TRIFANE

Trimaran Semi-Submersible FOW platform

October 2024

General Description

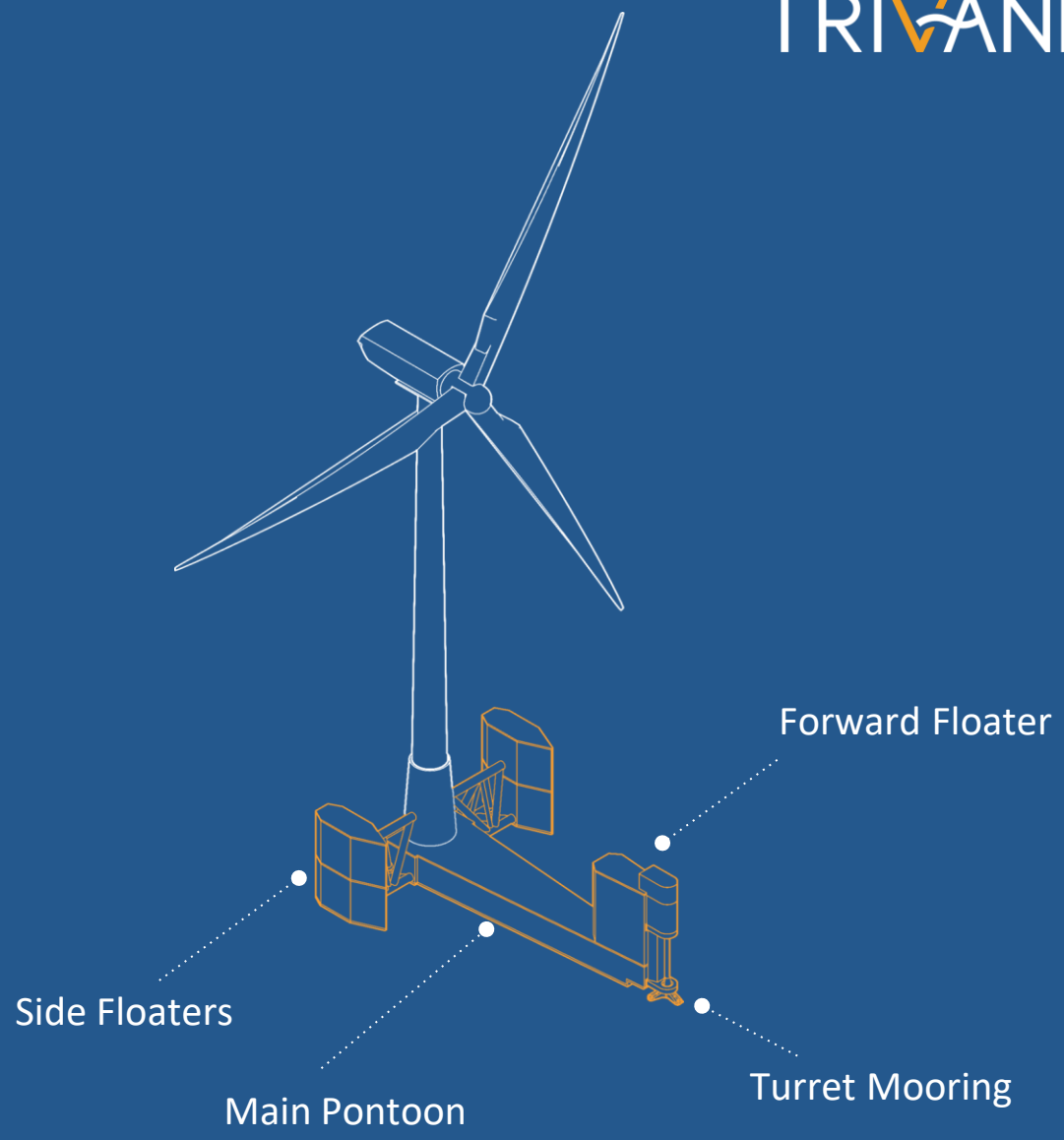
Trivane is a Patented Trimaran Semi-Submersible FOW platform carrying a 15MW Turbine, with a turret mooring system.

76m beam, 98.5m overall length excluding the turret.
Operational draft 20m. Unballasted draft of steel version 6m.

The Main Pontoon carries the tower support and also a **Forward Floater** with its Turret Mooring.

Two Side Floaters provide stability, connected to the main hull pontoon using pontoons or trusses with heave plates at the keel level.

The Turret Mooring, to which all moorings and export cables are connected, enables Trivane to weather-vane into the conditions at all times.



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Trivane Classic Trivane

Original design

Trivane Limited is a private UK company formed by Richard Martin in 2019 to design and develop new designs of Floating Offshore Wind (FOW) vessels.

Trivane initially developed a design in which all hulls are at the sea surface *(right image).*

Analyses and model tests were done in Plymouth.

Motions of these designs are acceptable in operational seas up to Hs = 6m but can be too high in say Hs = 13.3m, which is the extreme all year seastate in the Celtic Sea.

BEIS funding

In 2021 Trivane was awarded generous funding assistance from the UK Department of Business, Energy and Industrial Strategy (BEIS), with London Marine Consultants (LMC) as partners.

Since predicted extreme motions of Classic Trivane were too high it was decided not to build a prototype, but to use the BEIS funding to develop semi-submersible designs.

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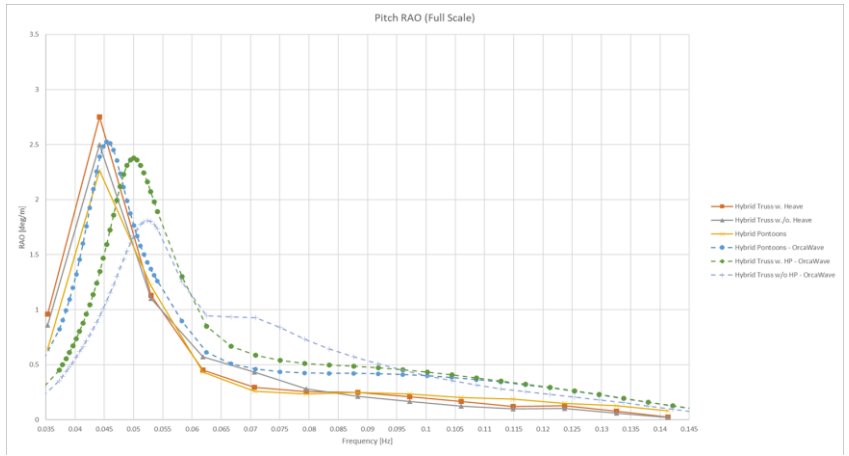
Main Participants

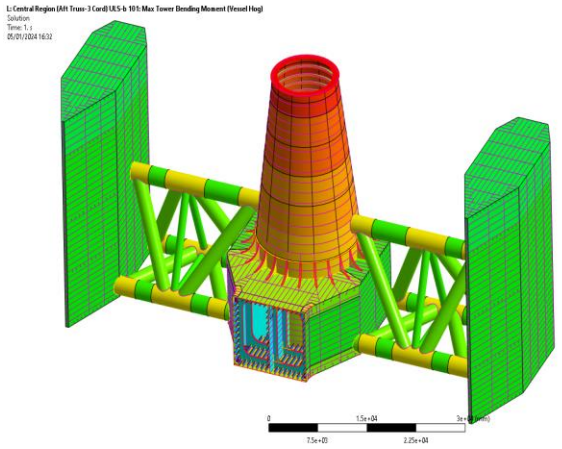
Trivane: Design and drawing of variants of their steel and concrete designs.

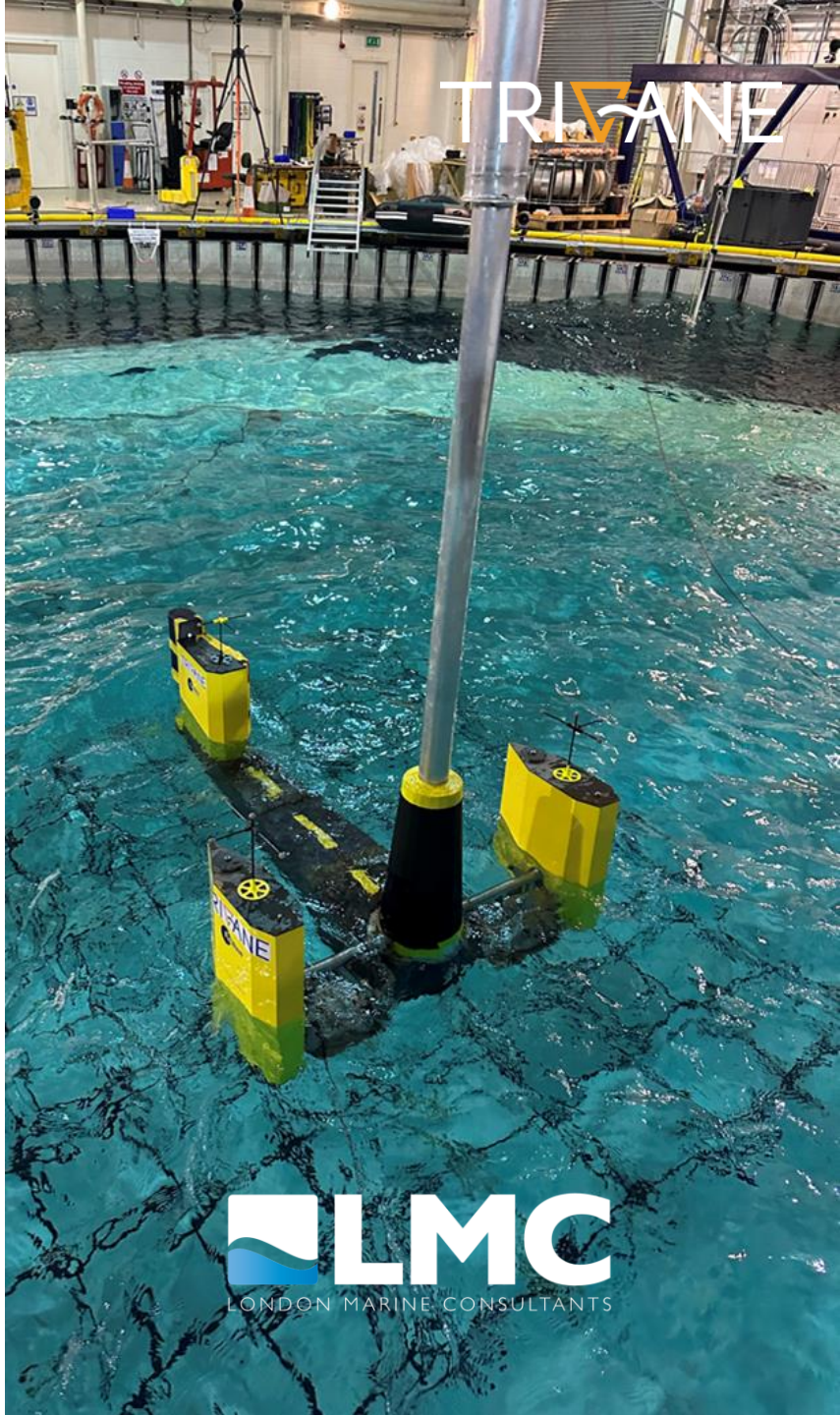
LMC: Analysis of Trivane's designs, by London Marine Consultants. Also **Morek** (model build) and **SISA** (Analysis of concrete versions)

FloWave: Four weeks of measurement of motions at their tank in Edinburgh, at 1:50 scale, to verify against calculations (see pitch).

LRS: Trivane is submitting its design to Lloyds Register of Shipping to grant Approval in Principle





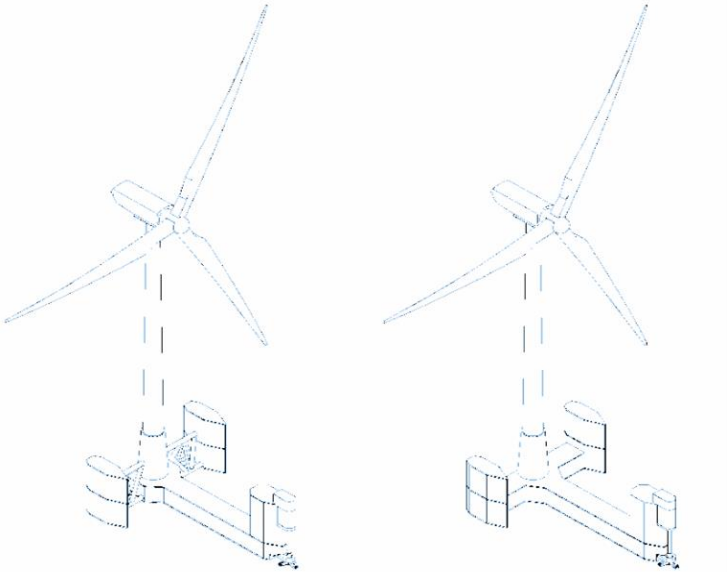


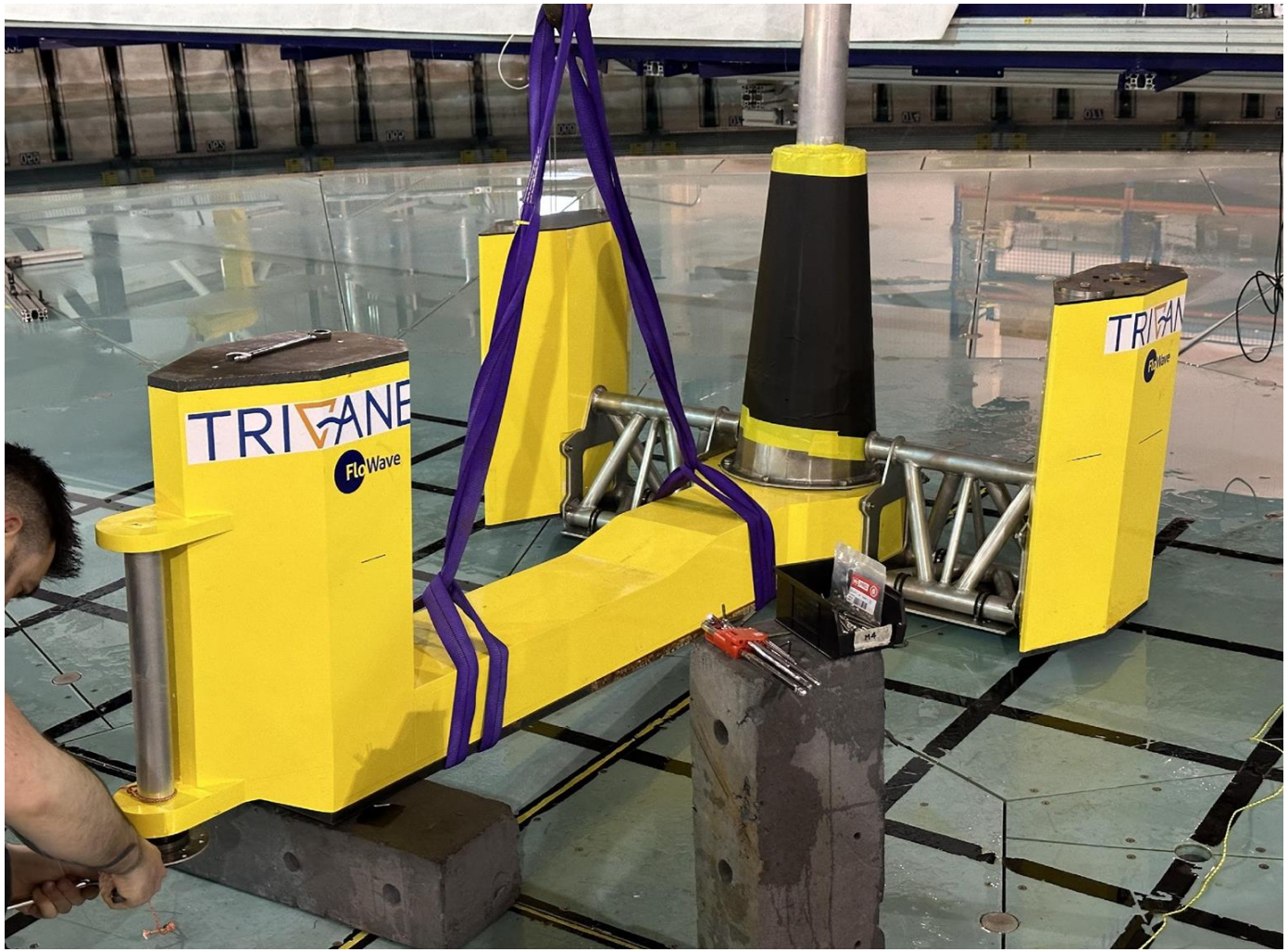
Parallel Sided Variant

In this preferred variant the main hull has sides that are parallel to one another.

The side floaters are connected via steel trusses with heave plates, or else by transverse pontoons.

It may be built in steel or in concrete with, for stability reasons, a steel forward floater





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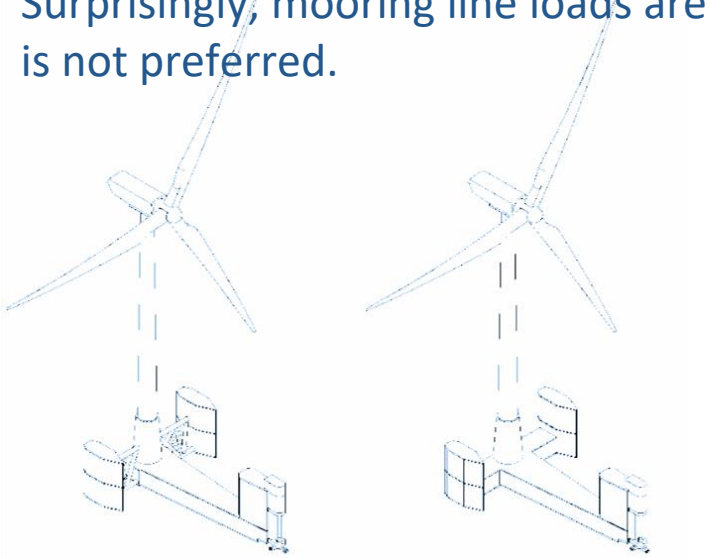
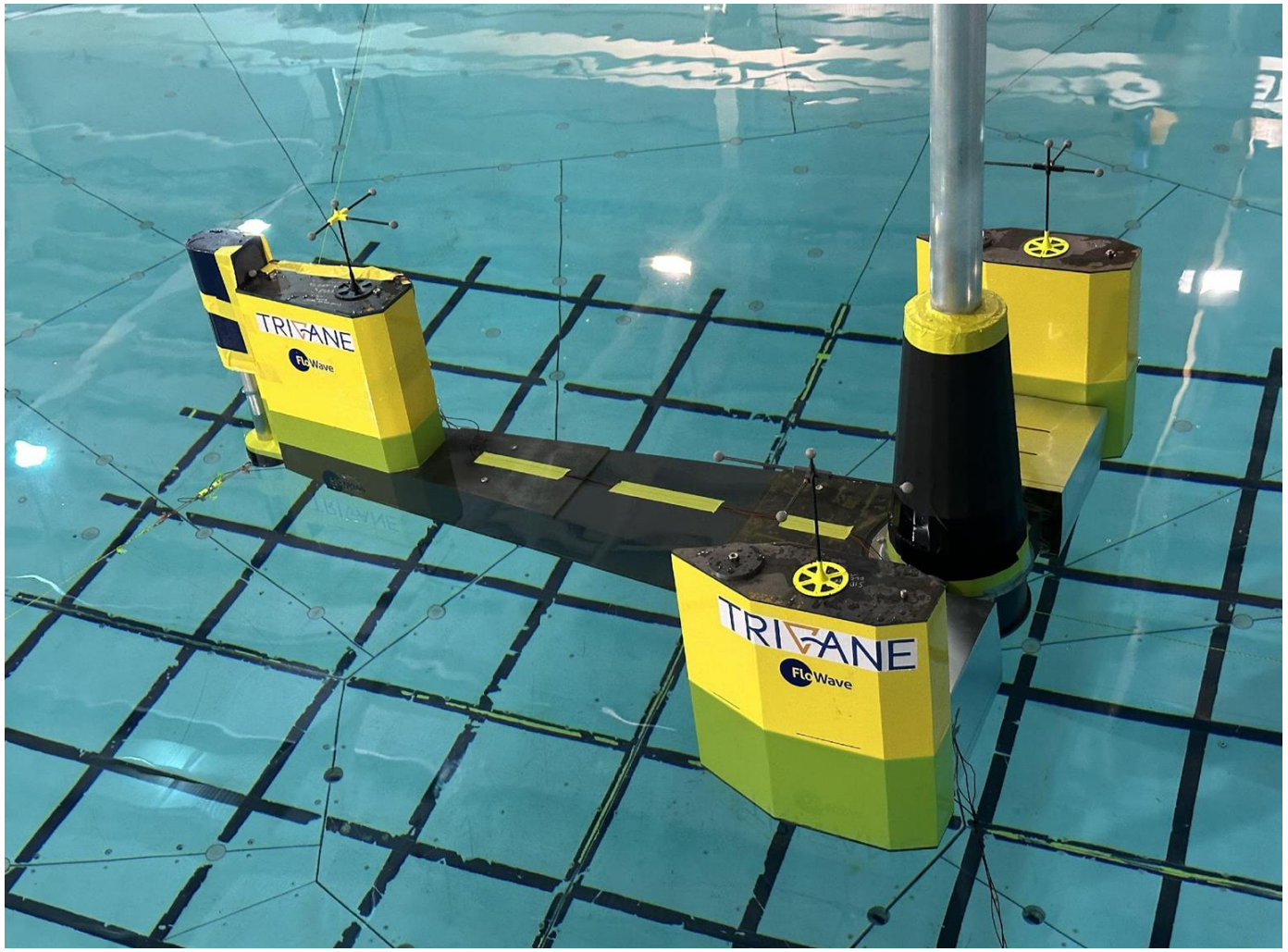
Delta Variant

This variant is the same except the main hull has sides that taper towards the bow.

It too may be built in concrete or steel. On th concrete variant the top halves of the side floaters are in steel and the forward floater is in concrete

Surprisingly, mooring line loads are higher, so this is not preferred.





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Turret

Adaptation of LMC designs

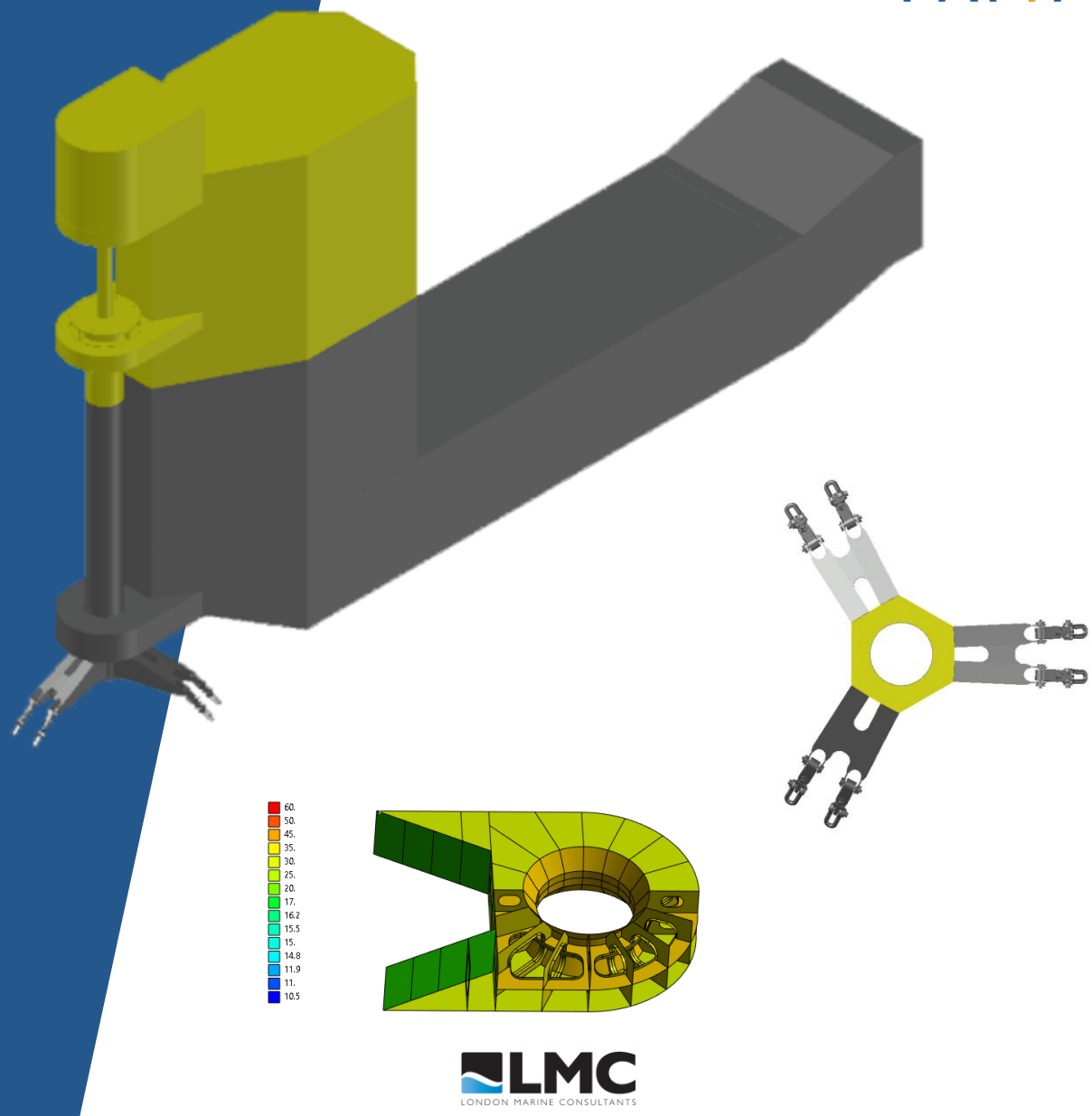
Richard is also a founder of LMC.

The turret causes concern to some, but it is relatively straightforward for Trivane because LMC has deployed 12 turret systems to date.

On Trivane, a ‘column’ turret is forward of the forward floater, with structures that support upper and lower plane bearings. No roller bearing.

The chain table at the base of the column receives the six mooring lines, thus giving redundancy in the lines.

There may or may not be an electric swivel on top of the column, depending on the location.



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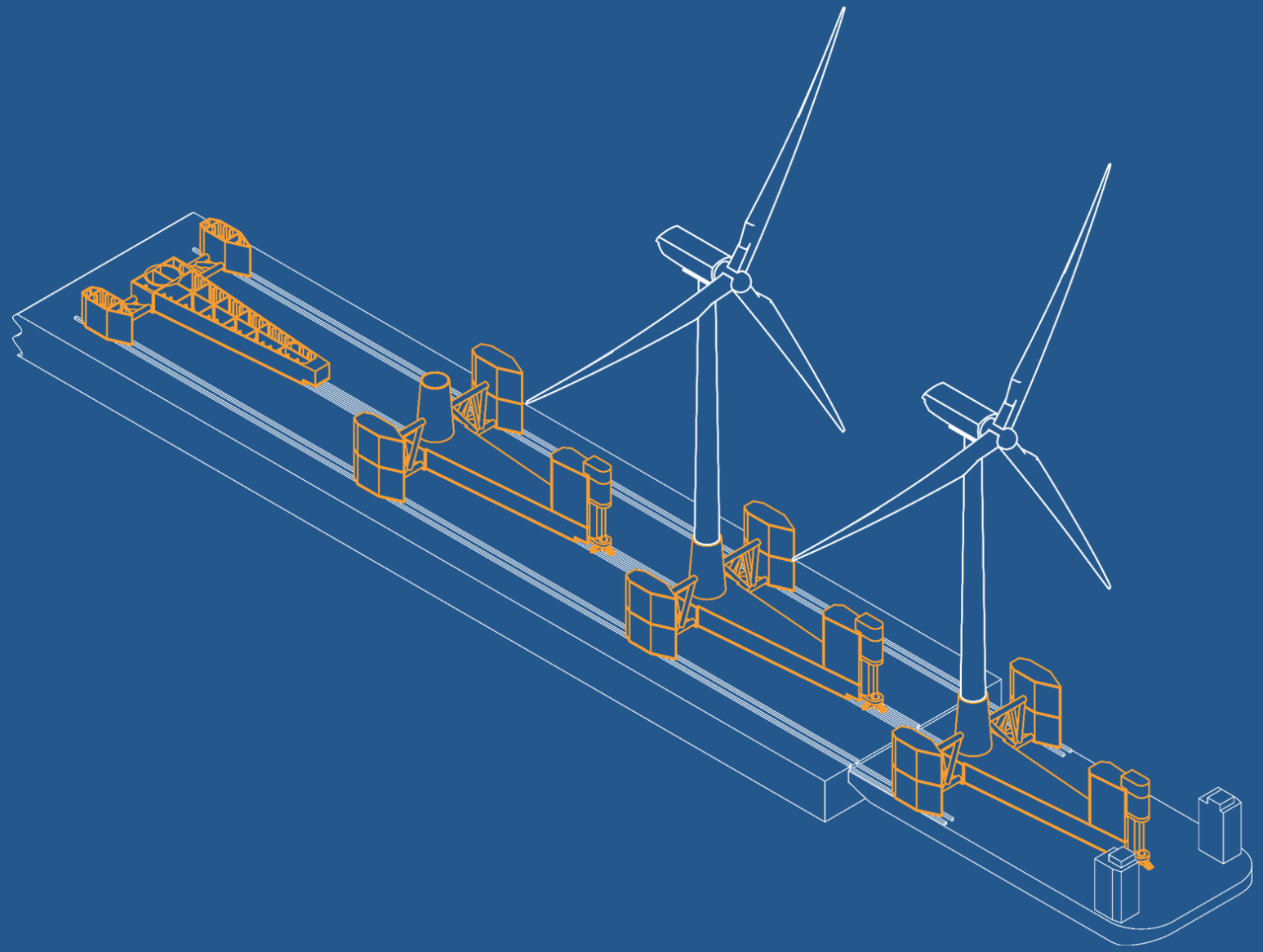
Jumping to the Answer

Concrete is half price

A) Build the entire concrete FOW platform sequentially and skid it onto a semi-submersible barge

B) The barge deploys to deeper water where Trivane is floated off and towed to site. Alternatively, the barge offloads at site

C) A possible alternative is to lift the platform into the water in two parts and join the main pontoon whilst afloat at quay (next slide)



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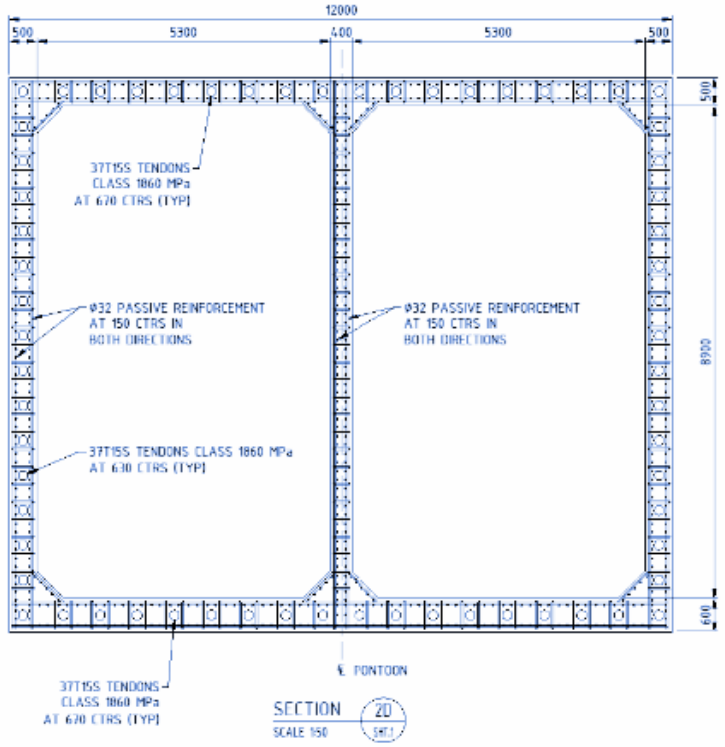
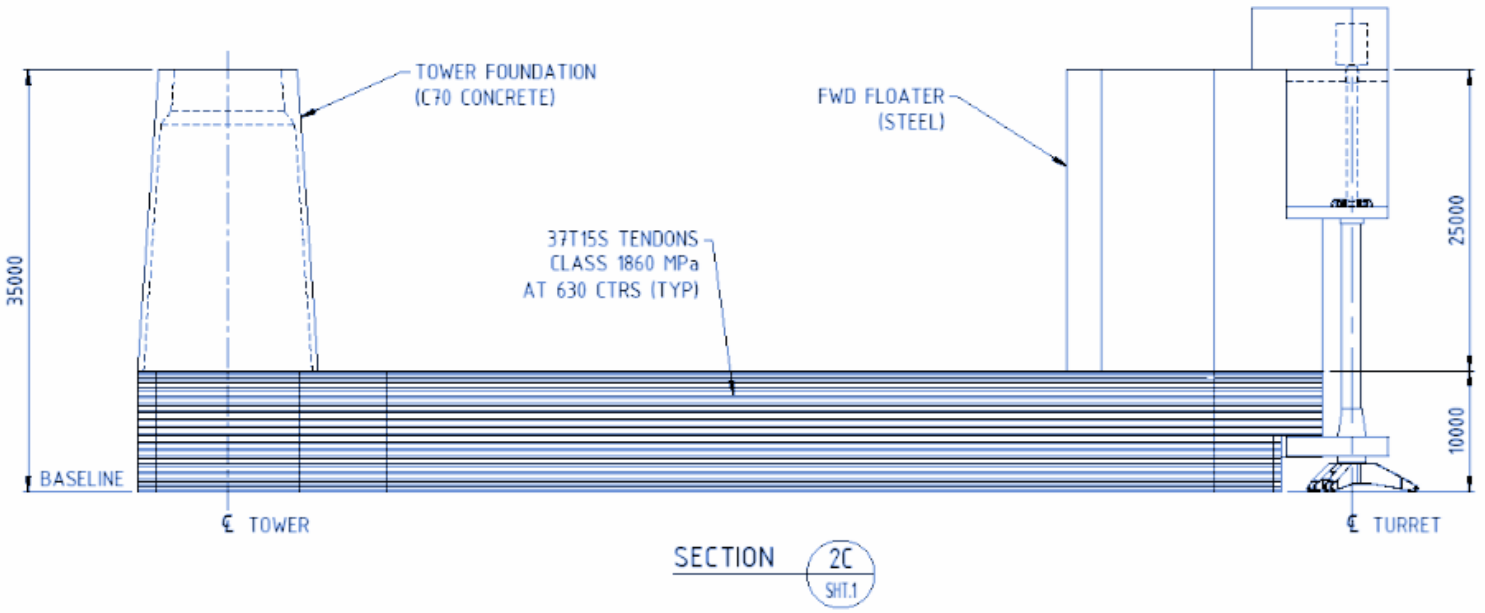
Straightforward to Build Square Hulls

Reinforced Prestressed Concrete



\\ Typical Section through Pontoon



\\ Prestress Tendons keep concrete in Compression

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SAFIER ENGINEERING METHODOLOGY FOR CONNECTING THE PONTOONS

SAFIER INGENIERIE SAS
En **ENGINEERIG CONSULTANCY** STRUCTURAL
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OFFSHORE FIXED FLOATING FOUNDATIONS

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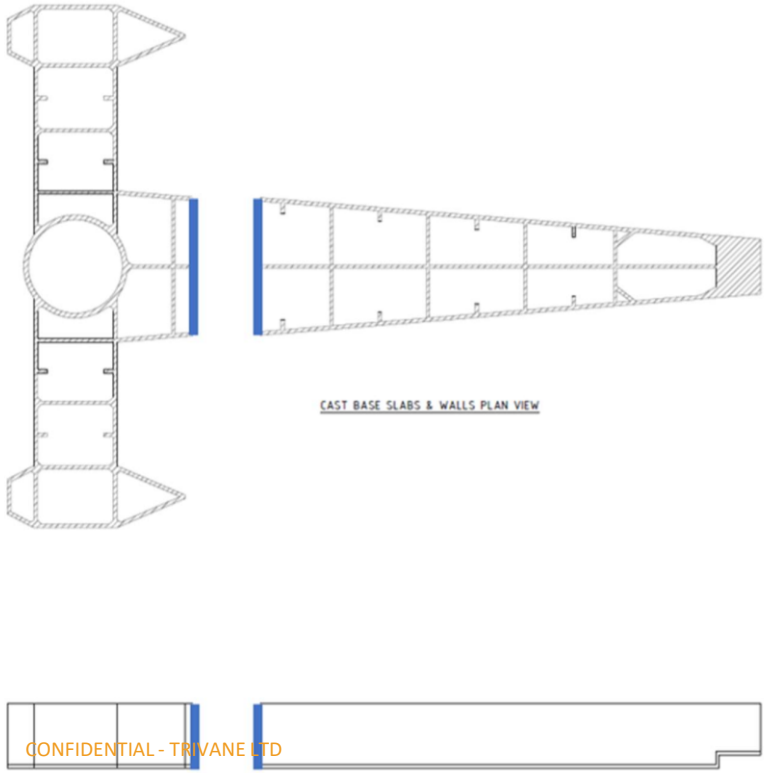
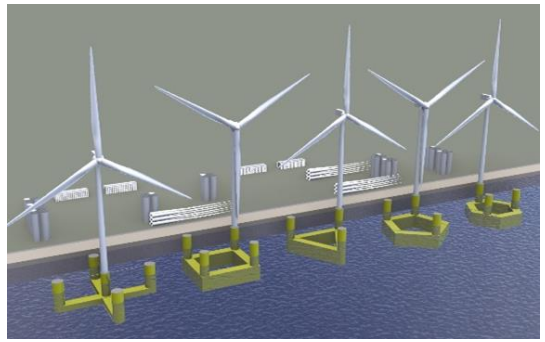
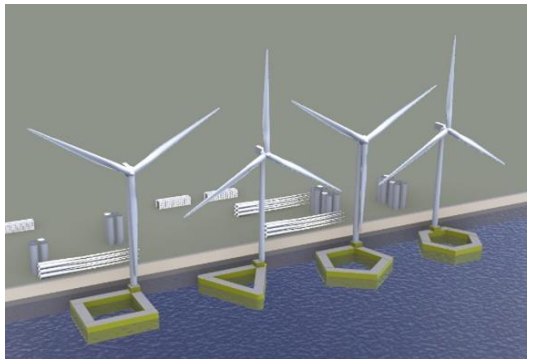
e-mail : sisa@safier-ingenieriesa.com

Industrial, economic, safe **assembly of concrete structures using C2C®** process in the sea



Monolithic concrete structures assembled in the water economically (industrial, local content, code compliant) **based on existing proven technologies** using patented C2C® construction technique.
Ensures the same mechanical resistance properties as monolithic construction
FOWT floaters may be produced in parallel and derisking production, reducing the need For port space.
Floating ports, port extensions, islands and hubs may be produced monothically on water





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Why Trivane?

Concrete is less than half price (£22 million Platform in Concrete)

VERY INDICATIVE RATES

Fabricated steel, including cost of steel, welding, assembly, lifting, NDT:

Prices vary wildly but in United Kingdom say GBP 8,000 per tonne

Concrete: Industry sources suggest Euros 2,000 per cubic metre. This means GBP 610 per tonne

VERY INDICATIVE PRICES

For the platform and turret alone without steel tower, turbine, blades, electrics, ballast arrangements, moorings, installation

Steel version of Trivane (parallel sided with pontoons)

Gross steel weight 6,000 tonnes yielding **£48 million**

Concrete version of Trivane (parallel sided with pontoons)

Weight of concrete 23,866 tonnes plus weight of steel forward floater and turret 900 tonnes yielding £14.6 million + £7.2m = about **£21.8 million**

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Why Trivane?

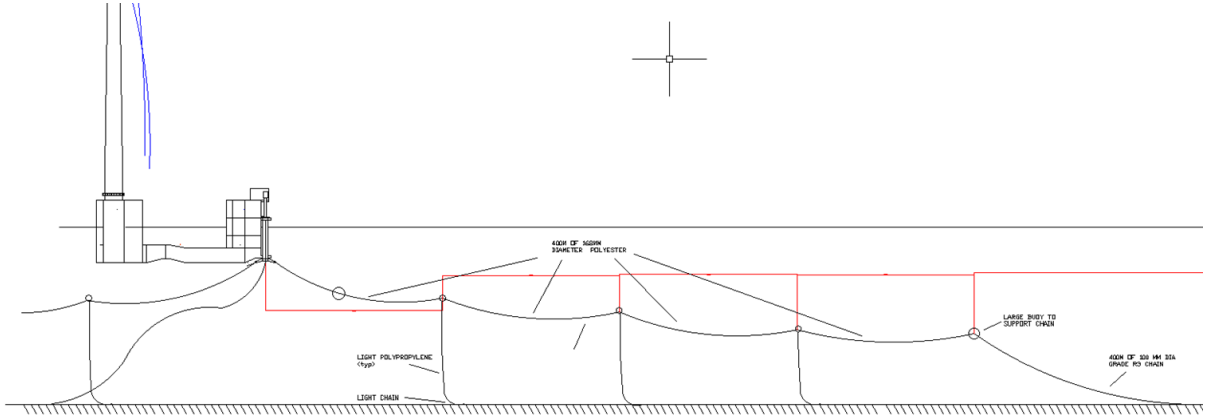
Low Mooring Line Loads

Some designs propose mooring chains of up to 140mm dia. Expensive, high transport costs and there are only a few large vessels that can handle such chain.

FOW devices have 10 x lower inertia than FPSOs, but much higher motions, which can lead to shock loads in the mooring lines. Trivane's ship-shaped hulls mean low mooring line loads. In addition, we reduce shock loads and hence component sizes, by having a long elastic part in each line

On Trivane, in 100m water depth, each mooring line has:

- 110mm diameter chain
- 208mm diameter Polypropylene
- A buoy keep the polyester in the water column



MOORING LINE ARRANGEMENT

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Why Trivane?

Low Tilt and No Roll or List

As a guide, the FOW platform must not incline by more than 5 degrees on average and 10 degrees maximum.

Analyses and model tests examined **just the static** tilt resulting from a Rated Wind load of 260 tonnes, which is applied at the nacelle by a 15 MW turbine.

Trivane designed a non-weather vaning ‘Octagon’ design with no turret. As shown on the photo, the static tilt was 6 degrees, and the dynamic tilt exceeded this.

For the weather vaning designs the static tilt was 3.5 degrees. Furthermore, since it weather-vanes, these can be pre-ballasted in order to trim Trivane down by the bow by about 1 degree. Thus, the actual tilt on application of the Rated Wind load is only 2.5 degrees. Roll and list are negligible.

This is a clear advantage of a weather-vaning FOW platform. No active ballasting is needed.

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Why Trivane?

Flat Plate Construction (For Steel Versions)

Many, but not all, FOW designs include large diameter cylinders. These can only be made at a few fabrication facilities

All steel versions of Trivane, and the forward floater on the concrete version, are made of stiffened flat plate, apart from the tower support structure on steel versions. The flat plates can easily be fabricated by any yard or fabrication shop

Sheets can even be stiffened at many facilities, even inland, and sent by train, lorry of barge to the assembly yard thus enlarging the supply chain

So Trivane can be made in quantity, in almost any country, without the need to upgrade or change existing yard facilities

Costs are thereby reduced compared to other designs consisting of large diameter cylinders

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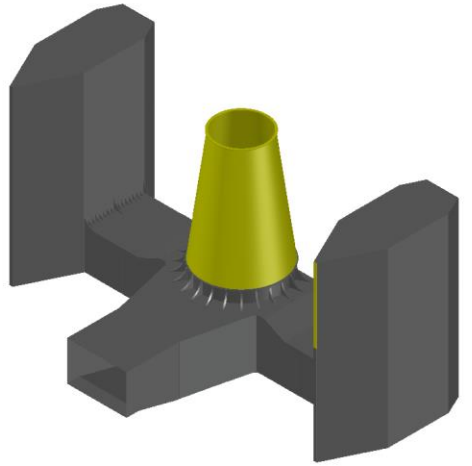
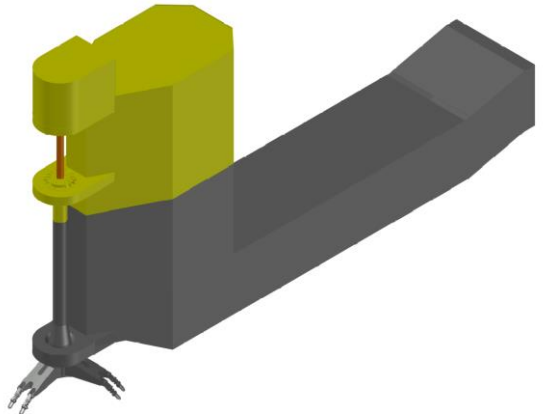
Why Trivane? :

Assembly in Port at 6m draft (For Steel Versions)

Many designs need to be loaded onto an expensive heavy lift ship in order to leave port. Trivane steel designs are stable, afloat on their own buoyancy and with the turbine onboard, with a draft of only 6 metres. Once offshore, Trivane is ballasted to an operating draft of 20m.



The hull steel hulls can be fabricated in two parts. They are lifted into the sea and the two parts are then welded to one another whilst afloat in port prior to loading the tower and turbine.



There are also proposed methods for connecting two concrete parts whilst afloat (next slide).

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TRIVANE

A unique trimaran semi-submersible FOW platform.

Trivane's patented trimaran design ensures it weather-vanes into the conditions.

We are **seeking funding** to build & deploy a Trivane prototype.