Validation Process for Human Factor in Complex Upstream Oil and Gas Operations
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Abstract
During drilling, completion and production operations, engineers and work crew often encounter critical situations requiring rapid decision making with insufficient information about their root causes while facing unknown consequences. Of concern is their experience and training to handle crisis management and in meeting the appropriate standards of care for the health and welfare of the workers and as well as their social and business responsibilities. The petroleum industry has been keen to exercise and mandate zero tolerance in oilfield accidents. Major operators, most large size independent and national oil companies have each adopted in-house standards and certification of their engineers and workers. In spite of these efforts, the industry continues to receive criticism when it comes to human and environmental safety issues. The nature of oil industry is becoming such that one act of mishandling of a crisis situation by any size company can have a drastic impact on the entire industry. We discuss the necessity of step changes in adopting universal standards for validation of the experience and training to successfully manage a crisis situation using advances in Information Technology as a means of enhancing trustworthiness of global upstream operations.

Introduction
Over the last decade, positive changes have taken place in the dynamics of upstream process management using Information Technology and collaborative based decision support systems (DSS). Besides the incentives to improve operational efficiency, modern day workflow processes for upstream oil and gas operations require engineers and crew to exercise their judgments with utmost considerations for the safety of personnel and the environment. When emergent situations arise, primary value propositions such as maximizing profits or minimizing cost are not necessarily the optimal objective functions. Events such as the Santa Barbara spill of 1969 and the tragic incident of April 2010 in the Gulf of Mexico have each had drastic economic impact on the Industry and negatively impacted the industry. Safety expectation for oil and gas operations at all levels are now on the radar screen of not only the regulatory agencies, but also many citizen’s group and bloggers. Terminologies such as BOP, marine risers, “fracking” (hydro fracturing) are now becoming popular topics of discussions. To enhance the well being and economic and social impact considerations for the industry, the time has come for the development of a global oil industry certification program. Leaders in upstream oil industry, academia and professional societies must examine the current requirements and help to develop global standards and new validation processes that will be followed before a human element is allowed to engage in oil field operations. The timing is ripe, as the advent of the tools and capabilities of Information Technology has opened up opportunities that can significantly help in this standardization process.
Statement of the problem
A major cause is oilfield accidents related to poor operating practices, inadequate safety training or human error. This is an issue of concern to the whole industry because a mistake by any size company has widespread impact on the reputation of the industry at large. As such, there is a need for a common base certification that if widely adopted can help to increase the public's confidence in the capabilities and the competence of the oil industry. While many companies conduct their own certification processes and exercise strict safety guidelines and in spite of multiple layers of safety measures and controls, there are urgent needs for the oil industry to add additional layers of credibility to its safety records.

Today's petroleum engineering graduates receive a very broad education. Nevertheless, upon graduation they are not yet experienced enough to go into the work place and take responsibility for the practical and technical aspects of many oilfield situations. They need a way to get experience before they deploy to the oilfield environment. Thanks to the progress in smart oilfield technologies, the time has come up for a validation process that can provide the engineering work force a way to get training for oilfield safety under a virtual oilfield environment.

Smart Oilfield Technologies
The upstream oil industry is adopting smart oilfield technologies as a means of boosting production, increasing recovery factor and for minimizing workovers. This is all done via placement of sensors and data recording networks, ICV's, application of artificial intelligence, data mining and decision support systems, all benefitting from a collaborative type of decision support environment. Perhaps an important dimension of these technologies is the adaptation of risk management tools through advances in sensors and sensor technologies. It is essential to extend these technologies to the realm of environmental and human safety.

Much has been published about the certification of field engineers and providing adequate training of field workers for handling safety issues. Current certification standards for petroleum engineers can not alone prevent accidents; but smart technologies are adamantley needed to assist in real-time decision making in or order to assist in visualize and predict conditions the might lead to accidents, but with sufficient notice to act properly to correct and prevent a crisis situation. This paper reviews ways that leadership can be demonstrated for taking advantage of the technologies of smart oilfield operations and creating a validation process for not only measuring the competency of responsible decision makers, but also by providing enhanced training.

Oilfield Accidents
Oil industry operations, from the exploration stage to the refining of the oil and gas, can be hazardous. Oilfield workers need to have developed the necessary hazard awareness and detailed knowledge of risk control to allow them to perform their duties safely and effectively. Oilfield accidents can involve severe injuries or death and sometimes result in the spillage of toxic fluids or vapors. Examples range from low flying helicopters in seismic operation to equipment failures in production operations. During drilling, related accidents involve heavy equipment and high pressures. Oilfield accidents may result in fires, tong injuries, high pressure line ruptures, tubing failures, casing failures, well head equipment failures, blowouts, explosions, electrocutions, derrick collapses, or toxic exposure. Metal component failures occur because of overstress, corrosion fatigue, welding defects, manufacturing defects, regulator failure and design defects.

In both drilling and production operations, situations can arise where confusing alarms occur with inadequate access on a real time basis to an explanation of the events unfolding, creating a situation where an engineer may not be able to rapidly decide on the proper courses of corrective actions. What also can increase risk is a sense that a task should be accomplished as quickly and efficiently as possible. However, with fatigued workers and tight schedules, this can subtly cause safety to be compromised. During drilling and completion operations, a rushed work environment can often result in a fatal lack of communication between rig operators, heavy equipment operators, and the other contractors operating on site. In summary, at every turn and in every phase of work in the oilfield, there are possibilities for small mistakes or unforeseen equipment or component failures that have enormous consequences. It is generally believed that most injuries are caused by unsafe acts. They can be prevented by clear and involved leadership in defining workplace standards. The questions at hand is to what extent can one can count on human heuristic leadership when surprise failures occur and what can be done to proactively predict failures and keep workers out of harms way.
Statement of the Problem
Oil field workers deserve a safe place to work. Oil well drilling, completion and production operations require the use of heavy equipment, high-speed machinery and involve lifting of pipe and equipment, pressurizing the wells, pipes and vessels and the use of combustibles and chemicals. In spite of sound engineering and management practices, the threat of fire, explosion, and toxic release is always there. Most oilfield accidents are caused by catastrophic equipment failure, inadequately trained employees, insufficient safeguards and predictive capabilities, rushed work environment, faulty communication between the various operators, lack of collaborative decision making and violations of safety policies and procedures.

Ethical dilemmas may surface in the course of engineering work because there may be occasions when there are conflicts of interest and loyalty between the different roles of the engineer. The dimensions of these ethical dilemmas are heightened by the impact of accidents to the local community in terms of loss of life or the injuries resulting in total or partial disability, which is far more costly than any damage to properties. Damage to property affects community in terms of losses of revenues, employment, rebuilding cost and can cause economic constraints.

However, with the advent of digital oilfield technologies there are opportunities for real time surveillance of ‘leading’ rather than ‘lagging’ indicators of accident causing failures. Further, the adoption of certified training in a virtual Collaborative DSS can allow a certified on-site decision maker to use digital oilfield technologies to address a crisis situation in a more effective manner.

Oilfield Management
Safe operation of oilfield requires discipline, precision and ethical standards. Command and control systems, tracing back to military systems, and optimization standards such as maximizing profits or minimizing cost are not in themselves adequate and effective and cannot address the complexity of integrated operations. In an oilfield operation, petroleum engineers always have more information than the “managers,” so they are really in the better position to make decisions. This is particularly true in emergent situations requiring rapid, independent decisions that are in the interest of an engineer’s organization and society as a whole. Yet decision making, when particularly affecting the health and safety of workers, requires more than established rules and procedures and ethical conduct. Digital sensing and mapping of operational components can empower engineers in exercising their judgments tempered with the utmost considerations for the safety of personnel and the environment. That is an ideal state to be in, where one can prevent major safety and environmental disasters before they progress too far. Digital mapping of defects and real time failure prediction can provide an effective alternative to fuzzy oilfield management process.

Licensing Issues
While professional licensing and codes of ethics are in place in engineering professional societies, by and large licensing of petroleum engineers is not required in the industry. Even for those who go through licensing programs, indications are that the licensing standards measure competency in technology subjects rather than in decision making abilities under critical conditions.

The practice of petroleum engineering is and has been one of the professions that can impact the health and safety of workers and the surrounding environment. One may compare the management of oilfields to what is expected from health professionals in a hospital. Those in the medical profession are responsible to operate and make on site decisions that first and foremost protect life and safety of patients. Petroleum engineers are also expected to monitor operations and make decisions that can prevent accidents, prevent loss of life, and to minimize the risk of injuries to field workers and the neighboring population and to minimize damage the environment.

Licensing is required before one is allowed to practice in the medical and health services field, in counseling services and for several other activities where the safety of the public is at stake, such as driving a car or a motorbike. Society feels safer when dealing with licensed professionals. Unlike many professions, however, a majority of petroleum engineers are not licensed to conduct their professional duties. That is neither required nor is rewarded by the operating companies. Part of the problem is that the current licensing process is similar to passing the written portion of the driving test. Actual oilfield accidents cannot be arranged for the benefit of providing the licensee candidate prior experience and training to handle an emergency or emergent situation. Hospital workers, from nurses to medical practitioners, spend years under supervision, working with actual patients and emergency situations to get the necessary skills for crisis management. No such a thing can be arranged for oilfield operations. However, there is possibility of addressing by providing training in virtual training facilities.
There are also other parallels for exercising judgment in an oilfield vs. applying medical knowledge in the management of medical conditions. On par with the professional status recognition given to health practitioners, practicing petroleum engineers must also be able to see themselves as independent, professional practitioners rather than technical employees reporting to managers. This is not easy, as the tendencies are for companies to maintain top-down control of their employees.

The question arises what is a proper validation process for addressing competency of practicing petroleum engineers? In modern medical fields the practice is moving more and more toward immersive visualization of patients and their related information. Thanks to the advent of smart field operations, similar opportunities are evolving in oilfield operations but the primary emphasis has been more in the area of asset value optimization. The ability to make decisions with safety in mind, regardless of other optimizing factors, requires a special level of engineering ethics and professionalism that must be cultivated either in a real or simulated experience. A modern day petroleum engineer however needs the training and tools that can do that. Once deployed in the field engineers must be provided with information management tools that can inform them about impending events. The engineer must be able to operate with systems which are well designed, are in good operating conditions, have good maintenance record and are monitored regularly. A major emergency can develop because of failure of operating systems. In the end, it is not a well written emergency plan that can save the day, but rather careful evaluation of anticipated possible events and development of a plan, together with appropriate experience and training, to predict and mitigate such situations.

A path forward for the industry is to use advanced sensor and sensor nets, together with artificial intelligence techniques for analyzing streaming data from dynamic operations and evolving situations as well as legacy data. In addition, this information to be useful in a real-time situation must be seamlessly collected and visualized to detect the onset of impending equipment or operational failures. Licensed petroleum engineers in charge of field operations must be equipped with the understanding and use of such data mining capabilities. This can come from suitable drills and rehearsals in virtual environments.

Certification Process
Managing human error is fundamental to the viability and profitability of oil and gas companies. New capabilities being developed for the economic aspects of asset management can help in upgrading the traditional system safety approach. The goal should be reducing errors in most oil and gas operations. Innovative tools are required that can turn errors into effective error management solutions. Managing human error, which was once considered beyond the reach of safety professionals, has now been made possible through sensor nets, data mining and computer aided monitoring. They can help effectively in integrating human factors into traditional safety management systems. We suggest that the more widely the above techniques are adopted by E & P companies, the better for the industry as a whole.

We can divide the implementation of the above into two broad categories. One component can be accomplished with standardized and transparent cross-industry Safety Training Programs with mock accident scenarios to provide students with virtual “real world” experience. These situational test cases can help in preparation of reactive solutions to sudden hazardous conditions. But the other component, which is as important, is the monitoring of every key component of the facilities during drilling, completion and production, allowing for the prediction of the onset of an impending failure. This second component needs customization for a particular field setting and operational environment. Universities can certainly help and can have a role, if industry invests in the development of standardized virtual training systems.

Virtual Simulation of Drilling Work Flow Processes
Discussion about the potential benefits of virtual simulators for training new petroleum engineers has been around for some time. The use of drilling simulator for reducing the learning curve in well control and drilling optimization is a widely accepted practice.

Similar simulators for training in other areas of petroleum engineering are expected to eventually become common place. But one that has the highest priority is the category of virtual simulators for monitoring general oilfield safety during exploration, drilling and production operations. These simulators can allow training opportunities and measurement of risk perception under simulations of actual conditions. Responses to realistic oilfield hazards can be measured and reviewed via a virtual reality simulator.
A review of the SPE published competency matrix spells out what competencies are expected from various groups of petroleum engineers. Competency matrixes are developed by SPE and has been discussed by BoBo and Reece3 and Fattahi and Riddle4. Understanding work flow processes in drilling, completion, and production engineering is just one element of competency. Actual conditions often place engineers in a situation where they need to make decisions under stress and manage enforced conditions. Lack of certified training in crisis management, and lack of guidelines and rules of professional responsibility for engineers to follow in meeting the appropriate standard of care, can result in major operational disasters. The competency matrix for petroleum engineers needs updating to require understanding and training in virtual settings and skills in the use of sensors and sensor nets and artificial intelligence based prediction of impending events. Such augmentations, which are necessary for training and better equipping practicing engineers, should include a library of continuously updated case studies of failures.

Conclusions
Special emphasis is made on the need for human factor validation in upstream oil and gas operations using standardized industry wide virtual training facilities. Validation of human factor competency issue requires training with effective information management systems, AI based performance monitoring and robust decision support system in a collaborative environment. (DSS). The SPE competency matrix for training practicing petroleum engineers requires augmentations for oilfield safety under ever evolving operational challenges. The goal is to promote a global set of validation requirements for licensing a new generation of practicing engineers with hands-on training in virtual settings using information based collaborative decision support systems. Information visualization related to safety issues should become an important part of competency building for the human element. For the real monitoring of field conditions, this approach would be an improved alternative to standards that do not as immediately provide a means for tracking events and decisions.

References