



Remote Monitoring and Management: Maximizing the Safety and Efficiency of Rig Automation

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Abstract

Rig automation has traditionally focused on improving safety and efficiency through the use of equipment designed to reduce manpower/human interaction and assume repetitive tasks and operations. As more parts of a drilling rig become automated, there has been a change in how rig personnel interact with equipment. A system of remote monitoring, diagnostics and technical support has been developed to make this interaction more seamless and expand the focus of rig automation. Analysis of field data derived from rig equipment operations using remote monitoring and management has shown benefits of reduced downtime, improved preventive maintenance and increased safety when compared to operations without. Application of this enhanced rig automation technology has the potential to change the future of drilling operations, spares planning and equipment development from a reactive mode into a proactive mode, keeping drilling contractors and operators one step ahead of the curve.

Introduction

To improve safety and efficiency, drilling equipment manufacturers have responded with tools that eliminate the need for humans to be present during the performance of particular operations such as racking pipe in the derrick, bringing drill pipe to well center, make up and breaking out of connections, etc. These machines have evolved into complex, robotic designs, using sophisticated sensor technology to determine both their position relative to other pieces of equipment and the best path/movement required to complete an operation. Operation of the equipment has been paired down to allow, in most cases, a single person to run the tool with the help of control systems and interfaces such touch screens and joystick style controls. When something does not function quite right, it can become a nightmare to isolate the cause. This often requires extensive external inspection, internal debugging of program files and numerous other high tech operations. There is usually a shortage of time necessary to conduct this troubleshooting and a shortage of qualified personnel on board the rig. This results in the dispatch of special personnel (most often from the equipment

manufacturing company) out to the rig to assist in troubleshooting. As is often the case, there is very little data with regard to the failed operation and personnel have to rely on verbal data, which can be in error. In short, troubleshooting has become proportionally more difficult as automation and system complexity increase. The e-drill™ system developed by Varco has been designed to remotely monitor drilling equipment and effectively eliminate time wasted troubleshooting. It additionally helps reduce, through the use of remote diagnostics, the need to send a person out to troubleshoot the equipment. This applies both to rig personnel on board and experts from shore.

Description of System

The remote monitoring system utilizes the current technology of the Internet to connect automated rigs to a service center that is manned 24 hours a day, 7 days a week. On board the rig, data is collected from various equipment controllers and stored locally in a data logger, similar in capabilities of those seen on modern day air transportation. Storing data locally avoids the possibility of losing data during the loss of communications. As shown in Figure 1, equipment controllers, the data logger and Human Machine Interfaces (HMI) are linked together on board the rig in a local network. Data from this network is routed to a Virtual Private Network (VPN) device on the rig that encrypts the information before passing it along to the rig's routing and satellite transmission system. The data logger is configured to collect data from each individual controller. Data tags are determined for each system based upon what information (pressure, torque, temperature, position, load, etc.) is essential for diagnosis of operational problems. The data logger is also equipped with controller programming software to allow for reprogramming remotely.

Figure 2 illustrates the connection of the data logger and local network to the rest of the remote monitoring system. Encrypted data packets are transmitted from the data logger using a VPN device and the rig's existing communications network. Information can be "piggy backed" onto the main communication links already in existence and transmitted to the client's network. The encrypted data can then be passed from the client's

network via the Internet to a centralized service center. From there the information packets are unencrypted for use by personnel manning the center. Subject Matter Experts (SME) can link to and view information from the service center either through the center's company intranet or externally via the Internet utilizing remote desktop applications. This method allows for fast, efficient and low cost communications in a non-intrusive, easily configured and installed package. The remote monitoring system logs the data locally and only transmits real time alarms and system parameter changes needed to identify problems, failures and status changes in equipment. In this format and configuration the remote monitoring system can send encrypted data packets in bursts at very low bandwidth (less than 50Kbs), thus reducing the load on rig communications systems.

The system has various automated features to display the information for both the service center and the client. Alarm conditions are displayed real time in the center as well as on the Internet for client viewing. Clients can also view incident reports, equipment override counts and parameter changes in real time via a website on the Internet. This allows clients to make real time decisions with real time information.

Case Studies: Time Reduction

In the following case studies the primary benefit derived from the remote monitoring system was to reduce time required to troubleshoot the problem as well as eliminate several steps normally taken by rig personnel during the troubleshooting process.

Pick-up/Lay-down System A Pick-up/Lay-down System (PLS), designed to remotely hoist tubulars from the V-door position to vertical and back again, was hoisting properly, but would not lower or allow pipe setdown. Using the remote monitoring system, historical data for the PLS was checked and trended to reveal that a sensor, which was part of a thread compensation cylinder sub-assembly, was not changing states. This was an indication of some sort of physical impediment. Sensor failure was eliminated through internal diagnostic checks as well as the trending data, which revealed a signal was present. The rig crew was instructed to visually check the sensor and discovered that a bracket holding the sensor was bent. A repair was affected and the PLS was again operational. Total time to check, trend data and pinpoint the sensor malfunction was 5 minutes. Without the remote monitoring capabilities, the rig would have needed to operate the PLS system while checking inputs and display counts in the control logic as well as checking power supply to sensors. Observation may have been required of the PLS in override mode, which disables safety interlocks between the PLS and other equipment. Operation in this mode would have

required other equipment operations to be suspended. Total duration of troubleshooting without the remote monitoring capability would have required approximately 6 hours including suspended operations of other equipment. The remote troubleshooting was carried out without requiring operation of the PLS or suspension of other operations.

Pipe Handling Machine A Pipe Handling Machine (PHM), designed to automatically trip stands of drill pipe and collars, break them out or make them up and rack them for the next trip, was not lowering to the proper destination. Through the remote monitoring system historical data and present data of the PHM function were trended and displayed to reveal that the PHM had taken a false index and would not lower any further because of interlock programming. Identification of the root cause as a false index allowed the rig to safely use interlock override to re-index the tool and continue operations. Total duration of troubleshooting was 30 minutes. Without the remote monitoring capability, the rig would have investigated both control issues as well as mechanical malfunction. Having the capability to remotely access historical data by expert personnel, allowed a complete investigation of the control system first without having to utilize rig personnel and without having to troubleshoot for mechanical malfunctions. Total duration to troubleshoot the problem without remote monitoring would have required a minimum of 1-½ hours, not including mechanical troubleshooting.

Automated Iron Roughneck An Automated Iron Roughneck, designed to spin in, make-up, break-out and spin out connections at well center, was (while in automatic mode) traveling to the pipe at well center, but not stopping in the proper vertical position. Investigation via remote monitoring of the operational trends revealed that an improper sequence had been followed initially to teach the Automated Iron Roughneck where to stop vertically after detecting the tooljoint position. The rig was informed of the correct procedure and the Automated Iron Roughneck was re-taught properly to allow for operation in automatic mode. Total duration for resolution was 20 minutes. Without remote monitoring, troubleshooting would have involved checking sensors on the tool for correct adjustment and verification of signals, troubleshooting control system logic and eventually rebooting the control system. The improper teaching sequence may have been repeated causing the same operational malfunction. Total duration to troubleshoot without remote capabilities would have required more than 6 hours and would also have required operation of the tool for troubleshooting purposes only. It is possible that the rig would have continued operations in manual mode, requiring more time to complete the operation than in automatic mode. Identification of the improper teaching sequence would possibly never have been identified.

Case Study: Accuracy and Trust

In this next case study trust became an issue with regard to the root cause identified by the remote monitoring system. Rig personnel spent unnecessary time troubleshooting other areas before addressing the area originally identified by the remote monitoring diagnosis and resolving the issue.

A Pipe Racking System (PRS) was experiencing traveling problems with the upper drive outrunning the lower drive. The rig attempted to correct the problem by reinstalling the control program, but after the existing version was deleted from the control CPU, the reinstall failed. The CPU was assumed to be bad and replaced with another CPU. Reinstallation continued to fail with this replacement CPU as well as another CPU. After remote monitoring service personnel were contacted and consulted, the original CPU was tried again and successfully installed. Subsequent testing of the control system revealed no apparent problems and it was suggested that the rig check the mechanical integrity of various drive components. The rig personnel were insistent that the issue was not mechanical and wanted a consult with a Subject Matter Expert (SME). The SME walked the rig through various control system parameters and adjustments to no resolution and again suggested a check of the mechanical integrity of the drive components. Subsequent inspection revealed that a mechanical linkage swivel had loosened enough to allow the upper drive to come forward of the lower drive at stops. Although the problem was corrected, time to resolution was longer than necessary due to lack of trust on the part of rig personnel as to the accuracy of the initial diagnosis.

Case Studies: Elimination of Hazards

This series of case studies deals with incidents that were diagnosed with the remote monitoring system and illustrate the ability to discern root cause when diagnosis without would have revealed no definite cause. In all cases a potentially hazardous situation would have gone undiagnosed.

Fingerboard Latch A Fingerboard Latch on a Pipe Racking System (PRS) opened during a tripping operation, allowing a stand of pipe to become unsecured. The remote monitoring system was used to trend signals involved in the tripping operation. It was discovered that during a pipe grabbing operation, the operator had initiated an override in an attempt to get a better grip on the pipe and subsequently activated the fingerboard sequence a second time when it was not required. This left the pipe unsecured. Operational training was conducted with rig personnel to avoid this scenario when conducting override sequences. Total duration to identify the operational error was 15 minutes. Without the trending of data through remote monitoring,

the rig would have conducted an inspection of the fingerboards for malfunction and inspected the fingerboard control system including debugging of all I/Os. Resulting troubleshooting would not have revealed any problems with the system, however the root cause would have remained unidentified, possibly to occur at a later time if overrides were initiated during tripping.

PLS Excessive Overrides Remote monitoring and trending analysis of a Pick-up/Lay-down System (PLS) revealed excessive overrides being performed. The rig was contacted by remote monitoring service personnel and queried about the overrides. Remote monitoring service personnel were informed by rig personnel that overrides were necessary because the PLS would not allow pipe to be picked up off the conveyor and brought to vertical. Analysis of trend data from both the PLS and conveyor pinpointed a calibration issue with pipe length. The system was set for hoisting longer lengths of pipe and due to safety interlocks would not allow a shorter length of pipe to be hoisted because of perceived collision of the bottom of a long length pipe with the rig floor. The operator, in order to bypass this interlock and bring the pipe to vertical, was issuing override commands. The system was re-calibrated for the shorter lengths of pipe and operations continued without the need for manual override. Total duration for diagnosis took 30 minutes. Diagnosis without remote monitoring might have taken up to 5 hours. More importantly, the rig may not have reported the need for conducting manual overrides during this operation. Subsequent operations using manual override may have resulted in a collision between the pipe being hoisted and other equipment or the rig floor.

Traveling Block Collision Due to the resetting of a controller by rig personnel, the perceived block height for the hoisting system changed from 181 feet to 81 feet. Subsequent raising of the Traveling Block caused a collision between the Block and Derrick Crown. Investigation via the remote monitoring system identified the point at which the controller was reset. Pinpointing this root cause allowed for repairs to be carried out and the system re-calibrated without initiating additional investigation into other areas. Investigation into this incident without remote monitoring may have never revealed the root cause, allowing for operations to continue with unresolved issues.

Case Study: Other Equipment

The following case study illustrates the extent to which remote monitoring can be utilized to eliminate equipment from the root cause and direct investigation toward other parties equipment not directly involved in the remote monitoring process.

After a Top Drive System (TDS) had completed a make-up torque sequence and was ramping down, it was noticed that one motor on the Drawworks was dropping off or becoming disabled. The remote

monitoring system was used to trend data from the Drawworks motors, the braking system and the TDS torque sequences. Comparison of trends revealed discrepancies in the armature currents for the motors. A Subject Matter Expert was consulted and the relationship between the TDS ramp down and Drawworks motor drop off was narrowed to an issue with power supply and SCR malfunction. Although the SCRs were not part of the scope of equipment supplied and monitored by the remote system, the diagnosis and elimination of other causes allowed the rig to focus on this system. This enabled the rig to schedule a service visit from the proper company to affect repairs. Unnecessary service visits and troubleshooting were then avoided.

Additional Functionality

The remote monitoring system has proven beneficial in other area such as the commissioning of new tools. By utilizing the remote monitoring capabilities of the system, onshore engineers can provide additional expertise to the commissioning process. For example, during the commissioning of a Pipe Racking System (PRS), engineers onshore assisted the commissioning by providing confirmation of the tools proper function as it was performed on the rig in the Gulf of Mexico via the remote monitoring system. This not only maximized the expertise available, but also improved the quality of the tool commissioning by verifying the correct movements and functions through real-time data transmission.

Conclusions

Case studies of the remote monitoring system have shown that time to determination of root cause can be dramatically reduced. Safety of automated rig equipment is improved through the remote monitoring system in a number of ways. The system can discern root cause in situations where troubleshooting without the system might never have revealed the cause. Rig personnel can forego operating the equipment in an attempt to observe faults. Steps are eliminated in troubleshooting procedures that require personnel to come in contact with equipment, eliminating the potential hazard of injury. Incidences do not go undiagnosed, and repairs and operations can proceed with confidence. Accuracy of the diagnosis reduces time and eliminates unnecessary troubleshooting procedures. Time reduction and elimination of potentially hazardous situations equate to a safer, more efficient work environment. The remote monitoring system has proven itself to be an essential component of any automated rig.

Future applications of remote monitoring will include statistical analysis of accrued data. By analyzing trends in equipment performance, customized software can be developed to detect conditions that may lead to failures, thus enabling the system to become proactive rather than reactive. This predictability can also be

incorporated into preventative maintenance programs, allowing spare parts and manpower to be properly scheduled months ahead of time.

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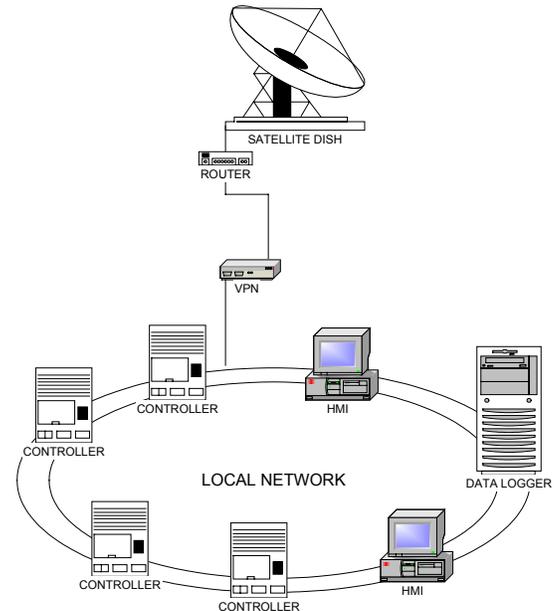


Figure 1

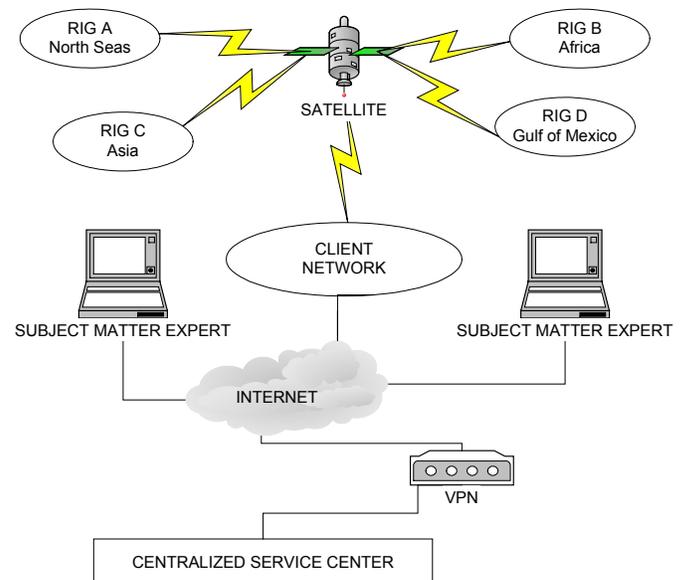


Figure 2