Application of Real-Time Monitoring of Offshore Oil and Gas Operations: Workshop Report

DETAILS

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Application of Real-Time Monitoring of Offshore Oil and Gas Operations

Workshop Report

Committee on the Application of Real-Time Monitoring
of Offshore Oil and Gas Operations

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NOTICE: The project that is the subject of this report was approved by the Governing Board of the National Research Council, whose members are drawn from the councils of the National Academy of Sciences, the National Academy of Engineering, and the National Academy of Medicine. The members of the committee responsible for the project were chosen for their special competencies and with regard for appropriate balance.

This report has been reviewed by a group other than the authors according to the procedures approved by a Report Review Committee consisting of members of the National Academy of Sciences, the National Academy of Engineering, and the National Academy of Medicine.

This project was sponsored by the Bureau of Safety and Environmental Enforcement, U.S. Department of the Interior.

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Preface

The Bureau of Safety and Environmental Enforcement of the U.S. Department of the Interior asked the Transportation Research Board's Committee on the Application of Real-Time Monitoring of Offshore Oil and Gas Operations to conduct a workshop on the use of real-time monitoring systems by industry and government. In discussions about the statement of task at the committee's first meeting in December 2014, the sponsor confirmed that the workshop agenda and summary report, and the committee's final report, would focus on the Gulf of Mexico region and would be designed in such a way as to address the five issues listed in the statement of task (Box P-1). They would also be informed by the two reports mentioned in the statement of task and described in more detail in Chapter 1. (The workshop's full agenda can be found in Appendix A.) In preparation for the workshop, the committee provided each of the panelists a copy of the two reports and a standard set of questions to address (Appendix B). The presenters were not limited to these questions, but the committee wanted to ensure that, at a minimum, specific issues relevant to the statement of task were addressed.

The purpose of the workshop was to explore the topic of real-time monitoring (RTM) of offshore oil and gas operations. The workshop report summarizes presentations made by invited panelists and other remarks by participants in the committee's workshop in Houston, Texas, on April 20–21, 2015. This report—the first of two that will be issued by the committee—summarizes the prepared remarks of workshop presenters, comments made by the workshop audience, and the ensuing discussions. A workshop report is not intended to contain any consensus findings or recommendations, in accordance with National Research Council workshop guidelines, and does not necessarily reflect any consensus views of the committee, the workshop participants as a whole, or the National Academies of Sciences, Engineering, and Medicine. Although the committee's statement of task allows for findings in this specific case, the committee is still gathering information and deliberating. The committee's second and final report, scheduled for release in 2016, will contain findings and recommendations.

Chapter 1 provides relevant background information for the workshop on the application of RTM in offshore oil and gas operations. Chapter 2 summarizes the workshop's presentations and discussions of RTM in offshore oil and gas operations. Appendix A details the workshop agenda and Appendix B provides the standardized questions that were distributed to the panel participants prior to the workshop. Appendix C identifies the workshop participants and registrants.

Box P-1

STATEMENT OF TASK

An ad hoc committee will conduct a study to advise the Bureau of Safety and Environmental Enforcement (BSEE), U.S. Department of the Interior, on the use of real-time monitoring systems (RTM) by industry and government to reduce the safety and environmental risks of offshore oil and gas operations. As part of its efforts, the committee will organize and hold a public workshop that is informed by a recently released BSEE external technical report on RTM for oil and gas operations and the preliminary findings from an internal BSEE RTM workgroup.

The committee will develop the workshop agenda, select and invite speakers and discussants, and moderate the discussions. Subsequently, the committee will (1) issue an interim report summarizing the presentations and discussion at the workshop and any findings the committee draws from the event and from the BSEE technical report and (2) hold additional meetings to develop and provide a final report with findings and recommendations on the use of RTM by the offshore oil and gas industry and BSEE that address the five issues below.

Specifically, the final report shall address:

1. The critical operations and specific parameters that should be monitored from drilling and producing facilities to manage and mitigate environmental and safety risks (e.g., to reduce the risk of well kicks, blowouts, and other sources of casualties).
2. The role that automation and the use of predictive software tools should play in RTM.
3. The role that condition-based monitoring (CBM) should play in RTM and describe how the operating equipment using CBM could be tailored to and/or used for RTM.
4. Whether RTM should be incorporated into BSEE's regulatory scheme in either a prescriptive or performance-based manner.
5. How BSEE should leverage RTM to enhance its safety enforcement program.

This report was reviewed in draft form by individuals chosen for their diverse perspectives and technical expertise. The purpose of this independent review is to provide candid and critical comments that will assist the institution to make its published report as sound as possible and to ensure that the report meets institutional standards for objectivity, evidence, and responsiveness to the study charge. The review comments and draft manuscript will remain confidential to protect the integrity of the deliberative process.

The committee thanks the following individuals for their review of this report: Vice Admiral James C. Card (USCG, retired), Independent Consultant, The Woodlands, Texas; Elmer (Bud) P. Danenberger, Independent Consultant, Reston, Virginia; Delores M. Etter (NAE), Southern Methodist University, Dallas, Texas; Marcia K. McNutt (NAS), American Association for the Advancement of Science, Washington, D.C.; R. Keith Michel (NAE), Webb Institute, Glen Cove, New York; and Donald L. Paul, University of Southern California, Los Angeles, California. Although the reviewers listed here provided many constructive comments and suggestions, they were not asked to endorse the workshop summary, nor did they see the final draft of the report before its release. The review of this workshop report was overseen Ali Mosleh (NAE), University of California, Los Angeles, and Henry G. Schwartz, Jr. (NAE), Independent Consultant. Appointed by the National Research Council, they were responsible for making certain that an independent examination of this report was carried out in accordance with institutional procedures and that all review comments were carefully considered. Responsibility for the final content of this report rests entirely with the authoring committee and the institution.

The committee gratefully acknowledges the work and support of Mark S. Hutchins, who served as study director and assisted the committee in the preparation of its report under the overall supervision of Stephen R. Godwin, Director, Studies and Special Programs. Karen Febey, Senior Report Review Officer, managed the report review process. Timothy Devlin and Claudia Sauls assisted with meeting arrangements and communications with committee members.

Richard A. Sears, *Chair*
Committee on the Application of Real-Time Monitoring
of Offshore Oil and Gas Operations

List of Acronyms and Abbreviations

24/7	24 hours a day, 7 days a week
API	American Petroleum Institute
BOEMRE	Bureau of Ocean Energy Management, Regulation, and Enforcement
BOP	blowout preventer
BSEE	Bureau of Safety and Environmental Enforcement
CBM	condition-based monitoring
HSE	health, safety, and environmental
IADC	International Association of Drilling Contractors
KPI	key performance indicator
MMS	Minerals Management Service
NAE	National Academy of Engineering
NRC	National Research Council
OCS	outer continental shelf
OEM	original equipment manufacturer
RTD	real-time data
RTM	real-time monitoring
SEMS	safety and environmental management systems
TRB	Transportation Research Board

Contents

1

Introduction

Chapter 1 gives a brief overview of actions taken in the area of real-time monitoring (RTM) by the Bureau of Safety and Environmental Enforcement (BSEE) since the accident on the Deepwater Horizon drilling rig in 2010. This chapter also provides a brief history of real-time data (RTD) collection and monitoring of oil and gas operations. Next, the chapter briefly summarizes two reports, one by a company called 838, Inc., that provides background material on RTM and available technologies, and one by an internal BSEE workgroup, the Real-Time Monitoring Team, that reviews the potential uses of RTM technologies for both the government and the oil and gas industry. The chapter also reviews two notices of proposed rulemaking issued by BSEE during the planning of the committee's Houston workshop.

BACKGROUND

In the aftermath of the Macondo well blowout and Deepwater Horizon rig explosion in April 2010, BSEE[1] began searching for the most effective oversight role that it could play in enhancing the safety of offshore oil and gas operations. Immediately after the accident, BSEE carried out a rulemaking process that required operators to implement safety and environmental management systems (SEMS) (TRB 2012). Subsequently, the agency began urging industry to make a deeper commitment to a strong culture of safety in all operations. The agency also sought improvements in implementing its mandate for best available and safest technology (BAST).[2] BSEE also began to introduce initiatives to its regulatory program, including near-miss and failure reporting, third-party verification and certification, and RTM of facilities.[3] On the basis of recommendations in external committee reports on the investigation of the Deepwater Horizon drilling rig explosion, BSEE's RTM initiative began as a way of exploring how RTM technology could improve offshore drilling safety and

[1] At the time of the accident, the Minerals Management Service (MMS) had authority for offshore oil and gas operations. In June 2010, MMS was renamed the Bureau of Ocean Energy Management, Regulation, and Enforcement (BOEMRE). On October 1, 2011, the U.S. Department of the Interior reorganized BOEMRE and established two new, independent bureaus—BSEE and the Bureau of Ocean Energy Management (BOEM).

[2] For more information concerning the implementation of BAST, see NAE and NRC 2013; the entire report is available at http://www.nap.edu/catalog/18545/best-available-and-safest-technologies-for-offshore-oil-and-gas-operations.

[3] D. Morris, BSEE, presentation to the committee, December 2014.

operations. One report from the Office of Inspector General of the U.S. Department of the Interior contained recommendations identifying potential areas for improvements to the offshore safety program (OIG 2010). Of particular relevance is Recommendation 18:

> 18: Analyze the benefits of obtaining electronic access to real-time data transmitted from offshore platforms/drilling rigs, such as operators' surveillance cameras and BOP [blowout preventer] monitoring systems, and/or other automated control and monitoring systems to provide BOEMRE with additional oversight tools.

Additionally, the National Academy of Engineering (NAE) and National Research Council (NRC) committee that evaluated the causes of the Macondo well blowout and Deepwater Horizon drilling rig explosion made many recommendations to reduce the risk of future blowouts in its 2012 report (NAE and NRC 2012). Two general recommendations addressed RTM:

> Recommendation 3.4: The instrumentation on the BOP [blowout preventer] system should be improved so that the functionality and condition of the BOP can be monitored continuously.
>
> Recommendation 3.5: Instrumentation and expert system decision aids should be used to provide timely warning of loss of well control to the drillers on the rig (and ideally to onshore drilling monitors as well).

Although the RTM technologies offered new opportunities, BSEE had to consider what (if any) implications these technologies could have for BSEE's regulatory and oversight role.

To learn more about RTM technologies and best practices, BSEE conducted site visits to RTM centers during the summer of 2012 and then established an internal RTM team in the fall of 2012 to develop preliminary findings on how the oil and gas industry and BSEE could benefit from the use of RTM technologies. After working for more than a year, the BSEE RTM Team produced a final summary report, *Summary of BSEE's Real-Time Monitoring Study* (BSEE Summary Report), detailing its findings and recommendations (BSEE 2014). More recently, BSEE commissioned a report to provide background on currently available technologies from the company 838, Inc. That report, *An Assessment of the Various Types of Real-Time Monitoring Systems for Offshore Oil and Gas Operations* (838 RTM Report) is dated February 10, 2014 (838, Inc. 2014).[4] In July 2014, BSEE requested that the NRC Marine Board conduct a study on the use of RTM of offshore oil and gas operations.[5]

[4] The complete 838 RTM Report and final presentation are available at http://www.bsee.gov/Technology-and-Research/Technology-Assessment-Programs/Projects/Project-707/.

[5] More information about the study and the committee is available at http://www8.nationalacademies.org/cp/projectview.aspx?key=49661.

RTM AND OFFSHORE OIL AND GAS OPERATIONS

Monitoring of basic sensor data on drilling rigs has been an important part of drilling operations since the 1940s (Booth 2009, 2010). As technology advanced, the ability to capture more and better-quality data improved, and the information and data were sometimes used for trend analysis and anomaly detection on the rig. Improvements in telecommunications technology added value by allowing data transmission to other locations, data aggregation from multiple sources, and data analysis, all while permitting remotely located staff to engage with rig personnel. The opportunity to collect and manage data through a centralized onshore facility allowed many contractors to provide enhanced services (Booth 2009). Although many operators have used on-site (on the rig) RTD to monitor dynamic drilling processes (e.g., surface measurements and downhole tool readings) for years, some operators have, more recently, incorporated enhanced remote RTM as part of their standard management practices.

For some large operators, the business case for remote RTM of drilling operations was made on the basis of improved efficiencies and enhanced risk management through better operational planning and execution. Although a business case may drive the purpose and justification of remote RTM centers, that case will differ for each company. Remote centers are almost always operated by highly experienced technical staff members, many with offshore experience, that monitor and communicate directly with rigs through both formal and informal protocols, providing an additional level of well monitoring for managing risks (Booth 2010).

Well site personnel are assigned primary responsibility and decision making for all drilling operations. During drilling operations, remote monitoring centers can focus on abnormal trends or well events, providing an additional "set of eyes" for the rig, offering advice, support, and improved access to onshore technical experts; this allows rig personnel to concentrate on drilling operations. If rig personnel encounter operational issues that require assistance, RTM makes it possible to collaborate with specialists onshore, without the need to fly them out to the rig. Remote centers can also check the incoming information stream for valid and reliable data, which allows the development of a knowledge base and additional post-processing data analysis. RTM "improves HSE [health, safety, and the environment], reduces subsurface NPT [nonproductive time], and facilitates operational excellence;" additionally, RTM "improves the operator's ability to effectively manage its leases."[6]

Smaller operators may employ some elements of RTM, but some of these operators have concerns about the cost and practicality of continuously monitoring all drilling operations by an onshore staff. Staffing a 24-hours-a-day, 7-days-a-week (24/7) RTM center may be difficult given the limited number of qualified technical personnel. Wells and operations may have different risk or complexity profiles,

[6] B. Gaston, Shell, presentation to the committee, December, 2014.

depending on such circumstances as geological factors, operational conditions, the extent of drilling, and the production history. RTM could be an appropriate tool when applied to more risky and complex wells and activities.

The next section summarizes a recently completed research project by the company 838, Inc., that reviewed and assessed RTM technologies.

838, INC., ASSESSMENT OF RTM SYSTEMS REPORT

In the fall of 2012, BSEE's Technology Assessment and Research Program awarded a contract to the company 838, Inc., for additional research on the use of RTM for offshore oil and gas activities. This section summarizes many of the main topics from the more than 200-page report submitted by 838, Inc., and includes terms and concepts as used by the authors (838, Inc. 2014). The main tasks, along with many corresponding conclusions and recommendations for the research project, are listed in order below.

Task 1

What is the current state of real-time monitoring (RTM) technology? Perform an independent assessment of the various RTM data systems available for offshore oil and gas operations, with a focus on: (a) drilling activities and (b) production technologies.

Task 1 is addressed in Chapter 1 of the 838 RTM Report. The report found five basic uses for RTD technologies:

1. Subsurface and formation analysis and well planning and modeling tools.
2. Wellbore stability and drilling integrity (downhole) monitoring and analysis.
3. Instrumentation for drill floor and rig operations.
4. Bandwidth requirements for data collection, transmission points, wireless and wired, and standardized languages.
5. Onshore center—data aggregation standardized interfaces; screens; display of relevant data; user interface; predictive capabilities; and monitoring and alarming potential.

Although 838, Inc., polled 164 oil and gas exploration and production companies with current operations in the Gulf of Mexico, only 76 companies responded. Of those that responded, more than half (41) reported using some type of RTD, and, of those that use RTD, 80% (33 companies) say that they send those data onshore. Of the

41 companies using RTD, 39% have some type of operations center; only 17% use a monitoring center that is staffed 24/7. The 838 RTM Report also notes that the use of RTD is increasing as sensor technology advances.

Task 2

What is the cost–benefit of RTM? Perform a cost–benefit analysis of the systems identified that details: (a) potential costs to industry, (b) potential increases in safety performance, (c) government resources needed for implementation, and (d) necessary training for all parties involved.

Task 2 is addressed in Chapter 7 of the 838 RTM Report. The authors noted that businesses need to be able to show both a return on investment and, ultimately, profitability. As part of their research on the cost–benefit analysis for RTM, the authors indicated that a cost–benefit analysis for a small company will differ greatly from one for a larger company. Other issues can influence the results of cost–benefit analyses, such as the timespan covered by an analysis or the area of focus (onshore or offshore). The authors also emphasized that some benefits are intangible and difficult to assess and that most corporate cost–benefit analyses are proprietary. For the report, the authors limited the scope of the cost–benefit analysis and included specific assumptions; they also stressed that the report's cost–benefit analysis is only for illustration purposes.

Even when conservative estimates are used in the cost–benefit analysis, the authors of the 838 RTM Report conclude that the use of RTM centers is justified. They note that barriers to the introduction and use of advanced principles for exploration and production are not always financial and that the government may have a role in promoting use. Likewise, they note that the benefits of RTM centers are not always financial; they can include improvements in safety and the environment. According to the authors, an RTM center can be a "powerful tool for increasing efficiency and elevating safety" (838, Inc. 2014, p. 218).

Task 3

What training is needed for RTM? Discuss options for training programs or contracted services that would be needed to incorporate the identified systems into BSEE's processes.

Chapter 2 (for Task 3) of the 838 RTM Report included training options for incorporating systems necessary for RTD monitoring into an oversight role and the importance of standardization for the purposes of regulatory oversight. Before any effective training program can be developed, the authors believe that BSEE should

ensure that the oversight system is clearly defined. The authors discussed principles of safety oversight and system safety models, and introduced three training scenarios for the purpose of incorporating RTM into BSEE processes.

Scenario 1 proposed a focused internship and syllabus of instruction with an oil and gas operator. Scenario 2 involved curriculum development; BSEE, in conjunction with industry, would develop a curriculum for training courses designed to help its personnel to a better understanding of the RTD technology available in the industry. Scenario 3 suggested the development of a simulation center within BSEE that would be modeled after an industry real-time operations center. Established and maintained within BSEE, this center would train BSEE personnel in best practices, using actual (de-identified) data to perform simulations or to replay actual events.

The authors conclude that their example of safety oversight, as discussed in Chapter 2 of the report and as used in other regulated industries, is a proven model. This system safety model would manage the standardization of training while ensuring that stakeholders continue to generate industry best practices, evolving with technological advancements. Helping BSEE understand RTM through standardized training could also enhance industry safety. The authors recommend a combination of Training Scenario 1 and a hybrid of Training Scenario 2 and Training Scenario 3.

Task 4

What are the critical parameters and operations to monitor? Identify all necessary information that has to be collected, calculated, or monitored during operations to improve the current level of safety.

Task 4, which discusses critical operations and parameters, is addressed in Chapter 4. The authors focus on data and information that are more related to improved safety and less to nonproductive time and other operational efficiencies. Drilling operations produce multiple data flows, with the amount of data produced growing as technology advances. The authors note that collaboration centers with demonstrated reliability or performance improvements share five common success factors:

1. Environment—placing the operating condition of equipment in context;
2. Data—collecting and managing data by exception;
3. Analysis—employing both predictive analytics and deep diagnostics as complementary technologies;
4. Cooperation—communicating observations, recommendations, and lessons learned through collaborative tools; and
5. Management—utilizing a knowledge management system for organizing findings.

The authors list and discuss collected, monitored, and calculated information for well operating conditions. Examples of data collected include pressure, hydraulic, torque, tension, and temperature. Monitored data can include fluid dynamics and pressures, mud flow and quantity and density, and mud temperature and properties. Calculated data examples can include hydrostatic pressure, pore pressure, and equivalent circulating density (ECD).[7]

The authors also discuss the importance of modeling and modeling tools for well planning and well development. Using RTD with available modeling technology offers great benefits to offshore operations, from drilling a well to post-drilling analysis. The authors list many types of process models that are available, including geomechanical and hydraulic ECD models (838, Inc. 2014, p. 125). These types of models, they note, can provide proactive responses to daily operational challenges, rather than reactive ones. Simulations with post-processed data are also important modeling tools, allowing the creation of operational and training simulations that provide improved situational awareness and procedural understanding.

Suggesting that there is a need for a cultural shift within the industry to improve the safety of deepwater operations, the authors propose that operators demand from their contractors both improvements in the monitoring systems used and a higher quality of data collected, measured, and evaluated. The authors conclude that modeling of the well environment before the start of drilling has meant greater insight into the process and that the use of simulation programs that incorporate RTD during drilling operations contributes to increased efficiencies and can promote safe operations. Training simulators can enhance the experience of personnel, which can also improve safety.

Task 5

How can RTM be used for condition monitoring? Identify technologies and data that might be helpful in measuring field performance of critical equipment with the goal of predicting potential failures.

In Chapter 5, the authors survey current sensor technologies used by industry to measure and report performance and to predict failure of monitored equipment. The authors describe sensors and transducers and discuss how each works and is used to report conditions or to measure various instruments. Next, they discuss virtual sensors that merge collected data from existing sensors and with other historical performance data to predict conditions. Virtual sensors are also associated with data reconciliation, a process control technique used "to verify measured data by reference to a process

[7] For a detailed list of data collected, monitored, or calculated, see 838 RTM Report (838, Inc. 2014, pp. 110–124).

model" (838, Inc. 2014, p. 136). The authors also describe fiber optic sensors as an important new technology for condition monitoring—they are small and reliable, can withstand high temperatures, can manage multiple sensing points on a single fiber, and are immune to most interference. There is also no spark hazard with fiber optic sensors. Other new technologies include fiber Bragg grating, an optical sensing technology used to measure such variables as temperature, pressure, weight, and flow, and microelectromechanical systems, a technology consisting of very small components (micro valves, pumps, and actuators) that can sense relative motion. Next, the report discusses the concept of the digital oil field and the importance of collecting, managing, and analyzing data. The foundation of the digital oil field is reliable and valid data, which, in turn, form the basis for all analysis and decision making. The authors briefly examine possible areas where technology could replace currently performed industry inspection techniques, such as the inspection of subsea pipelines and risers, liquid storage tanks, and floating vessels.

The authors conclude that advancements in sensor technology have allowed industry to increase the amount and improve the quality of collected data from critical systems, leading to more efficient and reliable equipment. For example, the authors suggest that the analysis of newer, previously unavailable data from fiber optic sensors have permitted better decisions with a smaller margin of uncertainty. According to the authors' research, the amount of currently recorded data is only a subset of the total available data; as more data are collected and recorded, industry will need newer and better methods of data storage, transmission, and analysis. The authors also suggest that newer sensors and the data they provide could replace many current inspection methods that are labor intensive.

Task 6

What RTM requirements should be incorporated into BSEE's regulations? Identify how RTM could be incorporated into the BSEE regulatory regime in either a prescriptive or a performance-based manner.

The authors of the 838 RTM Report conclude that incorporating RTM requirements into the BSEE regulatory regime could have great benefits for the oil and gas industry, including promoting safe and efficient exploration, extraction, and production of hydrocarbons. The authors also maintain that the inclusion of RTM in BSEE's regulatory regime should incorporate the principles of system safety if BSEE is to remain an effective regulator. The authors discuss components of system safety programs, including "as low as reasonably practicable" risk, root cause analysis, human factors analysis and classification, and predictive analysis, that would complement both each other and RTM regulations.

The authors also state that voluntary reporting could enhance safe operations. To ensure that that the industry as a whole understands incidents and accidents, the authors suggest the implementation of industrywide data sharing among operators; BSEE would receive de-identified data, with any proprietary information protected. The authors also recommend that BSEE implement a voluntary safety reporting system that would expand the "reporting of unsafe working conditions" under the SEMS regulations and that BSEE identify and promote industry best practices and technology.[8]

Task 7

How can automation enhance RTM? Perform an assessment of automation technologies and their impacts on (a) human and environmental safety, (b) efficiency improvements, and (c) cost to industry.

In Chapter 6 of the 838 RTM Report, the authors assess the current principles of automation and the automation now available in the oil and gas industry and detail automation's effects on human and environmental safety, efficiency, and overall costs to the industry. They note that the automation and control of many offshore processes promises to improve safety, performance, quality, and reliability, but that the industry is divided into those companies that can afford this technology and those who might not be able to afford it. The authors note that the need for automation "is driven by the difficulty in tightly controlling critical well parameters during drilling operations for extremely deep wells" (838, Inc. 2014, p. 160). The authors also conclude that

- Automation promises to limit human exposure to dangerous environments and to enhance safety through better control,
- Automation can be enabled with the introduction and advancement of newer technology, and
- The incentives for automation are the realization of economies of scale and predictable quality levels.

The authors add that automation has definite human health and safety benefits, but that it also has several pitfalls and challenges surrounding its use, including mode confusion,[9] complacency, the need for preventive maintenance, reliance on timely and high-quality data, and several other limitations, such as security threats and vulnerabilities.

[8] In her workshop presentation, Susan Dwarnick of BSEE indicated that BSEE is moving ahead with this recommendation of a reporting program that captures information about incident near misses and trends and then returns that information back to industry.

[9] Mode confusion is when an automated system behaves in a way that was different from what was expected, and the operator was not aware of or did not understand what the system was doing.

The authors discuss the status and progress of current automation technologies in such areas as fluid control, continuous motion rig, pipe handling, and autonomous undersea vehicles. Overall, the authors note that automation in the upstream oil and gas industry is in its initial stages and looks promising, but that some tasks in oil and gas operations may never be fully automated, always requiring some human involvement.

Final Thoughts and Recommendations

The 838 RTM Report authors conclude that the use of RTM centers is viable, and that the financial return from using RTM technology is supported by the study and the continued use of RTM by large operators. They observe that any government regulation of the use of RTM should be introduced gradually, starting with the drilling of high-risk wells. Further, they indicate that regulations should include the need for onshore monitoring of well parameters by a separate safety center. Small and medium-sized operators, they note, could use a common onshore monitoring center to share the financial burden; the government also could provide incentives to these operators to encourage use of such centers. The report authors also recommend that any RTM operation be audited periodically by the regulator to ensure that monitoring is occurring. They note that other countries are providing a roadmap through funding or supporting the introduction of automation on drilling rigs. The authors suggest that the U.S. regulator should fund and promote research in automation research to help foster an atmosphere of cooperation and could also form a team with regulators from foreign governments to share ideas and create a roadmap to fuller automation of drilling rigs.

BSEE RTM SUMMARY REPORT

This section summarizes the *Summary of BSEE's Real-Time Monitoring Study* (BSEE Summary Report) (BSEE 2014). Established in October 2012, the internal BSEE RTM team focused on two primary questions:[10]

1. Use of RTM by industry: What minimum requirements should BSEE consider establishing in its regulations for the use of RTM technologies by the offshore oil and gas industry?
2. Use of RTM by BSEE: How should BSEE use RTM technologies to carry out its safety and environmental protection responsibilities more efficiently and effectively?

[10] For more details on the questions the team considered, see the BSEE Summary Report, Table 1, "Questions Considered by RTM Team" (BSEE 2014, p. 5).

– How could BSEE use RTM to supplement and enhance its existing inspection program?
– How could BSEE use RTM to expand and enhance its safety and enforcement missions?

To accomplish its work, the team formed three subgroups that corresponded to three general categories of offshore activities: drilling operations, completion and workover operations, and production operations. Each subgroup was given the task of identifying critical operations and parameters during each offshore activity that should be monitored using RTM technologies. The subgroups' complete feedback is listed in Annexes 1, 2, and 3 to the BSEE Summary Report.[11] The feedback includes operations such as well control, negative tests, and kick detection for drilling, completions, and workovers, and emergency shutdown and temperature safety element status for production.

Use of RTM by Industry

According to the BSEE Summary Report, some major oil companies use RTM centers to monitor high-risk drilling and production operations,[12] especially those in deep water. The report lists several components as critical for an effective RTM center. The first is the stream of data received from offshore sites that allows companies to provide a network of experts to support or assist their offshore operations. In direct communication with offshore sites, these experts can provide advice and troubleshoot issues from onshore without having to be flown out to the drilling rig or production platform. A second component is the communications link between the center and the offshore control room. Constant communication between an offshore site and the onshore center is vital if onshore personnel are to maintain awareness of offshore operations; center staff otherwise could misinterpret RTM data. Effective communication between offshore and onshore staff demands clear protocols and procedures on how to identify, verify, and escalate safety concerns, and also guidance on who should talk with whom. The third component is that the center be staffed with experienced and highly trained personnel who must then gain the trust of offshore personnel.

Use of RTM by BSEE

BSEE's internal RTM team also considered BSEE's role in monitoring RTM data from offshore facilities. Below is a summary of key issues that the BSEE team discussed:

[11] The BSEE Summary Report contains feedback from the Drilling Subgroup (Annex 1, p. 14), the Completions and Workovers Subgroup (Annex 2, p. 17), and the Production Subgroup (Annex 3, p. 20) (BSEE 2014).
[12] Although they are defined differently within the industry, high-risk operations are often a function of many factors, including, but not limited to, drilling depth, water depth, anticipated high temperature or pressure (or both), and complexity.

1. The BSEE team notes that RTM has the potential to be a powerful enabling technology that could transform offshore safety and environmental oversight for both industry and BSEE.
   - Any new step to improve BSEE's inspection and enforcement program should consider (and possibly develop, test, and implement) reforms based on RTM technologies and risk-based inspections to supplement the current program.
   - BSEE should develop a risk-based strategy to determine which RTM opportunities provide the best return on investment and which activities still require on-site inspections. The focus would likely be on high-risk activities involving deepwater drilling and casing and cementing, with additional focus on problematic facilities and operators.
   - Because the objective is to improve its regulatory oversight of critical operations and equipment, the use of RTM could allow BSEE to shift technical resources to evaluate these operations and equipment more quickly.
   - Implementing a RTM program would be a change from BSEE's current inspection program and would require a different skill set than BSEE's traditional inspection activities do.
   - Any new program should be implemented in phases, with consideration for managing potential workload and hiring a sufficient number of staff.
2. An important task, according to the BSEE team, is to identify critical operations and parameters for drilling, completion, and workover and production activities.
   - Identifying the critical operations and parameters to be monitored has to occur before discussing any potential role for BSEE or requirements for industry.
   - Given its limited resources, any BSEE RTM oversight program would have to focus on critical operations—those that pose the greatest risk of a well control event; however, defining a critical operation may be difficult, because a well control event could occur at any time during downhole activities.
   - As detailed in Annexes 1, 2, and 3 to the BSEE Summary Report, the BSEE RTM team and its subgroups spent a considerable amount of time and effort identifying which critical operations and parameters to monitor during drilling, completion, and workover and production activities.
3. The team adds that it should consider what value-added role or roles BSEE personnel would take through overseeing critical drilling, completion, and workover operations.
   - Active oversight of downhole operations would be a new role for BSEE, one quite different from its current safety program for well operations, which primarily focuses on the review and approval of drilling plans and the inspection and testing of drilling and production safety equipment.
   - To avoid becoming a distraction during critical downhole operations, BSEE personnel providing oversight would need to have the proper qualifications,

experience, and technical training to contribute to the safety of the offshore operations; however, the team notes, recruiting and retaining personnel with such highly specialized skills and knowledge can be challenging for the federal government.

- Even with the right expertise, the team believes that government personnel would be challenged in assuming an oversight role during complex operations without quickly assimilating all the safety issues and risk factors for a particular well operation.
- Additionally, according to the team, any BSEE oversight role must consider potential legal implications.

4. Without direct communication between BSEE and the facility's offshore control room, the team believes that any RTM data could be misinterpreted and have limited use.

- Providing BSEE personnel with an additional direct communication link to the facility's offshore control room could become a distraction to the offshore facility.
- Because of concerns about proprietary information and potential legal liability for regulatory noncompliance, companies may be reluctant to share RTM data.

5. The BSEE team expresses concern that obtaining RTM data from multiple operators poses many unknown technological and legal challenges.

- Any BSEE monitoring system incorporating various offshore RTM systems and data formats would have to resolve compatibility and technical issues, such as connectivity issues, bandwidth limitations, and cost factors.
- Any legal issues regarding the protection of proprietary information and the legal implications of collecting and storing RTM data would have to be resolved.
- Any new requirement that industry provide BSEE with access to RTM data could necessitate rulemaking by BSEE.

6. The BSEE team observes that Daily Drilling Reports from the International Association of Drilling Contractors (IADC) could provide useful information for BSEE oversight of drilling operations.

- BSEE should determine if IADC Daily Drilling Reports could provide adequate oversight of drilling operations as a low-cost, low-technology alternative to BSEE monitoring of RTM data feeds.
- BSEE regulations require operators to submit form BSEE-0133, Well Activity Report, to the BSEE district manager on a weekly basis. However, IADC publishes a Daily Drilling Report form that provides more detailed drilling information than form BSEE-0133.
- Requiring the IADC Daily Drilling Report form to be submitted electronically to the BSEE district manager on a daily basis could be beneficial, although such a requirement might require rulemaking by BSEE.

Options for Incorporating RTM

The BSEE RTM team discussed various scenarios for incorporating RTM oversight into the agency's safety regime. Below are the three options that the team identified:

1. Oversight through RTM centers. BSEE personnel could travel to the RTM center of each offshore operator in order to access RTM data and monitor offshore activities.
2. RTM Internet portal. BSEE could establish an RTM Internet portal (a specially designed, password-protected website) that would allow BSEE personnel to access RTM data from offshore operators whenever needed by logging onto the portal.
3. BSEE RTM center. BSEE could establish and staff its own centralized RTM center, similar to an air traffic control center used by the Federal Aviation Administration or a vessel traffic service center used by the U.S. Coast Guard.

The BSEE RTM team deemed that oversight through RTM centers (Option 1) and oversight through an RTM Internet portal (Option 2) are the more promising scenarios for incorporating RTM oversight into BSEE's safety regime. Of those two, the BSEE RTM team believes that Option 1 would be easier, faster, and less costly to implement. Also, although Option 2 might provide useful data for monitoring offshore activities, the team noted that more research is needed before such a portal would be a viable option. Determining how to implement any RTM technologies for mitigating risk would require more research and outreach to industry and subject matter experts. The BSEE RTM team suggested conducting a public workshop to collect feedback about potential knowledge gaps and to obtain input guiding BSEE on a recommended path forward.

The BSEE RTM team also recommended further evaluation of the idea of using IADC's Daily Drilling Reports as a lower-cost alternative to implementing RTM technologies. The IADC Daily Drilling Report includes more information than form BSEE-1033 and the IADC form also appears to be widely used by industry. The team concluded that updating BSEE regulations to require the electronic submission of the IADC form to all BSEE regions on a daily basis makes sense.

On the basis of its discussions and recommendations, the BSEE RTM team suggested additional research in the following four areas:

1. Consider whether to implement a BSEE oversight and emergency response capability for monitoring critical offshore oil and gas activities via the RTM centers already being used by offshore oil and gas operators (Option 1 above).
2. Conduct research on the feasibility of collecting RTM data streams from offshore drilling rigs and production platforms and developing an Internet portal so that BSEE personnel can access the RTM data (Option 2 above).

3. Conduct a more detailed evaluation of RTM technologies and best practices for drilling, completion, workover, and production operations by holding a public workshop and conducting follow-on research. The purpose of the public workshop and follow-on research would be to define more clearly
   - What the critical operations and parameters to monitor using RTM technology are;
   - What industry's role should be in monitoring RTM data, and what the minimum requirements should be; and
   - What BSEE's role should be in monitoring RTM data.
4. Evaluate the potential use of IADC's Daily Drilling Report for drilling safety oversight by BSEE.

NOTICE OF PROPOSED RULEMAKING

During the period between the committee's first meeting in December 2014 and the workshop in Houston, Texas, in April 2015, BSEE released two proposed rules. One rule, concerning requirements for exploratory drilling on the Arctic outer continental shelf (OCS), was issued on February 24, 2015 (*Federal Register* 2015a);[13] the other concerned BOP systems and well control and was issued on April 17, 2015 (*Federal Register* 2015b).[14] Both proposed rules include RTM components as part of the new requirements.

Arctic OCS Exploratory Drilling Operations

Overall, the proposed rule would add to and revise existing regulations in Title 30 of the *Code of Federal Regulations* for oil and gas activities focused on Arctic OCS exploratory drilling and related operations that use mobile offshore drilling units. Although it is only a small section in the proposed rule, the RTM component would require companies to gather RTD. Specifically, the section would require the following data (*Federal Register* 2015a):

> §250.452 What are the real-time monitoring requirements for Arctic OCS exploratory drilling operations?
>
> (a) When conducting exploratory drilling operations on the Arctic OCS, you must have real-time data gathering and monitoring capability to record, store, and transmit data regarding all aspects of:

[13] The new requirements for Arctic drilling are available at https://federalregister.gov/a/2015-03609.
[14] The proposed blowout preventer rule is available at https://federalregister.gov/a/2015-08587.

> (1) The BOP control system;
> (2) The well's fluid handling systems on the rig; and
> (3) The well's downhole conditions as monitored by a downhole sensing system, when such a system is installed.
>
> (b) During well operations, you must immediately transmit the data identified in paragraph (a) of this section to a designated onshore location where it must be stored and monitored by qualified personnel who have the capability for continuous contact with rig personnel and who have the authority, in consultation with rig personnel, to initiate any necessary action in response to abnormal data or events. Prior to well operations, you must notify BSEE where the data will be monitored during those operations, and you must make the data available to BSEE, including in real time, upon request. After well operations, you must store the data at a designated location for recordkeeping purposes as required in §§ 250.466 and 250.467.

The rule would also require operators to transmit the data during operations to an onshore location, where it would be stored and monitored by technically capable personnel who have the authority, in consultation with rig personnel, to begin necessary action to a potential event or data abnormality.

BOP Systems and Well Control

Released on April 17, 2015 (on the Friday before the committee's workshop), the proposed regulations would consolidate equipment and operational requirements—common to other subparts—and incorporate (and revise some) guidance provisions from several Notices to Lessees and Operators (NTLs) that are related to offshore oil and gas drilling, completions, workovers, and decommissioning. At present, the proposed rule focuses on BOP requirements, incorporating many industry standards, and revises or reforms requirements in the areas of well design, well control, casing, cementing, real-time well monitoring, and subsea containment.

For the RTM component in §250.724, the proposed rule states (*Federal Register* 2015b):

> § 250.724 What are the real-time monitoring requirements?
>
> (a) When conducting well operations with a subsea BOP or surface BOP on a floating facility or when operating in an HPHT [high pressure, high temperature] environment you must, within 3 years of publication of the final rule, gather and monitor real-time well data using an independent, automatic, and continuous monitoring system capable of recording, storing, and transmitting all aspects of:

(1) The BOP control system;
(2) The well's fluid handling systems on the rig; and
(3) The well's downhole conditions with the bottom hole assembly tools (if any tools are installed).

(b) You must immediately transmit these data as they are gathered to a designated onshore location during operations where they must be monitored by qualified personnel who must be in continuous contact with rig personnel during operations. After operations, you must preserve and store this data at a designated location for recordkeeping purposes as required in §§ 250.740 and 250.741. You must designate the location where the data will be stored and monitored during operations in your APD [Application for Permit to Drill] or APM [Application for Permit to Modify]. The location and the data must be made accessible to BSEE upon request.

(c) If you lose any real-time monitoring capability during operations covered by this section, you must immediately notify the District Manager. The District Manager may require other measures until real-time monitoring capability is restored.

Records and Reporting

§ 250.740 What records must I keep?

You must keep a daily report consisting of complete, legible, and accurate records for each well. You must keep records onsite while well operations continue. After completion of operations, you must keep all operation and other well records for the time periods shown in § 250.741 at a location of your choice, except as required in § 250.746. The records must contain complete information on all of the following:

(a) Well operations, all testing conducted, and any real-time monitoring data;

(b) Descriptions of formations penetrated;

(c) Content and character of oil, gas, water, and other mineral deposits in each formation;

(d) Kind, weight, size, grade, and setting depth of casing;

(e) All well logs and surveys run in the wellbore;

(f) Any significant malfunction or problem; and

(g) All other information required by the District Manager.

§ 250.741 How long must I keep records?

You must keep records for the time periods shown in the following table. You must keep records relating to:

(a) Drilling; until 90 days after you complete operations.

(b) Casing and liner pressure tests, diverter tests, BOP tests, and real-time monitoring data; until 2 years after the completion of operations.

(c) Completion of a well or of any workover activity that materially alters the completion configuration or affects a hydrocarbon-bearing zone; until you permanently plug and abandon the well or until you assign the lease and forward the records to the assignee.

ORGANIZATION OF WORKSHOP REPORT

At its first meeting in December 2014, the committee confirmed with the sponsor that the workshop agenda (Appendix A) and final report would focus on the Gulf of Mexico region and would be designed in such a way as to address the five issues listed in the statement of task (Box 1), in addition to being informed by the two reports mentioned in the statement of task and described above in this chapter. A standard set of questions relevant to the statement of task is listed in Appendix B. Chapter 2 summarizes the prepared remarks of workshop presenters, comments made by workshop participants, and the ensuing discussion in chronological order from the April 20–21, 2015, workshop. The panel participants and general attendees are listed in Appendix C.

Box 1

STATEMENT OF TASK

An ad hoc committee will conduct a study to advise the Bureau of Safety and Environmental Enforcement (BSEE), U.S. Department of the Interior, on the use of real-time monitoring systems (RTM) by industry and government to reduce the safety and environmental risks of offshore oil and gas operations. As part of its efforts, the committee will organize and hold a public workshop that is informed by a recently released BSEE external technical report on RTM for oil and gas operations and the preliminary findings from an internal BSEE RTM workgroup.

The committee will develop the workshop agenda, select and invite speakers and discussants, and moderate the discussions. Subsequently, the committee will (1) issue an interim report summarizing the presentations and discussion at the workshop and any findings the committee draws from the event and from the BSEE technical report and (2) hold additional meetings to develop and provide a final report with findings and recommendations on the use of RTM by the offshore oil and gas industry and BSEE that address the five issues below.

Specifically, the final report shall address:

1. The critical operations and specific parameters that should be monitored from drilling and producing facilities to manage and mitigate environmental and safety risks (e.g., to reduce the risk of well kicks, blowouts, and other sources of casualties).
2. The role that automation and the use of predictive software tools should play in RTM.
3. The role that condition-based monitoring (CBM) should play in RTM and describe how the operating equipment using CBM could be tailored to and/or used for RTM.
4. Whether RTM should be incorporated into BSEE's regulatory scheme in either a prescriptive or performance-based manner.
5. How BSEE should leverage RTM to enhance its safety enforcement program.

REFERENCES

Abbreviations

BSEE	Bureau of Safety and Environmental Enforcement
NAE	National Academy of Engineering
NRC	National Research Council
OIG	Office of Inspector General
SPE	Society of Petroleum Engineers
TRB	Transportation Research Board

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2

Summary of Workshop Discussions

Richard Sears, *Stanford University (Chair)*
Susan Dwarnick, *Bureau of Safety and Environmental Enforcement*
Darryl Fett, *Total E&P USA*
Barry Gaston, *Shell*
Joseph Leimkuhler, *LLOG Exploration*
Lisa Grant, *Noble Energy*
Steven Kendrick, *BHP Billiton*
Dale Bradford, *Murphy Oil Corporation*
Anil Wadhwa, *Baker Hughes*
Kevin Goy, S*chlumberger*
Andreas Sadlier, *Halliburton*
Chuck Salminen, *Weatherford*
Lee Geiser, *Petrolink*
Eric van Oort, *Genesis Real-Time Systems*
David Stevens, *Chevron*
Chris Hall, *Marathon Oil*
Steve Bodden, *Stone Energy*
Amro Hamza, *Anadarko*
Tom Moroney, *Shell*
Harris Reynolds, *Diamond Offshore Drilling*
Jean-Paul Buisine, *Transocean Offshore Deepwater Drilling*
Tony Hogg, *Pacific Drilling*
Brian Wright, *CAD Control Systems*
Daniel Marquez, *Athens Group*
Holly Hopkins, *American Petroleum Institute*
Evan Zimmerman, *Offshore Operators Committee*
Alan Spackman, *International Association of Drilling Contractors*
Anton du Preez, *National Ocean Industries Association*

In his opening remarks, Richard Sears, Chairman of the Committee on the Application of Real-Time Monitoring of Offshore Oil and Gas Operations, discussed the context of the committee's study, the workshop, and the committee's statement of task, and reviewed the workshop's agenda. The remainder of the chapter summarizes the presentations and discussions that occurred over the 2 days of the workshop.[1]

[1] Copies of all presentations can be found at the workshop's website, http://www.trb.org/PolicyStudies/WORKSHOP.aspx.

OVERALL IMPORTANCE OF REAL-TIME MONITORING FOR BSEE

Susan Dwarnick

In explaining the importance of real-time monitoring (RTM) to the Bureau of Safety and Environmental Enforcement (BSEE), Susan Dwarnick acknowledged that BSEE is seeking to understand what RTM looks like from the perspective of a regulator, but that it is working with industry to identify the best available and safest technologies. BSEE is introducing several new initiatives, including

- A reporting program that captures information about incident near-misses and trends and then returns that information to the industry,
- A program that identifies and manages the life cycle of critical equipment, and
- An inspection program that will identify facilities on the basis of risk criteria.

Third-party verifications and certifications are requirements of the existing Safety and Environmental Management Systems (SEMS) program, as well as the new proposed blowout preventer (BOP) rule, which was released on April 17, 2015. Additionally, she thought that BSEE should evaluate the use of third-party certifications instead of physically witnessing BOP tests at offshore installations.

Compliance inspections, which Dwarnick identified as the core mission of the agency, are required once a year, but BSEE is constrained by the number of available technical staff and elevated costs for helicopters. BSEE is responsible for more than 3,000 facilities that are managed by small and large operators and are located from 3 miles to 125 miles offshore. The challenge for BSEE is to determine effective alternatives that focus on risk-based inspections, rather than sending inspectors to each facility every year. The new proposed BOP rule incorporates several industry standards. It would require operators to gather and monitor specific components of real-time data (RTD) independently, automatically, and while continuously utilizing an onshore facility. Dwarnick emphasized that the new proposed rule does not define a role for BSEE, although the agency does reserve the right to access the data at any time.

DRILLING OPERATIONS

Total E&P USA

Darryl Fett

A large operator with worldwide assets, Total E&P USA uses limited onshore RTM for drilling and completion activities when collaborative efforts or support may warrant onshore assessments. Total does not routinely use remote RTM operations, even though this well information is available to onshore personnel from contractors over the Internet. Fett reported that Total does not intend to replicate well control monitoring onshore and that all responsibility should stay on the rig. According to

Fett, Total supports the use of technology that would allow the outsourcing of certain noncritical tasks—those related to administrative or reporting functions. Such use could provide a benefit by allowing rig personnel to focus on more critical work.

Total's Norway affiliate has the most experience with remote operation centers, where the emphasis is on information availability and collaborative decision making, and is considering expanding its use to include drilling engineering simulations. Fett reported that Total is planning a pilot, real-time support center in France for a 6-month period; the center would not be open 24 hours a day, 7 days a week (24/7) and it would focus on "support" more than monitoring.

Fett noted that specific criteria or risk thresholds for RTM requirements have not been specified and that industry use of automation and predictive software is still evolving. Total is considering the use of automation and predictive software for the center in Norway and for the pilot program in France, focusing mostly on drilling efficiencies, but such technology is not currently in place. As for condition-based monitoring (CBM), Fett indicated that Total could consider the wellbore and associated operations as the equipment being monitored and then use available tools to deliver reliable information for assessing trends; however, industry is still determining how best to use RTM technologies in drilling operations. Fett stated that the health, safety, and environmental (HSE) benefits of remote RTM centers have not been established.

Fett stated that BSEE could benefit by using the real-time infrastructure to move some "administrative/IT" [information technology] tasks onshore, so that site inspections could focus more on actual observations, and less on the "paperwork." Additionally, he believes that industry would prefer performance-based requirements over prescriptive requirements and that BSEE should ensure that any regulatory requirements are supported by data and experience. Fett encouraged BSEE to continue working closely with industry to find ways to leverage new technologies, allowing the technologies to evolve and to be built into organizations and cultures (evolution vs. revolution).

Shell

Barry Gaston

Shell, a large operator, has used remote RTM since 2002, first in New Orleans, Louisiana, and then at a second center in Houston, Texas, that started in 2006, after Hurricane Katrina knocked out its New Orleans center. Shell's RTM is centered on drilling, focusing on well control for its deepwater wells—watching all real-time fluid monitoring data, such as pit volumes, mud weight, flow in, and flow out. For deepwater drilling, monitoring includes plug and abandon operations for surface parameters and workovers that involve drill pipe operations, but not for coiled tubing operations. For completions, Shell streams data into the RTM center for quality assurance and control, and then forwards data to Shell's completions engineering teams.

Gaston stated that RTM automation in drilling is still in its infancy, but that Shell does use some predictive software related to connection-flow monitoring and a heat-check calculator for casing wear. The use of predictive software supplements what is done on the rig; it does not replace it. According to Gaston, Shell does not see a direct connection between CBM and drilling operations. Although it could be used for the monitoring of surface equipment, Gaston believes that CBM is not mature enough to play a role in downhole operations. He does think that CBM has greater benefits for production operations, for items such as engines and pumps that could be monitored continuously for the longer term.

Like other operators, Gaston encouraged BSEE to visit Shell's RTM center to view the data from the rigs, which would help to provide context and situational awareness. Although it provides another "set of eyes," RTM could not replace any activities on the rig. For Shell, the biggest benefit of RTM has been providing timely data to identify proactively equipment that is out of calibration or failing. Also, historical data provide a repository for possible incident investigations. RTM may lead to a reduction in on-site visits for BSEE for items that could be monitored remotely, such as BOP testing, but BSEE would still need sufficient staff to carry out such tests.

LLOG Exploration

Joseph Leimkuhler

LLOG Exploration is a private company operating as an independent operator in the Gulf of Mexico. Although it does not have a physical center, LLOG does use RTM beyond its on-site rig supervision, streaming the data virtually into the office and allowing onshore engineers the capability of monitoring critical parameters on all of the company's deepwater wells. For LLOG, monitoring the drilling of exploration or development wells where the pore pressure and fracture gradient trends are not well understood is a valuable example of RTM. LLOG ensures that RTM capability is in place for all of its deepwater drilling operations, both exploration and development. Downhole well operations are not conducted in a controlled environment and rely on estimated parameters within a range of assumed values. Any use of automation or predictive software would likely lead to false alarms and loss of confidence in the system.

Leimkuhler stated that BOP systems, updated to allow streamed critical parameter data, could be monitored because these systems are more mechanical and not reliant on downhole systems. This type of monitoring could add value if actions are consistent and responsive. However, Leimkuhler noted that this equipment is owned and maintained by the drilling contractor, and that any CBM would have to interface with the drilling contractor's data acquisition system. The use of these data for possible intervention decision making would have to meet the drilling contractor's

and the original equipment manufacturer's (OEM) data quality assurance and control standards, as well as work within the drilling contractor's SEMS program. Any intervention protocol would have to be approved by the operator via the operator's and drilling contractor's SEMS bridging documents.

Leimkuhler further noted that RTM of data by BSEE should not replace any on-site inspection programs, although such monitoring could supplement BOP pressure tests once remote monitoring of these tests is proved to be reliable. Also, a properly archived RTM data stream could enhance BSEE's on-site inspections and incident investigations by providing a common data set. While BSEE inspectors are on a rig, Leimkuhler stated, they spend a lot of time going over paperwork and documentation. By reviewing the paperwork before arriving on site, the inspector could spend more time examining equipment and observing operations.

Leimkuhler added that any new regulation should be performance-based and should not require a fixed structure, building, or office to house the RTM capability. Instead, the operator should be allowed to document how the data stream is (*a*) accessed in real time, (*b*) archived, and (*c*) accessed for use by the operator and contractors on a real-time and post-event basis to enable safe operations.

Noble Energy

Lisa Grant

Noble Energy's response model empowers the people on the rig, where the expertise is located, to make decisions. In case of a well control or process safety event, the rig team can act quickly. Noble's use of shore-based RTD monitoring assists the rig team, but does not take over the operation. An independent operator, Noble does not have a dedicated remote RTM center, and its use of RTD is not on a 24/7 basis. Noble does target high-risk or extremely complex operations for remote RTM—examples include jetting operations, critical formation integrity test operations, and pore pressure estimation—when it may want a second "pair of eyes" for collaborating with the rig team. Noble does not monitor a standard set of parameters and does not believe that all wells should be monitored. Because it has limited resources, Noble reviews each well to determine—on the basis of risk—if monitoring will benefit the operation.

Predictive software could be used to determine baseline trends and to flag deviations; examples include torque and drag modeling, equivalent circulating density (ECD) prediction, pore pressure prediction, and pressure profiles of production functions. But models are only as good as the data that go into them. Automation is not a viable option until sensor data and related processes are reliable and consistent, without a significant number of false alarms.

CBM could be used for preventive maintenance of equipment, where RTD-driven algorithms are used to create notifications on the basis of usage and estimated wear and tear instead of predetermined scheduled time intervals. Examples could include monitoring actual ton-miles for slip and cut procedures, BOP actuations and utilization for rubber-goods replacement, casing tests scheduled on the basis of anticipated wear as a function of rotating and tripping hours, and monitoring annular pressure buildup changes in production wells.

Grant suggested that BSEE monitor simple systems and fundamental safety systems to ensure compliance, such as BOP testing, purge alarms, and gas detectors. Although the remote monitoring of downhole data can be subjective and impede situational awareness of what is happening on a rig, BSEE could use RTM to supplement its compliance enforcement through such items as checking the frequency of BOP test results and BOP testing and functioning, as well as the frequency of casing test results. Another suggestion is that BSEE establish key performance indicators (KPIs), along with incidents of noncompliance (INCs), to help perform trend analysis and to understand compliance, and maybe even to discourage noncompliance between inspections.

In addition to monitoring simple safety systems to ensure compliance, Grant suggested, BSEE should provide guidelines for sensor accuracy and precision and guidelines on communication protocols for data transfers. However, new measures should not replace BSEE inspections on the rigs.

BHP Billiton

Steven Kendrick

An independent operator, BHP Billiton (BHPB) has RTM capabilities, and RTD are accessible to drilling and completions teams, including third-party vendors; however, BHPB does not staff a remote 24/7 RTD center. BHPB does have a room set up in its Houston, Texas, office where onshore personnel can remotely review operational data for drilling and completions and can communicate and collaborate with rig personnel. BHPB requires continuous monitoring of well-control data by rig personnel—BHPB and third-party personnel—but the company does not require remote RTM.

BHPB does not use automated or predictive software for drilling operations, although alarms are used on the rig to call attention to data that have left an expected range and should be reviewed. If automated or predictive tools are designed, they would be best suited for on-site use, because situational awareness of the rig is important. Some predictive software is used during well planning to indicate what to expect during operations, such as torque and drag and required pump pressure at different pump rates. When the data begin to deviate from planned parameters, rig personnel are likely to seek assistance from onshore.

The newer generation of rigs allows equipment manufacturers to log in remotely for troubleshooting and support of BOPs and some critical rig systems. Kendrick added that operators should investigate any additional functionality offered by equipment manufacturers.

Although it would not be in real time, BSEE could use archived data to understand issues, to verify information on International Association of Drilling Contractors reports, or to help in incident investigations. For BHPB, archived data goes back more than 12 years. BSEE could use RTM to supplement the monitoring of BOP test pressure and the reviewing of pressure test charts, but it should not replace on-site inspections because of the importance of BSEE's physical inspection of the rig.

Even with RTD available, BSEE would have a difficult time deciphering the data without full situational awareness of rig operations. Another suggestion from Kendrick was that BSEE could require the use of RTM for well-construction decisions and troubleshooting and for supporting rig personnel in making well-safety decisions. This type of requirement would not necessitate a center that was staffed 24/7.

Murphy Oil

Dale Bradford

Murphy Oil is an independent exploration and production company that uses RTM for offshore operations and for improving information exchange between rig personnel and non-rig personnel. RTM technologies allow data streams to be recorded and available continuously; however, the data are viewed and analyzed by a wide variety of support personnel on a continual basis. Murphy's operational and business models do not support a requirement for a dedicated remote RTM center with 24/7 staffing. In the event of a major well-control or well-containment incident, Murphy can access a 24/7 RTM center as a member of the Helix Well Control Group.

According to Bradford, Murphy monitors most available drilling data streams, including such drilling parameters as pit volume totalizer, weight on bit, rotations per minute, torque, flow in and flow out, rate of penetration, and equivalent circulating density and formation evaluation parameters such as resistivity, gamma ray, density-neutron, and gas levels. For exploration wells, Bradford reported that Murphy monitors real-time pore pressure and pressure-to-fracture gradient window analysis; for some development wells, Murphy uses the RTM center provided by the contractor. Drilling contractors and service companies employed by Murphy also collect and use data, although it may be for different purposes. For example, these contractors may be more interested in equipment performance and will monitor BOP controls and status, equipment condition, maintenance status, and other parameters from the contractors' facilities. Murphy is more interested in how equipment performance may impact the

overall drilling performance. For Murphy, any decision to use RTM is driven by the business case. For offshore drilling, and for some onshore drilling operations, a sound business case does exist for targeted, continual monitoring; however, Murphy does not believe that a sound business case exists for a 24/7 continuous monitoring center. Generally, Murphy does not use automation and predictive software in its operations, although limited predicted software is used for pore pressure and mud window analysis on certain wells. Bradford stated that in Murphy's view, the downhole environment is highly variable; any use of automation and predictive software should be limited because existing technology may be insufficient to accomplish the task and data streams may be unreliable. Any excessive reliance on automation, remote tools, or remote monitoring could undermine rig authority and lead to distractions and misinformation.

Bradford stated that drilling contractors are currently using CBM for their engines, dynamic positioning (DP) systems, BOPs, and other critical equipment, with some contractors having remote access and troubleshooting capability. Contractor and OEM personnel have the expertise to use CBM to manage the performance and safety of their equipment, but Bradford does not believe that BSEE has the necessary staff experience to leverage this technology.

Bradford believes that BSEE could use remote RTM for BOP witness testing that supplements on-site witness testing and that contractors could modify software to allow access to the data. Potential issues with remote witnessing include the accurate recording of valve positions, the remote understanding of test results, and access to and security of the data. Current BSEE inspections of offshore facilities involve data collection and data review. Bradford suggested that there could be value in making these data available remotely or prior to the inspection, so that the inspector can target specific areas or spend more time onboard talking to the rig personnel to determine overall competence, which is the real importance of on-site inspections. He also suggested that BSEE abstain from prescriptive rulemaking RTM protocols. Many offshore operators, contractors and service companies use a wide range of data streams on a continual basis, with each company having a different business case for using RTM. He added that the industry could do a better job of improving how the data are collected, integrated, and stored.

Discussion

During the discussion, the committee asked whether any direct benefit to HSE exists from the use of a remote RTM center, either from the technology or from established processes. For Shell's Gaston, the direct benefits to HSE are difficult to quantify, but one benefit is better team integration and better data quality. Several panelists stressed that RTM provides a lot of value in efficiency and saving money in well planning, and in the ability to recreate and understand events, but that from an HSE perspective,

remote monitoring has not caught an event before rig personnel have. Additionally, an important point of after-the-fact reviews of drilling operations is that a lot of those data were not necessarily being streamed off the rig in real time, but were only being stored on the rig. Data are definitely useful after the fact, and many of the panelists noted that their companies collect, aggregate, and archive data from multiple sources for this purpose.

When asked about the proposed BOP rule and monitoring all control aspects of the BOP system, many panelists agreed that the BOP is something that could be monitored, because it remains in a relatively static state most of the time. The BOP is close to an independent system that is isolated from the influence of the wellbore. However, LLOG's Leimkuhler would refer to the drilling contractor and BOP owner for advice on how to manage the monitoring of the actual parameters and the data stream from the BOP. Similarly, Fett stated that Total does not perform a lot of BOP monitoring, relying on the drilling contractor, but he declared that the BOP is part of a larger system and that Total, as an operator, is ultimately responsible for interfacing with the contractors and for managing all the associated risk. Gaston added that Shell does remotely monitor BOP tests and could stream all data into its office, but the ability to monitor the whole system on a continual basis is in an early state.

From the discussion, operators employ different models of RTM. The panelists reported that many companies would require a business case to justify the use of RTM or support building a dedicated remote monitoring center. Many panelists agreed that there is value in collecting and aggregating the different streams of data, but the value lies more in improving operational efficiencies than in well control. When asked about the time needed to start an onshore remote monitoring capability, LLOG Exploration's Leimkuhler responded that the initial setup of the information stream and screens can take place within a week. As far as developing trust and confidence in someone who is looking over your shoulder at the data, the time needed could be about 6 to 8 months. That period could be shorter if the interaction were to take place offshore on the rig, rather than in an onshore–offshore collaboration.

The amount of involvement or interfacing that operators have with contractors' monitoring of equipment varies between organizations. Operators rely on contractors to monitor and maintain their equipment in a safe manner, but operators will serve as facilitators in order to make proper risk decisions. Drilling contractors and operators use RTD in different ways, often to accomplish similar objectives. According to several panelists, the bridging or well construction interface documents establish that well control maintenance and equipment are the contractor's responsibility, but usually do not go into explicit detail about the different uses of data. Operators do use third-party auditors to review maintenance and control systems.

THIRD-PARTY RTM PROVIDERS

Anil Wadhwa

As part of a combined presentation, Anil Wadhwa of Baker Hughes started this panel session by providing answers to questions where general agreement existed among the panelists. From the perspective of third-party providers, real-time well monitoring involves the acquisition and aggregation of sensor data that are transmitted in a secure format to a data center where the data are processed before being made available to the end user. The main role of the third-party provider is to gather well data on behalf of its client, usually the operator, and then deliver the data to subject-matter experts; all decision making and all accountability belong to and remain with the operator. The service companies do use some level of automation and remote control, mainly for performance assurances and operational efficiency of equipment. The panelists who spoke agreed that RTM can supplement decision support for field operations through alarms and alerts, knowledge management, and data interpretation, and can also help with the predictive and preventive maintenance of safety equipment.

Schlumberger

Kevin Goy

Schlumberger, a large solutions and services provider, generally uses RTM information for performance assurance. To Schlumberger, real-time centers allow a collaborative approach to support operations by providing access to a global network of expertise, consistent situational awareness, and improved communications across all stakeholders. According to Goy, Schlumberger does monitor critical operations and uses CBM, especially for sensors on the bottom-hole assembly that provide shock and vibration information; the principal focus is on reducing nonproductive downtime. Schlumberger's five key lessons from running a RTM center include the importance of

- Developing companywide standards (e.g., RTM hardware, data security, and key performance indicators);
- Formalizing industrialized workflow for improved oversight and chain of command (i.e., who does what and when);
- Understanding your personnel, knowing their expertise, and having the right people in the right places;
- Having escalation and communication protocols established prior to the start of a job; and
- Using appropriate advanced monitoring tools.

Halliburton

Andreas Sadlier

Halliburton, also a large solutions provider, offers services and information at the direction of the operator or customer for improved operational decision making. For Halliburton, automation is limited to alarms and alerts in an effort to improve data quality (assurance and control), but potentially also workflows and decision making. Halliburton does not use predictive software. The company bases protocols and the chain of command on best practices and on the contract and service documents that are defined prior to the job start. Like the other panelists, Halliburton does typically monitor critical operations and parameters and uses CBM for downhole tools and equipment performance. According to Sadlier, RTM is a great training tool that allows someone to be exposed to various types of operations without having to travel to the various sites.

Sadlier believes that, to incorporate RTM technologies into BSEE's existing regulations, BSEE will have to understand the many different workflows and protocols and the different types of expertise needed for this technology. More important, BSEE must understand the challenges of collecting, distributing, managing, and securing the data.

Weatherford

Chuck Salminen

Weatherford, a large solutions and services provider, supplies RTM data and key information to rig personnel for decision making. Although it is mainly used for optimizing performance, RTM can help manage costs and avoid potential hazards. Data security is important; a well-established and auditable communications trail should exist between the remote center and the rig site. Although most communication protocols between onshore and offshore personnel exist on a client-by-client, project-specific basis, the rig always maintains authority.

As for critical operations and parameters, Salminen stated that Weatherford would prefer to monitor anything that has the potential of generating a critical safety event. If a remote RTM center will be asked to provide the same level of insight as if it were on the rig, then all rig data should be transmitted to the remote center; the scope should not be limited. For many of these critical sensors (e.g., pit levels, total gas, flow, casing pressure, and choke and kill line pressures), redundancy is important.

Depending on the definition of "predictive," Salminen stated, Weatherford uses predictive software for such things as hydraulics, kick, torque and drag, and wellbore stability. At the well site, the rotary steerable tool does have some automated capability in setting a path and maintaining a heading. Weatherford has the capability, with managed pressure drilling systems, to do automated kick and loss detection and

control at the rig site, but this is not something that they would want to do remotely. CBM is used to track the health and performance of equipment, both surface and downhole; this helps with preventive maintenance.

Petrolink

Lee Geiser

Petrolink is a vendor-neutral service company, meaning that it does not have sensors at a rig site. Petrolink works under contract for operators, who provide the data standards to be followed by Petrolink in acquiring data, aggregating and integrating data, and then processing and analyzing data. The role is to ensure that all the data that are produced at the well are captured and delivered; the data then become the property of the operating company. Petrolink can create alarms and alerts on the basis of parameters identified by the operator. Standardization of data formats and content could improve the efficiency of this task.

University of Texas at Austin

Eric van Oort

Third-party providers collaborate with operators and offer enabling tools, processes, and subject matter experts that help operators achieve operational excellence (in both performance and safety) in onshore and offshore well construction. Operational decision making and accountability should always reside with the operator, although contractors should be accountable for the quality and accuracy of information they provide. The chain of command and communication protocols should be tailored to the operator's existing structure.

Critical operations for operators include pressures, loads and torque, volumes, flow rates, temperatures, and operational readiness of equipment.

Van Oort suggested that regulators could monitor parameters associated with regulatory compliance and with the prevention of catastrophic events, such as blowouts and spills, but not monitor the day-to-day drilling operations and performance management. His presentation included historical data showing that the contributing factors for most U.S. blowouts between 1992 and 2006 were casing and cement evaluations, followed by drilling-event detection and BOP reliability verification.

CBM of critical equipment could play a role in areas such as monitoring top drives, mud and cement pumps, and BOP operation, as well as the regulatory information required by the operator, such as BOP tests, casing and shoe tests, and production casing high and low tests. All of this would require subject matter expertise, reliable input data, and state-of-the-art modeling algorithms to minimize false positives. To leverage RTM technologies, van Oort believes that BSEE could

build collaborative relationships and learn from experienced operators. He also suggested that BSEE could focus on events that have historically caused blowouts, and consider vendor-neutral IT infrastructure and commercial-off-the-shelf (COTS) solutions.

Panel Summary

Before opening the discussion, Anil Wadhwa of Baker Hughes summarized several repeated themes heard during the presentations:

- Although full-time remote RTM centers are possible and can support field operations, there is a cost.
- The ultimate responsibility for operations should remain with the rig and well personnel.
- Data generated from the rig belong to the operators.
- Despite technological advancements, reliable service is not 100% guaranteed.
- Cybersecurity issues and the use of mobile devices to display information have added additional risk to cloud-based services.

Discussion and Observations

Many panelists noted that remote monitoring centers (and technology) do not detect issues or well-control events before rig personnel do. The RTM centers of the service companies are looking primarily at equipment performance and trends and do not monitor well control. One panelist observed that remote centers complement the rig and that any interventions are specific to the provider's own equipment; to clarify, there is no "big red button" inside the operations center to shut everything down. However, van Oort stated that, while working at Shell, he had seen red-flag interventions from the center that averted a well-control event.

Many on the panel agreed that data latency is a lesser issue; there is more bandwidth to and from offshore than there was 5 years ago. Available information technology and data flows are evolving rapidly and current top-end solutions are likely to become obsolete within 5 years. Several panelists suggest that regulating in this environment is difficult and flexibility should be built in. Regulations for monitoring centers designed around today's technologies are also likely to become obsolete within 5 years.

Each operator has its own data requirements when interfacing with multiple contractors. Although standards do exist, several panelists stated that the standards are not always followed. Overall, many of the panelists suggested that the industry should agree on standards in order to exchange data faster. However, there is no real agreement across operators about what data they want to receive and how they want

to receive those data. Determining critical information may be essential in moving forward, but the panelists also suggest that industry needs to provide better or more reliable data, not just more data.

John Cushing of BSEE noted that the day's presentations and industry feedback validate many of the findings of the *Summary of BSEE's Real-Time Monitoring Study* (BSEE 2014). The oil and gas industry uses a wide range of RTM technologies and a standard approach clearly does not fit everyone. Situational awareness is important, and viewing data without the situational context can be misleading. Cushing suggested that the bigger question surrounding RTM technology could be about drilling safety and the roles of the industry and the regulator concerning drilling safety.

PRODUCTION OPERATIONS

Chevron

David Stevens

As a large operator, Chevron's decision to use RTM for production operations, which are largely steady state in nature, is driven by business need—primarily for production optimization, efficiency, and reliability. The company uses RTM to monitor, diagnose, and troubleshoot rotating equipment. Chevron's goal is to limit downtime, but Stevens does not believe that specific types of wells or operations and parameters should always be monitored. Chevron does not monitor its production facilities on a 24/7 basis and does not use RTM as a safeguard for personal safety or for process safety.

According to Stevens, Chevron uses predictive tools for leading indicators on rotating equipment and reservoir production management, and the company has seen tremendous benefit using CBM—or what Chevron considers RTM—for rotating equipment performance and reservoir management. Chevron's Stevens believes that BSEE should explain its intent better, or should define its objective for requiring the use of RTM technologies for anything beyond industry's current practice of using it for optimization, efficiency, and reliability.

Marathon

Chris Hall

Marathon is an independent operator that has some capabilities for monitoring remote operations, but these capabilities have only been used for hurricane evacuation. Information is transmitted to an onshore facility that has the functionality to replicate what offshore personnel can view, but the facility is not staffed 24/7. More often, RTM is used for remote diagnostic support of on-rig processes. The data could be used for earlier detection and notification of machinery failures.

CBM, along with predictive software, could provide the ability to schedule maintenance and proactive response to equipment failure. CBM is important elsewhere around the world, but Marathon does not use it in Gulf of Mexico operations because of aged technology and the limited bandwidth of current Gulf installations.

Hall suggested that data could be published to a browser-accessible Internet facility that provides BSEE with the capability of viewing or archiving specific data as needed. Because the data provided would not be digested in real time, Marathon, according to Hall, considers such efforts by operators to be not entirely useful. Although technology could reduce the number of trips that BSEE inspectors would have to make to offshore facilities, RTM should not preclude or replace on-site inspections. Also, questions remain as to whether BSEE would be able to hire an adequate number of subject matter experts for any proposed RTM operation. Hall noted that operators already enter some production data to an external website, but visiting BSEE inspectors may not be effectively viewing or using these data on a regular basis. BSEE's use of RTM technologies could be constrained by such issues as cybersecurity and companies' unwillingness to share all data. Additional constraints on BSEE's use of RTM include issues of intellectual property rights, weather and bandwidth limitations, and perceived and actual safety gains. Also, many facilities in the Gulf of Mexico are older and not equipped to facilitate RTM. What are the costs and the unintended consequences that could appear if RTM were required on all facilities? At the end of the day, Marathon's Hall believes that on-site inspections by BSEE are still needed.

Stone Energy

Steve Bodden

As an independent operator, Stone Energy's perspective is that all command and control should occur at the offshore facility. RTM has value for viewing operations and providing information for decision making, but the technology is used primarily for surveillance of well information and rotating equipment and for creating trend data. Stone does not have specific criteria for installing RTM capability, but does see a business case for its use in a production field with at least 3 years remaining, justifying the RTM costs for surveillance only.

Bodden believes that BSEE could perform parts of the annual inspections on specific platforms via video conference for control room visits, but this does not allow BSEE to assess the physical condition of the facility. Although video conference or control room visits for component testing of safety devices could reduce the number of offshore trips by BSEE inspectors, BSEE should not eliminate on-site inspection visits, which continue to provide considerable value. Bodden recommended that that BSEE not require mandatory upgrades of current pneumatic control systems and electronic control systems.

Anadarko

Amro Hamza

Anadarko is a large independent operator. Its onshore facility in The Woodlands, Texas, is not staffed 24/7, and any maintenance activities are limited to daytime hours. All offshore production facilities maintain responsibility and control. Like the other panelists, Anadarko uses CBM for large rotating equipment to predict possible failure, but this is a response to a business need (to limit down time), not to a safety need.

Hamza believes that BSEE should continue with annual inspections and not replace them with RTM. Anadarko performs and records monthly inspections. If BSEE would like to review these inspections, the data are available; however, witnessing inspections on the screen does not add confidence and should not replace annual inspections. RTM is an operational tool used to support offshore staff. As an oversight tool, RTM might not add value and may give offshore personnel a false sense of security.

Shell

Tom Moroney

Like other panelists, Shell has invested in RTM centers for production because a business case exists for them. Shell's collaboration centers support more than 60 facilities around the world and span the asset's life cycle. These centers share a common methodology, standardized technical solutions, and a high level of communications that capture lessons learned and allow for rapid sharing of information. The flow of information is important.

Shell does use CBM for the surveillance and maintenance of its equipment and sees value in its use. Moroney does not necessarily see a role for BSEE in CBM and does not believe BSEE can leverage a specific technology. Overall, he noted, Shell would rather see BSEE set performance objectives than prescribe RTM rules.

Discussion

Many of the panelists for production operations stated that RTM facilities send data by satellite and generally do not send video feeds from offshore (other than to and from the control room). For CBM of large rotating equipment, the operators on the panel suggest that this work is well integrated with OEMs or with third-party providers, or both. The operators represented on the panel felt that CBM allows them to intervene with critical equipment information before failure occurs, but this intervention often uses archived data or fleet data and does not necessarily rely on RTD. The general process is to capture data, analyze data, produce trends, and make decisions, but this process is not instantaneous (i.e., real time).

During the discussion, some of the panelists were asked to clarify RTM. To many on the panel, RTM is the ability to get information in real time for the operators, who are usually stationed on the rig. Remote RTM provides the same capabilities, but from a remote location. Additionally, the term "remote real-time command-and-control oversight" means that someone (usually at a separate location) contacts an offshore installation and requests that an action take place, either through human intervention or through automation. Many of the panelists responded by saying that although communication and consultation with onshore personnel are encouraged, all decisions are made by the production personnel offshore.

DRILLING CONTRACTORS AND EQUIPMENT MANUFACTURERS

Harris Reynolds, Jean-Paul Buisine, Tony Hogg, Brian Wright, and Daniel Marquez

Harris Reynolds of Diamond Offshore Drilling presented highlights from the discussion of the panel of drilling contractors and equipment manufacturers, while other panelists added remarks as necessary. Drilling contractors perform drilling, completion, and well-test operations for operators using drilling units that they own and operate, normally on a day-rate basis. Although contracted by the operators to perform operations at their direction, drilling contractors are ultimately responsible for the safety of the rig and of all the personnel operating on the rig. On-rig automation is commonplace for activities such as pipe racking and power management and other items where a business case has been made, especially in the area of safety. According to Reynolds, no offshore drilling rig has any process that is automated or controlled remotely from onshore. All command and control is located on the rig. He added that the chain of command on the rig has been well established and that decision making should include the situational awareness of all rig activities. Until there is solid evidence that equipment condition or status can be determined from data alone, Reynolds noted, RTM should continue to be a supporting tool for the existing chain of command on the rig. Adding an additional layer of management does not improve safety. Drilling contractors typically collect and provide all available data to the operators to use at their discretion. Normally, a list of which data an operator requires is written into the contract and the list rarely changes. Some contractors monitor equipment remotely using CBM and preventive maintenance, but this does not necessarily happen in real-time; data are usually archived and analyzed later. Given the right communication infrastructure, personnel onshore have the ability to see what personnel on the rig see, but this ability to transfer data in real time is not on every rig.

As for critical operations and parameters that should always be monitored, Reynolds noted that drilling contractors believe that all wells and offshore operations are critical and that they supply all data, as defined in the contract, to the operators. In addition, he highlighted that the U.S. Coast Guard defines critical outer continental

shelf activities in 33 CFR 140.305 under new Subpart D, and suggested that federal agencies synchronize divergent standards.

BSEE would like to leverage RTM technologies to reduce the number of trips offshore, but several panelists suggest that inspectors would not have full situational awareness unless they are on the rig. Reynolds suggests that any attempt to leverage remote RTM technologies should be prototyped before implementation, for example, by having BSEE inspectors wearing body cameras and microphones during BOP tests. Many of the panelists agreed with others at the workshop that such technologies should supplement, but not replace, inspections. Inspectors could have access to reports on BOP test results and equipment condition before the inspection. This would provide more of an operational perspective, so that inspectors could concentrate more on how the rig is operating as a whole and less on reviewing paperwork. Additional issues and risks of BSEE using remote RTM oversight include the training and experience requirements for onshore personnel and potential legal liability connected with BSEE oversight of drilling operations.

Brian Wright of CAD Control Systems discussed cybersecurity concerning industrial control and automation systems that are designed to work in harsh environments and for long life spans. Such a system is tested very thoroughly and is not touched again; historically, remote connectivity and security were not part of the original system design. Applying Windows security patches to industrial control software could have severe repercussions because of potential incompatibility issues. Wright also discussed the issue of the Stuxnet computer worm.[2]

Many of the panelists agreed that one important step to improve offshore safety is to address the competency of rig personnel through the ISO 17969 Guidelines on Personnel Competency.[3] This initiative has not been adopted by the industry but could be an important reference for such a discussion, and should be consider when advancing a requirement for an additional "set of eyes" to review operations from an onshore facility. Another important step involves training and the use of advanced well control simulators that are currently used throughout the drilling industry. Such simulators provide insight into issues faced by subsea engineers and supervisors.

Discussion

Several panelists stated that remote RTM of the BOP control system is available, and that personnel would have the capability of viewing all the data from the control system that the rig personnel see, but that remote monitoring is not currently being done. They added that the available data include hydraulic pressures, opening and closing pressures, and volumes, for example, but not the actual positions of the BOP rams. The technology to detect ram positioning may be available, but the main

[2] An overview of Stuxnet is available at http://spectrum.ieee.org/telecom/security/the-real-story-of-stuxnet/ and https://www.tofinosecurity.com/stuxnet-central.

[3] See http://www.iso.org/iso/catalogue_detail.htm?csnumber=61167.

issue remains deploying it in harsh subsea operating conditions while still producing reliable results. Until reliability approaches 100%, the danger of a false positive will prevent contractors from adopting the technology. Monitoring of BOP health is something that exists with current technology, mainly to determine how much life is left in the BOP, but BOP health is not monitored in real time or 24/7. Drilling contractors generally want to optimize maintenance practices.

TRADE ASSOCIATIONS

Holly Hopkins, Evan Zimmerman, Alan Spackman, and Anton du Preez

Many of the panelists agreed that remote RTM is used by shore-based personnel as a support tool to improve the efficiency of certain wellsite operations, which may also favorably impact safety and the environment. RTM technology is widely available, but its use is determined by an individual operator's business case. Some of the panelists suggested that BSEE clarify whether its intent for RTM focuses on safety, on improving oversight and reducing BSEE's inspection burden, or on BOP health monitoring and forensic investigation. Before determining the probable effects of RTM on the industry, the panelists would like to understand what objective BSEE is trying to achieve or what problem BSEE is trying to solve with RTM requirements.

The RTM requirements for drilling operations would be very different from the requirements for production operations, and these requirements are likely to affect the available labor pool for both industry and the regulator. Many of the panelists do not believe RTM should be a regulatory requirement. Some panelists proposed that any new rule be coupled with a clear understanding of what data are required, who will be able to view those data, and how the data will be used. The concern expressed during the presentations is that the access to or transfer of data be structured in such a way that the security of vital equipment and systems is not compromised. One panelist indicated that industry members would need to evaluate possible impacts and modifications to their internal procedures and management systems carefully. The new requirements could introduce uncertainty into the chain of command, have significant impacts on smaller operators, and potentially change competitiveness in the Gulf of Mexico. Additionally, one of the panelists suggested that BSEE clarify how the new requirements would interact with existing regulations on obligations and liabilities of contractors who are performing the activity.

A forum for the development of consensus-based industry standards and technical cooperation to improve industry safety performance and competitiveness is provided through the American Petroleum Institute (API). Many of the panelists suggested, however, that development of recommended practices or standards would be premature until the objectives and desired benefits of RTM were better understood. A robust understanding of RTM components that add benefits and produce a positive impact on safety is needed for both industry and regulator. The establishment of

common definitions is important because various actors in the industry may have different interpretation of what operations are critical. Trade associations can function as a forum for dialogue and a hub for sharing safety-related values of RTM. One panelist suggested that BSEE can do its part as a regulator to help coordinate information gathering and to cooperate on RTM research. The panelist added that BSEE can act as a conduit for the dialogue in evaluating RTM risks and for identifying unintended consequences of proposed requirements. API has assembled an RTM subgroup that includes more than 120 members, but the ultimate objective of this workgroup is to respond to any potential proposed rulemaking and then be responsive to this committee. According to one of the panelists, the industry does not agree that a best or recommended practice or a standard on RTM is needed, including what elements to consider.

As technology advances, RTM will continue to evolve. If regulatory requirements are to remain current and relevant, some of the panelists suggest that BSEE consider performance-based rules to achieve shared goals of responsible operations. Industry's main concern is trying to understand the perceived problem that BSEE is trying to solve by pursuing RTM requirements. RTM is one tool that could be used to achieve safe and responsible operations. If BSEE could provide a defined problem statement or a design-based type question, then industry could convene the necessary expertise to begin this discussion.

ADDITIONAL OBSERVATIONS

During the last session, Chair Richard Sears noted that the presentations and discussions from the 2-day workshop expressed many common themes and observations, but he emphasized that the committee is still gathering information and deliberating and is not ready to make any findings, conclusions, or recommendations. Any findings and recommendations will be included in the committee's final report, which will be released in 2016.

Several other participants during the open discussion periods of the workshop did provide comments. Sandi Fury of Chevron appreciated the discussion of RTM at the workshop but noted that the discussion was incomplete. She remarked that the workshop had lacked a discussion on how to drill safely or operate a production platform safely and that RTM is only one of many tools that support safe operations. Additionally, areas of concern, such as data quality and cybersecurity, should be addressed in future forums. She added that there is a willingness on the part of industry to have a discussion about RTM, but that there is a lack of understanding of what problem BSEE is trying to address with these requirements. Acknowledging the importance of these issues and concerns would be necessary for the success of any RTM program. She said she hoped that BSEE will recognize this need before moving forward with this rulemaking.

Robert Conachey with the American Bureau of Shipping made observations about BSEE's possible collection and use of data. His initial concerns centered on the potential legal and immunity issues that could arise when an operator provides data before an event occurs. He also questioned how proprietary technologies would be protected, given the competitiveness of the industry. Additionally, he cautioned that collecting more data after an event—focused on that event—may not be the best plan of action, since that type of event may not ever occur again. He suggested risk-based studies, such as failure mode and effects analysis, as one possible way to understand system functions and to identify failure modes, which, along with condition monitoring techniques, could help determine future maintenance needs. The data analysis could focus on probabilistic rather than deterministic methods.

Bill Nelson with Det Norske Veritas Germanischer Lloyd agreed on the importance for industry to identify or clarify the necessary decisions and the information required to make those decisions. He added that identifying the information and decisions is important for the regulator, which could benefit from some sort of common framework for its regulatory decision making.

Echoing the concerns of Conachey about collecting more data on previous events that may not happen again, Nelson notes that the nuclear industry faced a similar problem in planning for accidents after the Three Mile Island incident—knowing that severe accidents were possible, but not knowing what they might look like. In addressing this concern, the Nuclear Regulatory Commission developed an approach called Critical Safety Functions for systematically identifying the information needed to manage potential accidents without having to identify every possible scenario.[4]

REFERENCE

Abbreviation

BSEE Bureau of Safety and Environmental Enforcement

BSEE. 2014. *Summary of BSEE's Real-Time Monitoring Study*. U.S. Department of the Interior. http://onlinepubs.trb.org/onlinepubs/sp/Cushing_Summary_of_BSEE_RTM_Study_March_2014.pdf.

[4] For more information on Critical Safety Functions, see http://www.ans.org/pubs/journals/nt/a_32814.

APPENDIX A

Workshop Agenda

APPLICATION OF REAL-TIME MONITORING OF OFFSHORE OIL AND GAS OPERATIONS: WORKSHOP

Committee on the Application of Real-Time Monitoring of Offshore Oil and Gas Operations

April 20–21, 2015
Hyatt North Houston, Grand Ballroom
425 North Sam Houston Parkway East
Houston, Texas 77060

MONDAY, APRIL 20, 2015

7:30–8:30 a.m.	Registration, coffee, and networking
8:30–9:00 a.m.	**Open Session**
	Welcome, Committee Statement of Task, and Larger Real-Time Monitoring Picture Richard Sears, *Chair*
	Overall Importance of Real-Time Monitoring for BSEE Susan Dwarnick, BSEE
9:00–10:30 a.m.	**Panel 1: Large Operators Drilling Real-Time Monitoring** Darry Fett, Total Barry Gaston, Shell
10:30–10:45 a.m.	Break
10:45 a.m.–12:30 p.m.	**Panel 2: Independent Operators Drilling Real-Time Monitoring** Joseph Leimkuhler, LLOG Exploration Lisa Grant, Noble Energy Steven Kendrick, BHP Billiton Dale Bradford, Murphy Oil

12:30–1:45 p.m.	Lunch
1:45–3:30 p.m.	**Panel 3: Third-Party Real-Time Monitoring Providers** Anil Wadhwa, Baker Hughes Kevin Goy, Schlumberger Andreas Sadlier, Halliburton Chuck Salminen, Weatherford Lee Geiser, Petrolink Services, Inc. Eric van Oort, Genesis RTS
3:30–3:45 p.m.	Break
3:45–5:00 p.m.	**Day 1 Summary** Richard Sears, *Chair*, moderator

TUESDAY, APRIL 21, 2015

7:30–8:30 a.m.	Registration, coffee, and networking
8:30–8:45 a.m.	**Open Session** Richard Sears, *Chair*
8:45–10:30 a.m.	**Panel 4: Large–Independent Production Operations RTM** David Stevens, Chevron Chris Hall, Marathon Oil Steve Bodden, Stone Energy Amro Hamza, Anadarko Tom Moroney, Shell
10:30–10:45 a.m.	Break
10:45 a.m.–12:30 p.m.	**Panel 5: Drilling Contractors and Equipment Manufacturers** Daniel Marquez, Athens Group Jean-Paul Buisine, Transocean Tony Hogg, Pacific Drilling Brian Wright, CAD Control Systems Harris Reynolds, Diamond Offshore Drilling

12:30–1:45 p.m.	Lunch
1:45–3:00 p.m.	**Panel 6: Trade Association Perspective** Holly Hopkins, American Petroleum Institute Evan Zimmerman, Offshore Operators Committee Alan Spackman, International Association of Drilling Contractors Anton du Preez, National Ocean Industries Association
3:00–3:15 p.m.	Break
3:15–5:00 p.m.	**Open Discussion, Questions and Answers, Summary, and Path Forward** Richard Sears, *Chair*, moderator

APPENDIX B

Questions for Discussion

General Questions for Operators, Drilling Contractors, and Equipment Manufacturers (Panels 1, 2, 4, and 5)

BSEE [Bureau of Safety and Environmental Enforcement] is interested in establishing minimum requirements for the use of real-time monitoring in its regulations.

- Does your company use real-time monitoring for its offshore operations? If not, why?
- If your company does use real-time monitoring, what are the critical operations and specific parameters that your company monitors?
- Do you believe there are specific types of wells or operations and parameters (for drilling, completions or workovers, or production operations) that always should be monitored with real-time monitoring?
- Are there specific criteria or risk thresholds that your company uses to prompt real-time monitoring requirements (e.g., factors such as well or water depth, frontier area, HP/HT [high pressure, high temperature] wells, or well complexity)?
- Does your company rely on any automation and predictive software in real-time monitoring?
- What role could automation and predictive software tools play in real-time monitoring?
- Condition-based monitoring is viewed by BSEE as monitoring the operating condition of critical equipment and using any generated data to predict and proactively intervene when needed.
  - As such, what role could condition-based monitoring play in real-time monitoring?
  - Describe how operating equipment using condition-based monitoring could be tailored and/or used for real-time monitoring.

BSEE would like to use real-time monitoring technologies to accomplish many of its safety and environmental protection responsibilities.

- Real-time monitoring technologies could be incorporated into BSEE's existing safety and environmental regulations in order to replace or supplement its on-site inspection program.

- How could BSEE leverage such technologies?
- Which activities could real-time monitoring supplement or replace?
- What opportunities do you see for BSEE to use real-time monitoring to provide timely, functional, and value added inspections?
- What would you recommend that BSEE do in the real-time monitoring area?

Additional Questions for Drilling Contractors and Equipment Manufacturers (Panel 5)

- What is the scope of your services?
- Briefly describe the relationship between your company and an operator.
- What level of automation and remote control is appropriate to balance the accountability, responsibility, and operational efficiency between both?
- What are your suggested protocols for remote oversight and the established chain of command? How do think this should work?

Questions for Third-Party Real-Time Monitoring Providers (Panel 3)

Specific questions:

- Describe the role of third-party providers.
- How do you interface with industry customers, and how do you view this relationship?
- What services do you provide?
- How do the services lend themselves toward operational decision making?
- What about accountability between the operator and your firm?
- What level of automation and remote control is appropriate to balance accountability, responsibility, and operational efficiency?
- What are your suggested protocols for remote oversight and the established chain of command?

General questions:

- Are there critical operations and specific parameters that are typically monitored?
- Does your company rely on any automation and predictive software in real-time monitoring?
- What role could automation and predictive software tools play in real-time monitoring?

- Condition-based monitoring is viewed by BSEE as monitoring the operating condition of critical equipment and using any generated data to predict and proactively intervene when needed.
  - As such, what role could condition-based monitoring play in real-time monitoring?
  - Describe how operating equipment using condition-based monitoring could be tailored and/or used for real-time monitoring.
- Real-time monitoring technologies could be incorporated into BSEE's existing safety and environmental regulations in order to supplement its inspection program.
  - How could BSEE leverage such technologies? What advice could you give to BSEE?
  - Which activities could real-time monitoring supplement or replace?

Questions for Trade Associations (Panel 6)

- How would BSEE's interest in establishing minimum requirements for the use of real-time monitoring affect your general membership?
- What advice would your general membership provide BSEE for incorporating real-time monitoring requirements into its regulations?
- How can trade associations support efforts by industry and regulator in standardizing each other's needs?
- If the broader offshore industry were to adopt real-time monitoring in exploration and production activities, what is a realistic time frame for where its use is the norm rather than the exception?

APPENDIX C

Panel Participants and General Attendees

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