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**BARGE-ASSISTED DRAFT REDUCTION OF SEMI-SUBMERSIBLE DRILLING UNIT  
 GSF DEVELOPMENT DRILLER I  
 FOR TOW-OUT FROM INGLESIDE TO OFFSHORE GULF OF MEXICO**

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**ABSTRACT**

Because of its DP thrusters, the free-floating draft of the semi-submersible drilling rig *GSF Development Driller I* was too deep for a safe tow-out from Ingleside, TX, to open waters. In order to reduce the semi's draft, a large cargo barge was used to lift the rig 1.0 m (3.3 ft) and thus create a reasonable ground clearance. The barge was selected, based on dimension, ballast capability, deck strength, price, and availability. Eight support brackets were welded to the barge sides and strong diaphragms welded inside the four rig braces. Detailed time domain motion analyses were performed to study the behavior of the combined units during the tow and barge removal operation offshore. In April of 2006, during a favorable weather window, the combined units were successfully towed through the channels and once in deeper waters, the barge was ballasted down and pulled out from under the rig.

**INTRODUCTION**

After sustaining damage to the hull during hurricane Katrina, the semi-submersible drilling rig *GSF Development Driller I* was brought into the Kiewit yard in Ingleside, TX, for repairs and upgrades. Prior to the hurricane, its eight DP thrusters had been removed offshore for repairs. Post Katrina hydrographic surveys of La Quinta and Corpus Christi Channels showed that the majority of the channel depth was in excess of 46 ft. However there are some local areas where the depth was only 45 ft. With a displacement of 33,500 t, the tow draft of the rig including its DP thrusters is 13.7 m (45 ft) which is identical to the minimum water depth in the ship channel, leaving no margin of safety and thus risking grounding damage to the DP thrusters. A solution was found by inserting a large cargo barge between the rig pontoons and partly deballasting it to provide a 1.0 m (3.3 ft) lift - a modern version of the old "ship camels" used in Amsterdam in the 18-th century<sup>1</sup>. Special support brackets with softwooden cribbing

blocks were mounted to the barge hull, in line with new strong stiffeners inside the rig's cross braces. The created bottom clearance of 1.0 m (3.3 ft) allowed for the DP thrusters to remain in place while the rig with barge was safely towed through the channels, see figure 1. For maneuvering through the 17 nmiles long narrow channels, an advanced real-time navigation system that incorporated 3-D imagery of the channels was used. Once deeper water was reached offshore, the barge was ballasted and pulled free from the rig. While this barge removal operation appears fairly straightforward, the fact that it was performed offshore in open waters provided the tow-out team with a number of technical and operational challenges.



Figure 1. Tow-out of the *GSF Development Driller I* with a lift from *Boabarge 16*.

This problem was partially solved by employing so called "ship's camels", hollow caissons that were attached to the ships and then pumped dry, giving the ships some extra floating power and rising them just high enough to be able to pass Pampus. In North Carolina during the Civil War, flotation devices called "camels" would be slung from either side of Navy ships, inflated - thereby raising the ships a bit, enabling them to be dragged across the sandbar.

<sup>1</sup> Until far into the 19th century Amsterdam was only accessible from the oceans by way of the Zuider Zee. Because of a big mud bank (Pampus) just outside the city it was very difficult for heavy laden ships to reach the harbor.

## DRILLING RIG GSF DEVELOPMENT DRILLER I

The semi-submersible drilling rig *GSF Development Driller I* is a 5-th generation Friede & Goldman designed rig, built by FELS in Singapore in 2004. The rig is capable of working in water depths up to 2,286 m (7,500 ft) and drill to a depth of 11,430 m (37,500 ft). Its 74.4 x 74.4 m (244.2 x 244.2 ft) box deck structure is supported by four columns on two pontoons.

Each pontoon measures 98.82 m (324.2 ft) in length by 20.12 m (66 ft) in width, spaced 38.44 m (126.1 ft) apart. At 1.2 m (4 ft) above the top of the pontoons, 4 cross braces tie the 2 sets of columns together.

With a displacement of 33,500 t, the tow draft of the rig including its DP thrusters is 13.7 m (45 ft).

## DRAFT REDUCTION OPTIONS

In order to facilitate a safe tow-out after the repairs, a number of draft reduction options were studied, such as:

1. Reinstall the DP thrusters offshore after the tow-out (impractical as offshore reinstallation is complicated, expensive, and weather sensitive, with the likelihood of delays. It would also interfere with the testing and commissioning of the DP system);
2. With DP thrusters installed, remove deck weight to reduce overall draft (not practical as rig was floating on its pontoons with a TPI of 110 ST/inch, requiring an unrealistic large weight reduction to be effective);
3. Add buoyancy to the pontoons by means of small barges mounted to the pontoons (not practical as multiple bodies involved, complicated, and relatively ineffective, unless large buoyancy can be added. Barges on the outside would increase the overall beam and further restrict the maneuverability in the narrow La Quinta Channel);
4. Lift the rig with a single large cargo barge placed under the braces in between the pontoons.

After weighing all the various advantages and disadvantages of the available options, the last option was selected, see figure 2.

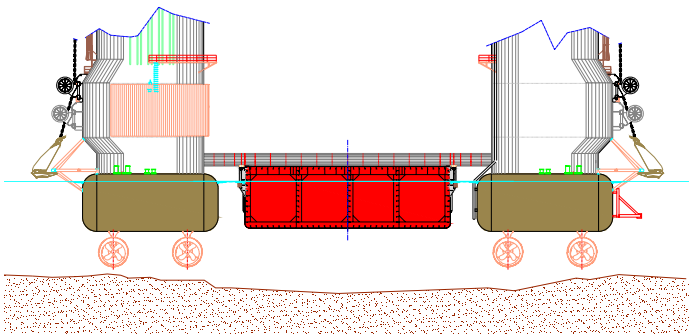


Figure 2. Barge placed between pontoons to lift rig.

## BARGE SELECTION

A number of cargo barges were studied. Selection parameters not only included hull dimensions, ballast capability, and deck strength, but also price and availability. The selection narrowed down to the Seaspan owned and operated *Boabarge 16* (ex *Goliat 10*), a submersible cargo barge with a length of 138.6 m (454.6 ft) and a beam of 30.48 m (100

ft). Its cargo deck is clear and the raised bow houses the ballast control room and winches. The hull is subdivided into a large number of ballast tanks by means of 7 transverse and 2 longitudinal watertight bulkheads. The barge is outfitted with ballast pumps and compressors. Ballasting is done using the pumps and gravity (by opening bottom valves in certain tanks). Deballasting is done using the pumps and the compressors (pressing the water out of the tanks through the bottom valves).

For all ballast steps from going down to go under the rig braces, to maximum lift of rig, the longitudinal strength of the barge hull was checked. At each step, the hull shear and bending stresses were well within the Class allowables. The barge stability was also checked at each of these steps. Since the barge's main deck never went under water, the stability was sufficient at each step, even with some of the ballast tanks slack. Including the ballast, the barge displacement at tow-out was 26,700 t.

Because this selected barge carried a foreign registration, a very careful legal review was necessary to see that the draft reduction and subsequent movement of the rig assisted by the barge would not violate the Jones Act.

## SUPPORT BRACKET DESIGN

The locations of the four rig braces did not coincide with the locations of the barge frames. Any internal reinforcement of the barge was to be avoided. Therefore, external support brackets were designed to guide the vertical lift loads directly into the barge side shells, see figure 3. The transverse location of the reinforced rig brace diaphragms was such that the moment on each of the brackets was relatively small (because of existing ring stiffeners, the new diaphragms could not be mounted any closer to the side shell). A 3-D FE model of part of the barge hull with a bracket was made to verify the stress levels in the bracket and the hull plating, see figure 4. Based on a design lift load of 500 t per bracket plus hydrostatic pressure on the shell plates, the maximum stresses in the barge hull were found to be between 33% of yield (shell plating) and 43% of yield (shell longitudinals). In the support bracket the maximum stresses were found to be up to 54% of yield. These maximum static stress levels left sufficient margin for additional dynamic stresses.

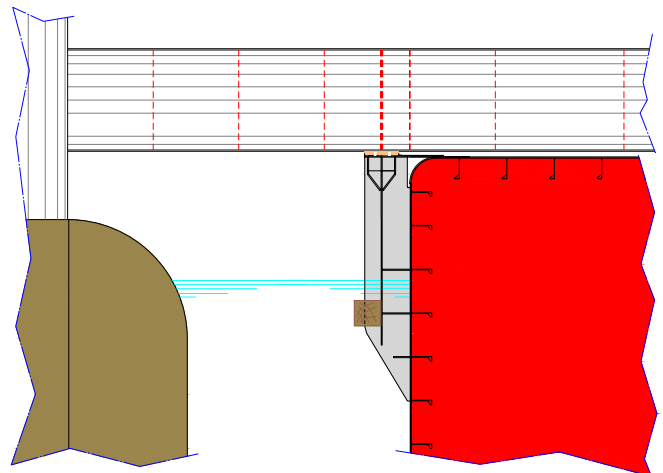


Figure 3. Support bracket concept – total 8 required.

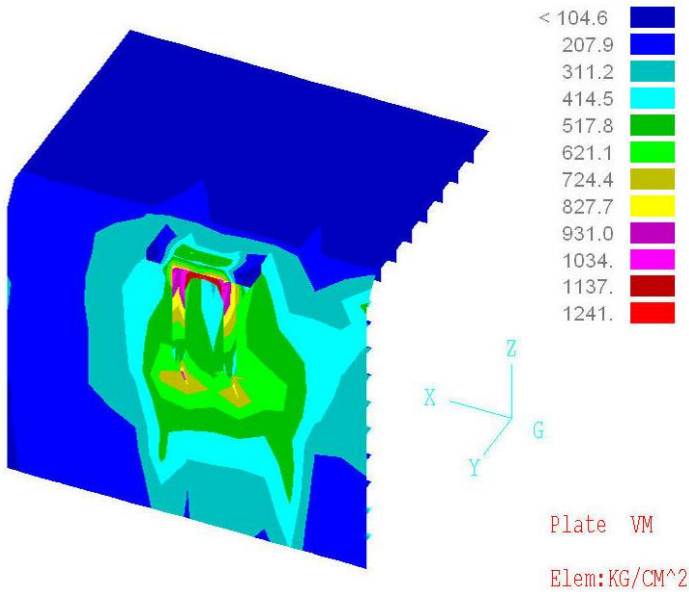


Figure 4. FE model of support bracket on barge hull.

Upon completion of the FE analysis, detailed fabrication drawings of the support brackets were made. All eight brackets were identical, simplifying the prefabrication and installation process.

### TIME DOMAIN ANALYSES

The selected barge matched the rig well. The waterplane area of the barge hull was nearly identical of that of the two rig pontoons combined, giving both units similar heave responses. To study in detail the behavior of the two mated units in a seaway, time domain motion analyses were performed. Using Ultramarine's MOSES software, the barge and the rig hulls were modeled, see figure 5. The rig hull was built up with 1,020 panels and the barge hull with 705 panels. All internal ballast tanks were included in the barge model. Using cribbing (compression only) springs, the models were connected at four brace support points (each point representing 2 support brackets) and the two guideposts forward. Four soft mooring lines were added to the rig to keep the models in position. The barge was ballasted such that each corner carried 1,000 t. Using 3-D diffraction theory, the combined units were then subjected to a range of wave heights, periods, and directions to study the loads in the support points (both vertical and lateral) under these various conditions and to determine the limiting operation wave conditions for the offshore part of the tow.

Given a .9 m (3 ft) significant wave height with a range of wave periods, the dynamic vertical support loads were calculated for all wave headings, see figure 6. In head and following seas, there is some pitch influence, while in beam seas the roll and heave components (which can be in or out of phase) dominate. The aft supports are more impacted by following seas, while the forward supports see higher loads in head seas. But beam seas dominate. Dividing the maximum support loads by the static support load (1,000 t per corner) gives dynamic load factors. For 8 s following seas, the dynamic load factor is found to be 1.25.

For the port aft support point, a dynamic load factor of 1.3 was found at 8 s beam seas coming in from the starboard side (heave and roll in phase). This same wave condition results in a dynamic load factor of 1.2 for the beam seas coming in from the port side, whereby heave and roll are out of phase. For the starboard aft support point, the reverse was found. At no time, gapping or uplift at any of the support points was found.

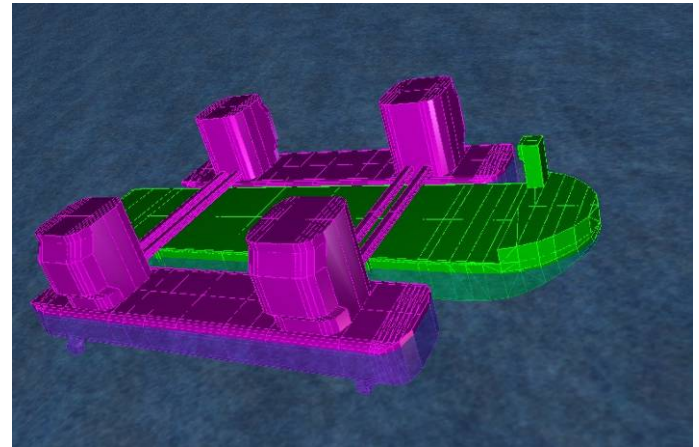


Figure 5. MOSES model of rig and barge combined.

Because of the strength limitations of the rig braces and barge support points, the tow-out wave height restriction was set at .9 m (3.0 ft). The motion output for the combined system in this limiting wave height condition showed a maximum pitch amplitude of 1.2 deg and a maximum heave amplitude of .2 m (8 inches).

Except for the 4 s beam seas case, the maximum lateral loads in way of the support blocks were found to be well within the 30+% friction resistance capability of steel on wood, eliminating the need for any lateral securings, see also figure 7.

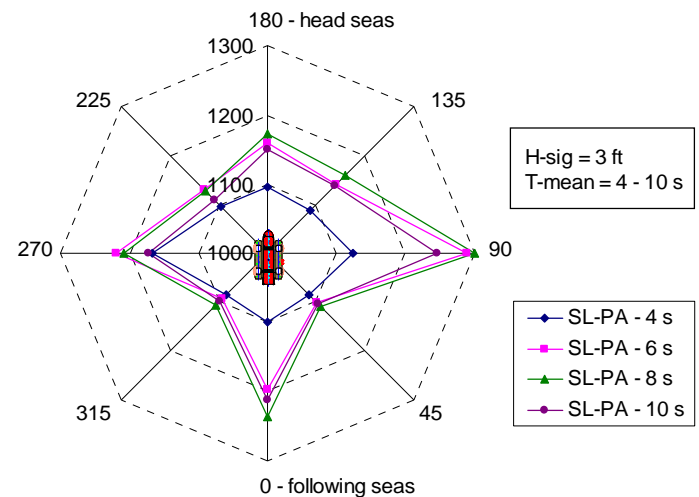


Figure 6. Support load (t) at the port aft point versus wave heading.



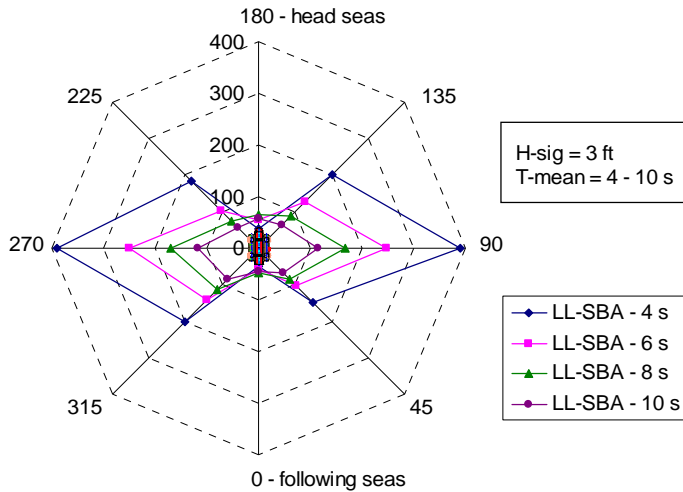


Figure 7. Lateral loads (t) at the starboard aft point versus wave heading.

During removal offshore, the ballasted barge has a natural pitch period of about 15 s. Short 3 ft waves, with a period of 5 s, make the barge pitch .23 deg and the vertical motion at the aft support is .12 m (single extreme amplitude). For a 10 second wave, the pitch motion increases to .77 deg and the vertical motion at the aft support to .46 m. The rig has a natural pitch period of about 10 seconds. A second time domain study was done to study the behavior of the barge just after separation, with only a small clearance between the barge supports and the rig braces. With the barge ballasted down and moored under the rig, the relative motions and contacts at the support points were studied, in head seas with a 3 ft significant wave height and a 5 s mean wave period. Most of the time, there was positive clearance between the braces and the support cribbing blocks. Occasionally however, the gap closed and there was contact. The maximum contact load on the aft support was predicted to be 370 t for a 3 hour exposure time. In reality, this configuration would not last this long, as the barge would be pulled out as soon as there was sufficient clearance under the braces to safely do so.

### PREPARATIONS TO THE RIG

Before the final barge was selected, it became clear that the four horizontal rig braces were of adequate overall strength to accommodate the cargo barge lift forces. However, these braces did not have sufficient local strength to take the lift loads. Inserting new heavy diaphragms did provide the required strong points in each corner. Once the barge selection was made, the location of the new support diaphragms could be fixed.

Before installation of the barge, the rig was re-moored at the yard with different spacer barges, creating a slot so the cargo barge could be inserted.

To protect the pontoon shell and some protruding drain and dump lines, 6 tire covered 11 x 20 ft Yokohama fenders were hooked up to the rig bollards, using quick release connectors. These fenders were first partly filled with water to avoid them

floating on the surface and riding up the rounded pontoon hulls when compressed.

The rig's free-fall lifeboats were secured for the tow-out. Given the configuration with the barge between the rig pontoons, these lifeboats could not be used in case of an emergency, as they would land on the barge. Small evacuations would be done with a helicopter. Because of the limited water depth, the rig could not sink in the channel and any large scale evacuation would be via the rig column ladders and the barge.

### PREPARATIONS TO THE BARGE

The cargo barge was surveyed to double check its suitability. Eight large support brackets, each weighing approximately 3,200 kg (7.0 kips) were prefabricated and welded to the sides of the barge, after local removal of some of the fendering, see figure 8. These support brackets provided the interface with the rig braces at the new diaphragm locations, and carried the lift loads directly into the side shell of the barge.



Figure 8. Support brackets welded to barge hull.

Two guide posts were welded forward on the deck to assist with the longitudinal positioning of the barge. The barge deck aft of the guide posts was cleared of any large obstructions, such as mooring bitts and chocks. A centerline painted on the barge deck would assist with the transverse positioning. All steel preparations were done in Port Arthur, TX. When the barge preparations were complete, it was towed to Ingleside, TX, to install the wooden cribbing blocks and fenders.

On top of each support, cribbing blocks, consisting of a layer of 5" softwood with a layer of plywood on top were mounted. These were secured to the support brackets with steel straps, sandwiched between the 2 layers. The 5" softwood layer allowed for some relative deflection between the various contact points. The plywood top thickness was varied between 1/4 and 2 inches to adjust for the as-built deviations in levelness on both the rig side as well as the barge side, in accordance with detailed elevation surveys of both of these. No corrections for any local tilt were made.

To provide fendering, large tractor tires were fixed to the barge aft corners. Wood blocks were mounted against the protruding vertical plates of the support brackets.

To avoid steel to steel contact during the barge removal offshore, a herring bone pattern of 4" by 4" softwooden beams was secured to the deck, on either side, aft of the guide posts, see figure 9.



Figure 9. Wooden fenders on barge deck.

#### INSTALLATION OF THE CARGO BARGE

When the rig was ready to receive the barge, the barge was ballasted down to a .9 m (3 ft) freeboard and maneuvered towards the rig, using local harbor tugs. Once in line with the rig, a line from a large forklift waiting on the quay was connected to the barge stern and the barge was slowly pulled between the pontoons, under a watchful eye of the attending marine warranty surveyor, see figure 10. The assist tugs pushed and pulled to keep the barge hull away from the pontoons and the protruding drain pipes. When the guide posts made contact with the forward rig brace, the barge was held in position by keeping tension on its stern wire. Come-a-longs were hooked up at the four corners, to lock the barge in position and assist with the fine-tuning. Based on the positioning marks on the aft brace, the barge was exact in position. However, the CL mark of the barge was still 6 inches off from the CL mark on the forward rig brace, and both (longitudinal) guide posts were tight against the forward brace. To get the forward marks in line, the barge needed to be rotated, which seemed unlikely (the position of the guide posts had been checked and double checked before and after installation). It quickly became clear that the CL mark on the forward rig brace was off center... Using a tape measure, the correct rig CL location was marked on the brace and some small adjustments were made laterally until the barge centerline was exactly under the rig centerline, both fore and aft. The barge was then deballasted until the wooden cribbing blocks made contact with the rig braces. Upon re-confirmation of the positioning fore and aft, the cargo barge was deballasted until the rig draft was reduced by 1 meter (3.3 ft). Total duration from unmooring the ballasted barge to

completion of deballasting was 8 hours (3 hours for maneuvering and positioning, 5 hours for deballasting).



Figure 10. Barge pulled in between rig pontoons.

Because of the limited support area available, the cribbing blocks were loaded to a high static pressure of 42 kg/cm<sup>2</sup> (600 psi), close to the crushing limit of the yellow pine wood, see figure 11.

With the installation of the barge, the rig's initial stability, GM, reduced from 72.5 m (237.9 ft) before, to 54.9 m (180.1 ft) after barge installation. The added displacement of the barge however more than compensated for the GM reduction when resisting overturning moments. Any listing or trimming of the rig and barge combination by shifting fluids or weights, or by lifting loads with the rig cranes, caused a redistribution of loads on the support brackets. In order to limit the maximum load on any single support to 650 t (500 t design load plus API-RP2 allowable 1/3 stress increase), trimming and listing was limited:

- Rig trim was limited to .5 deg or .7 m (27.5 inches) difference between bow and stern;
- Rig list was limited to .25 deg or .4 m (12 inches) difference between port and starboard.



Figure 11. Port aft cribbing block compressed after lifting rig.

While waiting for a suitable weather window, yard activities on the rig were wound down and completed. The rig was stripped of all unnecessary deck loads and fluids, to further minimize its draft and maximize the bottom clearance. A tow-out meeting was held to inform all parties involved of the upcoming activities.

**WEATHER FORECASTING**

The tow-out and consequent barge removal operation were both weather sensitive, the first with respect to wind speeds and the latter with respect to wave height and period. Because of the size of the combined units, the channels were to be closed for all other shipping traffic by US Coast Guard, for which they and the Corpus Christi Port Users needed at least a 48 hours advanced notice. To have the best possible weather information available, an on-site meteorologist from Impact Weather was hired and set up at the yard. The 48 hour forecasts were compared to the actual wave conditions offshore, as measured by the NOAA buoys, see also figure 12. Early April, the tow-out window opened up when a fast passing cold front created a temporary northern wind which knocked down the high southerly swell, and with insufficient duration to build a new swell. The predicted tow-out wind speed of 14 knots was just within the 15 knots limit - unusual favorable conditions, giving that an annual Windfest festival was going on in a neighboring town. The 48 hour forecast was spot on, and the offshore waves died down as predicted, in spite of an unforeseen surge.

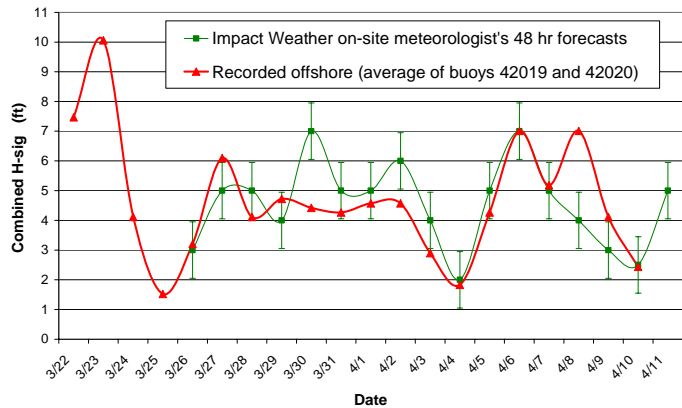


Figure 12. Comparison daily 48 hr wave forecasts with actual measured wave heights offshore Corpus Christi.

**TUG CONFIGURATION FOR TOW-OUT**

Although the large wind area did not change much, adding the barge under the rig nearly doubled the total mass to be moved to 60,200 t in total. The wetted surface and lateral areas also increased significantly, all of which required increased handling power. A suitable tug configuration was designed in close cooperation with the towmaster, local pilots, and the local Signet Maritime tug captains.

The small freeboard and large top corner radius made it difficult to push against the rig pontoons (see also figure 2). The anchor racks on all four corners and a submersed cursor support structure on the starboard outside provided further

restrictions for the assisting tugboats. The barge hull, with a freeboard of 2.2 m (7.2 ft), protruded both fore and aft past the rig pontoons, thus providing excellent push areas for the assisting harbor tugs, see figure 13. The anticipated maximum push and pull forces of the tugs were much less than the total friction restraint between the cribbing blocks and the rig braces.

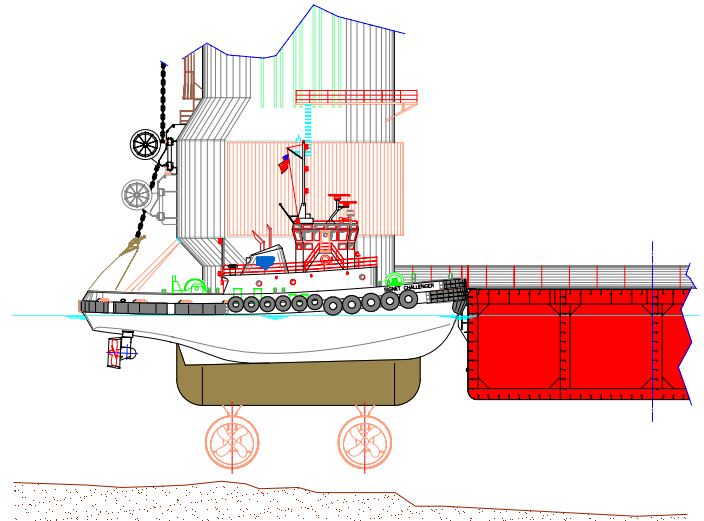


Figure 13. Signet Challenger pushing directly against barge hull.

The harbor tugs were used fore and aft in athwartships direction, more or less acting as transverse thrusters. The bigger oceangoing tugs were used to pull on the barge's tow bridle and push aft against the barge transom, see figures 14 and 16.

Once the tow arrived in the wider Corpus Christi channel, the configuration was changed and the smallest tugs released and dismissed. Getting ready to hold offshore, the large harbor tugs were moved from the forward ends of the pontoons to the aft ends. The lead oceangoing tug was moved from the barge bridle to the port tow bridle of the rig. Another oceangoing tug joined the units and hooked up to the starboard side tow bridle. The tug that pushed the barge, now hooked up to the barge tow bridle, for pulling the barge out after ballasting down.

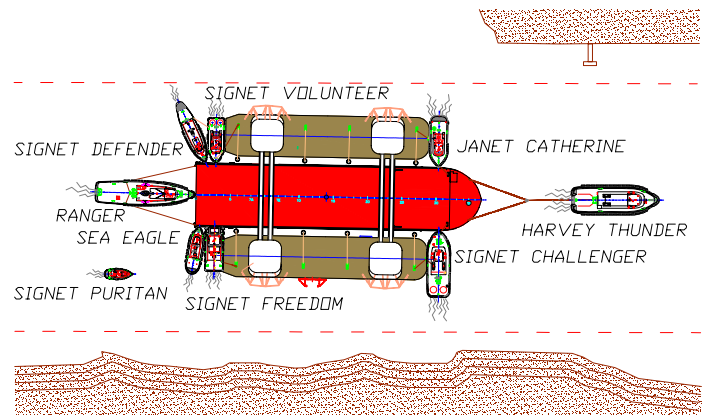


Figure 14. Tug configuration during tow-out through the 400 ft narrow La Quinta Channel.



The rig's own DP system, although not yet fully commissioned, was operational and standing by during the transit. Because of the close proximity between the thrusters and the channel bottom and sides, it was the intention not to use these thrusters and run the risk of sucking in a foreign object and damage a thruster, unless absolutely needed in case of an emergency. The tugboats maintained good control throughout the tow-out.

### 3-D NAVIGATION SYSTEM

An advanced Geo Century real-time Skyfix DGPS navigation system that incorporated 3-D imagery of the channel for the total passage was used to ensure that the rig stayed inside the safe canal boundaries at all times, day or night, see also figure 15. Continuous updates on the true distances between the rig thrusters and the channel bottom as well as sides were displayed in real time. Because of the size of the combined units, the US Coast Guard would normally have restricted this 12 hour voyage through the narrow channels to daylight hours only. However the proposed use of the 3-D imagery provided a high level of confidence that the tow-out could be executed safely, even during darkness. A central navigation visualization and control unit was installed on the navigation bridge of the rig, and hooked up to the various input sensors. Auxiliary slave display systems were installed on several of the assist tugs. All auxiliary units were in contact with the main control unit, using real time telemetry. Because the tug captains could monitor where the rig was and where it was heading at any time, they could take immediate action to minimize any deviation from the intended path and to control its movements, oftentimes before being requested to do so by the towmaster or pilots.



Figure 15. Geo Century 3-D display of thruster clearance with bottom and sides of channel.

### TOW-OUT AND BARGE REMOVAL

On April 9, 2006, upon confirmation of the favorable weather forecast by the on-site forecaster, the tow-out commenced. A final sail-away meeting was organized on the rig to inform everybody and once again go over the procedures. Around mid afternoon the local tugs were hooked up and the

mooring lines cast off. Using the assist tugs, the rig and barge combination was successfully maneuvered away from the deep hole at the dock, rotated 90 degrees and moved to the center of the very narrow La Quinta Channel, see also figure 16. During this first maneuver, a short blast with the starboard outboard thruster was given to check the response of the rig with barge.



Figure 16. Tow in La Quinta Channel, passing Ingleside on the Bay.

The channels were closed for all shipping by the Coast Guard. In addition to the advanced navigation system, conventional marker buoys were also deployed for visual guidance as a back up to the electronic navigation.

After an uneventful 17 nmiles long tow, the Aransas Pass jetties were past just after midnight, and the units were subjected to heavy cross currents. The rig's DP thrusters were briefly activated to compensate for this (the athwartship assist tugs were released earlier in the Corpus Christi channel).

The selected deep water spot was reached early next morning. It was still dark and the combined units were held in position until daylight. With 2 to 3 ft head seas at 6 s, the instrument readings on the rig's bridge showed that the combined units were heaving about .05 m (2 inches) and pitching up to .2 degrees, well within the design maxima. Roll motion was negligible.

Weather conditions remained within the operational limits as predicted and the last phase of the tow-out was set in motion. Having no seafastenings to remove before separation did not only save valuable time but also eliminated any need for personnel out on the barge deck working with torches, chain falls, etc. The tugs were reconfigured for offshore towing, and the tug used for pushing aft on the barge was moved to the front and hooked up to the barge's tow bridle.

Starting at 6:45, the cargo barge was ballasted down according to the planned sequence. First the rig was lowered level back to its own unsupported draft. Then the barge stern was ballasted to create a gap with the aft braces. Continuing ballasting the barge down also freed the bow supports and the barge started to become lively, heaving and pitching in the

waves. At this time (9:40), the two mooring lines were released and the barge was quickly pulled out from between the rig pontoons, lightly bumping the rig braces with its deck fender blocks only once on the way out. The rig's DP thrusters were used to rotate the rig about 2 degrees to starboard when the barge started to shift during the move out, thereby eliminating any lateral barge to pontoon contact entirely. The challenging tow-out was successfully completed, see figure 17.



Figure 17. Barge pulled out from under rig braces.

#### AFTER THE TOW-OUT

With the semi-submersible drilling rig *GSF Development Driller I* safely delivered back into deep waters, the final testing and commissioning of the DP system could be completed.

The rig braces were randomly checked to see if the lift operation caused any excessive stresses on the major connection welds between the braces and the columns. No such damage was found, eliminating the need for a full 100% check.

The rig proceeded to its drilling commitment at Grand Island, after first taking on a full load of fuel and potable water, see figure 18.



Figure 18. Rig taking on fuel and water from a supply vessel.

After removal, the cargo barge *Boabarge 16* was completely deballasted and mobilizing back to Port Arthur, TX, where the support brackets and guide posts were removed. All fenders, chocks, and bollards removed for the operation were reinstalled and the barge was re-delivered to its owners.

#### LESSON LEARNED

During the preparations for, and execution of this challenging rig tow-out and offshore barge removal operation, a number of valuable lessons were learned:

- Time domain motion analyses provide good insight in the behavior of complex models and their interactions, and allow for quick checking of a large number of possible scenarios;
- Friction can be used as a reliable seafastening restraint for weather restricted operations;
- Redundant positioning aids provide a back-up when one fails. Positioning paint marks need to be in the correct location and independently checked and re-checked during and after application;
- Good, reliable weather forecasts are important for wind and/or wave sensitive operations. Having a meteorologist on site shortens the line of communication and allows for face-to-face dialogues and good understanding of the forecasts;
- The 3-D graphic navigation system is a great tool for the towmaster, pilots, and tugboat captains during critical space restrictive tow-outs;
- Involving the marine warranty surveyor at an early stage of the project ensures that everybody is on the same page and avoids last minute changes or withholding of approval.

The success of the tow-out and barge removal was made possible in large part by the active contributions of all parties involved. The rig owner organized a number of large meetings, involving the consulting naval architect, towmaster, channel pilots, tugboat operators, rig OIM and crew, yard personnel, and marine warranty surveyors. These meetings were held to keep everybody informed on the plan and its progress and to address all concerns. Comments and suggestions to further improve the various phases of the planned operation were solicited and incorporated in the final procedures. These final procedures allowed for deviations of the plan, if local situations dictated a need to do so.

#### ACKNOWLEDGEMENT

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