Catamaran Floating Crane
1.0 General
This specification describes a self-propelled floating crane with catamaran type hull designed to transload 2400t barges into panamax breadth geared or gearless bulk carriers at the rate of 40,000 tons per 24 hour day in seas up to 2.5m.

For loading cape size vessels, a shiploader module can be added at any time. With the shiploader module, transload rate increases to 1 x 2,400 dwt barge per hour.

Design life is in excess of 200,000 operating hours.

1.01 Crane Warranty
Our standard warranty is 2 years or 4,000 operating hours parts and labor excluding consumable parts and 10,000 hours warranty on the draw works and roll path.

1.02 Capacity
The crane is able to empty a 2400t barge in 1.5 hours into a panamax. For production calculation over 8 months, 240 days, assume 200 working days at 12 barges per day for a rate of 5,760,000 tons. One crane will achieve between 5 and 6 million tons.

Production can be increased by more than 50% by adding a telescoping shiploader module to the rig. The shiploader is a stand alone self-powered unit and is radio controlled. This module is required for loading cape size vessels.

2.0 Crane
The crane is a TDC 4025 balanced deck jib crane, all electric power with the following features:

- 40 metric tons duty cycle capacity at 25m working radius
- Full load line speed 70 m/min hoisting, 80m/min lowering
- Actual transloading capacity 70 cycles per hour
- Crane sizing based on cycle rate 60 per hour
- Daily rate 35,000t basis 20 hours working
- Balanced deck continuous roll path
- Electric joystick control
- Single layer reeving including boom hoist
- Easily repaired locally
- Low level of technology
- 50,000 hour overhaul period
- All parts available locally
• High speed slew with tagline winch
• High speed luffing for loading geared vessels
• Automatic lubrication
• Airco
• Dual pendant wires

2.0.1 Roll Path
This crane is designed with low technology and easily repairable components for high reliability, easy local repair and high longevity. For example, the roll path is a continuous circle of hardened forged steel wheels running between two crane rails. This is known as a continuous roll path balanced deck design.

This eliminates the use of a slew bearing which is expensive, long lead time and difficult to replace. Our roll path can be completely re-built within a few days at anchorage without undecking the crane using local parts and local labor.

A large diameter king pin with aluminium bronze bushing provides the means for the upper to rotate on the lower. The center bushing is segmental and can be replaced without undecking the upper for excellent repairability. Automatic lubrication is provided to ensure the kingpin bushing receives grease while the crane is operating.

The center of gravity of the upper is always inside the roll path, eliminating any uplift.

This system has been chosen to give outstanding stability to the upper both in the transverse and longitudinal direction. This is very important for rough weather operations.

2.2 Ring Gear and Slew Drives
A forged steel segmental ring gear is bolted to the base. These segments are easily replaced and offer the possibility to shift segments in the unlikely event a tooth is broken. You are never out of business. One spare gear segment comes with the crane. The gear segments can be re-built or replaced without undecking the crane.

Slewing speed on a large crane is limited by outrun of the bucket. We provide a power tagline winch to keep the bucket from running out in front of the crane during high speed slewing. This allows for faster slewing speed ranging up to 2.5 rpm.
Dual slew drives are provided to evenly distribute wear on the ring gear segments and eliminate horizontal forces from the pinions acting on the kingpin due to the moment couple created.

The crane is able to operate at full capacity with only one of the swing gears operating.

The large diameter (8.0m) ring gear and dual slew drives offers outstanding slew capacity in rough weather along with low pinion tooth load for longevity and high factor of safety. The ring gear is lubricated automatically with open gear grease.

**2.3 Boom and Sheaves**

Our boom is constructed of heavy wall, square section carbon steel tubing with yield strength of 350 Mpa. Diagonal sections are heavy wall round tubes sized to fit the full width of the chord sections to allow clean transfer of sheering forces without local bending on the face of the chord.

These materials are chosen to allow local repairs to the boom without any special precautions.

We have chosen a lattice boom to keep the weight and therefore inertial loads as low as possible for high speed slewing and for operations in rough sea.

Our boom length is kept as short as possible to minimize transverse bending moments due to rough seas and slewing moments. Our boom is very wide at the base and has a low slenderness ratio to allow high impact and transient dynamic loads during operations.

This boom is built for high side loading, impact and repairability.

Our sheaves are fabricated steel with flame hardened rope treads. We use this construction to ensure toughness and for repairability. The sheaves can be rebuilt or repaired locally. We use 4340 large diameter shafts and aluminium bronze bushes with oversized hub. With autolube, these sheaves will last up to 25,000 hours before re-bushing and you are never in danger of a sudden sheave failure during operations.

This design is chosen for toughness, low risk and ease of repair using local resources.
2.4 Holding and Closing Winches

Our winches are extremely rugged, simple constructions built for decades of continuous operations. We use a steel fabricated triple reduction gear reducer with massive gears, bearings and shafts. We use 4340 steel, heat treated for our shafts to give very high toughness and strength.

All wire ropes are contained on one layer of the drums for long wire rope life.

Each of the winches is designed to support the entire lifted load. Load speed is 70m/min hoisting and 80 m/min lowering with full load.

Operation of the winches is by electric powered joystick for very simple operation requiring minimal skill level. The control system is extremely simple with plug and play components. We use Caterpillar joysticks and PLC.

A 1200 rpm AC electric motor flange mounts vertically on the reducer driving the high speed shaft. The electric motor has a through shaft design with drum brake on the outboard side. This is a holding brake however is designed to act as a dynamic brake when needed.

The low speed shaft is 350mm diameter running continuously through the drum to an SKF spherical steady bearing on the outboard side. The drum is constructed with heavy hubs with keyway at the reducer end of the drum. The drum is shrink fit onto the reducer shaft to make a complete assembly consisting of reducer, drum and steady bearing that can easily be removed for repairs.

Lubrication of the gear reducers is a splash system and powered lube oil pump. The lube oil pump ensures all bearing and gear surfaces are lubricated on startup and during low speed operation. The lube oil pump also takes oil from a large capacity external sump and passes it through a filter and cooler. This ensures a good supply of clean, cool oil.

Shaft seals are multi labyrinth with double contact seal and purgable grease outer seal. Oil travels along the rotating shaft to a built in drain at the outside of the bearing to allow oil to drain back into the sump. Even when the contact seals fail, oil is retained inside the reducer. The outer purgable seal ensures no contaminants enter the box or damage the shaft or seal face from the outside.

Our seals are split to allow replacement without dismantling.

Our drums are manufactured by Lebus International with cast manganese lagging that bolts to the drum. Drum laggings can be easily replaced and last in excess of 100,000 hours.
2.5 Boom Hoist, Pendants and Tagline
Our boom hoist is designed for high speed continuous use consisting of a triple reduction fabricated steel reducer and vertically mounted electric motor identical to the holding and closing winch. All shafts, seals and bearings are interchangeable between the holding, closing and boom winches.

The output shaft of the boom winch extends in each direction through a drum to a steady bearing to provide two widely spaced boom hoist drums. We use this design to provide wide spacing of the wires to the A-frame to resist side loading in rough seas and high speed slewing.

Wide spacing of the pendant wires also provides excellent support for the boom during side loading.

Four individual wire ropes, two from each drum powers the A-Frame. This system ensures that if one wire breaks, the boom will not be lost in a fall.

We use four pendant wires from the A-Frame to the boom tip. Each pendant is designed to carry the full load to ensure that if one line breaks, the boom will not fall. Pendant wires are widely spaced at the A-frame to provide excellent lateral support for the boom tip to resist side loading.

When loading geared vessels or vessels with fold up hatch covers, high speed luffing is essential on every cycle to get around obstacles. The crane is designed to luff from 25m to 12m radius in less than 12 seconds for this reason.

We provide a powered tagline winch, 8t line pull, which puts constant tension between the bucket and the boom heel. This allows the operator to slew the crane at high speed but maintain control of the bucket runout. Constant tension is adjustable on the crane console.

The tagline winch also allows the operator to haul in the bucket to avoid obstacles. One of the buttons on the left joystick is programmed to haul in the tagline winch.

2.6 Operator’s Cabin and Controls
The crane operator’s cabin is built for low noise and high comfort to reduce operator fatigue. Air conditioning is provided along with tinted windows to reduce heat buildup in the cabin.

The more comfortable the operator is, the more productive he will be.
This crane is very easy to operate and it will not be difficult to find people fighting for this job. You will never be held ransom by the need for high skilled people to operate.

Operation of the holding and closing winches is on the right joystick. To open and lower, shift the joystick to 01:30 o’clock. To close and hoist, shift to 07:30 o’clock.

The center button on the right joystick locks the two winches together for simultaneous operations. This is particularly useful for slowly lowering a full bucket for example.

Slew and boom are on the left joystick. The center button on the left joystick hauls in the tagline winch. A selector switch is provided on the console to allow the crane joysticks to operate in different modes. These modes are as follows:

- Grab crane
- Barge Fleeting
- Crane Fleeting
- Navigation

In grab crane mode, the joysticks operate the crane functions.

In barge fleeting mode, the joysticks operate the mooring winches controlling the barge alongside to allow the crane operator to position the barge. The barge can also be shifted by local control of the mooring winches.

In crane fleeting mode, the joysticks operate the mooring winches controlling the crane to ship mooring allowing the crane operator to shift alongside the vessel. The crane can also be shifted by local control.

In navigation mode, the crane joysticks operate the four propulsion thrusters to allow navigation of the rig from the crane cabin. Navigation can also be controlled from the Nav Deck.

Any of the secondary functions for the joysticks can be locked out if it is not desirable to give control of these functions to the crane operator.

**2.7 Crane Power**
The crane is diesel electric with an overall requirement of 1,000 kw, 440v, 60hz. Power can be provided through the crane center or a package generator can be mounted on the crane upper.
Any manufacturer’s generator can be used. Our standard supply is Caterpillar C32 or 3508 for ease of service and replacement. The dg set is a separate module that can be removed from the crane in a few hours and replaced with a new unit.

If power is provided through the crane center, the crane is able to share power with the dg sets powering the rig with an either/or arrangement.

3.0 Hull Structure and Stability

3.1 Hull Structure
Catamaran style hull has been chosen to provide excellent sea going and operational characteristics in heavy sea. The pontoons are 6.0m wide, 4.0m deep and the operating draft is 2.5m. No ballast system is required.

Particulars:

LOA .............50.0m
Breadth..........20.0m
Pontoon Depth....4.0m
Operating Draft....2.5m
Crane Deck.......14.0m above base line
Crane Deck 18.0m x 30.0m

A crane deck is located 14.0m above base to allow the crane operator to have excellent visibility and control over the operations at the extreme operating conditions.

Hull construction is extremely rugged design with very generous scantlings to provide ruggedness and long life. All materials used in the hull construction are Grade A.

Rubbing guards reinforced by internal stiffening are provided on the outboard side of the pontoons to resist mooring loads.

The hull is designed for very easy construction to keep initial and long term costs under control. The individual pontoons have a cylindrical bow and stern which is easy to fabricate and provide very good hydrodynamic characteristics at the design hull speed.

Scantlings of the sides, bottom and inside shell are 12.0mm. Scantlings of the outside shell are 16.0mm. Stiffener spacing is 800mm with web frames located every 2.4m.
The pontoons are connected to the crane deck by inclined fabricated struts in the longitudinal direction which transfer the crane deck loads to the pontoons. In the transverse direction, horizontal beams are provided well above the water plane to tie the pontoons together and to transfer mooring loads and sea going loads from without causing bending moments in the hull struts.

The overall effect is to have the horizontal beams and inclined struts interact with the crane deck structure to form an arch. This is a very strong, robust structure.

This structure is very direct, transferring the major loads directly in compression with very little bending moment being produced.

3.2 Stability and Hull Form

Several individual aspects of the rig stability need to be examined as follows:

- Rig overall transverse stability
- Longitudinal stability of the crane upper
- Transverse stability of the crane upper
- Damaged Stability

3.2.1 Rig Overall Rig Transverse Stability

The rig overall metacentric height (M) is 22.91m above base line. The maximum GZ of the rig in worst case loading is 11.59m above base. This results in 11.32m GM at maximum GZ. This provides well in excess of 10 ft-degrees under the righting arm vs list angle curve at maximum GZ suggested by LR Classification Rules for Floating Cranes.

Having such a high GM in combination with Catamaran hull maintains a very steady platform in heavy seas from the bow or stern. This allows the rig to travel in heavy seas as well as operate without excessive listing and pitching.

Under static conditions, the rig will list less than one degree as the crane rotates in the worst case. This occurs when the crane is boomed up with no load and crane over the side.

3.2.2 Longitudinal Crane Stability

The crane upper center of gravity shifts as the crane is loaded and unloaded. We examine the crane upper on its own as if it were not connected to the rig to evaluate the stability. The crane upper center of gravity shifts from approximately 2.0m in front of the king pin to approximately 2.0m behind the kingpin from load to no load.
In the worst case loading, the crane upper center of gravity is more than 2.0m inside the slewing circle. The rig is able to list more than 20 degrees before any uplift is experienced by the hook rollers.

The crane upper is extremely stable under operating conditions allowing it to operate in very rough conditions and have the cg remain within the slew circle. The implication of this is that the cg is also within the slew pinion circle at all times which allows for very fast, effortless slewing even when the rig is heavily listed. The center of gravity is directly in line with the slew pinion. This is the secret to fast cycle times and long life of the slew pinions and ring gear.

3.2.3 Crane Transverse Stability
In most situations, longitudinal stability of the crane is the primary factor in overall design. In the case of operating in heavy sea, side loading and transverse stability are major factors to consider.

In this case we use the balanced deck design with 10m roll path to provide outstanding transverse stability for the crane upper. In order to stabilize the boom we use a short boom length, wide spread on the pendant cables and A-Frame to provide support for side loading.

3.2.4 Damaged Stability
The catamaran pontoons are subdivided longitudinally to provide port and stbd tanks in each pontoon. There are 5 transverse watertight subdivisions in each pontoon providing a total of 10 watertight tanks in each pontoon. If the rig gets holed from the side, the most likely scenario, it is able to suffer extreme damage and remain upright.

In our view this is very important considering the number of times barges are brought alongside in heavy seas.

Yokahama fenders are provided however, the hull must be very strong in the transverse direction and be well subdivided.

3.2.5 Hull Form
The catamaran style hull form with raised crane deck is chosen to minimize pitching in heavy waves and maintain high stability with the crane raised above the sea.

In consideration of simplicity and ease of construction, the pontoon lines are very straight with cylindrical bow and stern. Up to 10 knots hull speed there is very little advantage in making the lines any finer.
Underway, the hull is well designed to handle head or stern seas. In 2m waves the hull is able to achieve 8 knots and remain very steady. In lesser seas and light winds the rig is able to achieve 10 knots.

4.0 Machinery

4.1 Propulsion
4 x electric powered Ulstein or equal azimuth thruster propulsion units are provided, one on each corner extending from the bottom of the hull. This provides outstanding maneuverability of the rig, allowing it to travel sideways.

Each thruster is 300 kw Al-bronze fixed pitch propeller and vertically mounted electric motor. The electric propulsion motors are interchangeable with the crane winch motors.

Control of the thrusters is from a control console on the Nav Deck. It is also possible to shift navigation control to the crane cabin to allow the crane operator to maneuver the rig directly.

Position indicators and full range of control features are provided on the thruster control console for very simple, effective maneuvering.

4.2 Diesel Engines
The rig can be equipped with a number of powering options. The crane and thrusters never operate simultaneously therefore we do not require power for both. The system is either/or crane or propulsion.

Any number of power combinations are possible however, we prefer the concept of 2 x 1,000 kw dg sets to power the thrusters or crane plus deck machinery and hotel load. A small (100kw) dg set is provided for standby mode.

The dg sets and feeder panels are located inside the crane base where they are well protected and out of the way.

4.3 Tanks and Pumps
- Diesel fuel 20t located inside crane deck structure
- Lube oil drums stored inside crane base
- Waste oil 4t tank located inside crane deck structure
- 4t potable water located inside crane deck structure
- 6t non-potable water located inside crane deck structure
- 4t waste water tank
- 4t grey water tank
5.0 **Outfitting**

5.1 **Deck**
4 sets mooring winches 15t capacity x 50m/min electric driven with warping end
1 set windlass with cable lifter + md + we.
6 sets mooring bits and open chocks on crane deck (3port, 3 stbd)
6 sets mooring bits and open chocks on each pontoon
12 x 25m long polypropylene mooring lines
6 x Yokahama mooring fenders
2 x winch control stations
Repair room located in crane base with tools and welding equipment
Deck lighting 10 x 500kw flood lights

5.2 **Hotel**
Accommodation is provided as a removable module located under the crane deck. The following is provided:

- 4 x sleeping rooms for double occupancy
- 1 x Officer’s quarters
- 1 x infirmary
- 1 x laundry (washer and dryer)
- Shower room and toilets
- Galley
- Meeting Room and Planning Office
- Nav room (radio, radar, GPS, Propulsion)

Adequate lighting and air conditioning are provided. The accommodation is not fancy but it allows crews to remain onboard for continuous operations.

5.3 **Safety Equipment**
Safety equipment required by regulatory bodies shall be provided such as:

- Inflatable raft
- Life vests
- Fire extinguishers
- Rescue boat
5.4 **Stairs and Railings**
Inclined stairways and safety railings are provided between decks and on all working platforms such as the crane deck and pontoon deck. Stair treads will be hot dip galvanized non-slip. Railings will be heavy gauge, hot dip galvanized.

Railings on the outboard pontoon decks and crane deck are sectional. Pieces can be removed for mooring rope access.

5.5 **Electrical**
Electric installation shall be in accordance with Classification Society Rules using Class approved materials. See section 4.2 for dg sets. The following electric appliances are provided:

- Power distribution panel for DG sets
- Synchro panel for dg simultaneous operation
- 1 x 10 kw lighting transformer
- 1 x lighting panel
- 1 x distribution panel for deck winches and windlass
- 2 x open deck winch control stations
- 1 x distribution panel for crane
- 1 x power distribution panel for hotel

The accommodation block is provided with a 300 amp panel and 10 kw transformer (440v to 220 volt) which can be fed directly from one of the feeder panels.

6.0 **Hull Coatings**
All new steel shall be blasted and coated with pre-construction primer.

Exterior Hull 2 x epoxy + 1 x antifouling below waterline
Crane 1 x zinc + 1 x epoxy + 1 x stripe coat + 2nd epoxy + 1 x polyurethane
Accom Block Exterior 1 x epoxy
Accom Block Interior 1 x alkyd

All surfaces shall be clean and prepared in accordance with manufacturer’s recommendations. Coatings shall be applied by airless spray.