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RFID and environmental sustainability: Case of Weatherford firm in the oil and gas drilling industry

(Work-in-Progress)

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ABSTRACT

This paper features a one-case study analysis focusing on Weatherford, an oil and gas exploration firm operating in 75 countries and the firm's use of radio frequency identification (RFID) for its TRIP1 system used to direct the work of function tools downhole in a well reservoir. Two theoretical frameworks, the Socio-Technical Systems Theory and the Affordances Theory are used to interpret Weatherford's RFID deployment in this one specific application. This study uses the qualitative case study method and content analysis in evaluating the primary data. The importance of RFID specifically for applications in the oil and gas exploration industry ties in directly with the current urgent concern of society for environmental sustainability.

Keywords: Radio frequency identification (RFID), environmental sustainability, oil and gas drilling, sensors, environmental threats..

INTRODUCTION

Today's concern for environmental sustainability warrants the investigation of modern technologies that can help especially in the oil and gas drilling industry, one with a direct significant impact on society's energy consumption. Radio frequency identification (RFID) is one such technology and its application in Weatherford is examined in this one-case study paper. Operating in 75 countries, Weatherford delivers innovative energy services undertakes both deep water and onshore oil and gas exploration projects worldwide. Two theoretical frameworks, the Socio-Technical Systems Theory and Affordances Theory, are used to understand this firm's RFID system deployment in its TRIP1 system.

LITERATURE REVIEW

This section will cover a discussion of the basics of RFID systems, the use of RFID in the oil and gas drilling industry, the Socio-Technical Systems Theory, Affordances Theory, and Weatherford firm background.

Radio Frequency Identification (RFID) System Basics

Radio frequency identification (RFID) consists of the tag and the reader (Felemban & Sheikh, 2013). Information is usually embedded on the tags which is, then, detected by the reader, which subsequently transfers the data to any business software application in a firm's legacy system. RFID tags could be either active or passive. The RFID reader transmits a radio frequency interrogation signal while scanning the tags. When this signal is received by the RFID tag, it responds by transmitting the information embedded in it. One of the key benefits of using RFID tags is that having "line of sight" access to the tag is not required in order for the data to be accessed or read by the RFID reader. This means significantly more RFID tags can be read by the readers as they pass through warehouse portals, for instance. This is the limitation of the older technology --- the bar code, which the RFID tag has eventually replaced.

RFID System Use in the Oil and Gas Drilling Industry

RFID systems have been used for various purposes in the oil and gas drilling industry (Roberti, RFID Journal, no date). The following are selected examples of RFID system use in the industry by different firms and government agencies. British Petroleum (BP) uses both RFID and global positioning systems (GPS) to track material components intended for building exploration platforms shipped from its European warehouses to the Hyundai Heavy Industries warehouses in South Korea. In Australia, Bechtel used an RFID-based materials management system in the construction of three liquefied natural gas and export facilities in Curtis Island. An RFID-based system consisting of tags, readers, vehicle readers, and handheld interrogators was used by JV Driver Group in automating the monitoring of materials used in its construction projects in Canada. JV Driver Group is involved in construction services for the oil and gas, energy, petrochemical industries. Sempra Energy uses RFID for customer billing resulting in time savings gained from avoiding waste involved in monitoring unrecorded gas meters installed in the premises of about 3,000 Southern California Gas customers. Sempra Energy covers both Southern California Gas and San Diego Gas and Electric. The Argonne National Laboratory of the U.S. Department of Energy uses RFID to track and report on the status of barrels of nuclear materials held in the department's storage facilities.

Socio-Technical Systems Theory

Bostrom and Heinen (1977) presented the socio-technical systems (STS) theory which analyzes an organization's information system using the components of a work system proffered by Leavitt (1965). The socio-technical model proposed by Leavitt uses the following dimensions of organizational work systems as tools of analysis: task, structure, people, and technology. Piccoli (2008) broke down the "technology" dimension by referring to depicting it as an integrated set of software that transfer, compute, and record information.

Two subsystems constitute the STS system: (1) the tasks and technologies that make up the technical subsystem transform inputs into outputs; and (2) individuals in a work unit, their relationships, reward systems, and authority and work structures make up the social subsystem. Organizational systems usually set goals instigated by pressures from the external environment. The organization's internal environment consisting of both the technical and social subsystems, consequently, need to interact optimally to meet organizational goals in response to external pressures. The STS framework is another theoretical lens that can assist in analyzing an organization's experience in deploying a new information systems application using specific information technologies. The STS framework has been helpful in providing descriptive narratives supporting the different STS dimensions, but, at the same time, it has been remiss in accounting for the interactions of these dimensions in explaining their potential to change the organization. Thus, this case study uses the "affordances theory" (Gibson, 1986, 1977) and very specifically, the concept of "functional affordances" (Markus & Silver, 2008). These complementary theoretical lenses will bridge the missing gap and assist in showing how information systems relate to behavioral routines of end workers as manifested in their work practices (Leonardi, 2011) as they try to realize their action goals (Markus & Silver, 2008).

Affordances Theory

The word "affordance" used in information systems theory discussions was first derived from the domain of ecological psychology when Gibson (1986, 1977) used it to characterize how material objects offer both potential uses and constraints to actors or end users. Material properties of information systems allow "possibilities for goal-oriented action" or "functional affordances" of that form of technology (Markus & Silver, 2008). Chemero (2003) suggests, though, that affordances have to be perceived by the end user before they can be actualized. The term "functional affordances" refers to capabilities enabled by given forms of information systems or information technologies. The end user's ingenuity, the form of information system or technology, and the requirements of the organizational context all determine an end user's ability to extract certain "functional affordances" from the technology used (Leonardi, 2011).

Features of different forms of information technology can be used by human agents or ignored by them, depending their end purposes (Stinchcombe, 1968). Thus, both intended and unintended consequences of information technology are realized through functionalities of material artifacts that "afford" those consequences.

Weatherford Firm Background

Weatherford is a leading oil and gas exploration firm, present in 75 countries, operating in more than 350 locations, and avails of the services of 17,000 world class experts in exploration. It is dedicated to developing innovative energy solutions designed to be environmentally and economically sustainable (Weatherford, 2021b). Its key energy transition offerings are: (1) geothermal energy services; (2) carbon capture, utilization, and storage (CCUS); and (3) plug and abandonment services (Weatherford, 2021a). Its main range of services and products cover: (1) formation evaluation: the firm helps customers collect, interpret, and apply formation evaluation data to locate the optimal formation target; (2) drilling: Weatherford offers careful planning, expert engineering, and drilling technologies to help customers maximize drilling exposure; (3) completions: the firm offers modern completion technologies (i.e., completion means opening up a reservoir for production) to reduce risks, minimize costs, and optimize production for any completion; (4) the firm uses a strategy to ensure that the customers use innovative field management solutions to produce more hydrocarbons at the lowest costs (Weatherford, 2021b).

RESEARCH METHOD

This study uses the case study and content analysis methods in aligning the concepts prescribed by the two theoretical frameworks to the Weatherford RFID system. The primary data used was the transcription of the conference presentation talk of Euan Murdoch, RFID Completions Product Line Manager, Weatherford at the RFID Journal Live! Annual Conference and Exhibition, on September 26-28, 2021, Phoenix Convention Center, Phoenix, Arizona, USA. In addition, secondary data sources from academic and trade articles were content analyzed using key concepts in the frameworks. The following are accepted definitions of the content analysis:

Content analysis is any research technique for making inferences by systematically and objectively identifying specified characteristics within text. (Stone et al., 1966, p. 5)

Content analysis is a research technique for making replicable and valid inferences from data to their context. (Krippendorff, 1980, p. 21)

Content analysis is a research method that uses a set of procedures to make valid inferences from text. (Weber, 1990, p. 1)

The concepts used for content analysis were derived from the two theoretical frameworks that also formed the "context" of this study:

A context is always someone's construction, the conceptual environment of a text, the situation in which it plays a role. In a content analysis, the context explains what the analyst does with the texts; it could be considered the analyst's best hypothesis for how the texts came to be, what they mean, what they can tell or do. In the course of a content analysis, the context embraces all the knowledge that the analyst applies to given texts, whether in the form of scientific theories, plausibly arguedpropositions, empirical evidence, grounded intuitions, or knowledge of reading habits…. The context specifies the world in which texts can be related to the analyst's research questions. (Krippendorff, 2004, p. 33)

The primary and secondary data was analyzed within the context provided by the two frameworks, which are considered the "prior theory." "Analytical constructs operationalize what the content analyst knows about the context, specifically the network of correlations that are assumed to explain how available text are connected to the possible answers to the analyst's questions and the conditions under which these correlations could change….analytical constructs ensure that an analysis of given texts models the texts' context of use…" (Krippendorff, 2004, p. 34).

Following the methodological prescription of Krippendorff (2004), the content analysis procedure deployed in this study ensured that the following steps were performed. The focus was kept on the research question, which guided the entire inquiry. The key concepts covered by the socio-technical and functional affordances theories were used to identify relevant text materials in the primary and secondary data sources for analysis. Interpretations of the application of these theoretical concepts in the data sources were made within relevant contexts. Explanations made sought to operationalize the analytical concepts sought to be illustrated within the firm's experience. Inferences were made within the boundaries of the two theoretical frameworks used as answers to the key research question were sought.

STUDY FINDINGS

The following are the findings for Weatherford applying the two theoretical frameworks.

Socio-Technical Systems Theory

Social subsystem

Weatherford has a tight system where it supports environmental protection from the top down --- from statements of its corporate strategic commitments to cultural values it espouses, the nature of the products and services it offers its corporate customers, and human resources policies it has implemented (Weatherford, 2021a). Commitment to environmental protection is a critical goal on account of the type of services the firm provides, which pose direct threats to the state of the environment wherever the oil and/or gas exploration is taking place geographically. This is also one of the "four tenets" the firm espouses: waste management; water management; reduced impacts to land; and energy management.

In training its workforce, Weatherford puts a strong emphasis on teamwork and collaboration as these directly impact the firm's ability to undertake risky exploration projects on land or on deep water. Active employee engagement in company tasks and activities is gained through virtual townhalls, employee surveys, small group discussions, and site visits (Weatherford, 2021a).

Weatherford also encourages the development of creative engineering talents of its workforce, and count on its workers as key sources of innovative ideas needed to gain the edge brought forth by digital transformation and technological innovation (Weatherford, 2021a).

Weatherford's Board of Directors also has the Safety, Environment, and Sustainability Committee. One of the standards upheld by this committee is the "Operational Risk Management Standard" that stipulates all risk assessment requirements and responsibilities for all drilling and exploration geographical sites using the firm's products and services (Weatherford, 2021b).

Technical subsystem of Weatherford

Background Information on Oil and Gas Drilling and Exploration

The RFID system in this case study involves an application in oil and gas drilling and exploration, specifically the "upstream" sector of the industry. The following activities are involved in the "upstream" sector: exploring for oil and gas fields, drilling oil wells, and if hydrocarbons are located, digging wells to enable crude oil or natural gas to emerge from the depths of the earth (Stengel, 2014).

Before work can begin, engineers need to identify potential sources of hydrocarbons. The two methods commonly used are the geological and geophysical methods. The geological method involves using surveys for field mapping or aerial/satellite imagery to peer "within" the depths of the earth. On the other hand, the geophysical method uses seismic reflection using refraction, magnetic, gravity, or electromagnetic fields. Weatherford specifically uses seismic methods which depend on sound waves that are sent into the depths of the earth and which are reflected and refracted off the subsurface strata to be received by seismic receivers. Data gathered by these receivers such as arrival times of sound waves, amplitude variations and frequency reveal potential oil gas deposits.

The Weatherford case study detailed here involves deepwater hydrocarbon exploration. Offshore drilling usually uses a mobile offshore drilling unit or (MODU). The MODU is designed taking into consideration the following: "... ocean depth, seabed geography, average wind speed, average wave height, currents, environmental concerns, and cost…." (Stengel, 2014). Such a structure is usually the focus of serious environmental concerns and thus, whatever means can be deployed to lower the potential damage to the environment warrants serious considerations. The RFID system that will be described here contributes to ameliorating such concerns.

A major operation conducted when drilling the well has commenced is using a drill pipe that is fed down a borehole. Within this drill pipe, drilling fluid or mud is made to flow down this pipe and back up to surface to balance the underground hydrostatic pressure, cool the bit, and flush out stray rock cuttings that could hamper future work in the hole (Miesner & Leffler, 2006).

Engineers try to prevent and/or prepare for what is called "uncontrolled blowout" in such drilling holes. One way to do so is to use blowout preventers fitted at the borehole opening. A blowout preventer is used to seal a well and consists of hydraulically actuated steel rams that close around the drill string or casing (Miesner & Leffler, 2006). Equipment that collect data on pressures, rock types, permeability, porosity, and other subsurface attributes is put down the open hole before steel casing or a series of steel pipes are installed in layers to stabilize the well (Stengel, 2014).

The borehole is created in sections and once the process is completed, the steel casing is inserted into the hole and firmly cemented into place in order to seal off the area from water and contaminants. More importantly, it will prevent oil from leaching into the adjacent groundwater.

If the data gathered by the equipment positively indicates the presence of hydrocarbons, additional tests will be done to determine flow rates and formation pressure (Stengel, 2014). There are usually two anticipated outcomes: either there are commercially viable quantities of hydrocarbons in certain locations, or there are none. If the outcome is positive, a well-head valve assembly is installed on site, and appraisal wells are drilled to more precisely determine the amount of hydrocarbons present. If, on the other hand, there is not enough hydrocarbons found, it is simply sealed with cement plugs to avoid wellbore fluids from surfacing (Stengel, 2014).

If the tests firmly establish the presence of commercial volumes of hydrocarbons, the "development" phase of the oil exploration is poised to begin. At this stage, the development wells are built to draw out the hydrocarbons. The size of the reservoir, subsurface geology, surface geography, access, and the corporate budget will determine how many wells will be developed (Stengel, 2014).

Weatherford's TRIP1 System described in this case study is involved mainly in this "upstream" phase of oil and gas exploration. The TRIP 1 System uses RFID, after 10 years of development, in this manner: RFID tags contain content that direct the way tools should function downhole, or at the bottom surface of a well operation (Murdoch, 2021). Thus, the firm uses the RFID tags as a way to communicate with the tools already placed downhole. Tools are outfitted with RFID readers, which are powered up by batteries which are also brought downhole. These tools help to physically move or to do specific tasks as directed by the instructions encoded on the RFID tags. Examples of instructions might include --- the tag may tell a tool to open or close a valve, or to perform a specific task. Once the appropriate instructions are encoded in the RFID tags, these are dropped into a well being explored. These RFID tags are pumped down the tube, down to the well. The RFID readers on the tools, in turn, interrogate the tags once they are in contact with them. The tools determine if the tags are relaying instructions meant for them (Murdoch, 2021).

Engineering Challenges with RFID

Weatherford did its due diligence and tried to find a technology solution in the marketplace that would meet its needs (Murdoch, 2021). In the absence of a solution, their tech people found ways to enable to use RFID tags with temperatures of 450 degrees Centigrade and with pressures of up to 30,000 PSI (pounds force per square inch of area). An atmospheric chamber is used to house the RFID tags, antennas, and auxiliary equipment in order to protect them from the force of 30,000 PSI.

The second challenge is the limited space envelope available for the work. Once drilling reaches the bottom of a hole, there are only about 8 inches a hole, about eight inches across to work with. Meanwhile, there remains the need to transport the RFID tags to that location. The environment at those depths can also be very harsh --- with the presence of hydrogen sulfide, high levels of carbon dioxide, high temperatures, high pressure levels, and high levels of erosion. All these conditions pose a challenge for how the tool needs to be designed. As it is, there is only a very thin section available for getting the hydrocarbons back up the insides of these tools. Also, with the limited space available, engineers have only about one to two inches to play with in the wall section of the tube within which to pack all the electronics required.

Considering all these challenges in the drilling hole, Weatherford did try different technology solutions to deal with the given conditions (Murdoch, 2021). The firm chose to use a low frequency based system since the elements involved will be enclosed in fluid. The technology people also looked at FM and AM systems and compared their performance. They needed a solution with a read/write system that would allow the engineers to write entire instructions in the form of codes and embed them in the RFID tags.

Weatherford had to choose between an AM or FM system to do the job (Murdoch, 2021). The first system they chose was an AM system for a small metal conduit that had a coil antenna wrapped around it and was used to pump RFID tags downhole. It turned out that very few applications could really use this his AM system. Eventually, the technical team decided to work with an FM system that uses an off-the-shelf 23 millimeter glass encapsulated RFID tag that is mounted on or press fitted into a silicon carrier. Apparently, this set up gives the technical team the ability to carry the RFID tags into the fluid flow and stabilize them as they pass through the antenna. These glass-encapsulated RFID tags can be heated up to 80 to 90 degrees centigrade, but surrounding temperatures in the hole could go as high as 100 to 150 centigrade. Thus, to cope with these higher temperatures, a temperature screening system had to be created to protect the tags. The work also usually entails working only with hundreds of tags annually, rather than thousands of such tags. This works out well for the need to screen the RFID tags in order to survive given temperatures. When the temperature and pressure levels in the well get high, RFID tags are repackaged in containers with formal plastic coating. This will allow the RFID tags to withstand pressures of up to 25,000 PSI.

Among the mechanical challenges involved is designing the antenna system (Murdoch, 2021). It is important to make sure that the antennas are reasonably separated from metallic components of the system. This is one of the weaknesses of RFID systems --- they do not work well when adjacent to metallic elements. A rugged antenna design is used to ensure that RFID tags could withstand high vibration, high erosion, and high speeds of about 10 to 40 barrels per minute at which they will be pumped through the pipes. This works out to a velocity of about 8 to 13 meters a second. The antenna design involves the use of a double helix wound antenna which uses the PEEK plastic, which is known for its exceptional qualities:
"…
- Resistance to harsh chemical and corrosive environments, including hydrogen sulfide at elevated temperatures
- Superb hydrolysis resistance with high retention levels of mechanical properties after prolonged exposure to steam or sea water at elevated temperatures
- Broad operational temperature range
- Low levels of creep and excellent mechanical properties, which can be further enhanced by the addition of fillers such as glass and carbon fibers
- Abrasion and wear resistance under high loads (bearing grades)…" (www.curbellplastics.com, 2022)

A major technical challenge for Weatherford at this time is vastly improving the use of RFID tags downhole so they could be retrieved up to the land surface safely. At the moment, the tags have software code designed to direct the work of tools at the bottom of the well (Murdoch, 2021). But it is also critical to be able to use the tags to gather key data underground during the exploration process from accelerometers, pressure transducers, and other devices used. Data on pressure, temperature, torque, rate of penetration, etc., are only some of the data pieces that can be captured and analyzed using data mining algorithms to both solve operational problems and model improved future drilling activities (Greengard, 2013, August 19).

Types of Tool Activation Method Used by Weatherford

The first method used is the single cycle method wherein RFID tags are pumped down to the tools at the bottom of the well (Murdoch, 2021). The tools, then, register the tags and associates the tag that is supposed to work with a specific tool. Now, there is usually high pressure at the well bore, which is usually stopped from getting in by a piston. When a specific tool has to be used and is needed to function, a heater element is heated up by the tool's electronics; the heat emitted, then, melts the headlock core which allows the piston to pop up. The resulting pressure, then, able to transfer this hole to a bigger piston. As that fills up, it creates a force, slides a sleeve, and opens a valve to allow fluid to come through. All this work can only be done once with the single cycle method.

The next kind of method involves the use of pump-based tools. If the work requires opening and closing things repeatedly, then, a micro pump housed in a tool is needed to generate its own pressure in the tool.

The TRIP1 System was first successfully implemented in Nigeria, in one of its offshore fields, in about 1,015 meters of water depth (Murdoch, 2021). The project team took 60 percent less time in completing the work with 50 percent less workers. Also, the team estimated work completion with 70 percent less carbon dioxide emission with the use of the RFID system.

Affordances Theory

Strong et al. (2014) posit that the affordance theory has not really clarified how an affordance's potential is actualized, how affordances operate within an organizational context, and how affordances arise as a "bundle" of interrelated affordances. Strong et al. (2014) also developed the concept of "organizational affordances." In the framework of Strong et al. (2014), actions of organizational end users affected by the same information system or technology need to coalesce in such a way as to obtain desired organizational-level immediate outcomes. These, in turn, will eventually lead to the actualization of organizational level goals. Both outcomes and goals relate to "organizational affordances" end users intend to actualize. So, for instance, the functionality of the organizational affordance called "enabling intervention completion installation affordance" only materializes if the workers and engineers in the hydrocarbon exploration site properly deploy RFID tags so that they work with the function tools as intended. This requires the application of the right technical skills to ensure that the appropriate instructions are encoded in the RFID tags and that they will properly be read by the RFID readers associated with the relevant function tools downhole.

IT-related affordances are defined by Markus and Silver (2008, p. 622) as "… the possibilities for goal-oriented action afforded to specified user groups by technical objects…." These IT-related affordances are also called "functional affordance" in the context of this study. Zammuto et al. (2007) has a related "take' on this and calls attention to affordances that arise from the interaction of organizational systems and different forms of information technology.
Technology is not viewed as being "static" --- rather, it evolves through time, especially when implemented and used by individuals in an organizational context and "interpret" it during its use.

Actualization of affordances consists of "…the actions taken by actors as they take advantage of one or more affordances through their use of the technology to achieve immediate concrete outcomes in support of organizational goals…." (Strong et al., 2014, p. 70). In order to move from being an "affordance potential" to being an "actualized affordance," there are certain goal-directed actions required of the relevant end users in the oil and gas drilling industry. Once an expected functional affordance is actualized, then, it results in an immediate concrete outcome. An example of a specific immediate outcome is also the "enablement of intervention completion installation," which may also be viewed as an "intermediary state." This would be a state between the actualization of the outcome of encouraging engineers to spend more time learning about the content of reservoirs rather than struggling with the challenges of releasing and capturing the hydrocarbons, and Weatherford's ultimate goal of successfully preparing hydrocarbons for future processing in its various commercial forms (Strong et al., 2014).

Affordances from RFID Use

Enables Intervention Completion Installation

Before Weatherford used RFID, the workers needed to move a valve downhole, rig something up, go down with more drill pipes, big long wires, and coils of tubing to get the job done (Murdoch, 2021). The job took longer to do this way and it was risky because there was no guarantee that these equipment could be pulled back out onto surface ground level again. But now, with the use of the RFID tags that have encoded instructions directing how tools should function downhole, the amount of time it takes to do the work has been cut down significantly. Also, the time associated with all the lifting and pressure testing involved in using big heavy drill pipe movements has been reduced as well.

Encourages Engineers to Learn about the Oil Reservoir

With more time in their hands due to the time savings from the operational tasks, the engineers are encouraged to learn more about the oil reservoir, what it contains, and how to extract more hydrocarbons out of the deep wells. With more hydrocarbons extracted, then, fewer wells need to be drilled --- this is good for the environment since less waste will be produced in the production process (Murdoch, 2021; Environmental Protection Agency, 2000).

Reducing the Manpower Required to Work On Site

The TRIP1 system using RFID tags enabled Weatherford to reduce the number of workers involved in drilling wells (Murdoch, 2021). Normally, workers and experts would have to be flown in from different parts of the world. They would, then, flown using helicopters to deepwater exploration sites. There, supply vessels with heavy equipment would have to be sent out to the oil rigs. With the RFID systems in place, Weatherford has lessened the need for both manpower, equipment, and supply boats. In addition to the monetary savings, the new RFID-based method is reducing the carbon footprint associated with oil exploration.

Promoting Worker Safety During Work on Sites

By no longer requiring workers to go downhole, the TRIP1 system will be boosting worker safety(Murdoch, 2021). An RFID system now serves as the automated proxy for work that used to be performed by human workers. The software code etched on the RFID tags, which are subsequently picked up by the RFID readers that work with the tools, will now direct how these should function.

CONCLUSION

Both the Socio-Technical Systems Theory and the Affordances Theory have been useful in understanding the experiences of Weatherford in the deployment of the RFID system for its TRIP1 Completion Procedure. The successful deployment of RFID in this specific application will bring forth positive related benefits as well such as: improved oil recovery --- this means, even after initial production activities have been done with the well, advanced engineering techniques may still be applied in the future in order to extract additional hydrocarbons in the future (Hyne, 2012).

The social subsystem of Weatherford as embodied in the Socio-Technical Systems Theory strongly supports the deployment of RFID in the delivery of its products and services. The focus on team collaboration, development of innovative technological solutions through nurturance of native in-house talent--- especially those driven by environmental sustainability, and the tight governance over risks the firm takes with every project explain the success of Weatherford.

A major hurdle for Weatherford for now involves the technical subsystem ---the need to improve the use of the RFID system so that the tags can be safely and completely transported back to surface after they are used downhole (Murdoch, 2021). Also important is the ability to retrieve data from these tags and subject them to detailed analysis to improve drilling operations. At this point of its development, it appears that this is still an operational challenge for the TRIP1 System. In the meantime, fiber optic cabling is run at the backside of the tools used downhole to capture temperature and pressure data while using the RFID system.

REFERENCES

Bostrom. R.P. and J.S. Heinen (1977). "MIS Problems and Failures: A Socio-Technical Perspective, Part 1: The Causes." Management Information Systems Quarterly, 1(1), 17-32.

Chemero, A. (2003). "An Outline of a Theory of Affordances." Ecological Psychology, 15 (2), 181-195.

Curbell Plastics (2022). Definition of PEEK. Retrieved April 29, 2022 from https://www.curbellplastics.com/Research-Solutions/Industry-Solutions/Markets/Oil-and-Gas

Environmental Protection Agency (EPA) (2000, October). Profile of the Oil and Gas Extraction Industry. Retrieved 17 June 2022, from https://nepis.epa.gov/Exe/ZyPDF.cgi/50000EM6.PDF?Dockey=50000EM6.PDF

Felemban, E. and Sheikh, A.D.D. (2013). "RFID for Oil and Gas Industry: Applications and Challenges." International Journal of Engineering and Innovative Technology, 3(5), November, 80-85.

Gibson, J. J. (1986). The Ecological Approach to Visual Perception, Hillsdale, NJ: Lawrence Erlbaum Associates.

Gibson, J. J. (1977). "The Theory of Affordances." In R. E. S. J. Bransford (Ed.) Perceiving, acting, and knowing: Toward an ecological psychology, Hillsdale, NJ: Lawrence Erlbaum, 67-82.

Hyne, N.J. (2012). Nontechnical Guide to Petroleum Geology, Exploration, Drilling, & Introduction Third Edition, Tulsa, Oklahoma: PennWell Corporation.

Krippendorff, K. (2004). Content Analysis: An Introduction to Its Methodology, Thousand Oaks, CA: Sage Publications.

Krippendorff, K. (1980). Content Analysis: An Introduction to Its Methodology, Beverly Hills, CA: Sage Publications.

Leavitt, H. J. (1965). "Applied Organization Change in Industry: Structural, Technical, and Human Approaches." In March J.G. (Ed.) Handbook of Organizations, Chicago, IL: Rand McNally, 55-71.

Leonardi, P. M. (2011). "When Flexible Routines Meet Flexible Technologies: Affordance, Constraint, and the Imbrication of Human and Material Agencies." Management Information Systems Quarterly, 35(1), 147–167.

Markus, M. L. and Silver, M. S. (2008). "A foundation for the study of IT effects: A new look at DeSanctis and Poole's concepts of structural features and spirit." Journal of the Association for Information Systems, 9(10/11), 609–632.

Miesner, T.O., & Leffler, W.L. (2006). Oil & Gas Pipelines in Nontechnical Language, Tulsa, Oklahoma: PennWell Corporation.

Murdoch, E. (2021). Weatherford Reduces Carbon Footprint in the Oil Industry with RFID. Transcript of talk delivered at the RFID Journal Live! Conference, September 26-28, 2021, Phoenix Convention Center, Phoenix, Arizona, USA.

Piccoli, G. (2008). Information Systems for Managers: Texts & Cases, New York, NY: John Wiley & Sons.

Roberti, M. (no date). How is RFID Being Used in Oil and Gas?, RFID Journal, Retrieved on March 3, 2022, from https://www.rfidjournal.com/question/how-is-rfid-being-used-in-oil-and-gas Stengel, D.N. (2014). A Profile of the Oil and Gas Industry, New York, NY: Business Expert Press.

Stinchcombe, A. (1968). Constructing social theories, New York, NY: Harcourt Brace. Stone, P. J., D.C. Dunphy, M.S. Smith and D.M. Ogilvie, (1966). The General Inquirer:

Computer Approach to Content Analysis, Cambridge, MA: MIT Press.

Strong, D. M., O. Volkoff, S.A. Johnson, L.R. Pelletier, B. Tulu, I. Bar-On, L. Garber et al. (2014). "A Theory of Organization-HER Affordance Actualization." Journal of the Association for Information Systems, 15(2), 53–85.

ThermoFisher.com (2022) Definition of steel casing. Retrieved March 10, 2022 from https://www.thermofisher.com/blog/metals/oil-well-construction-casing-and-tubing/#:~:text=Casing%20is%20a%20series%20of,together%20to%20form%20casing%20strings.

Weatherford (2021a). Annual Report 2021. Retrieved March 30, 2022 fro https://www.weatherford.com/documents/annual-reports-and-proxies/2021/2021-weatherford-annual-report/

Weatherford (2021b). Sustainability Report 2021. Retrieved March 25, 2022 from https://www.weatherford.com/sustainability/

Weber, R.P. (1990). Basic Content Analysis (2nd ed.), Newbury Park, CA: Sage Publications.

Zammuto, R. F., T.L. Griffin, A. Majchrzak, D.J. Dougherty and S. Faraj (2007). "Information technology and the changing fabric of organization." Organization Science, 18(5), 749–762.