The need for alternatives to steel catenary and flexible risers has increased with the need for a larger number of risers in deeper water and on congested fields. Together with Total and INTECSEA, Heerema Marine Contractors (HMC) is developing a new riser system that increases the available suite of deepwater riser solutions. It is an offshore constructed hybrid riser bundle installed using heavy lift and pipelay vessels.

The novel concept described herein allows the construction of a bundled riser tower at the installation site, opening up the applicability of bundled riser towers to a larger (and often deeper water) area. Offshore construction can result in a simple and robust in-place design that is easier to inspect, and which offers the opportunity to exchange and remove individual risers or the complete tower.

The need to evolve the riser concept range is in large part due to the increasing water depth, number of conduits, riser diameters, and the ability of the various types of production floaters to receive the risers. Furthermore, the complexity of the field reservoirs increases insulation requirements for flow assurance, making pipe-in-pipe and heavy wet coating necessary. An important development is the successful introduction of bundled riser towers. These are constructed onshore, then towed and installed on location. A major advantage of these riser towers, apart from the decoupling from the floater motions, is reduced congestion on the seabed compared to the alternative of a large number of single risers. In addition, bundling of risers has economic advantages and mitigates the potential clashing of adjacent risers or structures. A disadvantage is that they are constructed onshore and towed to location. This requires a dedicated bundle fabrication site and, depending on the tow distance, impacts the fatigue of the tower.

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Although the concept is new, it is based on field proven TLP and pipelay technology. Introducing novel technology to the market requires due consideration of the economic viability, robustness, and safety of the system. This introduction was supported by Total through its evaluation qualification process, in which key risks and areas are identified and mitigated and the system is matured to a project-acceptable level.

The concept is considered sufficiently matured for a West African application and can be developed further to suit an increased payload and/or number of risers for different field applications.
factors related to other components in the development. These include the following:

- Risers system costs
- Track record and operator experience with the concept
- Concept robustness considering inspection and monitoring, maintenance, repair, and replacement
- Field layout and possible congestion
- Floater type (spread moored FPSO, turret FPSO, spar, TLP, or semi)
- Number and type of risers and flow assurance requirements
- Contractor (yard/equipment) availability.

An important advantage of the FSHR is the decoupling of floater and riser motions, and the reduction of payload on the floater. For congested fields, SLOR and bundled riser tower are the preferred solutions, particularly when it involves an increased number of production lines with larger (more than 10-in.) diameters in deeper water.

Novel riser concept

The hybrid exchangeable riser tower (HRT) system is based on offshore assembly of pre-fabricated components using heavy-lift and/or pipelay vessels where the core structure is installed first, similar to the installation of TLP tendons. Thereafter, individual riser assemblies can be installed on the perimeter of the buoyancy tank to create the complete tower.

The HRT is composed of the following main elements:

- A foundation structure. Either a driven pile or suction pile arrangement with a ratch mechanism for connecting the tendon. This component is field proven and has been used on previous riser towers.
- A tendon string with attached spacer structures. This component is novel but is based on TLP tendon connection technology, allowing offshore construction.
- A buoyancy tank. The buoy requires considerable payload capacity. It carries the weight of the risers, the tendon, including spacers, and part of the flexible weight. The size of the tank can be adjusted accordingly, and the current buoy concepts with diameters in the range of 10 to 13 m (33 to 43 ft) can accommodate payloads from 1,200 to 3,400 metric tons (1,323 to 3,748 tons). The height is governed by the lift height of the cranes given that the tendon string is attached to the buoy at deck level. Although the size and weight of the buoy (on the order of 2,000 metric tons, or 2,205 tons) is considerable, they are well within the capabilities of conventional heavy-lift vessels.

A number of riser assemblies consists of a riser segment (single line or pipe-in-pipe) with an upper riser assembly (URA) and a lower riser assembly (LRA). The riser assemblies are hung off at the perimeter of the buoy. Such assemblies are similar to short flowline segments or to SLORs, for which the fabrication and installation are field proven. A URA provides the connection to the buoy (for weight transfer) and a vertical connector for the top spools. An LRA provides the vertical or horizontal connector to the base spool and horizontally fixes the riser to the tower via a base structure with a sliding mechanism to allow for vertical expansion and stroking of the risers.

A top assembly. Rigid spools are used on the top of the buoy between the URA and the flexible jumper. These spools are installed after the flexible jumpers have been installed and fixed on the riser balcony.

A connection system for each flexible jumper. A flexible balcony connects the flexible jumpers to the buoy structure. The flexible jumper is first connected to the buoy and then to the FPSO.

Base spool arrangements. The base spools connect the LRAs with pipeline end terminations (PLETs) on the flowlines. They have configurations similar to previous riser towers and SLORs.

The HRT is installed in the following general sequence:

1. Prepare a seabed foundation through a driven pile or the use of a suction pile.
2. Construct the tendons (with attached spacers) onboard the installation vessel.
3. Connect the buoy to the tendon string and connect this structure to the foundation.
4. Build up each riser (including LRA and URA) and lower it on a crane or winch.
5. Displace the buoy laterally with a tug, and then connect the riser to the tower at the LRA. Continue attaching the all risers to the spacers through combined action of tug and crane, and hang off the riser URA on the buoy assembly.
6. Lower the base spools and connect the LRAs with the PLETs.
7. Once the FPSO has arrived, the flexible jumpers can be connected.
8. Connect the top spools between URA and spacers for the flexible jumpers.
9. Pre-commission the total system.

Key aspects of the novel riser tower technology are:

- Equal functionality compared to “traditional” HRT.
Open tower structure with improved inspectability and, if required, replaceability
Exchangeability of individual risers or addition of additional risers for phased field developments and/or flow assurance considerations
Application in remote areas not limited by (bundle wet tow) distance to shore
Limited fatigue damage to the risers during installation (by avoiding the tow and upending phases)
All main components can be fabricated locally onshore but the method also allows for competitive bidding from several international yards as the system is assembled offshore
Installation of the buoy structure can be a separate phase from the riser installation which optimizes schedule options.

Concept design
The concept design of the HERT system for West African application was based on the following:
1. Water depth at the FPSO of 1,712 m (5,615 ft)
2. Two 12-in./16-in. P-I-P production risers with gas lift through the pipe-in-pipe annulus
3. Two 14-in. water injection (WI) risers
4. Two 12-in. service line (SL) risers
5. Total riser payload (flooded) 2,135 metric tons (2,353 tons)
6. High thermal performance
7. Remote intervention/maintenance by ROV
8. Diverless installation
9. 25-year design life.

The system was jointly designed by HMC and INTECSEA using static analysis, response analysis, computational fluid dynamic (CFD) analysis, fatigue analysis of risers and tendon including first and second order, VIV and vortex induced motion (VIM) fatigue, installation and removal design, and design of spacer frame, base structure, URA, LRA, buoyancy tank, top and base spools, and more.

Key aspects were the riser and tendon stress responses and the fatigue performance given the novel application of the spacers. The response analysis under extreme storm conditions showed that the von Mises stress on all the risers and tendon was within the allowable range.

Future development
During conceptual design, the HERT was found to offer a number of options for adjustment to other field conditions such as deeper water and a larger number of risers. The size of the buoy is limited at present by the ability to connect the buoy above water, but it is also possible to connect the buoy submerged, allowing for a longer buoy length. An increased payload can then be achieved by fixing additional buoys to the submerged buoy.

References
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