Improved Riser Management Situation Awareness Through 3D Visualization

Gullik A. Jensen, Product Manager, Riser Management Systems, Kongsberg Oil & Gas Technologies

As with many monitoring and decision support tools, riser management systems originate from the engineering community so may assume a large degree of domain knowledge. Unfortunately, this knowledge is not always found among offshore personnel, which prevents the full potential of the monitoring tool to be realized. This may have a negative impact on riser operations and, in turn, on drilling safety and efficiency.

The Kongsberg Riser Management System (RMS) is a real-time monitoring and decision support system for safe and optimum operation of drilling and workover riser systems. Recognizing the potential gap between what the system can do to enhance these operations and what the operator can actually make it do motivated the development of a new user interface for the RMS operator station. It differs from traditional RMS interfaces as it has been developed based on a virtual model of the riser and its environment in three dimensions. The model is built from the data available in the system for riser and vessel representation and is updated in real time to reflect the changing state of the riser based on real-time sensor measurements and advanced computations.

Through the new user interface, the operator can navigate in a virtual space to inspect different aspects of the current operational situation, either by taking a step back for overview, or by zooming in to examine the details. The advantage of this technology is the improved operator perception of the actual situation.
that contributes to enhanced situation awareness. Likewise, through real-time 3D visualization, the operator can take full advantage and maximize the results gained from all RMS system features.

In operation, the updated user interface presents the monitoring and advisory features of the system in a context that the operator can easily relate to. This makes the system better suited to contribute to a safer and more optimal operation of the riser system during the drilling operation.

The Situation View

The new technology is implemented as a situation view, which is the natural focal point for user interaction during operation. The situation view consists of two parts:

- A spatial 3D model that incorporates all available data relevant to the drilling operation updated in real time.
- A system for navigation and filtering the data so that the operator can focus on the right information depending on the situation and the task at hand.

The situation view must be capable of handling many types of data, some of whose representation may not be immediately obvious. The list includes, but is not limited to:

- Geometry of structural components
- Position and orientation of structural components
- Estimated states for the riser
- Real-time sensor and estimated measurements
- Operational limits and advice
- System and equipment status
- Alarms and warnings
- Artifacts for improved understanding

Physical objects exist in a 3D space and are thus straightforward to incorporate with respect to size and position, including the riser, drilling vessel, wellhead, tensioner system, and physical sensors. The model is updated in real time to represent the current operational situation, so if, for example, the vessel is subject to waves or changing ocean current, this will be immediately updated in the model and in the situation view. The vessel motions can be seen in real time as well as the corresponding tensioner stroke, telescopic joint stroke, and flex joint variations and riser shape.

Operational limits typically represent constraints that structural or operational parameters must meet in order not to violate the safety level for the operation. Watch circles for vessel position is a well-established concept, where circles on the ocean surface show where the vessel must stay to be within safe operational limits. Advice, such as optimum vessel position, has a symbolic representation indicating the position on the sea surface in the situation view.

The new RMS user interface contains new ways of presenting monitored values for tensioners pull and stroke, flex joint angles, riser stroke, etc. Nonspatial measurements such as temperature, pressure, or strain are given as numeric values associated with the mounting location of the sensor in space updated in real time. In case a sensor fails or communication is lost, the operator is alerted to ensure that mitigating actions are taken, such as, switching to a backup sensor.

Fig. 3—A close-up of the lower stack and wellhead. The connector tensions and lower flex joint angle are displayed in labels.

Fig. 4—The traditional position plot view for showing watch circles and optimum position advice is available with the new 3D visualization technology.
Because all of these features are located in the same view, configuration errors or sensor failures will more easily be detected than for a conventional system. For instance, if a riser’s joint outer diameter is configured incorrectly by a magnitude of 10, it will clearly show. The human eye will detect such an error faster through 3D visualization than if it was presented, for example, in a tabular form.

Navigating Data

There is potentially a vast amount of information and data related to the operation of the riser system that can overload the operator and prevent situation awareness rather than facilitate it. Sometimes the relevant data is best seen from a distance. The spatial situation view can be navigated freely, so that the operator can move around in the virtual space and zoom in on features or zoom out to get an overview.

To facilitate operational awareness further, the information has been embedded in different layers, and predefined views have been defined for different monitoring features as a starting point for expansion of details. To ensure that the operator does not get lost when maneuvering in the 3D environment, he can at any time select a predefined view that instantly takes him back to the best starting point for the actual monitoring task. For the current release of the operator client, the following views have been defined:

- **The position plot** — A 2D projection of the ocean surface focusing on the optimum vessel position advice and the watch circles.
- **The topside view** — A 3D view showing the current situation on the riser topside, including the vessel and equipment onboard the drilling vessel. Focus is on sensors, estimated data, displacement of equipment and vessel.
- **The wellhead view** — A 3D view of the blowout preventer (BOP) and lower marine riser package.

Focus is on sensor data and estimated data for the sensors, tension, connector loads, and flex joint.

- **The riser shape view** — A 3D view shows the shape of the riser including the distance from the riser to the centerline from wellhead and up. The view also includes the ocean current profile and direction.
- **The tensioners view** — A 3D view focusing on the tensioner system status and measurements, including the stroke and pull of each tensioner.

Each view is designed to focus on a particular feature of the system. Although the views are not specifically task-centered, the technology will easily allow additional layers and views to be defined.

Riser Management

The riser is a critical component for offshore oil and gas drilling. During a drilling or workover operation, the riser is a temporary extension of the subsea wellbore from the BOP at the wellhead on the seafloor to the surface vessel from where the drilling operation is performed. The drillstring, as well as casing and tools, are operated through the riser, and it also serves as a conduit for the circulating drilling fluid during the drilling operation.

During riser operations in deep water and harsh environments, it may be a challenge to maintain operability and riser integrity. The RMS is developed to gather all relevant information in real time during operations and combine the available information in a way that gives the operator continuous advice on where to position the vessel together with the current operational margins for all parameters associated with the riser. In complex and strong seas, the ability of the RMS system to predict the optimum vessel position, as well as to monitor the full state of the riser has made it a standard system for most new drill vessel builds.

Technology Drivers

The motivation for taking the new technology onboard for the RMS is recent developments in the fields of human decision making and human interaction with computer systems for marine applications, and in particular, the field of situational awareness. Situation awareness refers to the operators’ understanding of what is going on around him, or more accurately in the case of a drilling operation, what is going on deep in the sea and ground below him. Situation awareness is divided in three levels: perception, comprehension, and projection. The elements that are relevant to this situational awareness are not necessarily a given set, but depend on the operation, the environment, and the operators’ task at hand. The new technology facilitates improved perception in offering a new approach on how to use the existing information in a more optimal context to support the operator in decision making.

Further Applications

The RMS situation view has been deployed in the newest release of the Kongsberg RMS system released in May 2013. The company has previously had good experience with deploying 3D visualization technology in multiple other applications, such as visualization of downhole drilling data and surface vessel coordination. This new application is, to our knowledge, pioneering the use of 3D modeling for visualization of operational riser monitoring and decision support applications.

The technology can be extended to support a larger set of tasks related to riser operations and riser integrity. In a wider scope, looking beyond the riser, extended applications are possible by adding the seabed topography and integrating other assets located on the seafloor and in the water. In the near future, this real-time 3D visualization will be an important part of the user interface for operational systems in marine and offshore applications.

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