Assessment of Real-Time Data Monitoring Systems

BSEE Bureau of Safety and Environmental Enforcement

Presentation of Findings | B3B Inc

4 Dec 2014

Introduction

- Discussion of the use of real-time data (RTD) to enable the Real Time Operations Center (RTOC) and the Real Time Monitoring Center (RTMC)
- Organized into seven tasks
- Broad industry overview of the use RTD and RTM
- Emphasis on the impact to safety
- Provide recommendations

Research Sources (1999-2013)

- 838 Inc. experience
- Interviews with 22 industry experts
- Industry Conferences
- OnePetro
- Oil and Gas Journal
- Oil and Gas IQ
- Offshore Magazine
- Oil, Gas, and Petrochem Equipment
- 47 other relevant journals and websites
- 400 Peer reviewed articles
- 3200 Studies articles, pamphlets, and websites

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Chapter 1

(Task 1) Assessment of the various types of real-time data monitoring systems available for offshore oil and gas operations

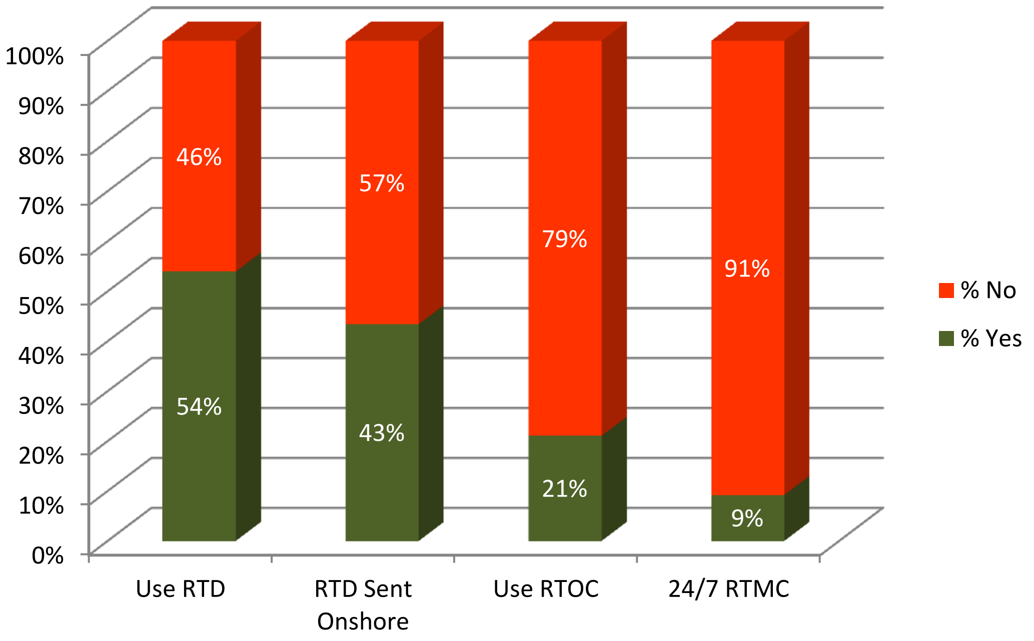
Best Available RTD Technology

Five categories for the Use of RTD

- Subsurface/Formation Analysis and Well Planning and Modeling Tools
- Wellbore Stability and Drilling Integrity (Downhole) Monitoring and Analysis
- Instrumentation for Drill Floor and Rig Operations
- Data Collection, Transmission Points, Wireless/Wired, Standardized Languages Bandwidth Requirements
- Onshore Center - Data Aggregation Standardized Interfaces / Screens / Display of Relevant Data, User Interface (UI), Predictive Capabilities, Monitoring/ Alarming Potential

Operators using RTD Technology

- Polled 164 oil & gas exploration and production companies with current operations in the GOM
- Responses received from 76 companies
  - 41 use Real Time Data (RTD)
  - 33 Send the data ashore
  - 16 use the data for RTOC
  - 7 use the data for RTMC



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Chapter 1 Conclusions

- Examined 4 implementations of RTOC/RTMC within the industry
- Advances in sensor technology (Best Available Technology) accelerating the use of RTD
- RTD is being used in the RTOC for well planning and reservoir modeling
- RTOC vs RTMC
- Company or Service Provider solutions for RTMC
- Fewer than half the companies using RTD, fewer than 10% RTMC

Chapter 2

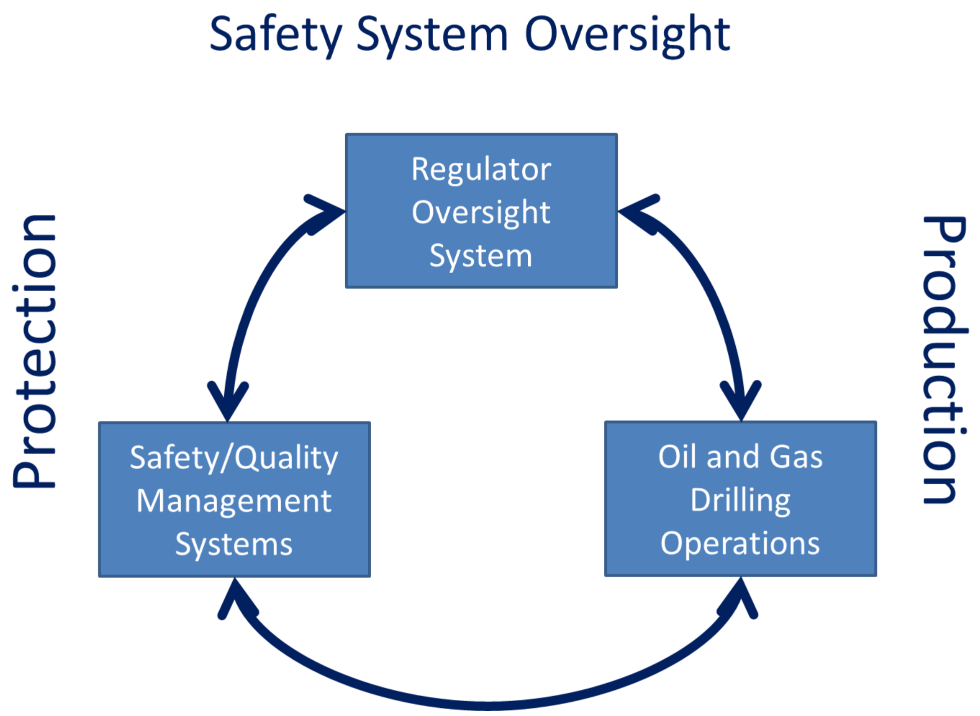
(Task 3) Discuss options for training programs or contracted services which would be needed to incorporate the identified systems into BSEE's process.

Foundation for Regulator Training

- Foundation for success
- System safety concepts:
  - Risk management strategy based on identification, analysis of hazards
  - Application of remedial controls using a systems-based approach
- Goal:
  - Optimize safety through identification of safety related risks
  - Eliminating or controlling risks by design and/or procedures
  - Based on acceptable system safety precedence

Safety Oversight System

- Regional Standards Office
- Principle Inspector (PI)
  - Intensive technical knowledge and skill
- Safety Inspector (SI)
  - Employ systematic tools ensuring operations comply with regulations and industry safety standards
- Safety and Risk
  - System Safety
  - Focus on Organization and Processes
  - Data Sharing



Training System Development

- Standardized Industry Data/Data Sharing
- Voluntary Safety Action Program
- Risk Management Process
- Training System Deployment
  - Development
  - Delivery
  - Sustainment
  - Currency/requalification standards

Conclusion/Recommendations

- The safety oversight model is a proven model that is used in other regulated industries
- The system safety model manages standardization of training and ensures the stakeholders continually generate industry best practices, evolving as technology advances
- Developing standardized training for BSEE to understand real-time data monitoring greatly enhances industry safety
- 3 Training Scenarios explored – recommend a combination of Scenario 1 and a hybrid of 2 and 3
- By implementing the safety oversight concepts discussed, industry collaboration becomes more available

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.

Chapter 3

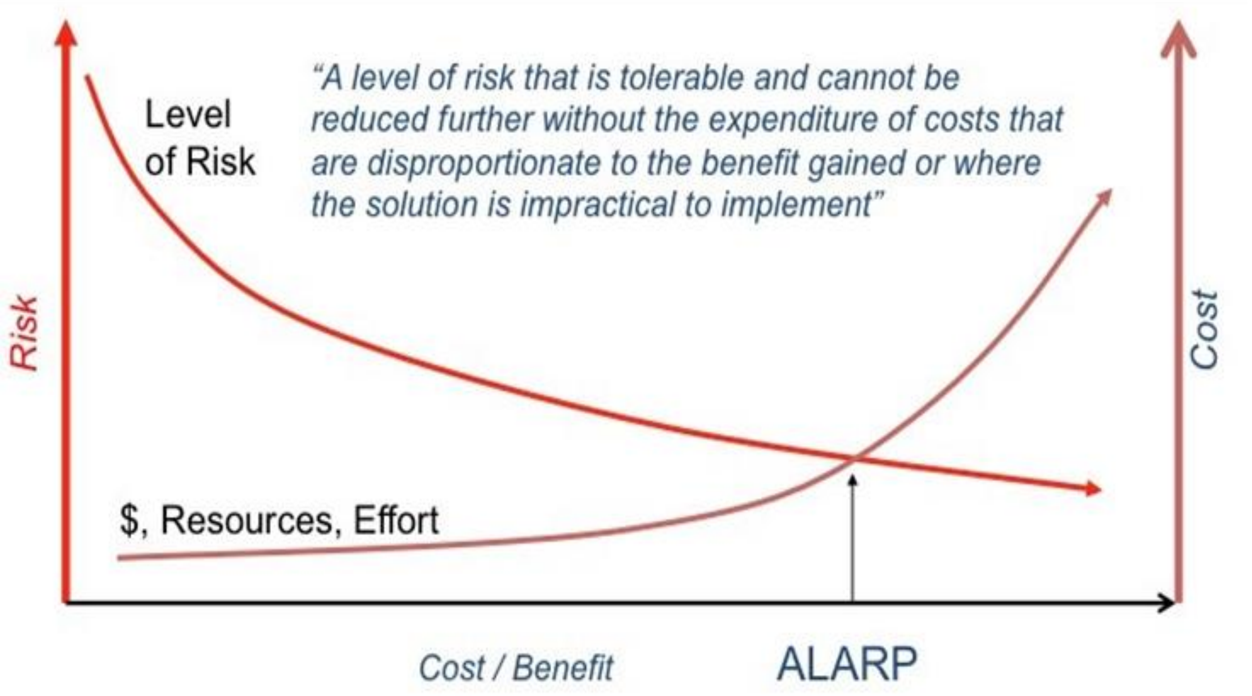
(Task 6): Identify how real-time monitoring could be incorporated into the BSEE regulatory regime in either a prescriptive or performance based manner.

Unreasonable Regulations vs. Balance

- Unreasonable regulations and unpredictable enforcement practices impose unneeded burdens on regulated entities
- Any reform is at least in part a reaction to perceived failures of what preceded the reform.
- Expectations for performance-based regulatory regimes are shaped by prior shortcomings as they are by concepts of what constitutes 'good' regulation.
- Useful to consider performance-based approaches to regulation as a reaction to the perceptions of overly rigid rules and inflexible enforcement.

Current Examples of System Safety Programs

- System Safety Components
  - As Low As Reasonably Practical (ALARP)
  - Root Cause Analysis
  - HFACS
  - Predictive Analytics
- Voluntary Reporting
  - Industry Wide Data Sharing
  - Safety Reporting System
  - Petroleum Safety Action Program (PSAP)



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BSEE Mandates and Regulations

- Industry Best Practices
  - Audits (Assist Visit) - create positive atmosphere and accurately defines the inspection
  - Measuring Regulatory Compliance - The standards for measurement should include the generation of metrics that would indicate leading and lagging areas
  - e-Inspection - provides an electronic means of capturing and storing data for all the parameters and conditions of properly outfitted instrumentation
  - Risk Based Inspection - prioritizes the risk and assigns greater oversight and inspection rates for high risk events and operations
  - Training for Auditors - To properly assess the compliance based RTM environment
  - After Action Report - To assist the operator in determining future steps to correct or enhance current operations

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Conclusions/Recommendations

- Mandating RTM use in oil and gas drilling and production can be implemented using a system safety approach
- Many industry and government organizations are moving toward a system safety approach to ensure regulatory compliance
- System safety program would be the most beneficial method of implementing RTM into the oil and gas industry using components of both prescriptive and performance regulation
- The true essence of a safety management system is to incorporate many different safety interdependencies in order to make the entire system work as a whole to improve safety

Conclusions/Recommendations

- The efforts of BSEE to implement system safety principles and to other proven methods should be done using examples from other industries.
- System safety implementation requires additional, complementing programs to be an all-inclusive safety program and are critical for driving down incidents and accidents:
  - Voluntary reporting
  - routine auditing
  - risk analysis
  - root cause analysis
  - human factors
  - industry-wide data reporting

1. The critical operations and specific parameters that should be monitored to manage and mitigate environmental and safety risks (e.g., to reduce the risk of well kicks, blowouts, and other source of casualties).

Chapter 4

(Task 4) Identify all necessary information which needs to be collected, calculated, or monitored during operations to improve the current level of safety. Identify any existing or proposed modeling tools that can be used in connection with real-time data to prevent incidents

Information Necessary to Improve Levels of Safety

- Data collection and organization
  - Environment
  - Data
  - Analysis
  - Cooperation
  - Management

Information Necessary to Improve Levels of Safety

- Collected Data Examples
  - Pressure
  - Torque
  - Tension
  - Temperature
  - Chemical Composition
  - Vibration
  - Weight
  - Position
  - Seismic
  - Corrosion
  - Visual Conditions
  - Time
  - HFACS

Information Necessary to Improve Levels of Safety

- Monitored Data Examples
  - Fluid dynamics/Pressures
  - Mud flow/quantity/density
  - Mud temperature/ properties
  - Continuous chlorides in/out
  - Drill gas Well control pressures
  - Wellbore pressures (along the drill stem)
  - Fluid pressures
  - Fracture and formation pressures
  - Pressure readings from shut-in
  - Torque
  - WOB – weight on bit
  - RPM – revolutions per minute
  - ROP – rate of penetration
  - Connection gas (CG), background gas (BG), trip gas (TG), short trip gas (STG), dummy trip gas (DTG)
  - Gas chromatography

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Information Necessary to Improve Levels of Safety

- Calculated Data Examples
  - Hydrostatic pressure
  - Overburden pressure/gradient
  - Matrix stress
  - Pore pressure
  - Formation fracture pressure
  - Equivalent circulating density – ECD
  - Equivalent static density – ESD
  - Mud densities and additives
  - Torque and drag
  - RPM
  - WOB
  - ROP
  - Cutting Volume

Modeling Tools to Prevent Incidents

- Real-time Processed - necessary in drilling HPHT wells ensuring the well is remaining within required safety margins
  - Drilling, completion, production and general surveillance benefit greatly
  - Proactive, rather than reactive responses to day-to-day challenges
  - Disciplines are now integrated in current operations
    - Both in the field and remotely, continual monitoring and remote data analysis includes and integrates areas such as drilling optimization, pressure management, pore-pressure predictions, and wellbore stability
  - Software models that utilize case-based reasoning and physics, together with real-time drilling and well data, enable immediate situational analysis and trend monitoring

Modeling Tools to Prevent Incidents

- Post Processed: Analysis of trends over longer periods of time
  - Data selected from a repository of pertinent data
  - Allows computing power and analysis to be applied to a problem
  - Allows discovery of long term trends potentially missed in real-time
  - Not limited to analysis of Geophysical Acoustic data
  - May be used to fuel a ‘learning’ system using previous data to predict future reliability
    - Electronic/ database equivalent of using lessons learned for future projects.
    - Example might be use of pump failure rates compared to the change of seasons to be able to predict the most critical time of year to prevent pump failures

Available Modeling Tools

- Strategic planning of E&P
- Risk based process simulations
- Geologic /Geomechanic/ Geosteering
- Well control modeling
- Fracture modeling and simulation
- Hydraulics/equivalent circulating density (ECD) modeling
- Dynamic modeling of wellbore pressures
- Torque, drag and drillstring modeling
- Bottom hole assembly vibration modeling
- Cementing Process
- Reservoir characterization models
- ROV operations simulations

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Conclusions/Recommendations

- A true cultural shift necessary in the GOM for deepwater exploration and production to improve the safety of operations
- Operators need to demand higher quality from contractors/service providers
- Modeling of the well environment prior to spud date offers insight
- Use of dynamic simulation programs incorporating real-time data during drilling contributes to a quantum leap in increased safety
- Rig simulation should utilize lessons and techniques from aviation
- Training simulators will also serve to improve safety through enhancing experience levels
- CRM training will help the industry avoid relearning the early lessons

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.

Chapter 5

(Task 5) Technologies and Data Helpful in Measuring Field Performance of Critical Equipment to Predict Potential Failures and Replace Current Methods

Technology and Data for Measuring Performance and Predicting Failure

- Sensors
  - Reports conditions
  - Typically electrical
  - Employed at a single point
- Transducers
  - Convert one form of energy to another
  - Electrical, chemical, mechanical, etc.
- Virtual Sensors
  - Use historical performance and data reconciliation
  - Reduces cost and risk

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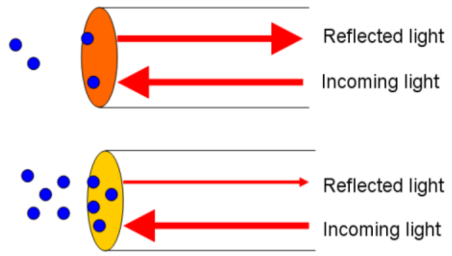
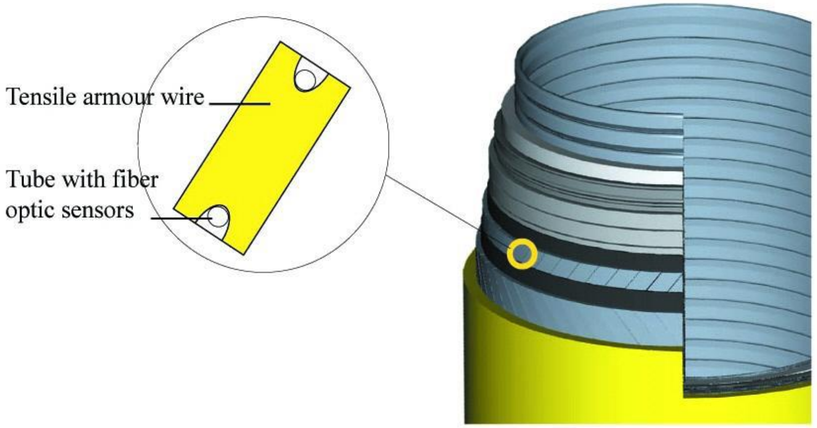
Technology and Data for Measuring Performance and Predicting Failure (cont'd)

- Fiber Optic Sensors
  - Small size
  - Multiple sensing points
  - High temperature (+1000°C)
  - High reliability
  - Immunity to interference
  - No spark hazard



- Fiber-Bragg Grating
  - Temperature
  - Pressure
  - Weight
  - Flow



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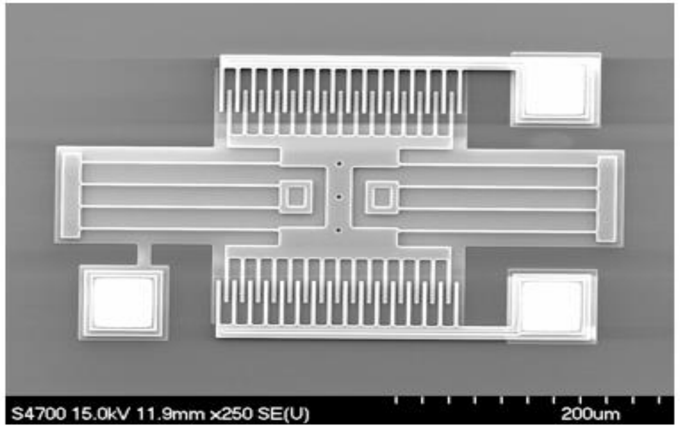
Technology and Data for Measuring Performance and Predicting Failure (cont'd)

- Micro-Electro-Mechanical Systems (MEMS)
  - Sense relative motion
  - Outperform "Macro" systems
  - Can also be micro valves, pumps and actuators
  - Handling small systems can be a challenge



Data Collection and Storage

- Collecting data
  - More data available due to new sensors
  - Reliability has increased
- Choosing data
  - Define “useful data”
  - Employ “data by exception”
- Cataloguing data
  - Need a standard for format, content, values
  - Metadata increases flexibility of cataloguing process
- Retrieving data
- Transmitting data
  - Bandwidth limitation is being solved

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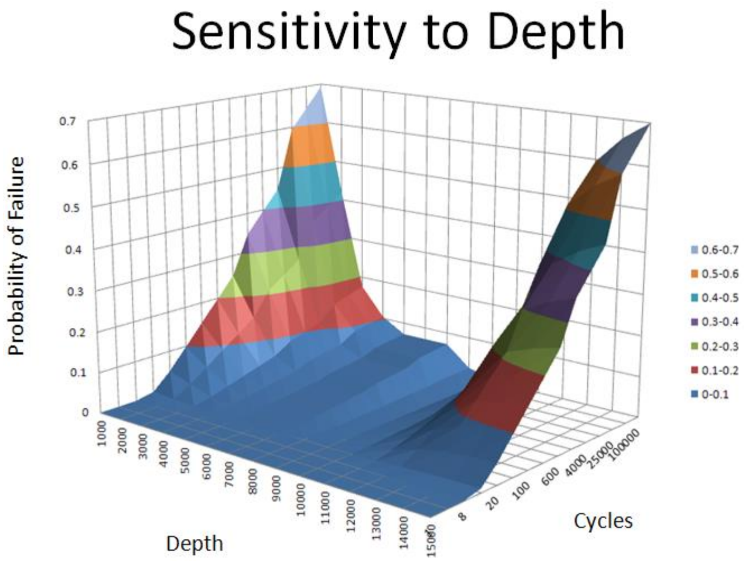
Real Time Data Streaming

- Data latency issues – Can mask problems
- Analysis – Transforms data into knowledge
- Post Processed – Allows more computing power to be applied
- Predictive Analytics
  - Uses historical data
  - Predicts future performance
  - Currently used in O&G for reservoir analysis
  - Could require dedicated testing



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Conclusions

- Recent innovations in sensor technologies have created a unique opportunity for the oil and gas industry to enter a new era of reliability for critical equipment
- Fiber optic cable has shown the ability to provide data not previously available.
- Analysis of data from new sensors allow decisions to be made with a smaller margin of uncertainty.
- Collection of larger amounts of data require new, modern methods of data storage, transmission and analysis.
- The amount of data currently being recorded is a small subset of the total amount of data available.
- The new sensors, and the ability to properly use the data provided, can replace many of the current labor intensive inspection methods.

2. The role that automation and predictive software tools should play in RTM.

Chapter 6

(Task 7) Assessment of Automation Technologies Impacts on Human and Environmental Safety, Efficiency Improvements, and Cost

Need for Automation

- Difficulty in tightly controlling critical well parameters
- Human exposure to dangerous environments can be avoided
- Enhancing safety through better control
- New technology enables automation
- Repeatable solutions provide economic value

Challenges and Pitfalls to Using Automation

- Mode Confusion
- Complacency
- Preventive Maintenance
- High reliance upon quality data
- Improper feedback
- Systemic limitations
  - Security
  - Development costs
  - Physical limitations to replicating human motion

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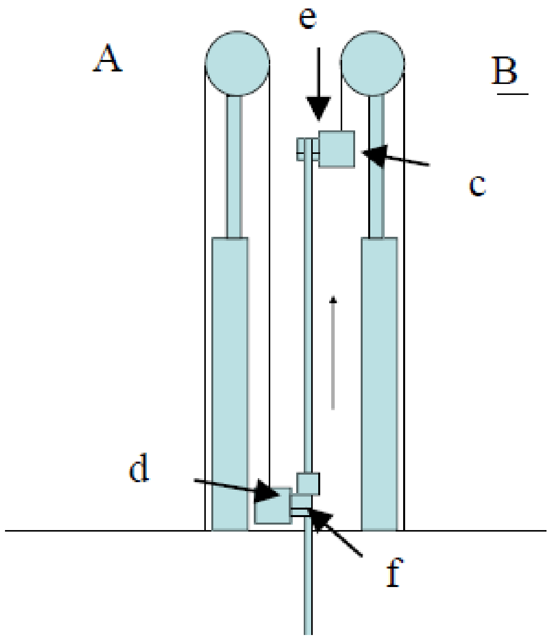
Assessment of Current Automation Technologies in the Oil and Gas Industry

- Areas using automation
  - Fluid Control
  - Drilling
  - Continuous Motion Rig
  - Robotics
  - Pipe handling
  - Automated Tongs
  - Cementing
  - Autonomous Undersea Vehicles



Conclusions

- Automation has many forms
- Tight control of critical parameters is needed
- There are challenges to using automation
- Positive impact to human safety
- Can improve efficiency and reduce cost

Chapter 7

(Task 2) Perform Cost Benefit Analysis of the systems identified that details potential costs to industry, potential increases in safety performance, government resources needed for implementation, and necessary training for all parties involved

Introduction to Cost Benefit Analysis (CBA)

- Need to be able to show return on investment (ROI)
- The results of a CBA by a small company will differ from a large company
- Other areas can be an indicator of CBA results (onshore and offshore)
- The timespan of the CBA will create different results
- Some benefits are intangible and difficult to value
- Corporate CBAs are proprietary

(RTOC)/(RTMC)

- Assumptions
  - 6-9 Wells supervised
- General benefits
- Use of Automated drilling rigs
- Current use of RTMC

Conclusions

- The use of conservative estimates for using RTMCs can easily justify their use.
- The barriers to the introduction and use of advanced principles for exploration and production are not always financial.
- The benefits of RTMCs are not solely financial.
- RTMC is a powerful tool for increasing efficiency and elevating safety.
- The implementation of automation on the drilling rig could provide large gains in efficiency that cannot be realized without RTMCs.

Final Recommendations

- RTMC
  - The study concludes that the use of RTMCs is financially viable
  - Safety and efficiency improvements are a result of increasing data knowledge
  - The financial return from using this technology is shown in this study and further evidence is provided by the continued use by large offshore operators
  - The use of RTMCs by small operators has been largely non-existent. There are several approaches that can be implemented to improve acceptance/use

Final Recommendations (cont'd)

- Government Regulation
  - The use of RTMCs should be initiated through the measured introduction of directives requiring use of RTMCs for drilling operations for high risk wells
  - Directives should include the need for onshore monitoring of well parameters by a separate safety center. The use of an onshore monitoring station could be leveraged by other medium/small offshore operators to share the financial burden
  - The RTMC operation should be audited periodically by government personnel to assure that current operations are being monitored

Final Recommendations (cont'd)

- Government Incentives
  - The use of RTMCs by medium/small offshore operators has been delayed by the initial capital expenditure needed to procure an RTMC facility.
  - Incentivizing small and medium sized operators could be investigated as a means of introducing RTMC to these operators.

Final Recommendations (cont'd)

- Fiber Optic Network
  - The use of onshore RTMCs is greatly enhanced by the ability to transfer large amounts of data from the offshore rigs
  - The cost of other operators gaining access to the network is very expensive and is more of a challenge for the smaller operator
  - The use of the network could be facilitated by government assistance with access. Government assistance can take many forms, from financial incentives to tax breaks to mandates for a nonprofit pricing structure

Final Recommendations (cont'd)

- Automation Research
  - The government should fund/promote research in automation.
  - The improvements in HSE are easily recognized when considering the gains in efficiency and lack of human error
  - Other oil producing countries are providing a roadmap by funding and/or supporting the introduction of automation for the oil drilling rig
  - The government initiative could also include teaming with other private and foreign government initiatives to introduce automation to share ideas and foster an atmosphere of cooperation

Backup Slides

Chapter 1

Definitions

- Real-Time Data (RTD)
  - Information delivered immediately or *nearly immediately* after collection. There is little to no delay in the timeliness of the information provided
- Real-Time Monitoring (RTM)
  - Monitoring of operations through the use of RTD
- Real-time Operations Center (RTOC):
  - Center of operations combining the functional use of RTD and RTM for the purposes of well development, completion and production
  - Typically combining the components of an Real-Time Monitoring Center (RTMC), Collaborations Center, and/or Knowledge Center

Definitions

- Real-Time Monitoring Center (RTMC)
  - 24/7 operation whose primarily function is optimization, well control and live trending
  - Centralized, onshore location with continuous data feeds from active well projects
  - Staffed with highly experienced drilling experts focusing on mitigating drilling hazards and preventing nonproductive time (NPT) while providing an added team member and safety observer to the onsite rig team

Definitions

- Collaboration Center:
  - A dedicated workspace, fully equipped with RTD capabilities enabling full integration of the onshore/offshore team working in a seamless environment for well operations planning, drilling and completion activities
  - Enables meetings with the onshore/offshore team, reviewing morning reports and planning current and future well activities
  - Capable of using mathematical models to support the expected operation
  - The Collaboration Center brings in or reaches out for the expertise necessary for achieving well development objectives and resolving issues

Definitions

- Knowledge Center:
  - Onshore RTD repository of experts with access to all aspects of planning and analysis data for services as requested by the drilling supervisor during well planning, drilling and completion operations
  - Not normally a 24/7 monitoring operation, but personnel may be on call to provide services at any time
  - Considered the company’s experience repository and center of excellence with respect to all phases of well development, completion and production

Observed Concepts of Operations

- Example 1: RTOC utilizing an RTMC with an integrated Collaboration Center
  - Data Wall
  - Collaboration Space
  - Well Operations Area
  - Huddle Rooms
- 12 hour shifts
- Direct access to rig teams (ROIP)
- Video is important
- Auditing requires integral knowledge of the operation

Observed Concepts of Operations

- Example 2: RTOC utilizing RTMC and an integrated Knowledge Center
  - Operations rooms
  - Team dynamics
  - RTD management
- Standardized sensor arrays
- RTD is invaluable
- Imaging below salt needs to be better

Observed Concepts of Operations

- Example 3: RTOC Utilizing a Knowledge Center for Analysis with Rig Execution
  - Drilling team managers on the rig have ultimate responsibility for drilling operations
  - RTD is monitored at the rig and transferred to the Knowledge Center or other storage
  - Knowledge Center acts as a resource for the drilling team manager enabling him to make pertinent decisions regarding the drilling operation

Chapter 2

Training Scenario 1

- Training Scenario #1 - Internship at an oil and gas operator with syllabus of instruction agreed upon by BSEE and the operator
- Advantages –
  - Quick exposure to industry best practices using real-time data
  - Collaboration between industry and BSEE
  - Enhanced understanding of real-time data and technology
- Disadvantages –
  - Could encourage BSEE interns to leave BSEE
  - Depending on the number of BSEE auditors/inspectors, could be challenging to manage which interns/operators cannot work together
  - Necessitates an industry-wide cultural change to collaborative environment

Training Scenario 2

- Training Scenario #2 - Bringing real-time data technology to BSEE
- Advantages –
  - Promotes technology understanding
  - Increases interaction between industry experts and BSEE
  - Provides industry collaboration on emerging technology
- Disadvantages –
  - The focus could be more on technology than its application
  - Possibly requires more coordination among vendors and BSEE for scheduling
  - Necessitates vendors sign onto the concept
  - Necessitates development of full syllabus of instruction

Training Scenario 3

- Training Scenario #3 - Development of a simulation center within BSEE that is modeled from traditional Real-Time Operating Centers
- Advantages –
  - BSEE is able to keep up with technology and real-time data usage
  - Industry/BSEE Collaboration
  - Information dissemination quicker and more efficient
- Disadvantages –
  - Could be expensive to setup and implement
  - Not actually working in an actual environment; it's simulated
  - Data acquisition; need to get the data from actual wells could be challenging considering the proprietary nature of the industry

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Chapter 3

Prescriptive vs Performance-Based Regulation

Prescriptive: Specifies an exact method of compliance and requirement to meet allowing for little deviation in components, plans, or processes

- Pro's
  - Standardized implementation method among all operations
  - Procedures that do not require interpretation or expertise to implement
  - Simplified audit process
  - Specifications and procedures designed to ensure that a material, product or method of service is suitable for its purpose and consistently performs in the manner it was intended
- Con's
  - Difficult to apply common regulations to uncommon conditions
  - Outdated standards as technology advances
  - Overly conservative standards that may be cost prohibitive
  - <u>Minimum</u> requirement in the regulation attitude
  - An over-reliance upon the regulations to ensure safety
  - The burden of incident/accident avoidance is on regulations, creating more regulations
  - May define a material, non-competitive solution
  - Inhibition of emerging industry best practices
  - Difficult to manage variations and waivers

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Prescriptive vs Performance-Based Regulation

Performance: Specifies a threshold of acceptable performance and a means for verifying that the threshold has been met

- Pro's
  - Flexibility for the facility operator to specify the method of compliance
  - The use of industry best practices that can be applied to any situation and yield the most cost-effective solution
  - The reduction of barriers to technical innovation
  - The methods of compliance can be less costly
  - The promotion of data sharing
  - Reduced regulatory footprint
- Con's
  - Difficulty in defining quantitative levels of performance
  - Reliance on experienced and qualified auditor
  - A need for a robust, train-to-proficiency, regulator training
  - Difficulty in evaluating compliance with established requirements due to challenges measuring parameters for evaluation
  - A need for standardization of the tools used for quantification

Precedent for Performance Based Regulation

- Executive Order 12866 (section (b)(5))
  - Primary federal regulatory planning and review directive adopted by the Clinton Administration and subsequently reaffirmed by the Bush Administration and supported under the current Administration
  - Federal agencies are directed to take into account in regulatory design the need for, and effectiveness of, regulations along with "incentives for innovation, consistency, predictability, costs of enforcement and compliance (to the government, regulated entities, and the public), flexibility, distributive impacts, and equity."

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Implementation of System Safety

- Level Zero: Orientation & Commitment
- Level One: Planning and Organization
- Level Two: Reactive Process, Basic Risk Management
- Level Three: Proactive Processes, Looking Ahead
- Level Four: Continuous Improvement, Continued Assurance

Implementation

- Five Step Process
  - Define goals/objectives with respect to safety
  - Review & choose specific targets, outcome indicators, and activity indicators
  - Adapt the indicators to ensure consistency with local procedures/standards
  - Identify what each indicator will measure and determine appropriate metrics
  - Apply the appropriate metrics to the indicators
- Industry Rollout
- Smaller Operators
- Continuous Improvement
- Process Assessment

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Chapter 4

Evidence Based Research

- Minimum acceptable levels of BAST – BSEE Defines
- Important lesson can be drawn from healthcare and evidence based medicine:
  - The scientific based healthcare community is continually pursuing new treatments and improved methods of treatment, but not at the risk of the lives being saved
  - Introduction of new treatments and protocols must show a "*conscientious, explicit and judicious use of current best evidence*"

Simulation

- Vary from simple computer programs to predict pressures, fluid flow and interactions to complex drilling human-in-the-loop (HITL) visualization domes giving personnel rig experience without ever being on the rig.
- Fully automated systems require a higher quality data stream from improved sensors at higher data rates through improved bandwidth
- Presently only real HITL can accurately judge the final design
  - In many highly variable scenarios the human element is still better suited at processing changing variables, applying experience and judgment to provide necessary information to the system to determine the next course of action

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Operational Simulation

- Real-time data: enables enhanced collaboration of all drilling activities
- Validation through simulation: improves accuracy of key drilling parameters such as ECD, temperature, pore pressure, wellbore stability and torque & drag
- 3D gaming software: real-time modeling for visualization and optimization of the drilling process
- Analysis of dynamic predictions: reduces the potential of drilling hazards, such as kicks, wellbore instability, stuck pipe and lost circulation contributing to reduced risks and increased safety margins.
- Providing real-time data to continuously updating drilling simulations: drillers, geologists, engineers and petro-physicists

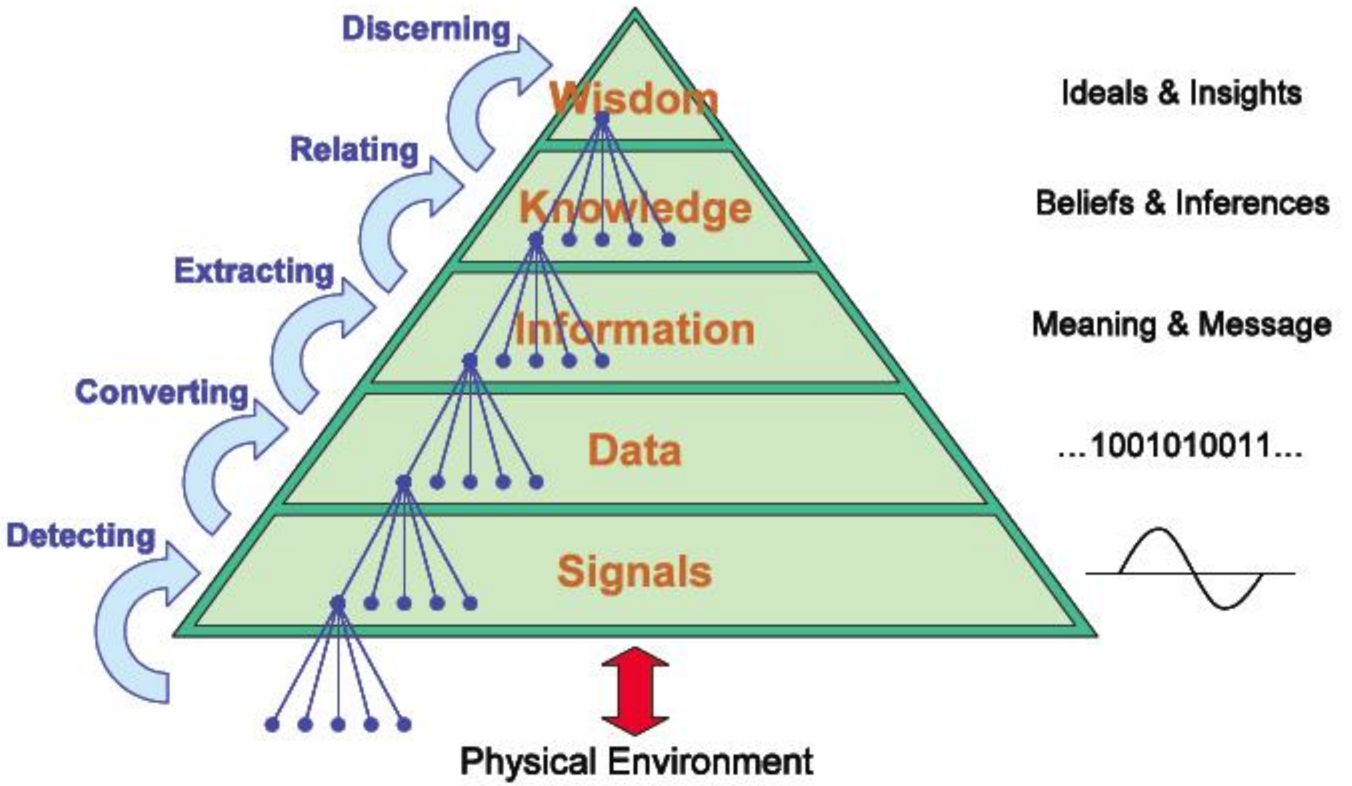
Training Simulation

- Mockups and visualizations of rig environment provide experience for skilled labor shortage
  - Improved understanding of platform theory, concepts and knowledge
  - Accelerate learning by providing operating practice and experience in normal and abnormal operations, plant startup, shut down and facility optimization
- Lessons from Aviation Simulation
  - Procedural training emphasis, but pilots still making inaccurate and inappropriate decisions in day-to-day operations and emergency situations
  - NASA produced Crew Resource Management (CRM) training showed majority of the crashes were human error failures of interpersonal communications, decision making, and leadership
  - Pilots are now also trained and evaluated on application of CRM techniques

Chapter 5

Cooperation

- Correlation
- Workflow
- Knowledge Transfer
- Knowledge Management
- Decision Making
  - Gathering data
  - Generating ideas
  - Making the decision
  - Executing the plan



Technology for Inspections

- Nondestructive Inspection and Testing
  - Ultrasonic, magnetic-particle, liquid penetrant, phased array, radiographic, remote visual inspection (RVI), eddy-current testing, ferrite testing, hardness testing and integrity services (corrosion/erosion) and low coherence interferometry.

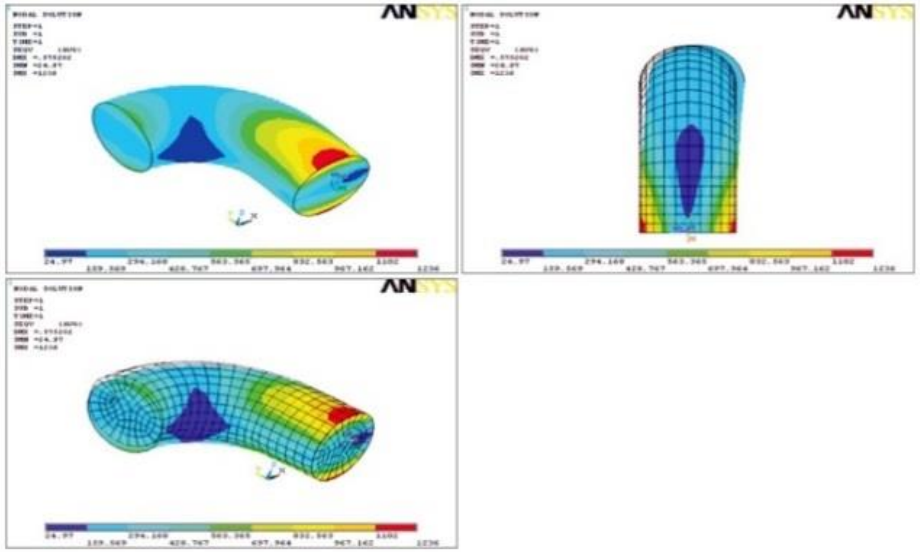
- Current Inspection and Testing
  - Subsea pipelines and Risers
  - Re-injection stations
  - Offshore and land-based production
  - Reservoir engineering
  - Refining
  - Liquid storage
  - Petrochemical
  - Liquefied Natural Gas (LNG) liquefaction
  - Compression stations
  - Floating Vessels
  - Manufacturing

BSEE Bureau of Safety and Environmental Enforcement

B3B Inc

Replacement Technology

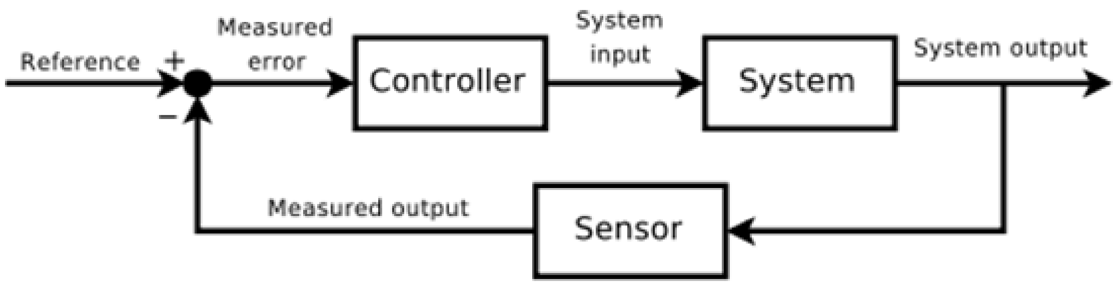
- Finite Element Modeling and Analysis
- Corrosion/Erosion Monitoring
- Distributed Sensors
- Visual recognition software
- Lasers for 3D representation



Chapter 6

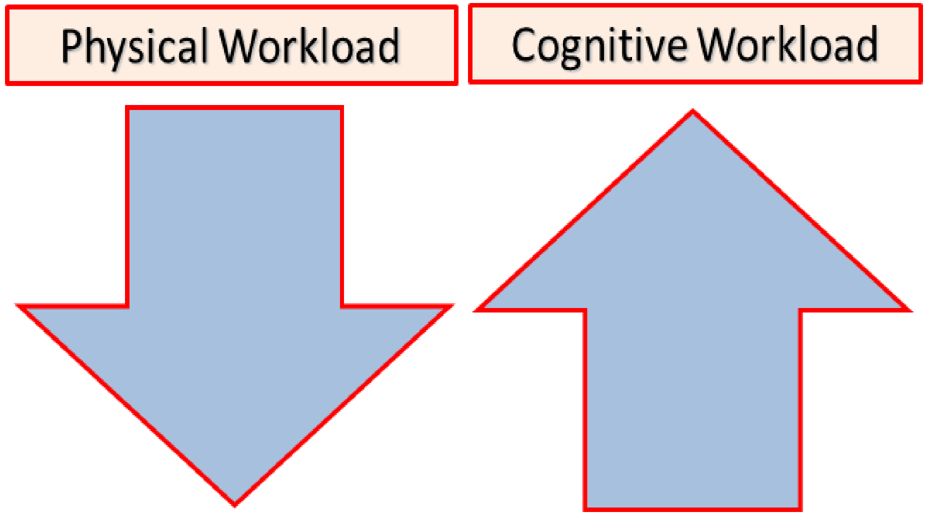
Definition of Automation

- Mechanization – excavator, pumpjack, tongs
- Agent Assisted – extensive human interaction required
- Computer Automation – spreadsheets, databases, graphics
- Programmable Logic Controller (PLC) – automation using “rigid” system
- Control
  - Feedback Loop
  - Highly dependent upon Sensors
  - Enabled by RTD



Impacts on Human Safety

- Mechanization
- Removing the Operator
- Removing the Hazard
  - Information Overload
  - Human error
  - Stress induced fatigue
  - Poor communications
  - Inadequate procedures
  - Insufficient information
  - Insufficient training



Impacts on Environmental Safety

- Automated Drilling Tools
  - Steering systems decrease drill time
  - Decrease environmental waste by generating less cuttings
- Centrifuges, Shakers and Dryers
  - Tightly maintain fluid to solid ratio
  - Returns base fluid to mud system
- Computer modeling
  - Increased use of historical data enhances the future model
  - Reduces risk of unforeseen conditions

Improvements in Efficiency & Cost

- Reduction in the number of workers
- Automation provides more efficient operation
- Tight control of drilling parameters
- Database of prior experience
- Need for Standards
- Infrastructure not needed
- Cost of implementation easier to predict

Chapter 7

Scope of Cost Benefit Analysis (CBA)

- Limited Candidates
  - RTOC/RTMC
  - Automation
- Financial Calculations
- Proprietary Information
- Business Practices
- Newer Rigs

Drilling Automation

- Automated Drilling Rig
- Automation Challenges
- Monetary gains
- Cost of the system
- Government Resources Needed
- Training of Necessary personnel

RTMC Cost to the Industry and Returns

- Cost Metrics
- Other benefits with economic value
- Government Regulation
- Government Incentives
- Fiber Optic Network
- Automation Research