rotating two or more twisted blades about a central shaft. The blades are attached to a *boss* (hub), which should be as small as the needs of strength allow - with fixed pitch propellers the blades and boss are usually a single casting. The power generated by the ships engine is absorbed by the propeller and converted to thrust.

Propeller efficiency : It is a measure of effectiveness of the power conversion by the propeller. The propeller efficiency is a major source of fuel economy.

Propeller efficiency = thrust power/ shaft power.

The various factors that influence the propeller efficiency are:

– Number of blades: fewer is better.

– Propeller diameter: bigger is better.

– Propeller revolutions: Lower is better.

– Blade area: Smaller is better.

– Surface area: Smoother is better.

Propeller design

Various design of propeller to achieve optimum requirements have been tried.

Some of them are:

☐Contra-rotating propellers.

☐Highly skewed propellers.

☐

☐

☐Overlapping propellers.

☐Rudder propeller systems

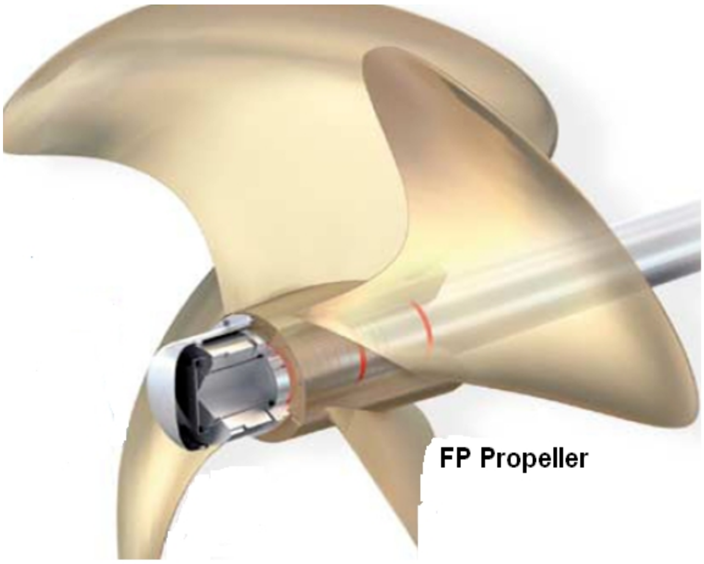
By skewing the blades, noise and vibrations can be reduced to a minimum

<u>Propeller types :-</u>

Propellers may be mainly divided into the following three groups:

- Fixed pitch propeller (FP propeller)
- Controllable pitch propeller (CP propeller)
- Contra Rotating Propeller(CRP)

Pitch: it is the distance that the blade



of the propeller would move forward or backward in one revolution if it did not slip wrt the water.

Fixed Pitch Propeller (FPP)

Propellers of the FP type are cast in one block and normally made of a copper alloy. The position of the blades, and thereby the propeller pitch, is once and for all fixed, with a given pitch that cannot be changed in operation. Most ships which do not need a particularly good manoeuvrability are equipped with an FP propeller.

Service:
It is most common among ordinary ships like container ships, bulk carriers, cruise ships and crude oil tankers sailing for a long time in normal sea service at a given ship speed.

Disadvantages:

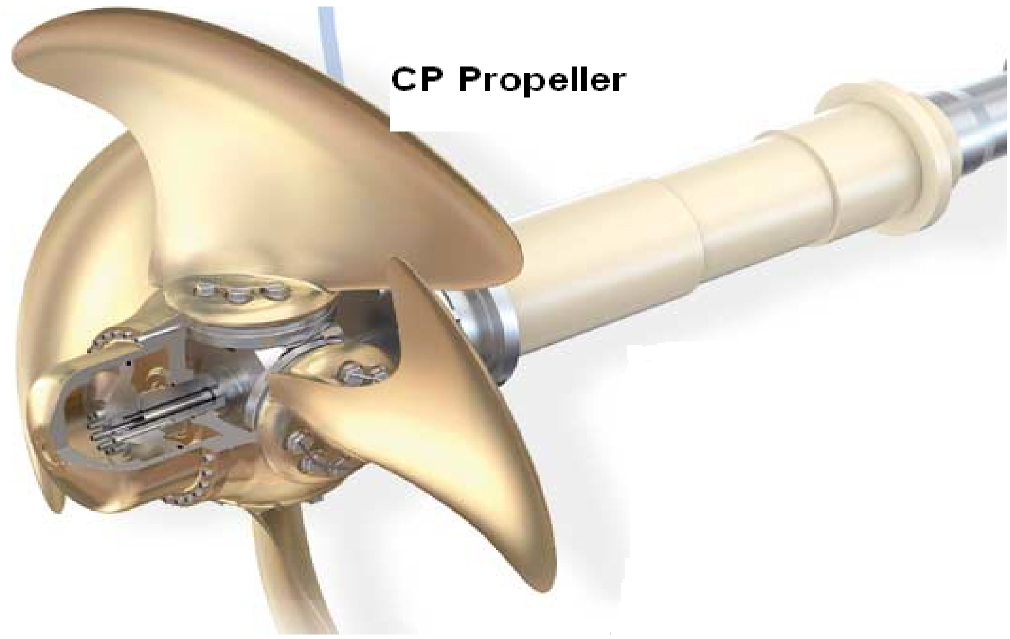
While it is true that a fixed pitch propeller (FPP) can be more efficient than a controllable pitch propeller, it can only be so at one rotational speed and the designed load condition. At that one rotational speed and load, it is able to absorb all the power that the engine can produce. At any other rotational speed, or any other vessel loading, the FPP cannot, either being over pitched or under pitched

Controllable Pitch Propellers (CPP)

Controllable pitch propellers (CPP) for marine propulsion systems have been designed to give the highest propulsive efficiency for any speed and load condition.

A **controllable pitch propeller** (CPP) or **variable pitch propeller** is a special type of propeller with blades that can be rotated around the drive shaft to change their pitch. If the pitch can be set to negative values, the **reversible propeller** can also create reverse thrust for braking or going backwards without the need of changing the direction of shaft revolutions.

Controllable pitch propeller



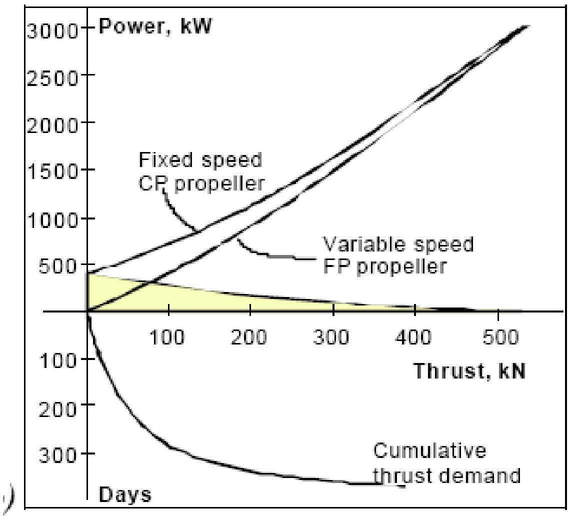
In controllable pitch propeller (CPP), the blades are rotated normal to the drive shaft by additional machinery - usually hydraulics - at the hub and control linkages running down the shaft. This allows the drive machinery to operate at a constant speed while the propeller loading is changed to match operating conditions. It also eliminates the need for a reversing gear and allows for more rapid change to thrust, as the revolutions are constant.

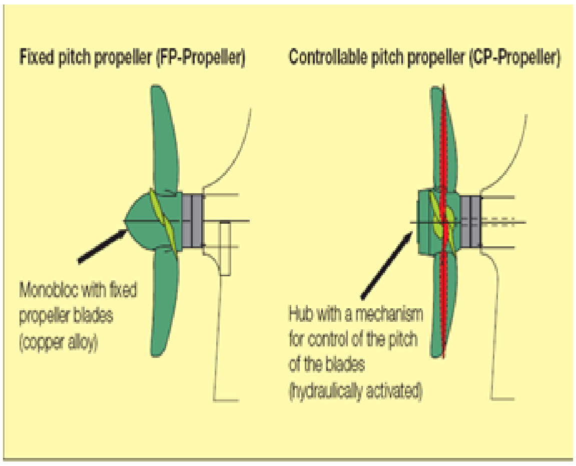
A correctly sized controllable pitch propeller can be efficient for a wide range of rotational speeds, since pitch can be adjusted to absorb all the power that the engine is capable of producing at nearly any rotational speed.

CPP vs FPP

- Propellers of the CP type have a relatively larger hub compared with the FP propellers because the hub has to have space for a hydraulically activated mechanism for control of the pitch (angle) of the blades.

- The CP propeller is relatively expensive, maybe up to 3-4 times as expensive as a corresponding FP propeller.
- Furthermore, because of the relatively larger hub, the propeller efficiency is slightly lower.





comparision of propellers

Benefits:

– The controllable pitch propeller also has a "vane"-stance, which is useful with combined sailing/motor vessels as this stance gives the least water resistance when not using the propeller (e.g. when the sails are used instead).

–The CPP also improves maneuverability of a vessel. i.e the fast change of propulsion direction, without slowing down the propeller .

–A reversing gear or a reversible engine is not necessary anymore, saving money to install and service these components. Although a CPP does require a hydraulic system to control the position of the blades.

–Disadvantages:

–It will, in general, be a waste of money to install an expensive CP propeller instead of an FP propeller for large vessels that make long trips at a constant service speed, for example crude oil tankers or the largest container ships.
– Furthermore, a CP propeller is more complicated, hence reduced reliability.
–With oil in propeller boss, possibility of pollution of sea with oil
–Increased maintenance on propeller and extra maintenance due to additional equipment involved (propeller pitch setting mechanism).

Service:
A CPP can mostly be found :

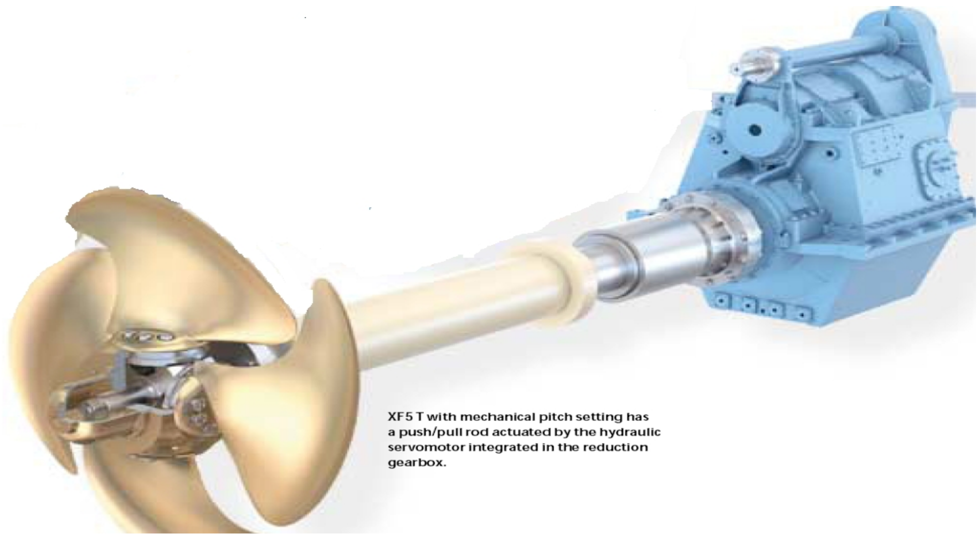
–on harbour or ocean-going tugs, dredgers, cruise ships, ferries and cargo vessels that sail to ports with limited or no tug assistance .

– in unidirectional machines e,g. diesel engine, gas turbine and steam turbine and double duty vessels such as tug and trawler.

REDUCTION GEAR BOX

Reduction gear box is required in medium speed engines, the propeller of which rotates at high speed. Since efficiency of the propeller increases with decreasing the rpm of the rotation of the propeller, the gear box decreases the rpm to a ratio to optimize maximum the efficiency. It is designed as a combined speed reduction unit with common hydraulic system for gear and propeller. The gear has a built-in hydraulically operated clutch and is provided with seating brackets for bolting to the ship's foundation. The input shaft is provided with keyway for mounting of the flexible coupling, and the output shaft with a cylindrical shaft or flange.

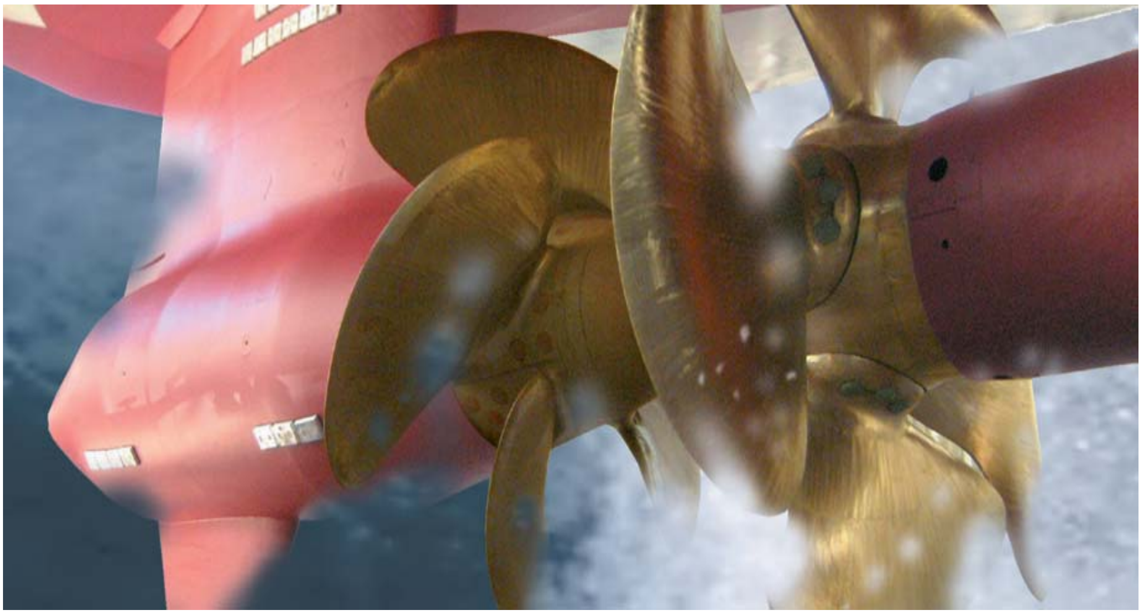
The hollow bored propeller shaft carries the single oil tube or the actuating rod. The reduction gearboxes are normally equipped with one-step reductions from 1.5:1 to 5.95:1 (6.25:1).



CONTRA ROTATING PROPELLER (CRP)

In the contra-rotating propellers, where two propellers rotate in opposing directions on a single shaft.

Contra rotating propeller increases the hydrodynamic efficiency by utilizing the rotational energy of the jet stream from one propeller, to create thrust from the other that rotates the opposite direction.
The CP propeller eliminates the need for a direct-reversing engine



Main advantages of CR propellers are:

-Vibration free

-Low noise

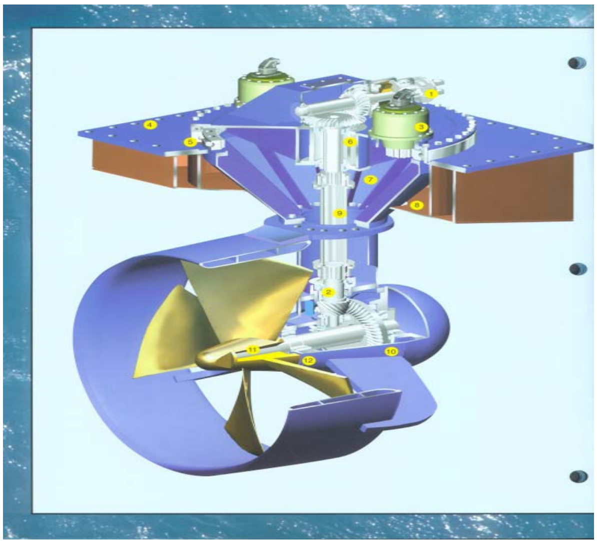
-Highest fuel economy

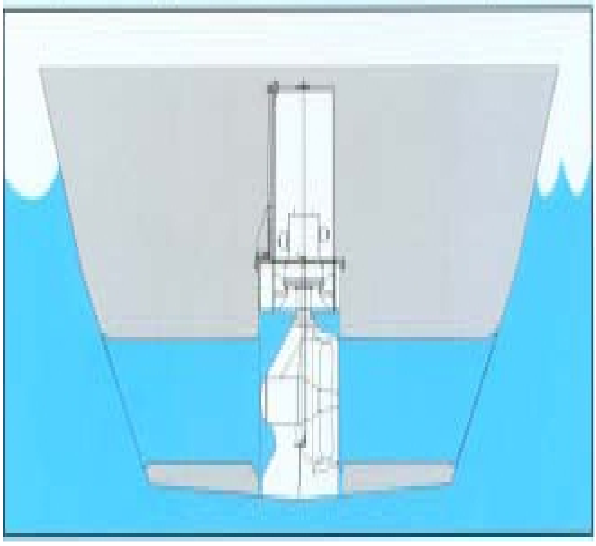
Service:
CR propellers are mostly used for Ro-Ro ships, shuttle tankers and similar ships that require a high degree of maneuverability.

THE AZIMUTH THRUSTERS

An **Azimuth thruster** is a configuration of ship propellers placed in pods that can be rotated in any horizontal direction, making a rudder unnecessary. These give ships better maneuverability than a fixed propeller and rudder system.

The basic idea behind an azimuth thruster is that the propeller can be rotated 360 degrees around the vertical axis, providing omni-directional thrust.





Types of Azimuth Thrusters

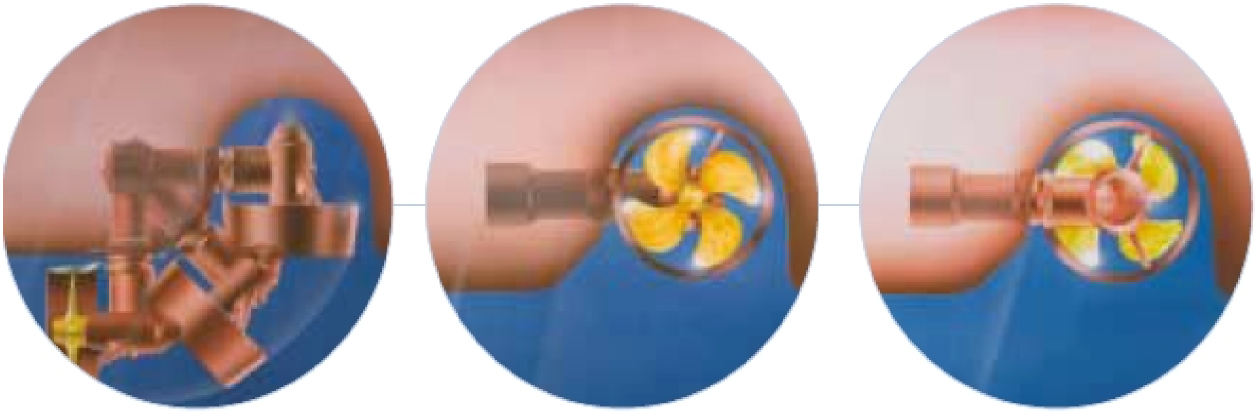
Azimuth thrusters are available as fixed installed, retractable and underwater-mountable. Mechanical azimuth thrusters are available with fixed pitch propellers FPP and controllable pitch propellers CPP.

1.Fixed installed thrusters are used for tugs, ferries and supply-boats.

2.Retractable thrusters are used as auxiliary propulsion for **DP-vessels** and **take-home propulsion for military vessels.**

3.Underwater-mountable thrusters are used as DP-propulsion for very large vessels such as semi-submersible drill rigs.

Working principle:
In order to improve the hydrodynamics and steering capability that is required for propulsion, the shape of the thruster has been adapted, such as the "mechanical pod". This is an azimuthing thruster, which is powered from an in-board, typically a horizontal motor, and the mechanical power is then transferred to the propeller with a gear.



The thruster is 360° rotatable and swings up into a shallow recess in the hull bottom.

The underwater shape is optimized for low hydrodynamic resistance at higher ship velocity, for higher propulsion efficiency.

Advantages:

A set of azimuthing thrusters replace a conventional propulsion and rudder steering system with integrated units that perform both propulsion and steering functions.

- vessel maneuverability is greatly improved, enable them to travel backward nearly as easily as they can travel forward.
- vessel can turn 360 degrees in its own length.
- vessel can dramatically position or hold station in open waters.
- vessel can berth under adverse weather condition.

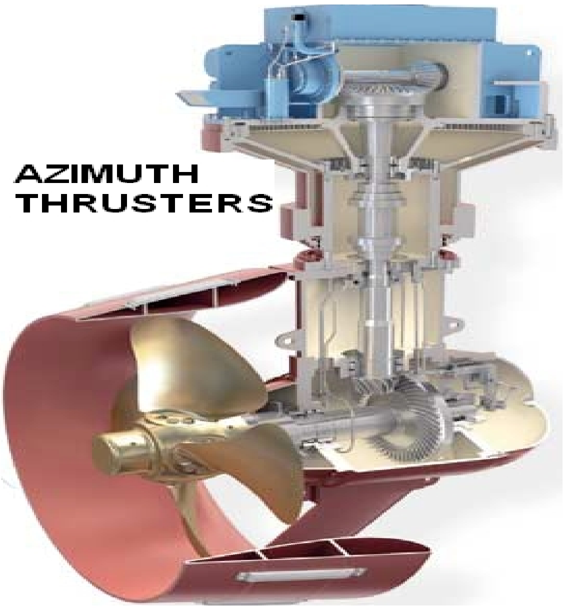
Primary advantages are electrical efficiency, better use of ship space, and lower maintenance costs.

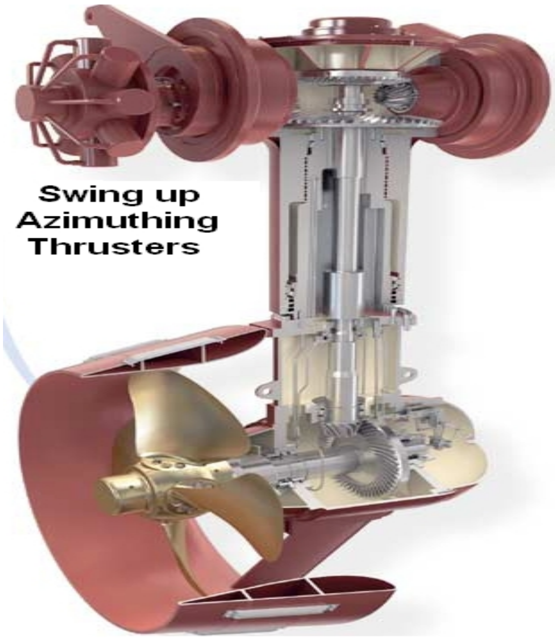
Disadvantages:

- limited ability for producing thrust at negative pitch or RPM, because they are designed and optimized for unidirectional thrust.

CRP Azimuthing thrusters

The use of azimuth thrusters with counter-rotating propellers and hull lines designed to give non-disturbed water flow gives a considerable improvement in efficiency over conventional propellers. The twin azimuth thrusters also contribute to added safety and manoeuvrability, which reduces manoeuvring time in and out of port.





Applications:
Suitable for:

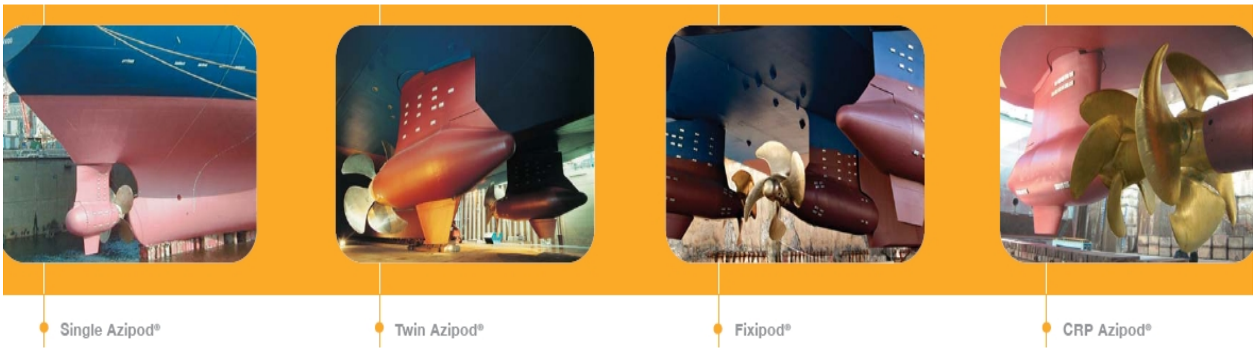
- *tugs*
- *offshore supply/service vessel*
- *cargo vessels*

Applications:
Suitable for

- *tankers*
- *cargo vessels*
- *cruise ships/ferries*
- arctic vessels

POD DESIGN

Podded propulsors have recently been introduced into marine industry and derived from the concept of azimuthing thrusters. There applications for years was in ice breakers and then cruise ships but currently they found application in **Ro/ pax** ferries, tankers, naval and research ships.
A podded propulsion is a propulsion or maneuvering device that is external to the ship's hull and houses a propeller powering capability. This, therefore, distinguishes them from azimuthing thrusters which have their propulsor powering machinery located within the hull and commonly drive the propeller through the system of shafting and spiral gearing. The mechanical system of the podded propulsor has a short propulsion shaft on which an electric motor is mounted. The propeller fitted in this type is fixed pitch.
ABB's Azipod and Rolls-Royce's Mermaid have similar outer appearance while Siemens-Schottel's SSP has a different design with two propellers.
Azipod® applications include:



- ***Single Azipod***® solutions are used for vessels such as tankers and cargo ships, and with a double-wound motor, a high degree of redundancy is achieved.
- ***Twin Azipod***® provides greater maneuverability and full redundancy from power generation to propeller. Twin Azipod® is the most widely used propulsion for cruise ships.
- ***Fixipod***® is a non-rotating pod that, combined with twin Azipod®, is a very attractive solution for large vessels with high power and redundancy requirements.
- ***CRP Azipod***® is a unique contra-rotating propulsion system designed specifically for high-speed, high-power vessels such as Ultra Large Container ships, LNG carriers and RoPax ferries.

Advantages

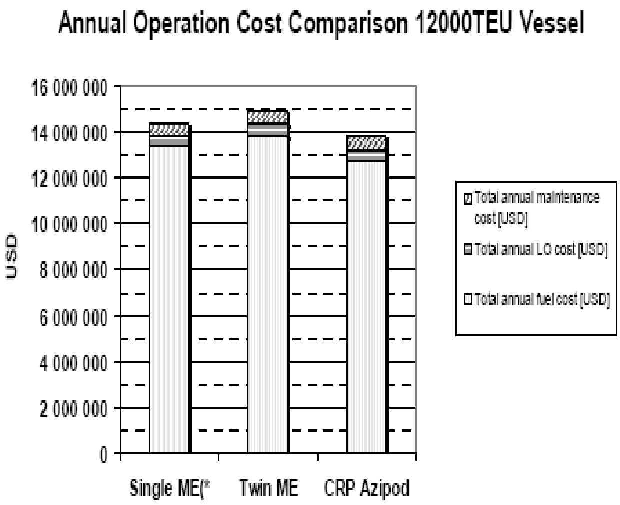
Technical

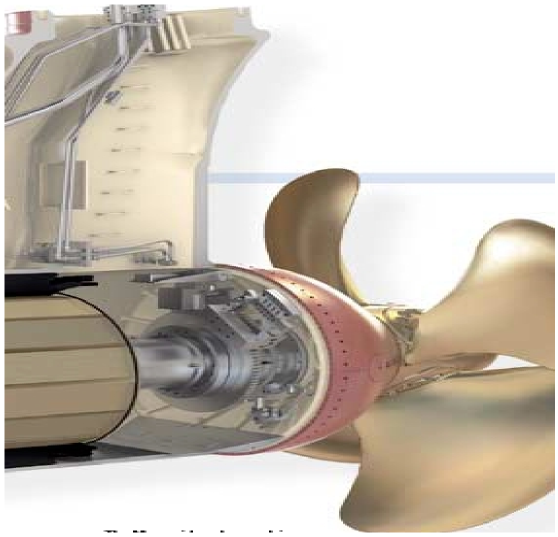
- Easy mounting at the shipyard
- Two independent propulsion systems give high redundancy
- Excellent reversing capability and steering during astern navigation
- Enhanced crash stop performance
- Superior manoeuvrability and dynamic performance
- Low noise and vibration characteristics associated with a conventional electric drive system

Economical

- Highest propulsion efficiency and therefore maximum fuel economy
- More cargo space, i.e. greater revenue

- Need for long shaftlines, rudders, stern thrusters and reduction gears is eliminated, resulting in space and weight savings.
- Increased propulsion system efficiency



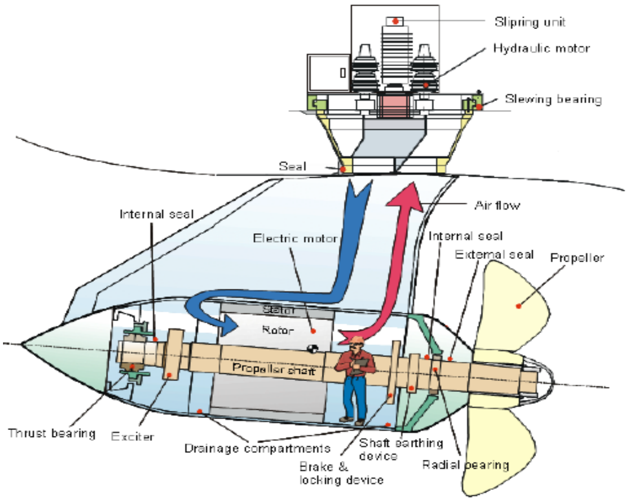


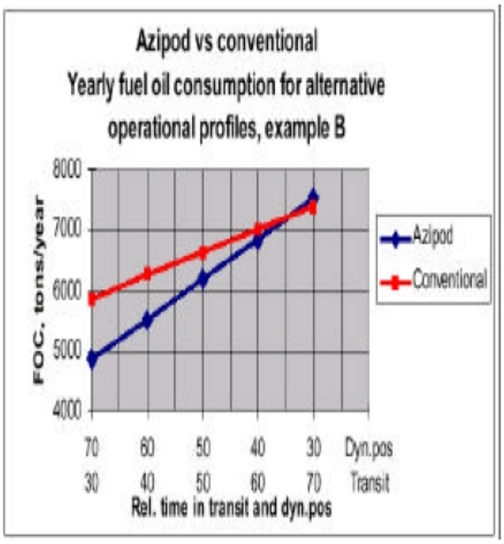
Operation cost calculation results for 12000 TEU vessel: total annual cost of fuel, lubrication oil and diesel engine maintenance and a podded propulsor design

Today´s most efficient propulsion solution – CRP azipod

The CRP Azipod® system encompasses several unique advantages resulting in the best hydrodynamic efficiency in the industry:

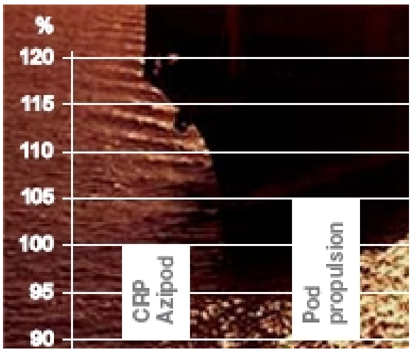
- *Thrust load is divided* over two contra-rotating propellers
- *Rotational losses are recovered*
- *Single-skeg hull form* offers better wakefield and lower resistance
- *Cavitation characteristics are improved* due to lower loading on the blades
- *Lower cavitational forces* due to smaller optimum propeller diameter and larger clearance to the hull
- *Better maneuvering characteristics,* especially in ports and channels





Typical applications:
Suitable for:

- offshore rigs
- cruise ships
- tankers
- Ro-Ro ferries

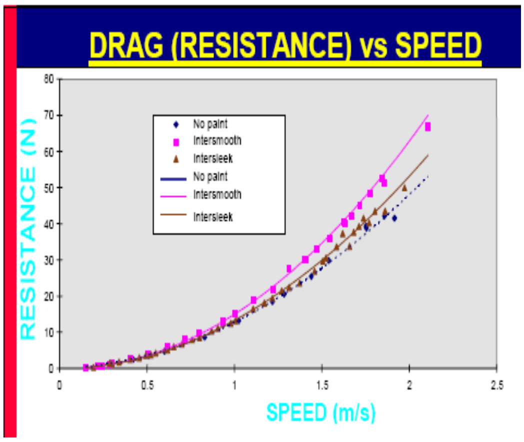


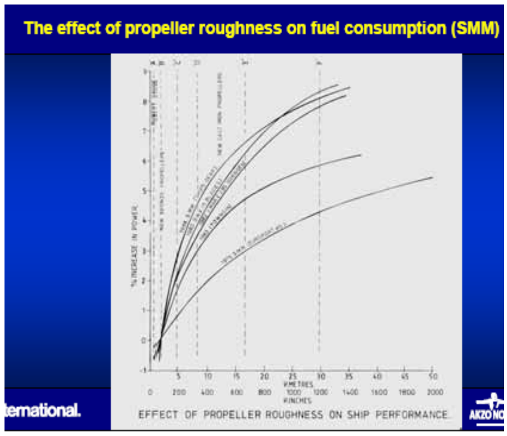
Required propulsion power at the same speed

HULL DESIGN

Fouling

Fouling is the ubiquitous growth, such as algae, tubeworm and barnacles, which settle on any submerged surface in the sea such as the ship's hull.the growthof this fouling is temperature dependent. Fouling is removed, usually, by under water cleaning and polishing.





The graph shows the increase in hull resistance without paint

The friction between hull and water is improved due to fouling, therefore, more use of power and less efficiency, increasing fuel consumption (fig.). This resistance increases with speed of the vessel as shown by the graph.

Certain coatings e.g. Sea-Slide coating reduces friction between hull and water and can be used over most anti-fouling paints. They have excellent drag reduction and can be used on personal water craft to improve speed and handling; on boats to improve speed and fuel consumption; on any other craft where reducing the drag through the water is important.

Effect in fuel consumption and efficiency due to fouling:
Fuel consumption per hour:
– with a silicone coated Propeller: 80.8 kg
- with an uncoated Propeller: 86.1 kg

A bad hull condition, surface roughness and overgrown propeller add significantly to power consumption of the ship, equivalent to as much as 20% excess fuel consumption.

Foul Release coatings can increase the efficiency of propellers in the following ways:
– No fouling where the coating remains intact
– No In-water cleaning required
- Reduced cavitation-induced noise in certain instances.

ACS Technology

According to DK group" the air cavity system is a revolution for the commercial vessel building industry. Air can reduce fuel consumption by 15% on slow speed vessels only taking 0.5- 1% of the propulsion power to keep the air compression going."

Benefits:

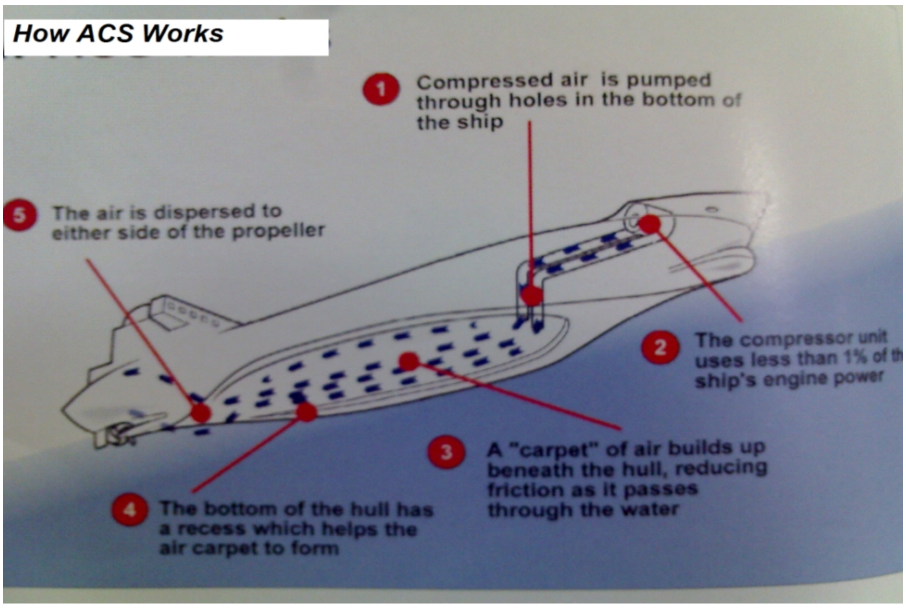
-Fuel saving of upto 15%, which for a 300,000 DWT VLCC corresponds to annual fuel savings of $ 3.5 million

-Reduction in CO_2 and other green house gases by upto 15%

-Improvement in safety by reducing vessel's emergency stopping distances by 50%.

Principle :

ACS works by improving the fuel efficiency of ships by reducing the frictional resistance of the hull surface. This is achieved by replacing the flat bottom surface of the vessel's hull with an air cavity .the ACS injects air into specially designed hulls, which reduces the frictional resistance of the hull surface against the water. A layer of air is generated between the hull and the water, allowing the vessel to effectively glide through water, reducing hydrodynamic resistance.



A number of industry partners such as Germanischer Lloyd, Force Technology, Maersk Broker are making contributions to help realise this project.

PENTAMARAN HULL DESIGN:-

Penta = five

Maran = hull

A European Ship Owner approached Nigel Gee Associates Ltd (NGA) with a request for a fast freight vessel capable of carrying 13,000 tonnes of cargo at 30 knots whilst using an installed power of only 30 MW.

Since ships of this speed and deadweight had previously required 50 MW, the Ship Owner's requirement seemed difficult than impossible.

The configuration of sponsons adopted is one having two shallow immersion sponsons near the stern of the vessel and two independent sponsons positioned further forward and having their keel lines clear and above the loaded waterline. As the vessel heels, one of the aft sponsons emerges from the water at quite a small heel angle. This would normally have the effect of immediately halving the slope of the stability righting lever curve. In the case of the vessel with two further sponsons forward, the sponsons are arranged such that one of the forward sponsons enters the water just before one of the aft sponsons leaves the water. In this way, the slope of the stability righting lever curve can be controlled as required by the designer.

At this point, it was realised that this type of vessel had a number of novel features and worldwide patents were applied for. The vessel was designated "Pentamaran".

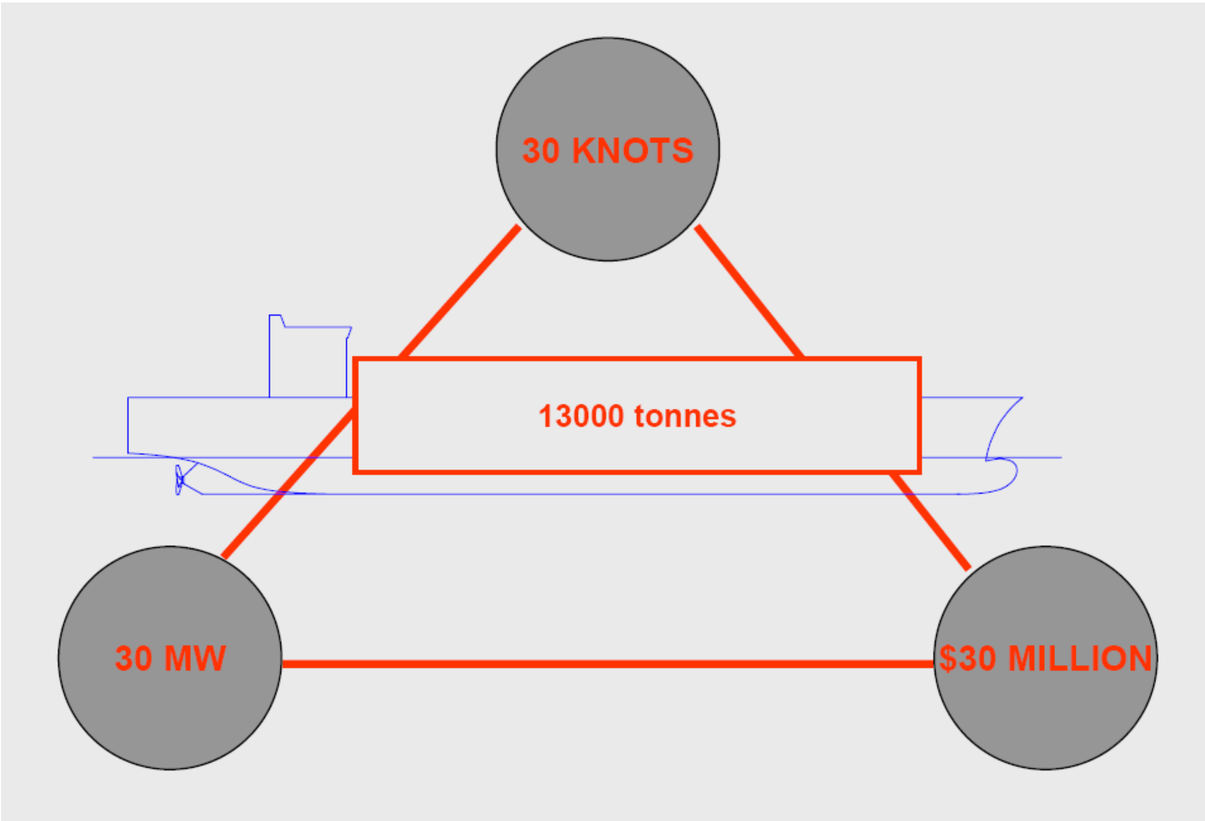
A further advantage of the Pentamaran over the trimaran is the ease with which the ship may be berthed parallel to a quay.

Detailed cost estimates indicate that the Pentamaran car ferry constructed in steel and powered by medium speed diesels driving water jets for a speed of 40 knots could be built for a selling price of approximately US$45 million

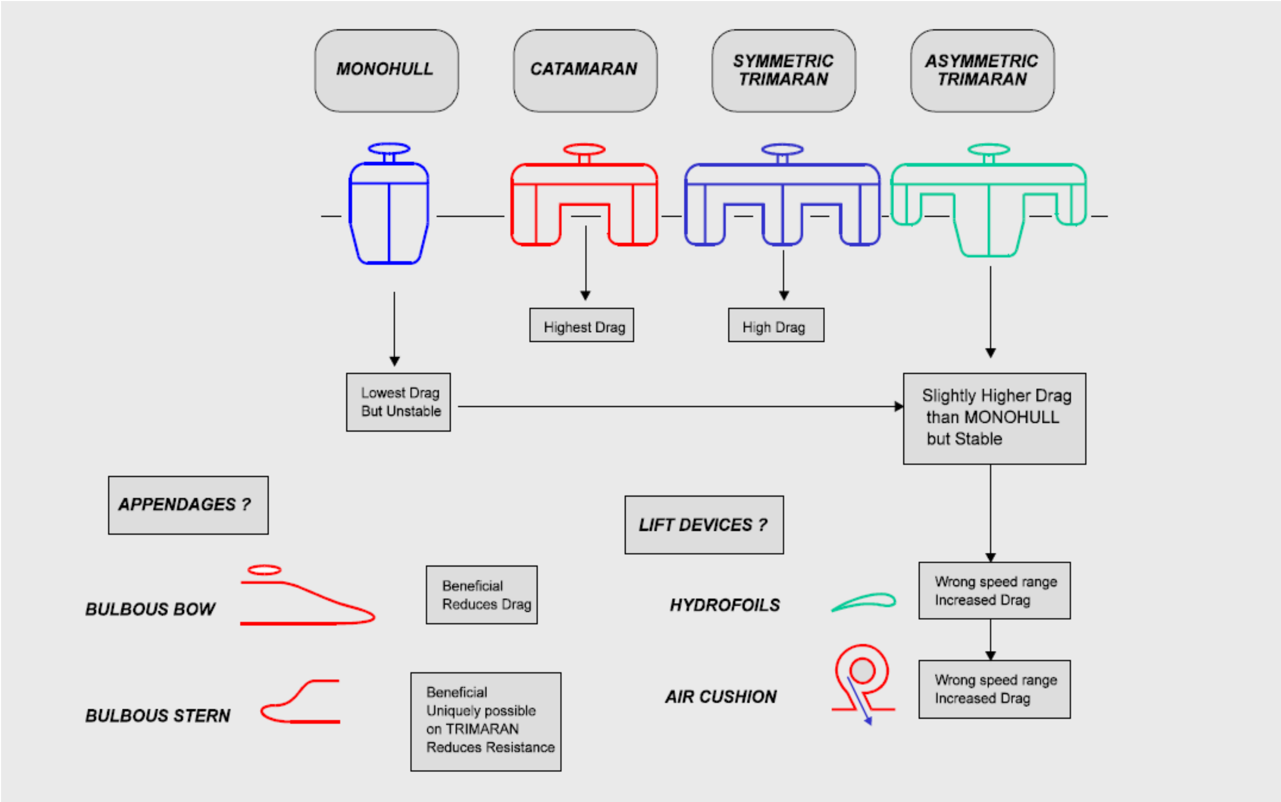
It can be seen that not only is the Pentamaran highly cost competitive in its speed range but, indeed, is a vessel which can be produced at one of the lowest costs per tonne of any high speed car ferry of any speed over 30 knots. Series production may lower costs even further.

In summary, then, the developed Pentamaran concept offers the market a product which will meet market requirements for fast freight or car ferry applications at low cost using familiar, reliable, maintainable materials and equipment installations.

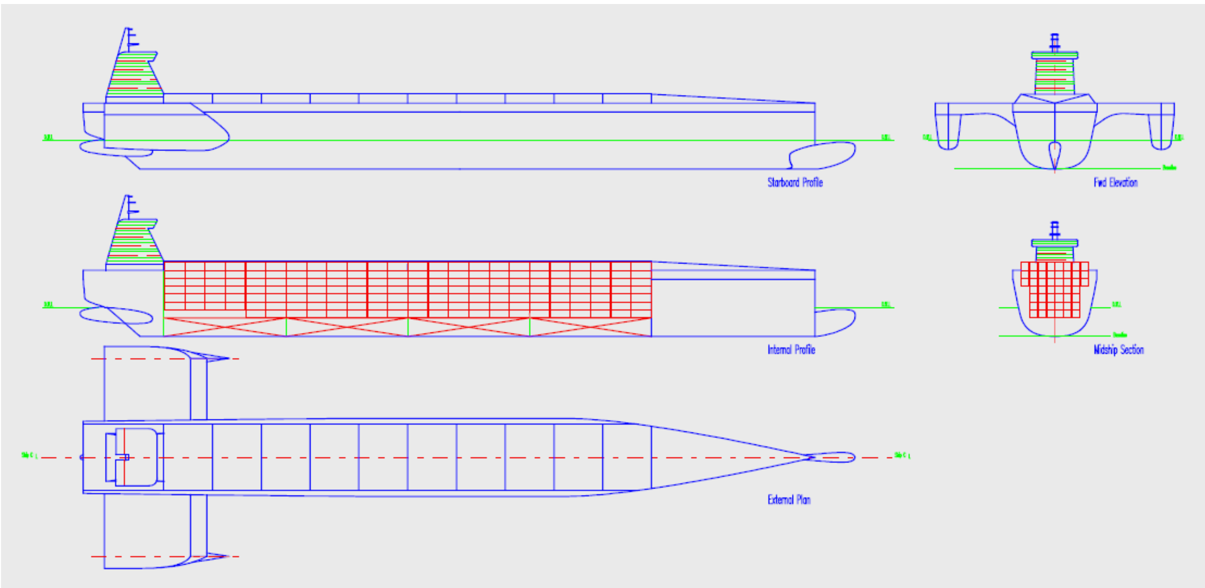
Some illustrious figures



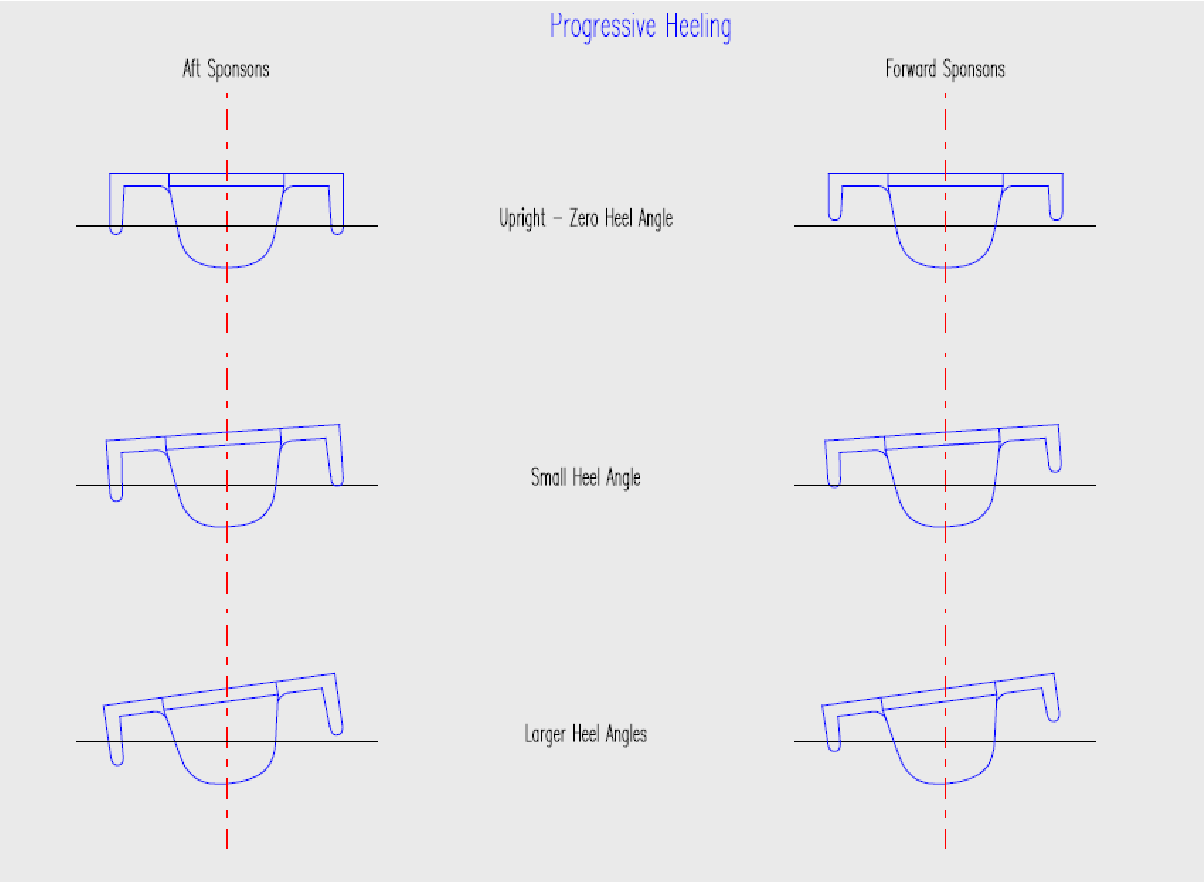
THE "30-30-30" PROJECT



PARAMETRIC STUDY SUMMARY



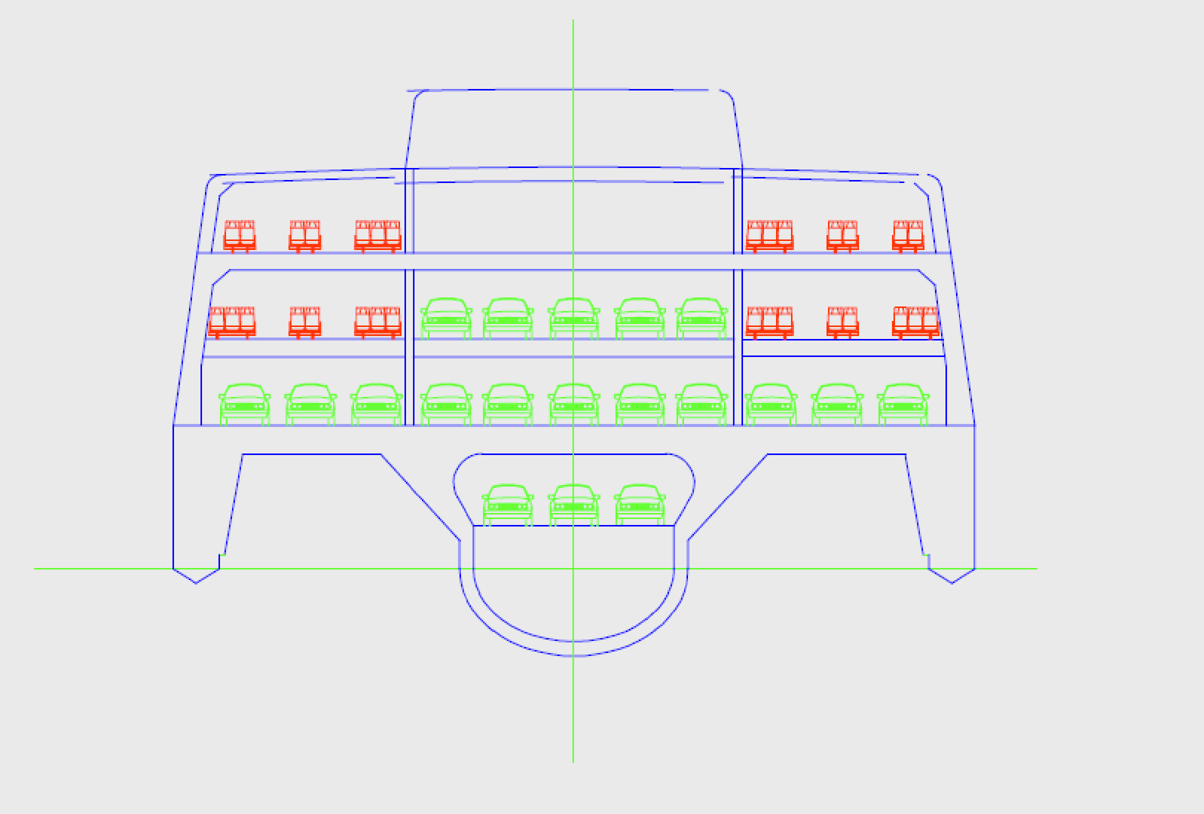
PRELIMINARY GENERAL ARRANGEMENT



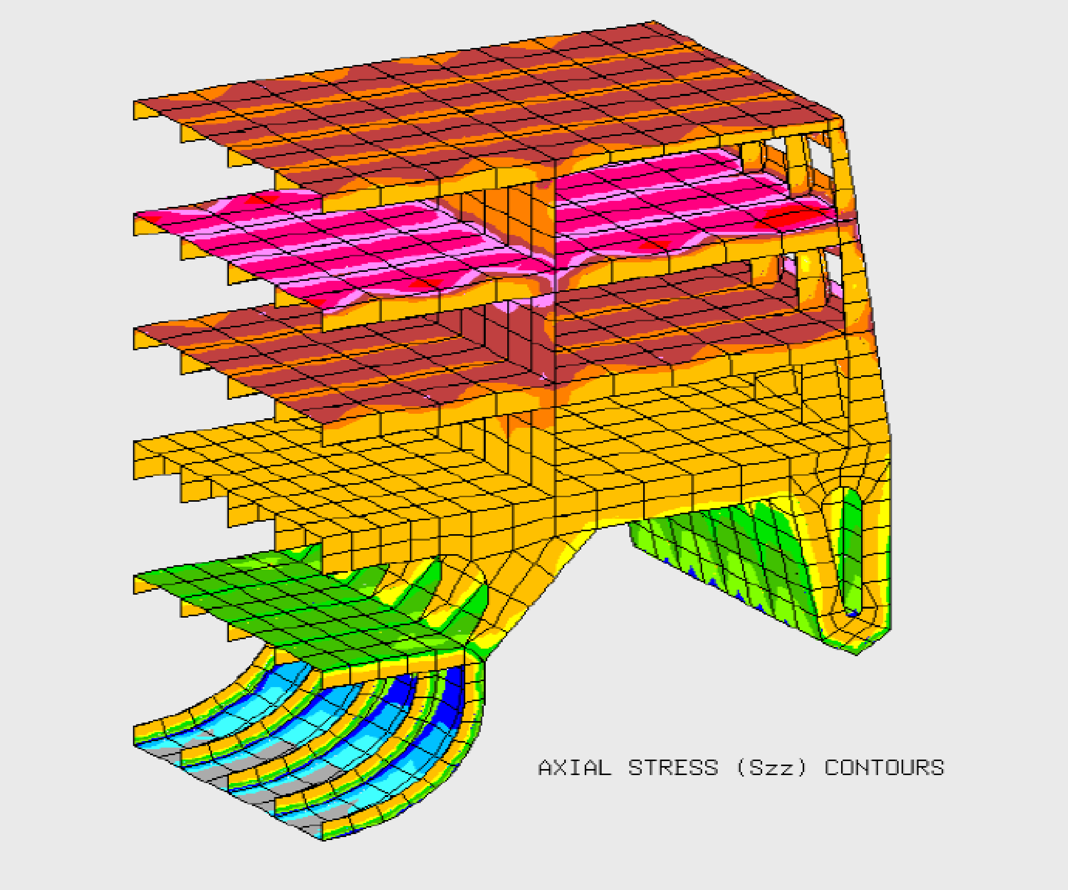
PENTAMARAN STABILISING CONCEPT

REQUIREMENT:	900 Passengers, 225 Cars, 40 knots.			
SOLUTIONS:	**1. CATAMARAN**	**LENGTH**	**POWER**	**COST**
		95 -100 M	32 MW	US$ 60 m
	2. MONOHULL	**LENGTH**	**POWER**	**COST**
		120 m	36 MW	US$ 50 m
	3. PENTAMARAN	**LENGTH** Approx	**POWER** Target	**COST** Target
		130 m	30 MW	US$ 40

PEAK MARKET REQUIREMENT



PENTAMARAN CAR FERRY MIDSHIP SECTION



BIBLIOGRAPHY

WEB SITES:

- www.castrolmarine.com
- www.manb&w.com
- www.lubemarine.com
- www.exxonmobile.com
- www.shell.com
- www.google.com
- www.wartsila.com
- www.bpmarine.com
- www.infenium.com