THE MSC XY-CANTILEVER

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Abstract

Some five years ago MSC started development of the XY-cantilever system. The system has now been applied on two MSC designed CJ70-150-MC drilling jack-ups. The first jack-up, named Maersk Innovator, has been delivered by Hyundai Heavy Industries to Maersk Contractors in Stavanger in January 2003. The second jack-up is nearing completion at the Hyundai yard in South Korea.

MSC developed the XY-cantilever and its integrated skidding system in order to expand the drilling envelope of the jack-up and to improve the drilling operations. Patents have been obtained in major industrial countries.

The classic cantilever can only move longitudinally relative to the hull of the jack-up. For transverse positioning of the drilling derrick, the drillfloor can subsequently be moved transversely relative to the cantilever structure.

The MSC XY-cantilever combines the cantilever and the drillfloor structures into one fixed package, which can move both longitudinally and transversely relative to the hull of the jack-up.

This paper provides:

- a discussion of the basic differences between the classic cantilever and the XY-cantilever
- a description of the XY-cantilever, its support structures on the hull of the jack-up and the integrated skidding systems
- an overview of the construction, commissioning and testing of the XY-cantilever for the Maersk Innovator
- an overview of the features of the XY-cantilever in terms of weight, cantilever reach, cantilever / main deck layouts and drilling capabilities.

General

Wellcenter movement

The classic cantilever can only move longitudinally relative to the hull of the jack-up. For transverse positioning of the drilling derrick, the drillfloor can subsequently be moved transversely relative to the cantilever structure.

In the new XY-cantilever system MSC has combined the cantilever and the drillfloor structures into one fixed package, which can move both longitudinally and transversely relative to the hull of the jack-up. Figure 1 shows the principle difference in wellcenter movement.

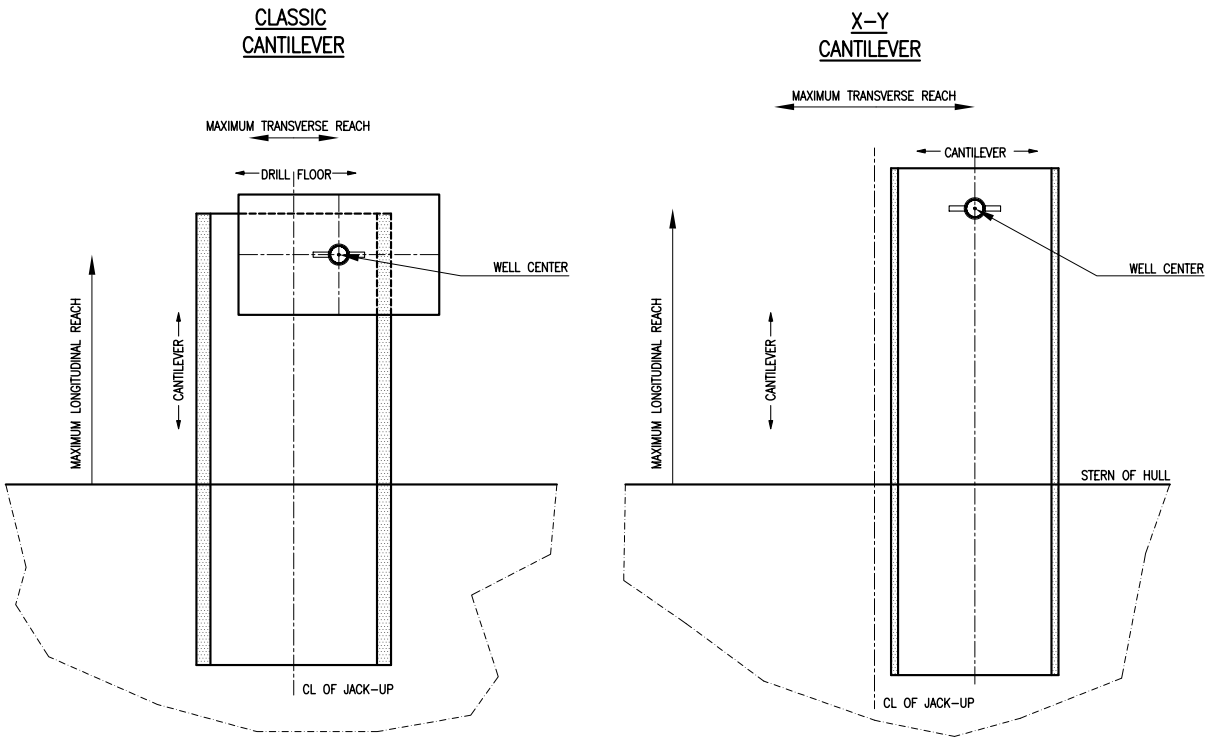

Figure 1: Difference in wellcenter movement

Structure

The classic cantilever structure basically consists of two longitudinal “cantilever” beams and two transverse beams carrying the drillfloor. The XY-cantilever is one box-shaped structure, with integrated cellar deck and drillfloor at the aft end and equipment spaces and a piperack deck at the forward end. Figure 2 provides a cross-section of the cantilever showing the derrick support points directly in line with the longitudinal side bulkheads of the cantilever. These bulkheads are also provided with the longitudinal skidding rails. The cantilever box-structure has three decks; the lower equipment deck, a tween equipment deck and a top deck supporting the cantilever piperacks. The entire XY-cantilever structure is supported by a pair of transversely arranged skidding deck rails on the main deck of the jack-up hull. The aft rail is arranged on the stern bulkhead, the forward rail is arranged on a transverse bulkhead further forward in the hull.

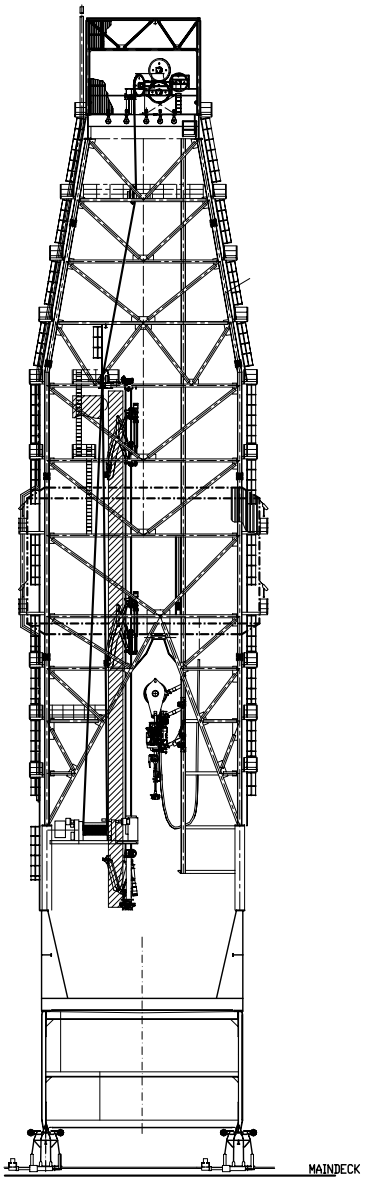

Figure 2: Cross section of XY-cantilever

Skidding

Figure 3 shows the skidding system existing of four so-called skid boxes which are arranged at the intersections of the cantilever skidding rails and the hull skidding rails. The height of these skid boxes is such that they provide a clear deck height of at least 3.0 meters underneath the cantilever for all cantilever positions. For transverse wellcenter movement these four boxes together with the entire cantilever structure are skidded over the transverse rails arranged on the main deck. For longitudinal wellcenter movement the entire cantilever structure is skidded over the top of the four boxes.

Transverse travel of the cantilever is only dependent on the available deck space in between the two aft legs of the jack-up.

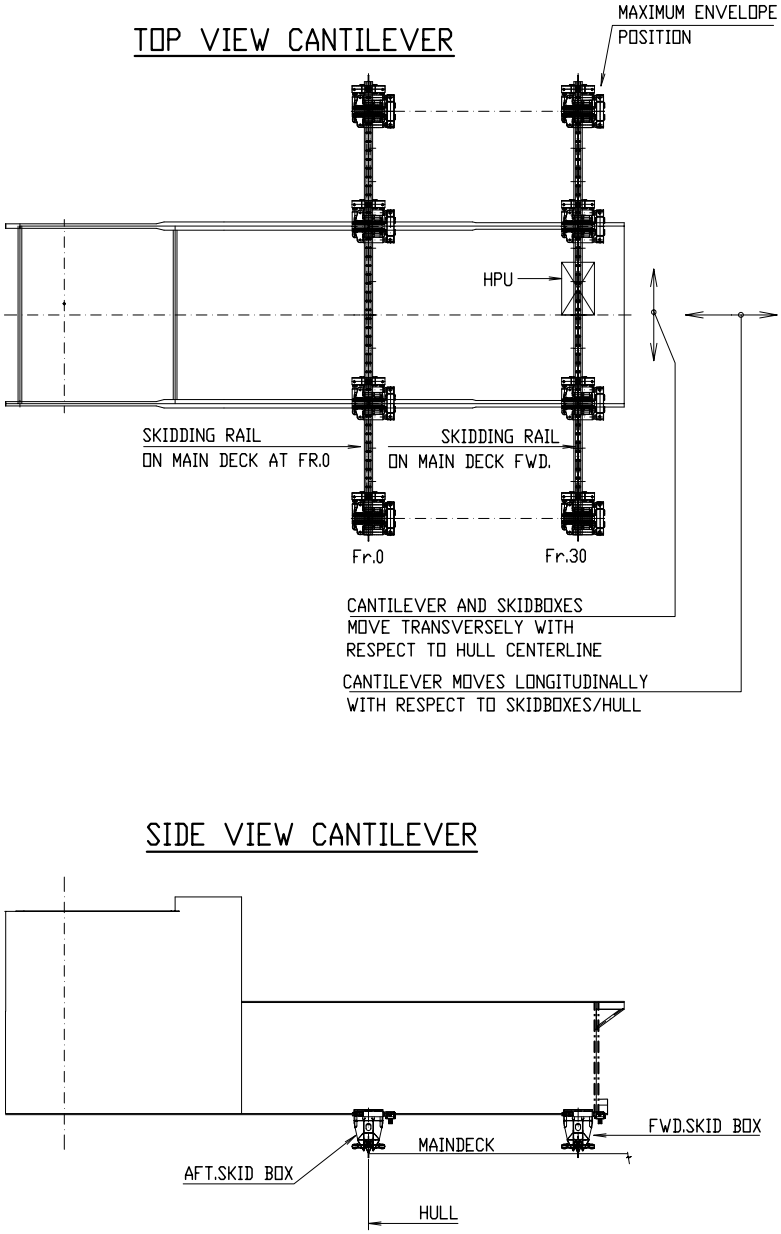

Figure 3: X-Y cantilever skidding system

Connections

Figure 4 shows that the piping and cabling between the hull and the cantilever are connected via a set of drag chains. The transverse drag chain is arranged forward of the forward skid boxes, and provides the flexible connection between the hull and one of the forward skid boxes. A longitudinal drag chain is arranged between the forward skid box and the cantilever.

The return mud flow, from the treatment tanks in the cantilever to the mud pits in the hull, is arranged through a set of mud ditches. The mud from the treatment tank flows into a longitudinal ditch that is arranged between the starboard forward and aft skid boxes. The mud flows out of the longitudinal ditch into a transverse ditch that is arranged on the main deck, just forward of the transverse drag chain.

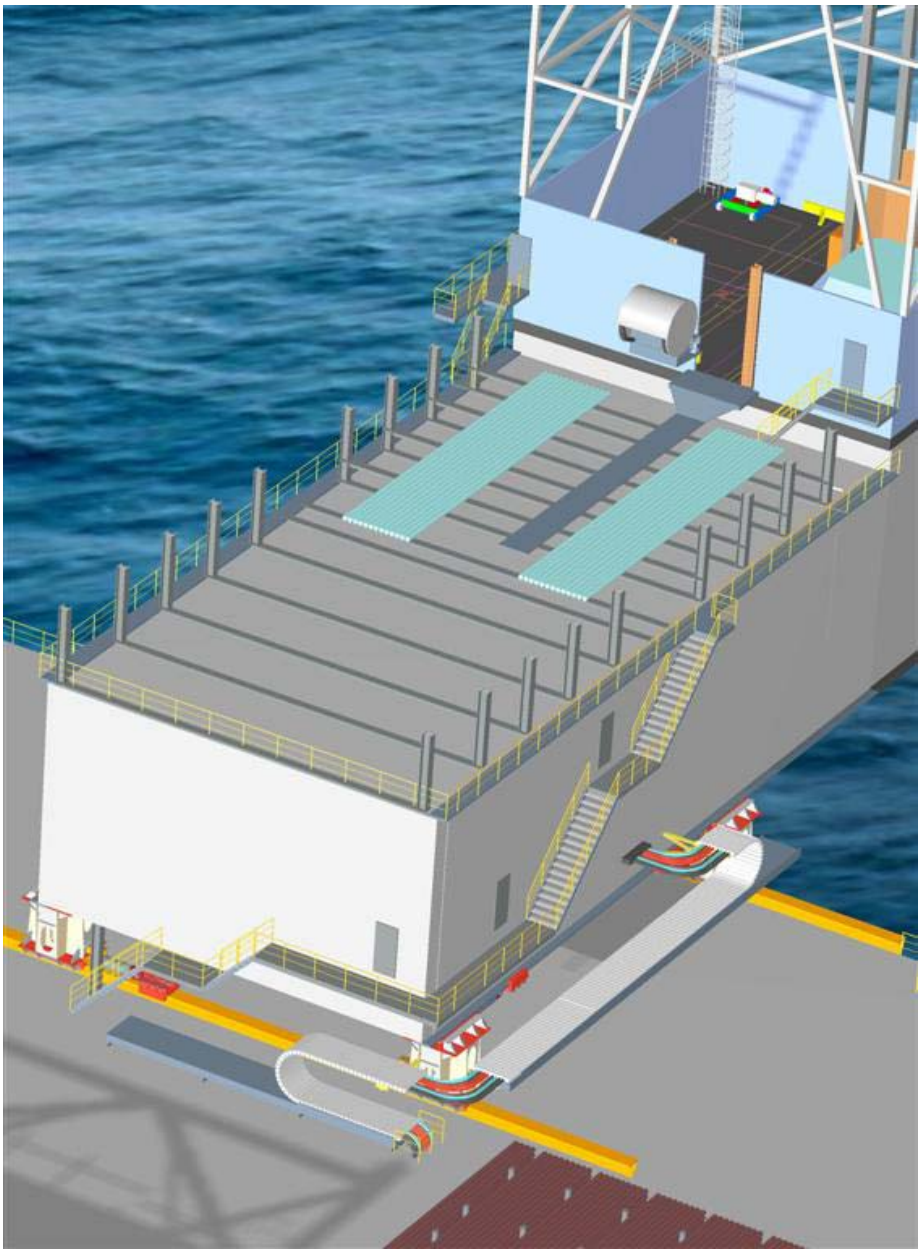

Figure 4: Piping and cabling between hull and XY-cantilever

Features

Reach

Figure 5 and 6 show that compared to the classic cantilever, the XY-cantilever provides not only large longitudinal and transverse reaches, but also that the maximum combined cantilever loading is available over the entire drilling envelope. With a 10 ft well spacing the 80 by 60 ft XY drilling envelope can cover 56 well positions, where the 75 by 30 ft classic drilling envelope can cover 23 well positions.

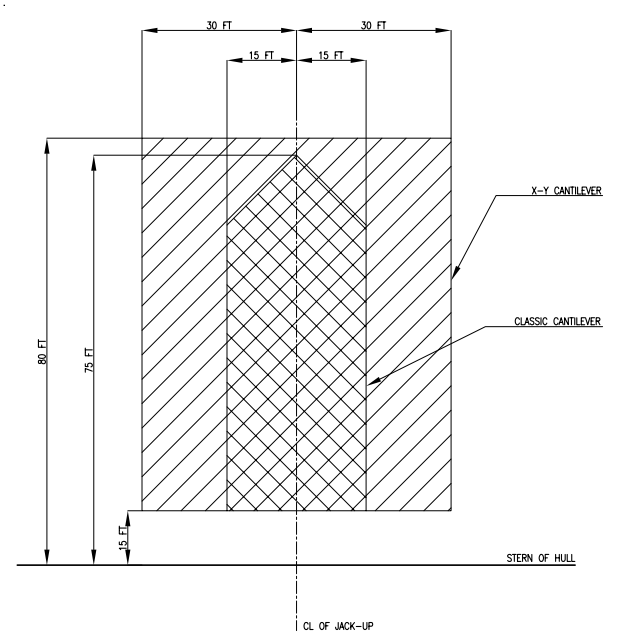

Figure 5: Full load drilling envelope

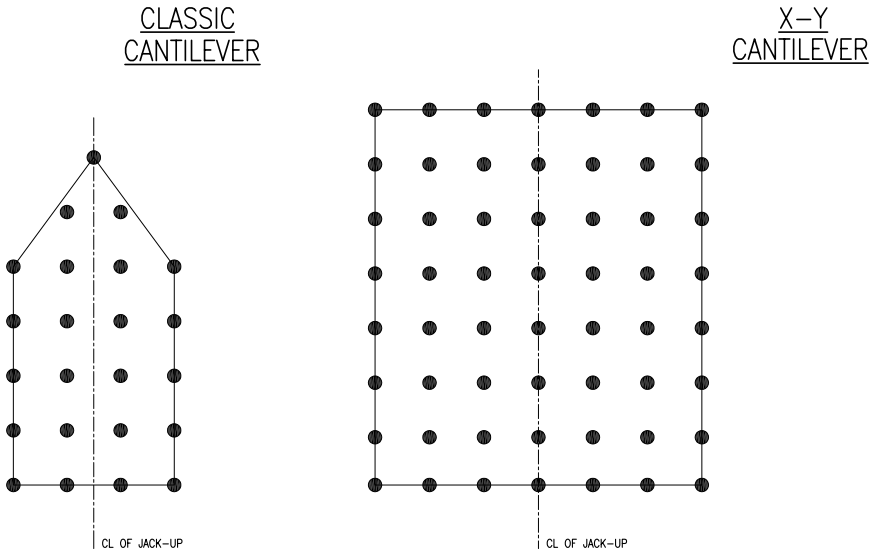

Figure 6: Well positions

Structural efficiency

Figure 7 shows that for the classic cantilever with the wellcenter in the extreme transverse position the weight of the drillfloor and the combined cantilever loads is almost completely carried by one beam. In the case of the XY cantilever this same weight and load is always evenly distributed between the two main longitudinal beams. The figure also shows that the XY-cantilever beams can be placed closer together since the width of the cantilever is no longer dictated by the transverse reach and BOP dimensions. Together with the much more efficient drillfloor structure and derrick support, this results in a significantly lower steel weight for the XY-cantilever.

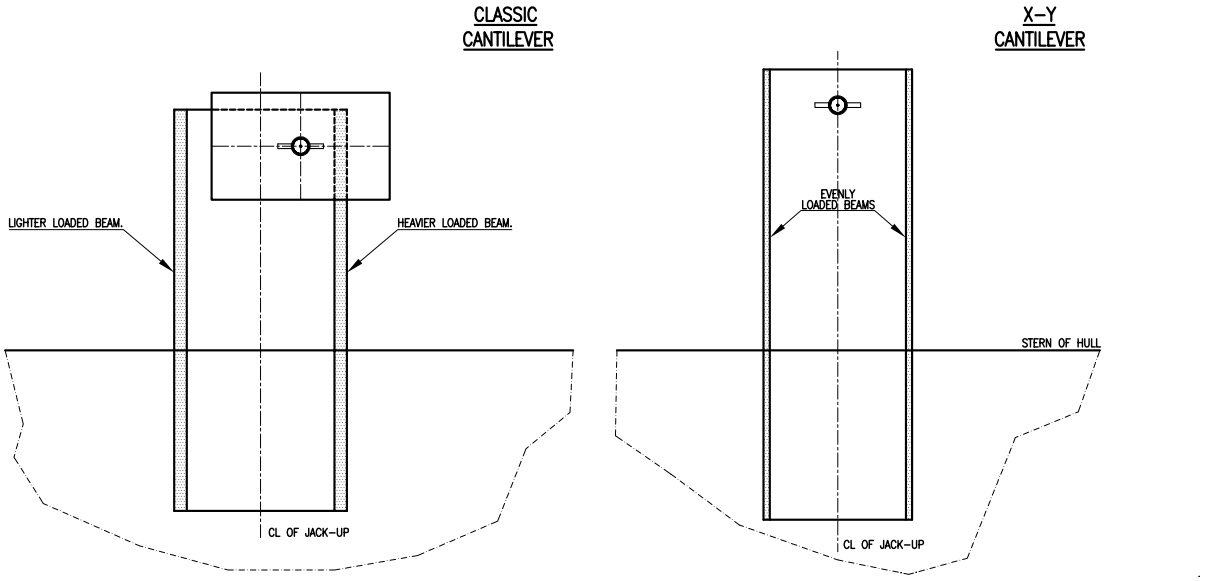

Figure 7: Loading cantilever beams

Drillfloor and cellar deck area

As the cantilever and the drillfloor are one unit, no (piping/ cable) flexibles are required between cantilever and drillfloor. This provides extra space in an important work area around and below the drillfloor

The BOP handling is more simplified, as the wellcenter is always in the same position with respect to the cantilever longitudinal beams. An overhead crane (longitudinal or transverse) or a cellar deck skid unit is only required between the wellcenter and the chosen storage/ test position. The BOP control hoses can remain attached during movement between these two positions. The cellar deck area is thus also less obstructed.

Conductor tensioning is always in one position, and can thus also be attached to the cellar deck instead of the drillfloor.

There is more freedom in the layout of (pipe handling between) drillfloor and cantilever, because of the fixed position of the drillfloor with respect to the cantilever.

Main deck obstruction

The elevated position of the cantilever above the main deck allows for installation of containers, cuttings transfer equipment and the use of a fork lift for transport of equipment. Figure 8 shows that contrary to the classic cantilever that is permanently covering a large area on the aft deck, the XY cantilever is not covering any area permanently. Together with the fact that the XY-cantilever has a reduced width this results in more free and more freely accessible deck area.

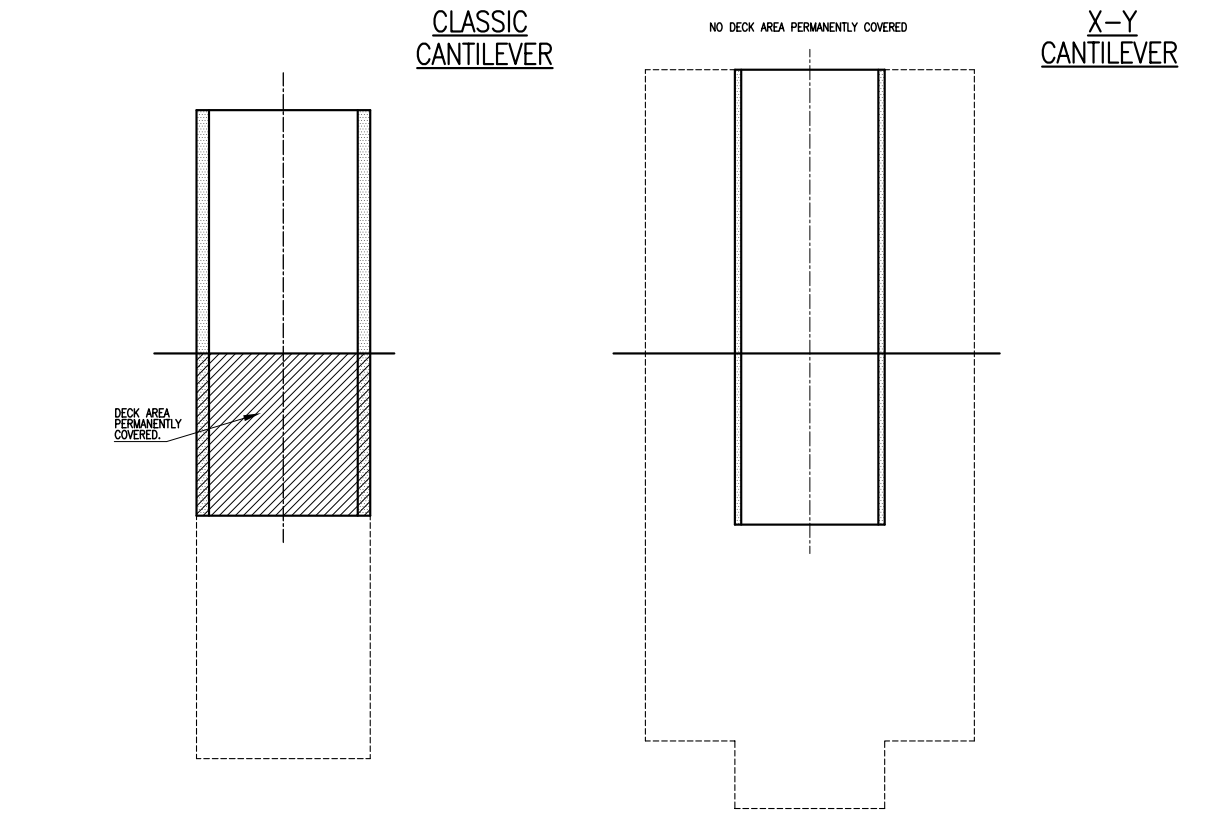

Figure 8: Minimum permanent deck obstruction

Air gap

In many cases when drilling over a wellhead jacket the air gap below the jack-up hull is not dictated by the height of the wave crest but by the height required to reach over the jacket and it topsides. Figure 9 shows that the position of the XY-cantilever, at least 3 m above the main deck, provides such additional air gap. The air gap of the hull can therefore be smaller. This reduces the length of leg below the hull and therefore also the overall loading on the jack-up.

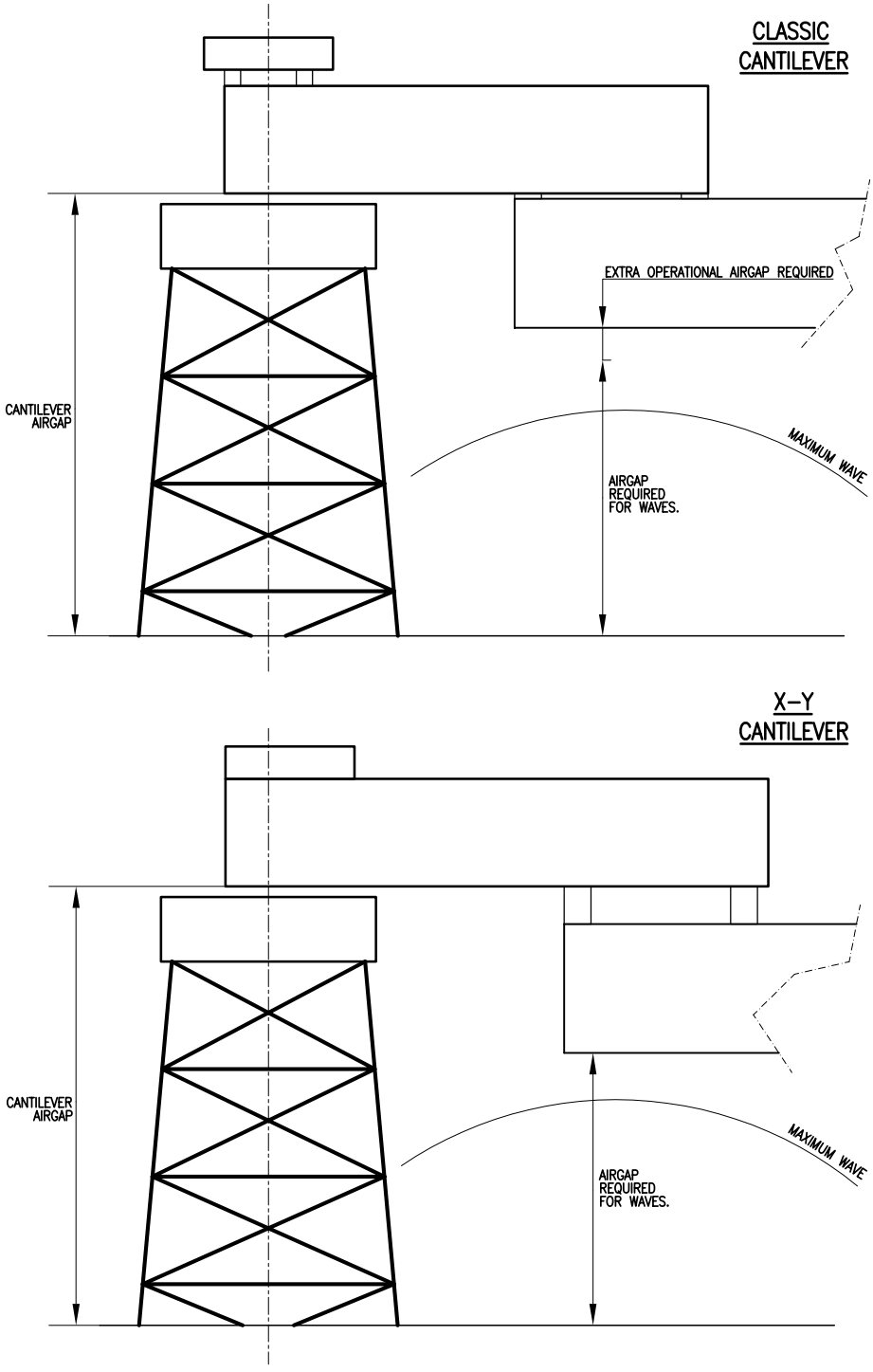

Figure 9: Working over a platform

Comparison

The table below is comparing the classic cantilever and the XY-cantilever for a modern 400 ft jack-up

Cantilever comparison for a 400 ft jack-up

		Classic Cantilever Configuration	***MSC XY-Cantilever Configuration***
Longitudinal reach	ft	75	80
Transverse reach	ft	15	30
Maximum combined load	Kips	2500	2500
Total length	m	44	46
Width	m	18.5	13.72
Beam height	m	8.0	8.0
Total steel weight	ton	1150	720
Total equipment/piping weight	ton	930	915
Skidding systems	ton	80	160
Total cantilever related weight	ton	2160	1795
Weight shift moment longitudinal	tonm	74000	57000
Weight shift moment transverse	tonm	3500	16500
Increase in Aft leg reaction from weight shift	ton	540	640

The numbers show that the XY-cantilever provides a two times larger drilling envelope for a significantly lower structural steel weight. The overall weight is approximately 20% reduced. Important for the design of the jack-up overall is the increase in vertical leg reaction in the aft legs due to the eccentricity of the cantilever weight in its extended position. Due to the fact that in case of the XY-cantilever the entire weight is moving over a larger transverse distance, the transverse weight shift moment is significantly larger. This however largely compensated by the lower longitudinal weight shift moment. This results in only a marginal increase of the aft leg reaction.

Skidding System

Each of the four skid boxes is equipped with two skidding systems, one operating on the deck rail and one operating on the cantilever rail. Figure 10 shows a complete skidding system. Each skidding system basically consists of a yoke interconnected to the skid box with two hydraulic cylinders. The yoke comprises two pins which can engage with a series of holes in the skidding rail. The pins are operated by hydraulic actuators.

The two aft skid boxes take the highest loads, when the cantilever is extended. In order to reduce the friction forces between the skid boxes and the rails, and consequently the required skid forces, hydraulically activated rollers are installed in these aft skid boxes.

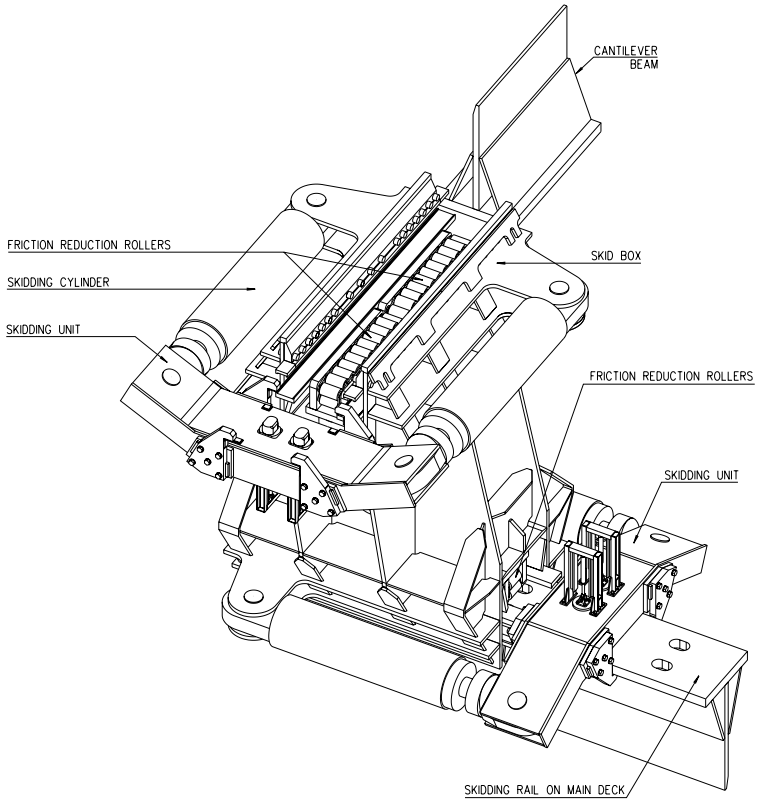

Figure 10: Skid box with integrated skidding systems

Hydraulic power to operate the system is supplied by an electric motor driven hydraulic power unit (HPU) arranged on the forward deck rail, in between the two skid boxes. The HPU is containerized and comprises amongst others two electric motors, each driving identical multiple hydraulic pumps, a oil tank, solenoid operated valves, filters and controls.

In case of failure of one of the electric motors or hydraulic pumps, skidding operations can continue at half speed.

Skidding operations are controlled by one person from the skidding control desk arranged at the HPU. Figure 11 shows the skidding control desk with levers and instrumentation to control the skidding systems and to verify their proper functioning. It is controlled by a Programmable Logic Controller (PLC).

Figure 11: Skidding control desk

From the skidding control desk the direction of movement is selected (longitudinally or transversely). The control is semi-automatic; each step is initiated by means of a single joy-stick, the subsequent steps are performed automatically.

The position of each skidding unit and the position of the wellcenter of the cantilever is indicated at the skidding control desk and determined by a stroke measurement system incorporated in the skidding cylinders. The stroke measurement system is also used to monitor the travel of each rail in order to ensure a parallel movement of the cantilever. In case the difference between two rail travels exceeds a set value the flow to the cylinders is automatically adjusted to correct the travel difference.

The XY-cantilever for the MSC CJ70-150-MC

Main technical data

– cantilever reach (wellcenter)		
– longitudinal, aft of stern	27.5 m	(90 ft)
– transverse, from hull centerline	+ 11 and – 9 m	(+36/-29.5 ft)
– cantilever weight (fully equipped)	3100 metric ton	(6835 kips)
– maximum combined load in operational conditions at 24.4 m (80 ft) reach	1400 metric ton	(3085 kips)
– maximum setback load in skidding conditions at 18.3 m (60 ft) reach	820 metric ton	(1805 kips)
– skidding capacity per skid box		
– longitudinal	600 metric ton	(1320 kips)
– transverse	600 metric ton	(1320 kips)
– average skidding speed	16 m per hour	(52.5 ft/hr)

A photo of the actual XY-cantilever of the MSC CJ70-150-MC is provided in figure 12.

Figure 12: XY-cantilever of the MSC CJ70-150-MC

Construction and testing of the XY-cantilever

The complete CJ70 jack-ups are built on the quay side at Hyundai Heavy Industries in South Korea. The XY-cantilever is built in three sections and assembled on supports with the cantilever in extended position above the main deck of the platform (figure 13).

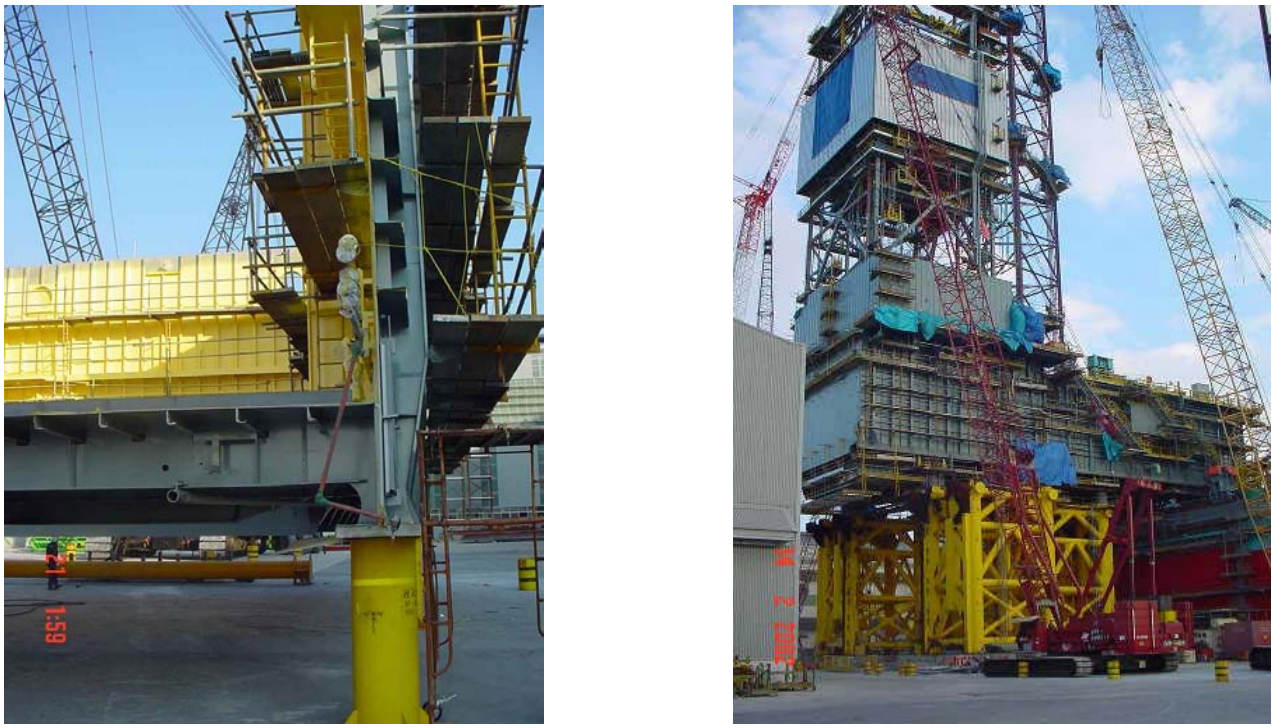

Figure 13: Construction of XY-cantilever

After construction of the skid boxes, the skid boxes with skidding cylinders, yokes and rollers are pre-assembled and placed onto the deck rails (figure 14).

Figure 14: Construction and assembly of skid box and skidding systems

Now the complete cantilever is lowered onto the aft skid boxes and skidded forward through the forward skid boxes. This skidding is carried out with the longitudinal skidding systems of the aft skid boxes. After this stage the construction of cantilever and skidding system is completed (Figure 15).

Figure 15: XY skidding system

After completion of the construction several tests are performed:

- Maximum skidding envelope test: with this test the maximum longitudinal and transverse reaches of the XY-cantilever is verified.
- Skidding load test: this test is used to verify the functioning of the XY skidding system with the cantilever loaded according to the maximum allowable loads for skidding conditions.
- Cantilever load test: this is a static load test for the 80ft extended position of the cantilever. The cantilever is loaded according to the maximum allowable loads for an operational condition. During this test the deflection of hull and cantilever are monitored in order to verify whether the inclination of the derrick is within the allowable range.