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# GLOBAL OIL & GAS, DEEPWATER CHALLENGES AND THE USE OF ALTERNATIVE METHODS AND MATERIALS FOR DEEPWATER OIL AND GAS PRODUCTION

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## Abstract

The easy oil has been discovered. The focus is now on the development of the remote fields, the marginal fields and/or the more technically challenging deepwater fields. Developers of oil & gas projects face many challenges some of which are location specific and others are more common such as high development cost, political obstacles and shortage of human capital. This presentation addresses these challenges and the engineering and materials development advances required to overcome them and to develop and produce the next generation of resources.

## Introduction

Conventional wisdom tells us that higher commodity prices should act as a catalyst for greater oil & gas supply, but that does not seem to work in these times. The oil and gas industry is facing many challenges of which several are briefly discussed in this paper together with the author's view of the need for lighter materials in the deepwater arena. There have been developments on the material selection front, i.e. the shift from chain mooring lines to polyester mooring lines, but the industry needs a paradigm shift from conventional materials, requiring heavy and expensive installation equipment, plus large and expensive drilling rigs and production platforms, to lighter material requiring relatively smaller rigs and production platforms and allowing such rigs and platforms to extend their capabilities into deeper and deeper waters.

## Global Oil and Gas Challenges

There are many challenges that players in the global oil and gas market face. The author intends to discuss some of these challenges and hopes the reader obtains a better understanding of the importance for our industry to use innovative commercial and technical methods for the exploitation of the remote, marginal and technically challenging deepwater oil & gas fields.

Excluding deepwater oil fields, output from 54 of the largest 65 oil producing countries is in decline. One member of the Organization of Oil Producing Countries (*"OPEC"*), Indonesia, is an oil importing country. In the next five years another five countries are expected to peak. Only Saudi Arabia, Iraq, Kuwait, United Arab Emirates, Kazakhstan and Bolivia have the potential to produce more oil then before. By 2010, production from these six countries and production from deepwater fields will have to (i) offset the decline of output in 59 countries and (ii) meet the increased demand from the rest of the world estimated to be 25 million barrels per day compared with the current global production of 84 million barrels per day.

Fifty years ago the world was consuming 4 billion barrels of oil per year and the average discovery rate (the rate of finding new undiscovered oil fields) was around 30 billion barrels per year[(1)]. Today we are consuming 30 billion barrels per year and the discovery rate is dropping towards 4 billion barrels per year[(3)].

Increased supply is needed to meet strong demand from the US, West Europe and from the world's fastest growing market, China. China and other developing countries are driving world oil demand. China's oil consumption has increased more than 90% in the last decade (from approximately 3.6 million barrels per day to more than 6 million barrels per day.) Other developing countries such as India are following a similar path. According to BP China's annual consumption per head is two barrels, which is 20% of the United Kingdom's production and 8% of US consumption. This consumption is likely to double in the next decade assuming that China's annual GDP will continue to grow at high single digit rates. Almost all of this has to be supplied by oil fields in other countries.

A major increase in spending is underway, $175 billion (source: Citigroup), but a lot of this spending goes to liquefied natural gas (*"LNG")* projects. Shortages of materials, infrastructure, resources with an extremely busy supply chain including services companies, in combination with the focus on remote, marginal and more technically challenging deepwater reservoirs, are leading to higher F&D cost. International Oil Companies ("*IOC*") are struggling to replace their reserves. ExxonMobil replaced its reserves in 2004 with the footnote that 94% of the new booked reserves came from Qatar LNG (source: The World Gas Supply Report). Leverage is shifting from IOC's to National Oil Companies (*"NOC"*). These NOC's historically focused on production from their large oil and gas fields, but now require technical support for the development of the more challenging fields, such as the remote, relatively marginal fields, deepwater fields and the heavy oil fields. The development of these fields requires different commercial structures and a better balance and relationship between the oil companies and the contractors. It is the author's view that services companies with unique expertise will still be in heavy demand, while the role of IOC's, other than in the global gas market, seems to be diminishing. Many NOC's are generating healthy cash flows and are less dependent on foreign direct investment (*"FDI"*).

The rapid increase in natural gas demand worldwide and the formation of a global gas market have also impacted offshore oil production. Historically, non-associated gas production was mainly a domestic event with the majority of the gas being produced onshore. Nowadays, a lot of domestic gas is being liquefied and shipped to overseas markets with the result that shipyards in South Korea are building a very large number of LNG carriers. This means that it has become much more difficult, and definitely more expensive, to build FPSO's and other deepwater platforms at these yards. The oil field services sector traditionally supported the NOC's in their oil production business. Nowadays this sector is using its resources not only to support the increase in oil production from more complex reservoirs, but also plays a critical role in the dramatic increase in worldwide gas production. Maybe the name "hydrocarbon field services companies" is a more appropriate name for these companies.

Oil and gas production in the global market has changed from a market dominated by IOC's to NOC's. The owners of the reserves are becoming more sophisticated and realize that the majority of the value creation should remain in the country of hydrocarbon origin. This important and justifiable shift brings the following challenges:

- More than 80% of the world's proven oil & gas reserves are managed by NOC's. NOC's often have different objectives than maximizing the oil & gas output. Sustainability and job creation are often considered to be of greater importance. These NOC's use their oil & gas reserves to create jobs in other industries and use their hydrocarbon base as leverage for foreign companies to invest in other industries in the host countries.
- IOC's are having an increasingly more difficult time accessing these NOC owned and/or controlled reserves. They are also losing their historic leverage (expertise and funds) that allowed them to share in the oil & gas revenues owned by the countries of these NOC's.
- The NOC's still need technology from the most technical of services companies such as Schlumberger. The IOC's are in the process of hiring new talent, the talent that most of these companies were not interested in retaining ten years ago. They realize that they need to invest in technical expertise in order to become a higher value added IOC in their quest to become a partner with NOC's. It is likely that these new recruits come from the oil field services companies, which has a negative impact on other companies they are serving and therefore will likely result in a net negative for the oil and gas industry. One does not need a crystal ball to forecast that recruiting, training and retaining people will be one the keys to success.
- Mounting tensions with Iran, Venezuela, etc. i.e. geo political challenges, political uncertainties, tensions and local content issues in almost all non-western oil and gas producing countries. This includes countries such as Trinidad and Tobago, where local content and sustainability is getting more and more important. The prevailing view in these countries is that production should not exceed reserve replacement and that gas production is preferred to be used as feedstock for the local industries such as the methanol plants and ammonia plants. LNG is important for Trinidad due to the demand for gas in the global market, but historically the return to Trinidad has not been that great due to the existence of old production sharing contracts. On a go forward basis, it is expected that Trinidad national companies will own the predominant capacity in any future LNG liquefaction trains.

IOC's are not aggressively increasing their investment in development drilling. The primary metric for stock appreciation is reserve replacement and since these companies are sitting on a lot of cash, their focus is to explore for new reserves or acquire new reserves instead of investing all their free cash flow in development projects. Their free cash flow exceeds their capital spending program needs and thus they have decided that buying back stock creates more value for their share holders than investing all their cash in new opportunities. As a consequence, there are a limited number of oil & gas development opportunities that meet the IOC's hurdle rate.

Hydrocarbon containing resources are in high demand, but human resources are in even higher demand. Traditionally, the western world provided the technology and resources necessary for the exploitation of oil and gas fields worldwide, but the energy industry has not been an attractive long term employer due to the boom and bust nature of the business. The industry faces an aging work force with the average age exceeding 50 years in many companies.

## Deepwater Oil & Gas Production

Production from deepwater fields is increasing worldwide and is becoming an important part of the wedge necessary to fill the supply / demand gap. It is expected that by 2010 all offshore production growth will be from deepwater fields and that by 2015 deepwater will account for 25 percent of all offshore production. More than 80 percent of the oil production in the US GOM deepwater trend originates from Deepwater projects (source: MMS 2004 Report). The following trends can be observed in the deepwater arena:

- An increase in the number of deepwater regions worldwide. The Campos Basin Offshore Brazil and USA Gulf of Mexico ("*US GOM*") have been and still are the two most active deepwater basins. Production from the US GOM deepwater trend is expected to grow to nearly 2 million barrels by 2008 (source: MMS 2004 Report). New deepwater regions are West Africa (Angola, Nigeria), West of Shetlands (UK), Norway and South East Asia Malaysia offshore Sabah. The deepest producing field in the US GOM is the Total operated Aconcagua field in the Mississippi Canyon area. This field is located in 7,000 ft. of water. Production is commingled subsea with production from two other fields (Camden Hills and Kings Peak) before it is processed on a platform located approximately 70 miles away on the Outer Continental Shelf ("*OCS*").

- A large number of new deepwater platforms is being installed (see Figure 1). This "real estate" has a positive impact on the relatively smaller deepwater fields that can now be made commercial by developing these smaller fields as tie-backs to deepwater platform.

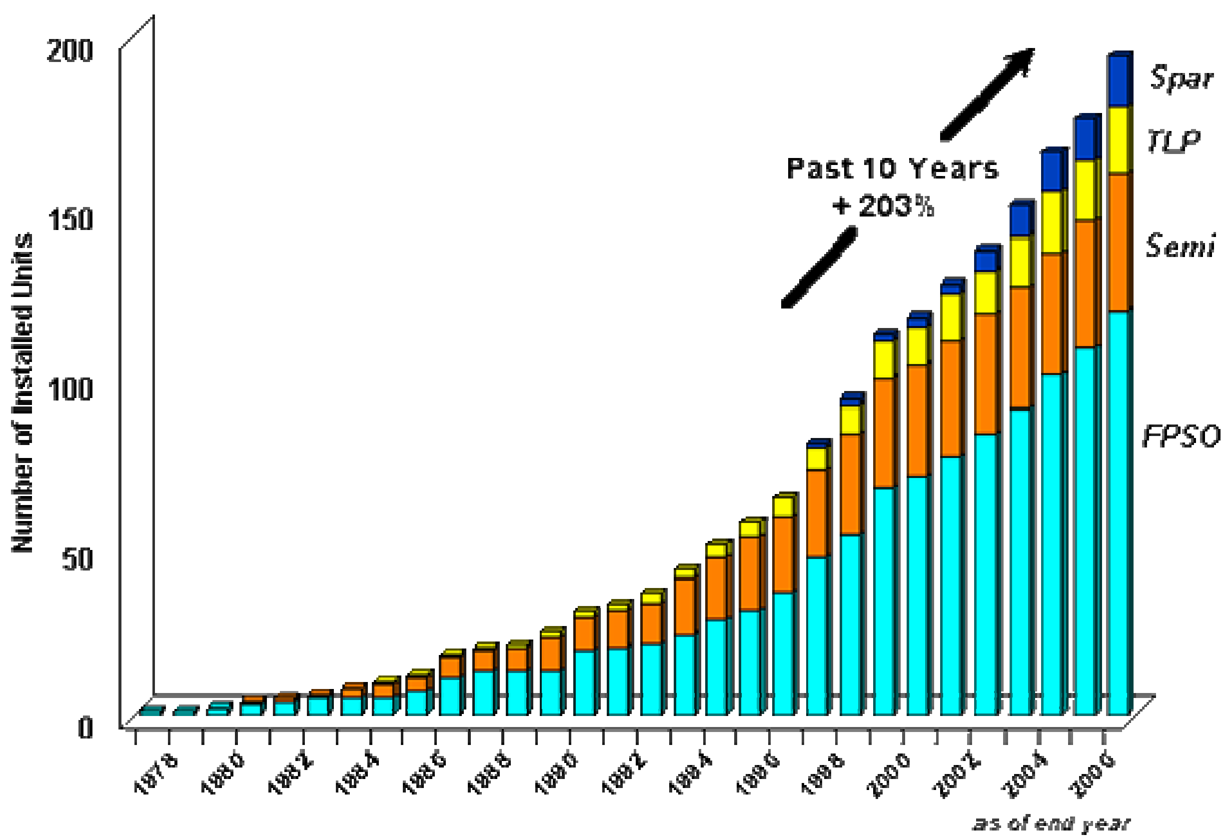


Figure 1. Deepwater Floating Platforms Worldwide

Figure 2 shows the Deepwater Fields Pyramid for the US GOM based on 2005 MMS data. The top section of the pyramid shows the number of billion barrel fields and the bottom section shows the number of approximately 50 BCFE fields, that historically have been gas fields, just off the edge of the OCS, that were developed as tie-backs to fixed platforms on the OCS. The lower half section of the pyramid represents smaller deepwater fields that require new infrastructure for their development. Right of access to deepwater platforms is a challenge that is discussed under the deepwater challenges.

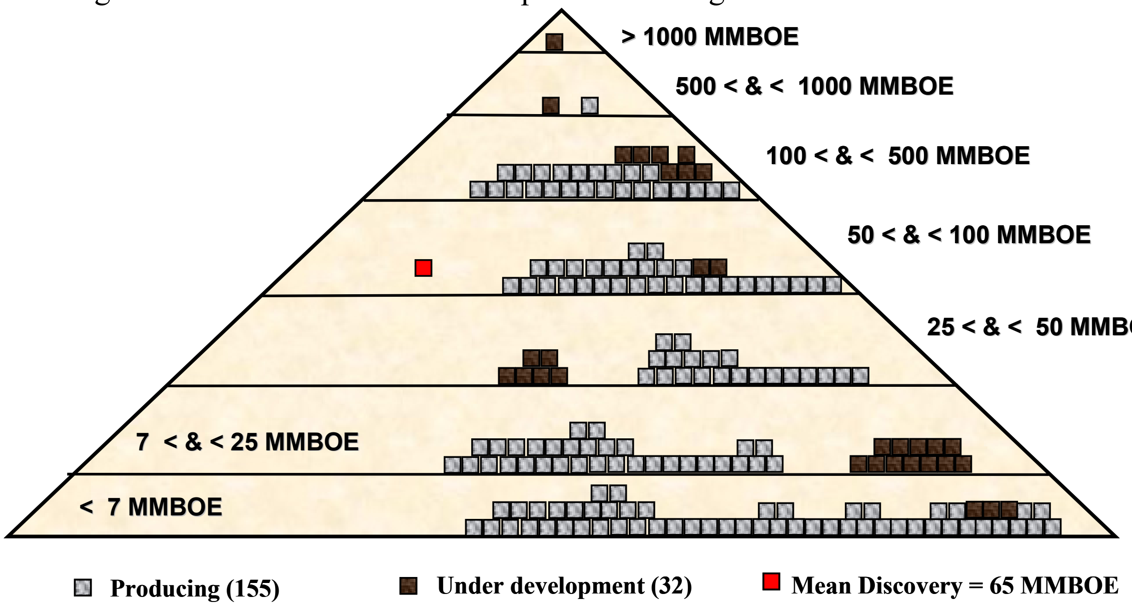


Figure 2. Deepwater Fields Pyramid

There has been a significant increase in the number of oil and gas fields that have been developed as subsea tie-backs to a host platform. The dramatic improvement in subsea technology has been the main driver behind this development. There are several platforms in the US GOM where hydrocarbon production is being processed from more than 5 oil & gas fields. For example, the Independence project in the Eastern Gulf of Mexico comprises 10 gas fields that are being developed as subsea tie-backs to a centrally located processing hub, the Independence Hub platform, in a water depth of 8,000 ft.

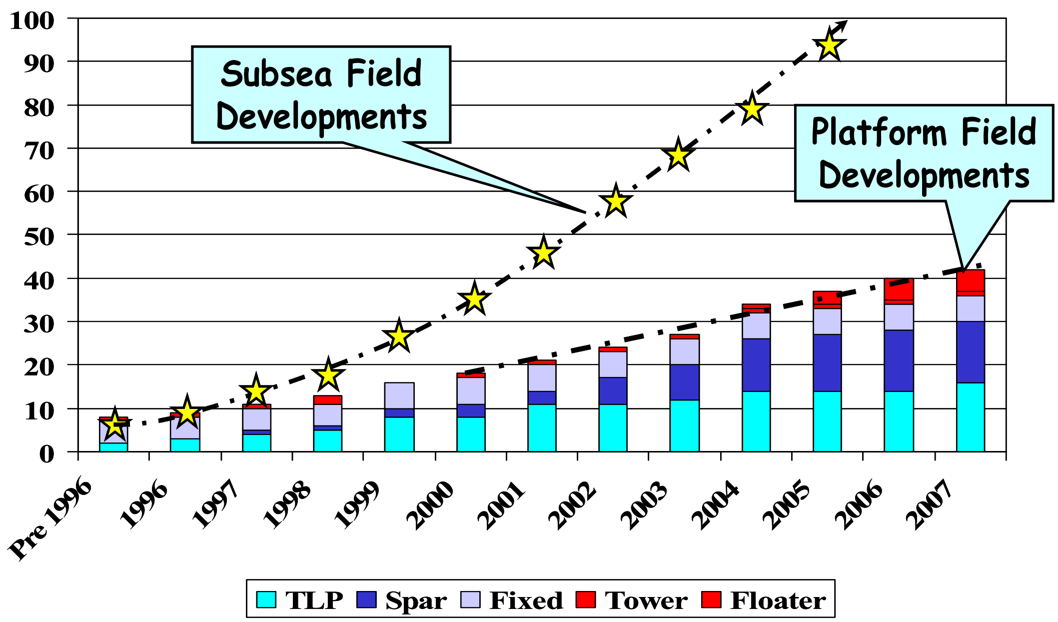


Figure 3. Increase in subsea field development in the USGOM

Deepwater production has its own challenges, although now that the deepwater market is becoming a more global market, with activities in more than five regions, a lot of these challenges are becoming global challenges. Some of the deepwater challenges are:

- Shortage of drilling rigs: The deepwater arena used to be limited to offshore Brazil and US GOM, but nowadays offshore Nigeria, Angola, Malaysia, Norway, and West of the Shetlands are all home to major deepwater discoveries. Additional rigs are being built, but it takes several years to build these expensive rigs that cost in the range of $450 MM to $600 MM. It often takes 100 days to drill a deepwater well, and sometimes even longer if the well has to be sidetracked or the operation is impacted by hurricanes or loop currents. Nexen Inc. recently announced that it would take several years before the company could commence the appraisal of its alleged world class Knotty Head discovery in the US GOM deepwater due to the shortage of deepwater drill rigs.

- The long lead time to bring discoveries into production: The OTC paper [(4)] titled "The Creation of Value through the Good Old 80/20 Rule" discusses this problem. Operators often take too much time "rightsizing" the infrastructure, including the platform required for the field development. The net present value ("*NPV*") of an investment can be increased by shortening the decision making process without taking short-cuts or increasing the execution risk of the project. A cynical reader could conclude that NPV is becoming less important for some IOC's that have more cash on their balance sheet than uses for the cash.

- Right of access to existing deepwater platforms: Almost all existing deepwater platforms in the US GOM are owned by oil and gas producers and the average capacity utilization is less than fifty percent. There are many smaller fields and prospects located in the vicinity of existing deepwater platforms, but these fields can not be developed due to the fact that the platform owners prefer to reserve the processing and payload capacity for their own future fields than to monetize these assets for third party owned oil & gas fields, since processing revenue is only a fraction of what the producer platform owners could generate if they would use the capacity themselves for their equity oil and gas. It is the author's opinion that it is preferable, in the interests of maximizing domestic energy production, for these deepwater platforms to be owned by third parties whose interest is aligned with any producer who wants to use the capacity to process its oil & gas production (see OTC paper 15108[(5)]).

- The increase in Hurricane activity (shown in Figure 4) in the US GOM impacts deepwater activity in this area in various ways; (i) by damage to deepwater platforms, and deepwater infrastructure (by runaway drill rigs) and OCS and onshore infrastructure, (ii) by higher insurance cost and introduction / lowering of aggregate insurance caps, (iii) by more stringent design criteria (wave height, current speed), (iv) by redeployment of moored deepwater drill rigs to other geographical areas due to higher insurance cost and (v) unavailability of construction equipment due to repair workload.

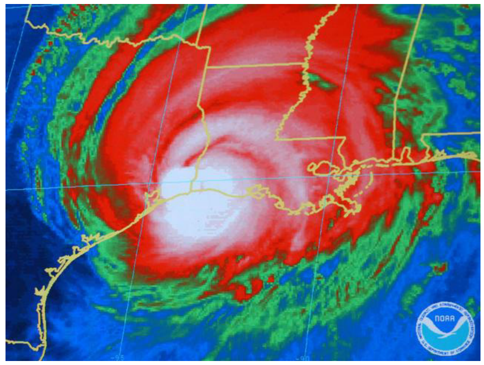

Figure 4. The Need for Alternative Methods and Materials

The application of innovative commercial and technical methods is crucial in order to make progress in the exploitation of the remote, marginal, or technically challenging deepwater fields worldwide. Deepwater platform ownership by third parties represents a solution for the limited access and relative lower capacity utilization on several of these deepwater platforms. Use of lighter materials can help (i) by extending the depth capabilities of semi-submersible drilling rigs, (ii) by increasing the payload of deepwater platforms to make them capable of processing hydrocarbons from more deepwater fields and (iii) by the construction of smaller and less expensive deepwater platform. The World famous architect Jan Kaplicky made the following remark in a recent interview (source: Business Week Winter 2005 – Europe Edition): "There are no new materials in architecture. People do use materials such as glass or cotton in innovative ways, but it's still the same stuff which the Egyptians or the Romans used"… What about the offshore industry? How much room is left for new materials?

Figure 5. Various Kaplicky Designs

It is the author's provocative opinion that the offshore industry is not in a much better shape than the onshore building industry. The industry has elected to build bigger platforms, installation vessels and drilling rigs to explore and produce oil and gas fields in deeper water instead of selecting lighter materials and smaller vessels and drilling rigs. The reason being that bigger rigs, platforms and installation vessels were the simple solution and the exploitation of the large deepwater fields did not require more innovative approaches. But nowadays, with the cost of this equipment sky-rocketing, it makes sense to study alternative materials in more detail for the exploitation of the remote, marginal and technically challenging deepwater fields. Nevertheless there are some bright spots and examples of areas where the industry is making substantial progress are presented below:

Floating platforms in deepwater were traditionally secured using mooring lines consisting of chain. The weight of these chains required additional buoyancy in the hull of the deepwater platform (Semi-submersible or Spar) resulting in bigger hulls, more steel and a higher cost. A bigger hull meant larger displacement forces caused by the current and the waves and wind, requiring additional tension in the mooring lines, i.e. bigger chains, and so on. In the early 2000's synthetic mooring lines were introduced.

The need for chain has not been completely eliminated but to a large extent, the make-up of the mooring lines is now chain-polyester-chain and results in a substantially lower load on the hull. The chain sections are still required at the bottom, connecting the polyester section to the foundation (a suction pile or anchor) and at the top, connecting the polyester section to the platform winches. An example is the mooring system of the Independence Hub platform in Figure 6.

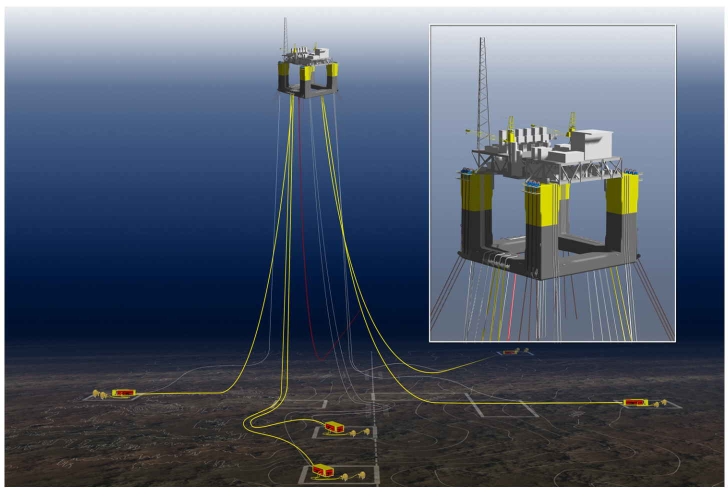

Figure 6. Independence Hub Platform

This deepwater platform, owned by Enterprise Products Partners, L.P. and Helix Energy Solutions Group, Inc., will be located in a water depth of 8,050 ft., almost 2,500 meters, in the US GOM and will have 12 mooring lines. Each of these 2.5 miles long lines is made of polyester with chain sections at the bottom and the top. The total horizontal offset of each mooring line is 10,400 ft.

## Steel Catenary Riser (*"SCR"*)

The 24-inch Independence Trail export pipeline will be the world's deepest gas export pipeline. It will originate as a 20-inch OD pipeline on the Independence Hub semi-submersible platform.
The SCR is a 20-inch seamless pipe that has a wall thickness of 1.21-inch and the 24-inch pipeline has a maximum wall thickness of 1.35-inches. This wall thickness is required to withstand the external pressure or the hydro-static pressure. The size and wall thickness of the pipe makes it very expensive to install. The dry recovery rate weight is 460 ton and the maximum tension that has to be applied for the installation of the SCR is 600 ton. This means that only a few construction vessels in the world can install such a pipeline and SCR. Alternatively flexible risers can be used or freestanding riser towers. Both alternatives free-up payload capacity on the platform. Unfortunately there are no flexible pipelines with a 20-inch OD as yet. Alternatives such as lighter materials should be investigated for future deepwater pipeline projects. This would allow more cost effective installation vessels to install these lines and free-up the pay-load capacity on the platform so that it can be used to process oil and gas

production from other fields in the vicinity, or it could be used to reduce the size of the platform and therefore the capital expenditure required thereby increasing the NPV of the investment.

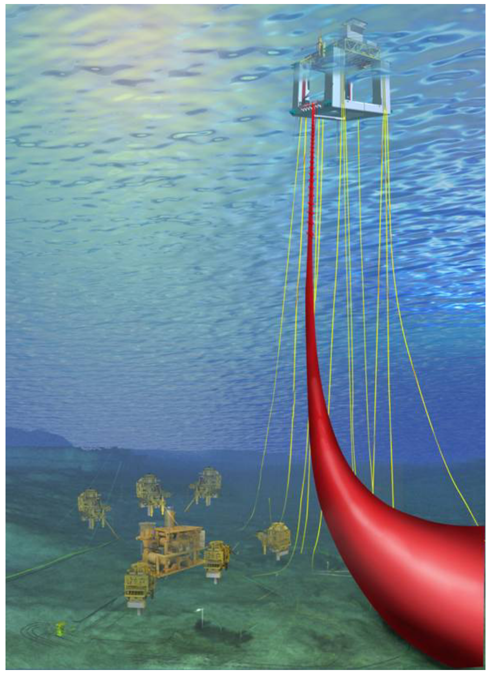

Figure 7. Independence Trail SCR

An artist rendering of a flexible pipeline is shown in Figure 8.

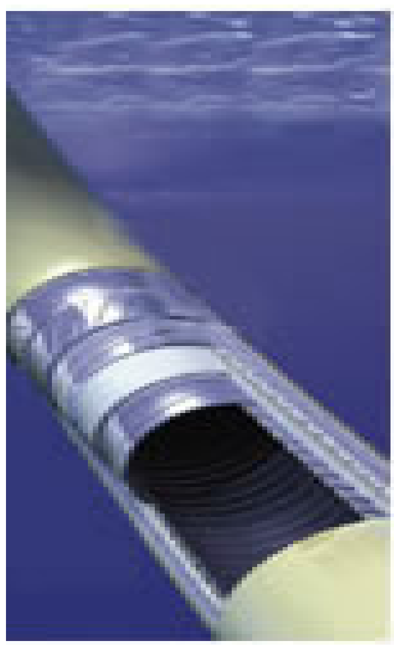

Figure 8.  Flexible pipe (Source: Technip)

Flexible pipe for oil and gas field developments has been used in the offshore arena for a long time. Flexibles consist of helically wound steel wires with a thermoplastic sheaths. Flexible pipe can be easily retrieved in order to be re-used on other field developments. Helix is considering the use of a free-standing riser tower for its Marco Polo Tension Leg Platform ("*TLP*") located in a water depth of 4,300 ft. in the US GOM. There is insufficient pay-load capacity available on this platform despite the fact that the platform is designed to (i) process 120,000 barrels of oil per day and 300 million cubic feet of gas per day, (ii) support six trees (dual casing and 4,300 ft. in length), (iii) six 6 / 7-inch 15 ksi flowline SCR's and (iv) two export SCR's. The oil capacity on the platform is fully subscribed, but there is significant gas capacity available. Unfortunately that capacity cannot be accessed, since there is insufficient payload capacity available to support other SCR's and umbilical(s). Using a buoyant free standing riser tower (see Figure 9) alleviates the need to "hang-off" a SCR and umbilical with their full weight on the TLP. The free standing riser tower can also be re-used and re-deployed once the production from the subsea field it supports has ceased.

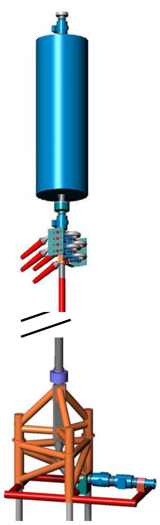

Figure 9. SLOR Riser Single Line Offset Riser (Source: 2H Offshore)

## Drilling and Production Risers

Weight on board drilling rigs, and riser tensions, are the main restrictions to rig use in deepwater when conventional drilling methods are used. Significant cost savings can be achieved by replacing heavier metals with lighter alloys. There are two main alternatives for reducing the riser weight, namely the use of composite risers and aluminum risers. Noble Corporation has pioneered the use of aluminum risers as drilling risers and has claimed that aluminum risers can be as much as 30 percent lighter than steel for on-board storage and place less strain on tensioning systems and creating savings in buoyancy devices compared with steel risers.

As exploration and production of oil and gas moves further into deepwater water, weight, cost and reliability of water-depth sensitive systems such as risers become increasingly more important. Therefore, the focus on the potential of composite materials for deepwater riser applications is growing. Composite risers are used to cover the different types of discrete high pressure pipes such as drilling risers, production risers, SCR's, etc. The main advantage that composites offer to deepwater risers are high specific strength and stiffness, light weight, corrosion resistance, high thermal insulation, high damping, and excellent fatigue performance. The lighter weight results in lower tensioning requirement for drilling risers and production risers, resulting in a reduction in buoyancy requirements for deepwater platforms and drilling rigs and therefore cheaper and smaller structures.

An alterative to conventional drilling methods is the use of either a surface BOP (blow-out preventer) or a free standing riser tower. Both methods reduce the load of the riser system on the rig, allowing them to drill in greater water depth that conventional methods allow.

Helix is in the process of upgrading its semi-submersible ("*Q4000*") for deepwater drilling capabilities. This rig, displayed in Figure 10 and 11, will be able to drill and complete wells in water depths of up to 6,000 ft. and exploration wells in water depths of up to 8,500 ft. using a surface BOP. It is envisaged that the use of composite or aluminum casing risers could extend the water depth capabilities of this rig beyond 8,500 ft.


Figure 10. MSV Q4000

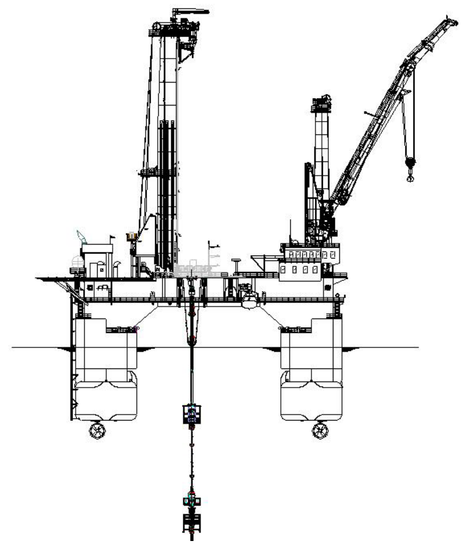

Figure 11. Q4000 with SBOP

An alternative to the use of lighter weight riser systems is the use of a free standing riser tower (see Figure 12) for drilling purposes. The BOP would be located on top of the free standing riser tower creating an artificial seafloor and the rig would drill through the free standing riser tower. The tower can be redeployed or kept as a production riser in combination with a floating production facility.

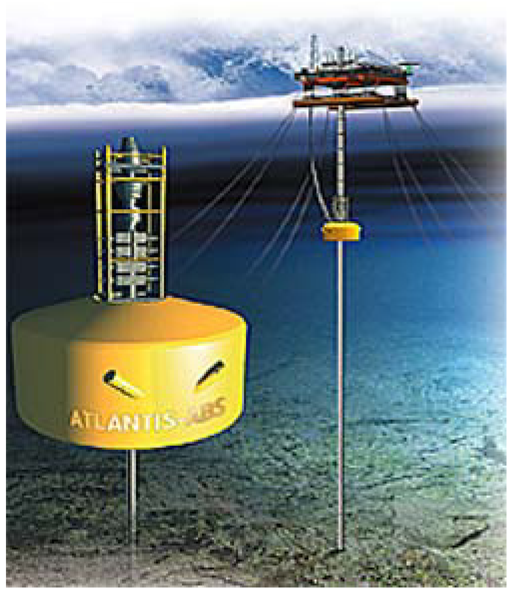


Figure 12. Atlantis Exploration Unit (Source: Atlantis Deepwater Technology Holding AS)

By using an artificial seafloor for exploration drilling in deepwater, the efficiency of the drilling operations will increase considerably, as there is no need to run the BOP and the drilling riser through the water column to the seabed, but only down to 200-300 meters. It is estimated that the total drilling cost can be reduced by 30-50% using a 2nd / 3rd generation drilling vessel, in combination with a taut-leg polyester mooring system, instead of a higher rated drilling unit.

Re-Deployment of deepwater production platforms is becoming more important. Alternative materials are less fatigue sensitive and often more easily recoverable (flexible flowlines and free standing riser systems) and therefore lower the re-deployment cost and increase the residual value.

## Conclusion

The easy oil is gone. The last billion barrel field was discovered many decennia ago. The oil and gas industry faces a number of significant challenges making the development of the remote, marginal and / or technically challenging deepwater fields more challenging but also more critical. There is a need for the oil & gas industry to become more innovative in the exploitation of these fields. The use of alternative materials will play an important role, and it is likely that the use of different materials will grow exponentially in the next ten years.

## Notes & References

1. Bart Heijermans is Helix Energy Solutions' Executive Vice President and Chief Operating Officer. Prior to joining Helix, Mr. Heijermans worked as Senior Vice President Offshore and Gas Storage for Enterprise Products Partners, L.P. from 2004 to 2005 and previously from 1998 to 2004 was Vice President Commercial and Vice President Operations and Engineering for GulfTerra Energy Partners, L.P. Before his employment with GulfTerra, Mr. Heijermans held various positions with Royal Dutch Shell in the United States, the United Kingdom and the Netherlands. Mr. Heijermans received a Master of Science degree in Civil and Structural Engineering from the University of Delft, the Netherlands and is a graduate of the Harvard Business School, executive program.
2. Helix Energy Solutions Group, Inc., formerly known as Cal Dive International, Inc. and headquartered in Houston, Texas, is an energy services company that provides innovative solutions to the oil and gas industry worldwide for marginal field development, alternative development plans, field life extension and abandonment, with service lines including diving services, shelf and deepwater construction, robotics, well operations, well engineering and subsurface consulting services, platform ownership and oil and gas production. Helix' vision is to be a leading provider of select life of field solutions on all energy projects but with a specialty for marginal energy resources, further differentiated by a preference to share risk / reward through participation in energy resource equity and a willingness to accept energy resource commodities in return for services provided. To accomplish this while providing a safe, supportive and stimulating work environment for its employees.
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