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Retrospective and Predictive Analysis of Cognitive Errors (TRACEr) Oil and Gas Industry (OGI): A Case Study of the International Association of Oil and Gas Producers (IOGP)

Engr. Dr. Umar Muazu Tadama (PhD)[1]; Dr. Muazu Haliru Tadama (PhD)[2]; & Engr. Dr. Bala G. Montang (PhD)[3]

[1]Chemical Engineering Department, Federal Polytechnic Mubi. [2]Geography Department, Kaduna State University, Kaduna. [3]Civil Engineering Departments, Federal Polytechnic Mubi. Adamawa.
umarmuazutadama@gmail.com

Abstract

This paper is a detailed comparative investigation of adaptability, fitness and performance consistency of three human error identification (HEI) tools: Retrospective and Predictive Analysis of Cognitive Errors TRACEr-Railway Industries (RWI), TRACEr-Air Traffic Control (ATC) and TRACEr-Lite. The study seek to remodel and adapt these HEI tools to better appropriately suit and regularly used in the oil and gas industries (OGI), the result indicated that TRACEr-Lite is regarded more closely rated to developed TRACEr-OGI in terms of usability and reliability in the oil and gas industries. In the analysis from table 1a, b and c TRACEr-OGI was extracted to obtained and identify human errors (HE) from already developed HEI tools. In the analysis in table 2 TRACEr-lite and TRACEr-OGI was used to extract and identify HE from the International Association of Oil and Gas Producers (IOGP) incidencesin the Russian or the Caspian region.The investigation result uncovered that the modification will improved the ratings of adaptability and usability in OGI. The oil and gas industries in their desire to

overhaul the current status of accidents and incidences in OGI exploration and production with a narrow window, are in dire need for a health and safety software in form of a guide that would reduce high risks and hazards associated with the industry in general and particularly with manage pressure drilling, well control and evaluation as well as the numerous zero tolerance zones in the refineries. This study is born out to response to these urge by the OGI via developing an incorporated health and safety tools refers to Technique for Retrospective and Predictive Analysis of Cognitive Errors in Oil and Gas Industries TRACEr-OGI. These model findings combined a remodel task demands from three human errors identification tools to proposed these guide that introduces the new PSFs peculiar to OGI that could detect risks prior to and during the process. The TRACEr-OGI tools offers highly precise risk identification and more easy to handle. Integrating the human factors in three HEI tools risk analysis had been yielding promising success in improving OGI accident risk assessment and hence improving safety culture and tools reliability in the overall OGI safety systems.

Keywords: Rail industry, Air industry, Oil and Gas industry,Human error, Risk, Incidents, Accidents, Drilling, Well control, Controller and TRACEr.

Introduction

Offshore Oil and gas drilling incidences

Oil and gas drilling incidences such as DeepwaterHorizon, Macondo well blowout and many other blowout related accident has gain notable consideration in the last few years (Theophilus 2017; Miltiadis 2013). This attention was aimed at finding an obvious technical solutions that would give an opportunity to drill with a narrow window in improved techniques compared with traditional practice (Bassey 2017; Leni 2014). General drilling challenges such as managed pressure drilling (MPD), measuring while drilling (MWD), bottom hole pressure (BHP), subsea, fractured and reservoir formations have proven to be unsafe for traditional drilling method (Theophilus 2017b). To managed the hydrostatic pressure against the formation pressure (& vice versa) especially during several switching between the dynamic to static states in MPD,huge Deepwater BHP variations between fluid pumping and no pumping (& vice versa) and drill rig movement into and out of the drill hole during managed drilling, would require the introduction of incorporated instruments or specialist for this operations (RSSB 2008; Quaife 2017) see appendix 1. For these reasons huge developments are required to address causes of failures in OGI, reliable human error identification tools are needed that would enable

precise and effective containment (Theophilus 2017d). A Retrospective and Predictive Analysis of Cognitive Errors in oil and gas industry, TRACEr-OGI will be a major improvements that will consistently utilize and are needed by OGI and authorities for offshore drilling operations to remodel the much needed risks and benefits (MWB 2011).

Problem Statements

The oil and gas industry has ventured on an unimaginable series of gigantic hazard exploration operations slightly into shallow water drilling, then deep-water and now ultra-deep waters all around the world (MWB 2011). These activities pose high risks greater than ever thought of in the sector. The complexities of man-machine systems and the new technologies employed, the hazards of subsea water environment, the hazards of high hydrocarbon reservoir pressures and temperatures (MWB 2011). Tomanage the risks involved with drilling challenges enumerated above, primary, secondary and tertiary well control barriers are employed (Leni 2014). The primary control aimed at inhibiting the influx of fluid into the wellbore via appropriate use of mud column weight to manage either the hydrostatic or formation pressure against one another. The secondary control are employed where the primary control fails to stop the blowout, it involves the use of blowout preventer (BOP) to close the annulus and wellbore influx coming out to the surface. While the tertiary control came into play when things get beyond the secondary control, it involves the use of highly technical expert in terms of both human and equipment to stop or reduce severity of the blowout (Theophilus 2017c).

Aim and Objectives

On the other hand, perhaps, lack of comprehensive optimization of human error identification HEI tools in the OGI may had resulted to risks and potential hazardous events recorded in OGI in the past years (RSSB 2008). The development of HEI in OGI allows for successful MPD, MWD and well control measures that were previously leading to kicks(Isaac et al., 2002). While incorporating a new model for HEI tool Retrospective and Predictive Analysis of Cognitive Errors TRACEr-OGI may give precise well control performance, it encapsulate new safety culture that need urgent attention for safe situational operations. TRACEr-OGI leant lessons from successful industry HEI tools such as TRACEr-RWI, TRACEr-ATC and TRACEr-lite.

In order ensure the safety of BHP an integrated HEI tools known as Retrospective and Predictive Analysis of Cognitive Errors TRACEr-OGI will enable precise BHP control that will diminish risks of kicks and subsequent fire explosion compared to traditional methods of control, especially when drilling in high pressure formation

zones (Theophilus 2017c). Newest studies shows that the use of drilling model systems like TRACEr-OGI would influence controllers/drillers PSFs and potential risk of human error. For instance an obvious understanding of the environmental factors and working conditions will keep the driller always alert and kin towards responding to any piece of information. According to Leni(2014) during model development analysis should be performed that would reduce the potential of human error in the work environment that control critical safety zones (Theophilus 2017b). It further use the International Association of Oil and Gas Producers (IOGP)data base so as to analysed real life situational description of functions and task performance.

BACKGROUND LITERATURE REVIEW

TRACEr-OGI Modelling and Development

A well-developed approach within the air traffic management (ATM) and rail way management (RWM) having real understanding of controller's error is refer to as TRACEr (i.e. 'Technique for the Retrospective and Predictive Analysis of Cognitive Errors') (Shorrock and Kirwan 2002) .TRACEr is a model dependent approach to HEI, giving room to both retrospective and predictive analysis (Shorrock 2002). The traditional version of TRACEr has eight taxonomies describing error and its recovery. It has the power to preview the past and look into the future (Theophilus 2017). It involves an iterative developmental form from literature review and error classification study.

Ergonomics for Performance Shaping Factors in OGI

A propose model diagram for performance shaping factors (PSFs), adaptable to the Retrospective and Predictive Analysis of Cognitive Errors TRACEr-OGI (Shorrock et al., 2001b). The structural approach is underpin on the working principle of a common known systems. This model diagram is put forward to visualise and capture the PSFs in OGI in a simplified and precise manner (Theophilus 2017). The taxonomies influences and effects on the operator in the control room in OGI are extracted and segregated to the factors in the model flow of working systems and PSFs, see appendix 2. The model systems identify the human-machine interface, and task, the segregated PSFs are the personal, organizational and environmental (Shorrock et al., 2001a). It is seen therefore that these factors have a continuous impact on the working systems environment, for instance job training have an impact on staff's technical skills just as input factors influences the overall work output (Hammerl 200; Theophilus 2017d).

Human Factors, Errors and Performances

Today's work input has tilted from being manual to highly cognitive or from the hands to the brain (Theophilus 2017b). Hence human effort are slightly substituted with

machines. A situation prevalent in OGI (Theophilus 2017a; Hammerl et al., 2008). Despite all shift human factor continues to shape not only human performance but also the automated systems, however these tasks are supposed to be in agreement with stipulated standards of precision. Human factor are listed in ISO-standard, 11064, part 1 in PSA (Leni 2014)

The complexity of the working environment grows parallel to the complexity of both the machine and human (Ifelebuegu 2017). Human are prone to more errors in complex systems (Theophilus 2017a). Human error reduction and detection model Retrospective and Predictive Analysis of Cognitive Errors TRACEr was used to identify controller's PSFs and subsequent human error from task analysis Figbelow.These taxonomies formed part of the reliability and usability analysis in HEI, see appendix 3.

The Drilling Control Cabin

The control room is the CPU central processing unit that processes all potential inlet streams and feedback with an outlet streams (Theophilus 2017c). The control cabin consist of a real time automated computer system refers to as PLC where an output values has to be made in response to any input variables (Theophilus 2017; RSSB 2008). The automated system here observe, inspect, monitor and control data from various sensors and terminals. In the case of drilling cabin it is the centre for managed pressured drilling (MPD), choke and manifold control system (CMCS), power and lightening system (PLS), fluid and circulatory system (FCS), piping and hoisting system (PHS), drilling personal and crew (DPC), data collection and validation system (DCVS), log and measure while drilling (LMWD). It controls these variables using a selected set of rules and process, it is indeed an interpreter or translator that conduct the transfer of information in and out and between man-machine-software (Leni 2014; Theophilus 2017c).

Well Control Systems

These are predictive control events measures to prevent blowouts (the forceful escape of oil, gas and/or water from the bottom hole to the surface through the wellbore) (Bassey 2017; Quaife 2017). It includes avoiding unwanted influx of fluids to the wellbore, and in the event that they happen to entered, then controlling the magnitude or severity of the flow, is the worst threats on the oil and gas industrial operations (Theophilus 2017a). Typical well control employed the use of 2 to 3 separate barriers which include primary, secondary and tertiary barriers. The primary barriers uses mud column weight to bring about pressure equilibrium between formation and hydrostatic pressure. The secondary barriers employed the functions of the various casing strings pipe and joints as well as the casing landing seats to prevent influx into the wellbore.

The tertiary barriers uses the last defensive measures which is the blowout preventer (BOP) When the BOP fails then the catastrophic even occurred (MWB 2011), see appendix 4.

Risk Control System (RCS)

An accident occurs when key hazards opposing the system successfully went through the barriers through an array of holes (defective points) fig 3 in the barriers formed by RCS (MWB 2011). Reason (1997) developed a perspective of managing the organizational accident applicable to well control, see appendix 5.

Drilling Fluids/Mud

This fluids often refers to life blood in drilling serves many functions: It suspend the cuttings to the surface, it cools at same time lubricates the drill bits, it is used in drilling column as hydrostatic pressures employed to counter balance the formation pressures in order to prevent blowout (Bassey 2017; Quaife 2017), also used to maintained the dynamic state in the wellbore in order to prevent collapsing of the formations, the fluid density is carefully used to overcome the fracture pressure of the formations within the drilling window Fig 4 (MWB 2011), see appendix 7.

Blow Out Preventer (BOP)

The BOP is a well control devices meant to shut in drilling well in case of kicks, or when well issues such as mud pit gain or loss occurred or an increase in pressures observed. It is the last stage of defence against kicks in well control. Various shut in devices or rams are attached to the BOP fig 5 whose usage depends on primarily on string pipe or casing (Quaife 2017; MWB 2011), see appendix 8

Lost Circulation

When the drilling fluids that are used in the wellbore get seeped into the formations instead of blowing out of the formations, a lost circulation occurs fig 6 lost circulation like blowout could lead to loss of well control where fluids continues to surge into formations (Bassey 2017a). A time will reach when the borehole fluid cannot counter balance the formation pressure because of lower hydrostatic pressure exerted by the mud column in the wellbore thereby allowing the influx of formation fluids into the wellbore casing or to the annulus(MWB 2011; Quaife 2017), see appendix 9.

Centralizers or Stabilizers

Devices used to station the casing central in the wellbore for efficient cementing work around the casing fig 10 An effective well evaluation will have complete sealed cement wall all around the casing from top to bottom in order to prevent or give room

to influx to the annulus (MWB 2011). The stabilizers consist of pipe and blades different designs, see appendix 10.

Reamer Shoe Track

The space between the float orguide shoe and the landing fig 11 function to make sure that the shoe is coiled round in equal cement wall thickness that prevent the passage of any contaminant (Quaife 2017), see appendix 11.

Manifold

These are arrays of pipes and valves made to control and monitor pressurised fluids from the reservoir, such as squeeze manifold employed in cementing job and choke manifold used in well control operations (Bassey 2017).

The Overall Well Control, Evaluation and Testing

It is highly recommended to keep track of fluids (oil, gas & water) production from the reservoir in order to manage effectively and evaluate both positive and negative potential benefits and risk (Theophilus 2017; Quaife 2017). It is important to route any well by measuring its produce fluids continuously, allowing the flow through the manifold will enable more test subsystems.Regular test are carried on any of the components discuss above and also on the mean systems as a whole (MWB 2011; Bassey 2017), see appendix 12.

METHODOLOGY

The accidents analyses in this study are those of fatal accidents from the international association of oil and gas producers (IOGP) database from the Caspian region which has five countries inclusive (IOGP 2017). All accidents from the year 2000 to 2020 had been analysed using TRACEr-OGI taxonomies. The Swiss cheese model and the relationship between TRACEr classifications were used to model the PSFs that are required to fulfil this analyses. They precisely suits the high risk OGI human error identification tools. (Sharrock et al., 2001a and b) see appendix 13.

Customization of Swiss cheese Model to Fulfil the TRACEr-OGI Analyses Requirements. The Swiss cheese model and the relationship between TRACEr classifications were used to model the PSFs that are required to fulfil this analyses. They precisely suits the high risk OGI human error identification tools fig 16 (Sharrock et al., 2001a and b), see appendix 14.Data Coding and the TRACEr-OGI PSFs: The data collected are so many that they hardly could make meaning to many reader until they are reduce via analyses (Theophilus 2017). To achieve this we employed the used of coding in excel to analyse and identify the seven subdivisions of TRACEr-OGI (table 1a, b and c) benefits to this accidents (Leni 2014). In the other

hand, it enable us capture accidents that are caused by combination of multiple unsafe acts and or errors. Each single error identify are coded individually using TRACEr-OGI taxonomies. The coded data were tabulated for statistical analyses, any events found to be present is recorded as one (1) in an appropriate cell and those not present are recorded as zero (0). The unsafe acts present are sum (∑) up for each category and used for the analysis.

RESULTS AND DISCUSSIONS

Having analysed the sum of 182 fatal accidents reports collected from the database of IOGP. It found 192 fatal incidents and 187 employee fatalities within year 2000-2020 central Russian region also refer to as the Caspian region, this region is made up of five countries (IOGP 2017). These fatalities were analysed based on employer, occupations and work functions to be able the see those who has the higher potential of risk.

Those contractors been the frontliner has the highest risk of fatalities, double or triple the numbers of the other employer's fatalities, followed by the company employer. For the occupation involvement, it is observed that apart from the unknown value that include those accidents that were not specified and those designated with unknown from the IOGP accidents reports (IOGP 2017). The occupation with the highest risk of fatalities is the transportation, followed by drilling and well servicing, then the others follows. However those occupations with less risk are the heavy equipment operators. For the work function those with higher risk of fatalities are those in production followed by those in drilling.

The major causes of accidents in the IOGP accidents reports were identified analysed and classified using TRACEr-OGI taxonomies. It identifies four dominant events leading to huge fatalities and great loss of properties. These include road traffic accidents, falling objects, inadequate training and equipment /tools failures. Other interesting events that followed these are the electrocuted, intoxication, poor supervision, fell from, and drowned in (IOGP 2017). The TRACEr-OGI has a distinct characteristic for identification and classification of all types of error that had occurred or is likely to be present. Its taxonomies were remodelled for retrospective and predictive analysis for cognitive errors. TRACEr-OGI as stated earlier was modified from three powerful human error identification tools (TRACEr-ATC; TRACEr-RWI and TRACEr-Lite).

Task or action errors forms the greater elements causing events in the IOGP accidents reports (IOGP 2017). It relate taxonomies of (What, Where and Who) in terms of performance (Shorrock 2002). It is not surprising therefore that communication error was next to task error in this analysis because it is the medium through which all sort of task pass through, so if the medium is defective the performance will surely be

defective too. It include transmissions whether clear or unclear, complete or incomplete, detection or late detection, little or much, etc. internal and external error on the other hand rise parallel in the analyses, the indoor factors do not outweigh the outdoor factors as discovered during this analyses. We further have errors arising from information, supervision, training and recovery which all are contributing to the events in the accidents.

CONCLUSION AND RECOMMENDATIONS

Typically a major accidents are severe events in terms of the major events fig 21, resulting to fatal accidents and employee fatalities or integrity loss and the subsequent catastrophic destruction/damage, and leading to irreparable or major loss to both resource and environs (IOGP 2017; RSSB 2008). Despite the huge collective efforts aimed at major accident risk control, a handful of recent alarming accidents has shown that control is yet to be sufficient enough in many critical zones.

Error classification must incorporate the even distribution of criteria for it to be used by operational practitioner and controller with or without formal education in human factor (Theophilus 2017). More attention needs be giving to contextual framework, validation, adaptability, flexibility, effective usability and resourcefulness. Without striking a focus balance on requirements and users' needs, techniques will not impact effectively as expected or even abandon at all (Shorrock and Kirwan 2002). Modelling a common framework that intertwined taxonomies for retrospective and prospective usage, if greater use is to be developed from the forward and backward response (Shorrock and Kirwan 1999). This study made an attempt to finding the more precise approach in the field of OGI. The preceding responses from operational controller shows that TRACEr-OGI is bridging the snap while striking the required balance.

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APPENDIXES

Appendix 1

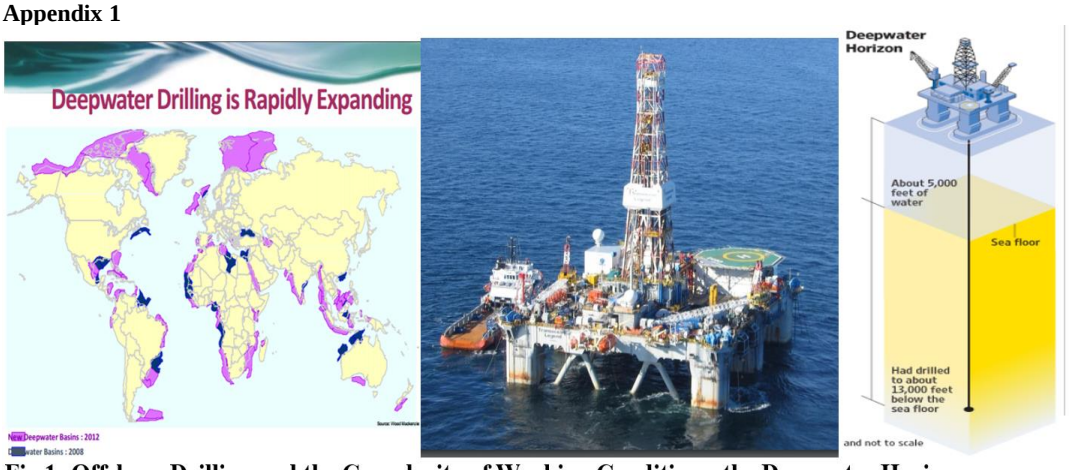


Fig 1: Offshore Drilling and the Complexity of Working Conditions, the Deepwater Horizon Source: (Ifelebuegu 2017)

Appendix 2.

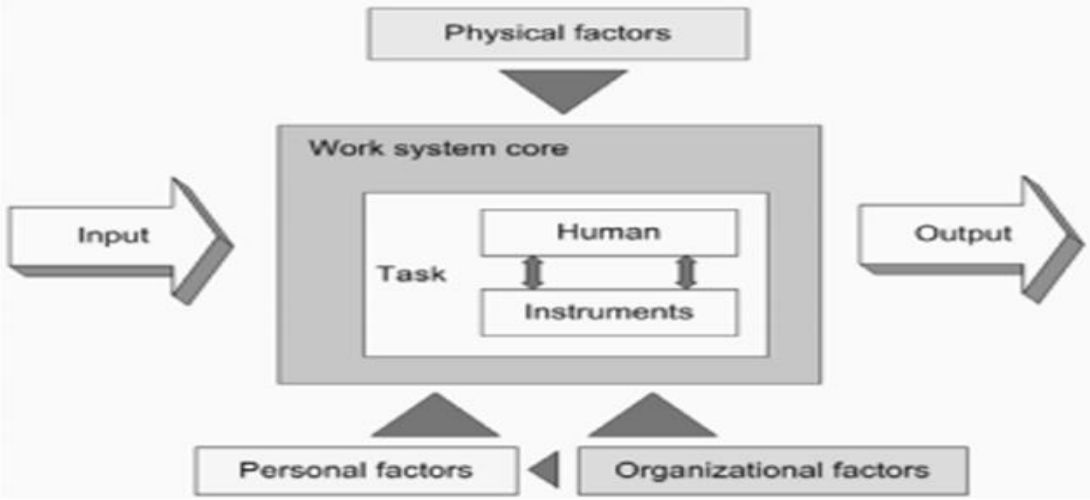


Fig 2: Model of Working Systems and Performance Shaping Factors
Source: (Shorrock 2000)

Appendix 3

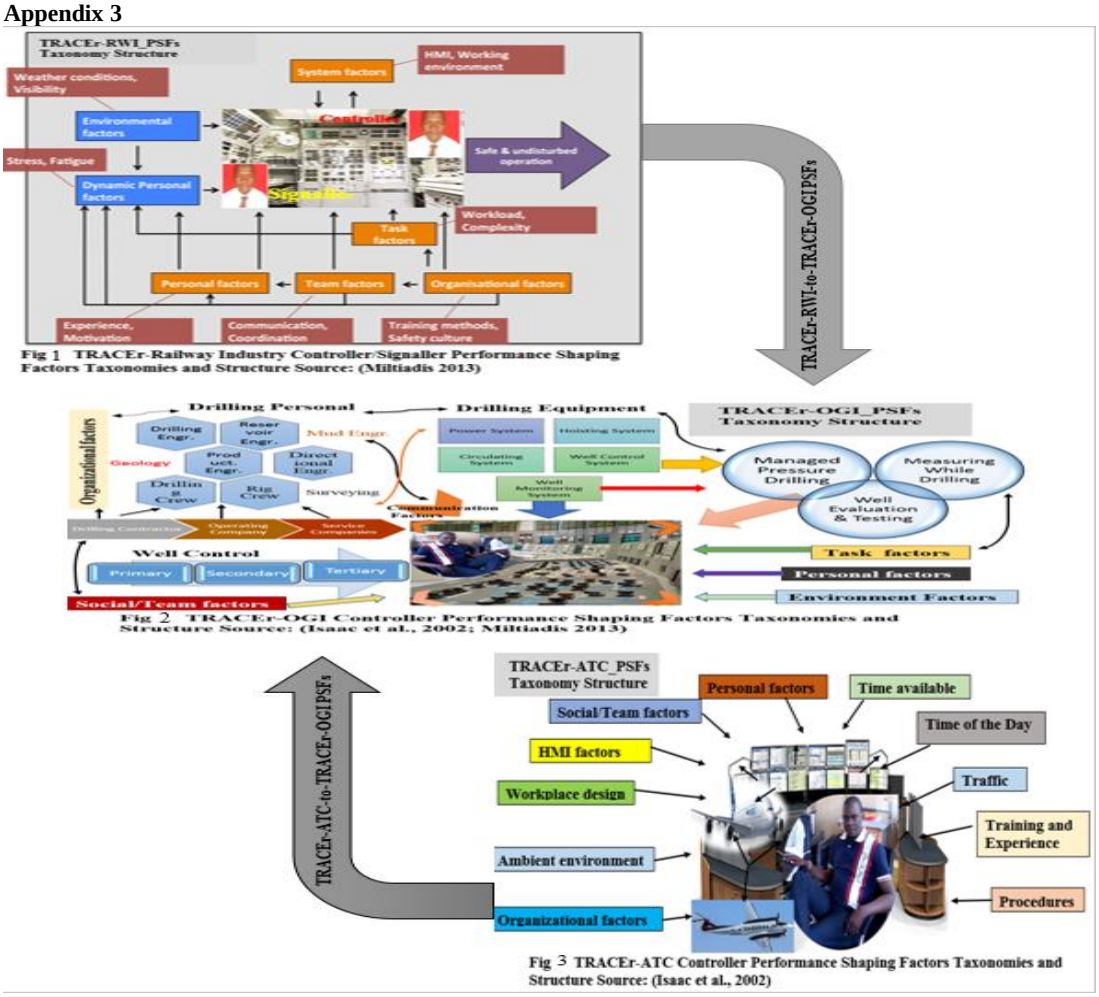


Fig 1 TRACEr-Railway Industry Controller/Signaller Performance Shaping Factors Taxonomies and Structure Source: (Miltiadis 2013)

Fig 2 TRACEr-OGI Controller Performance Shaping Factors Taxonomies and Structure Source: (Isaac et al., 2002; Miltiadis 2013)

Fig 3 TRACEr-ATC Controller Performance Shaping Factors Taxonomies and Structure Source: (Isaac et al., 2002)

Appendix 4

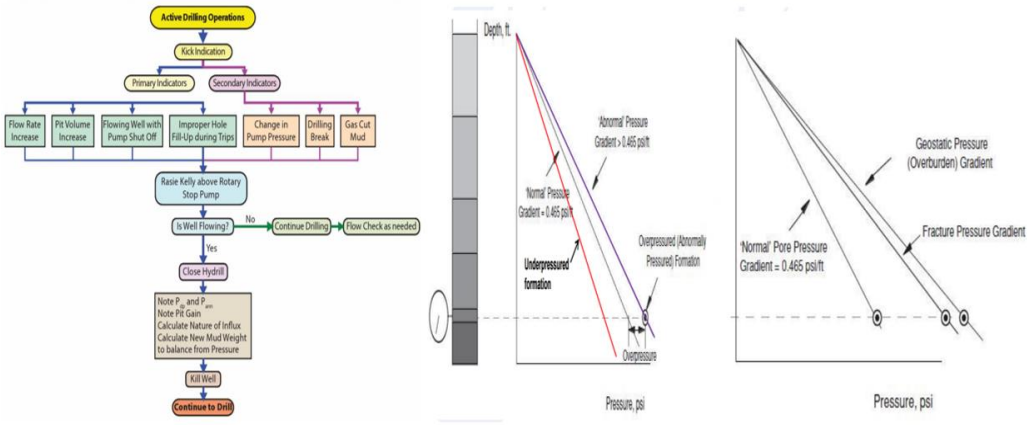


Fig 5: Well control technology and pressure analysis Source: (Bassey 2017; Quaife 2017)

Appendix 5

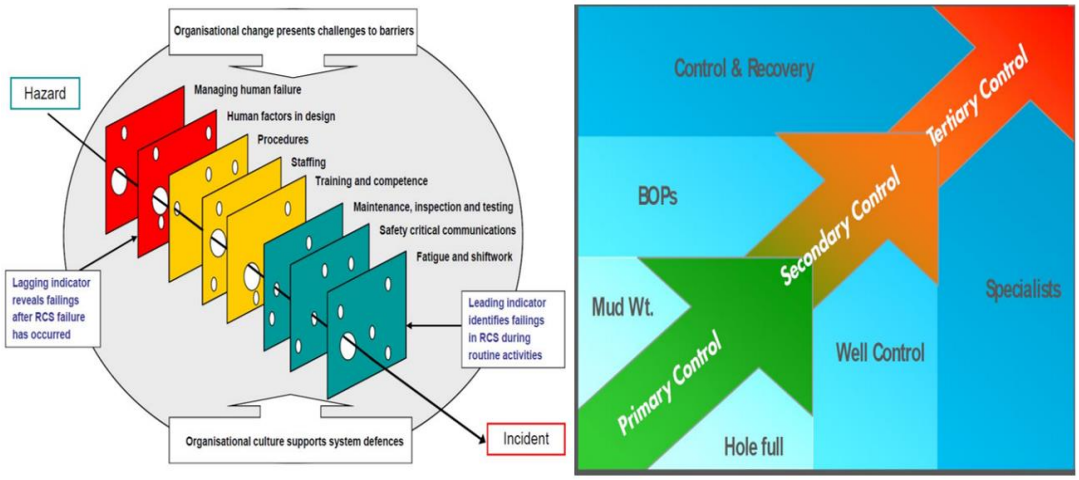


Fig 6: Accident resulting from successful penetration of multiple defective barriers Source: (Reason 1997)

Appendix 7

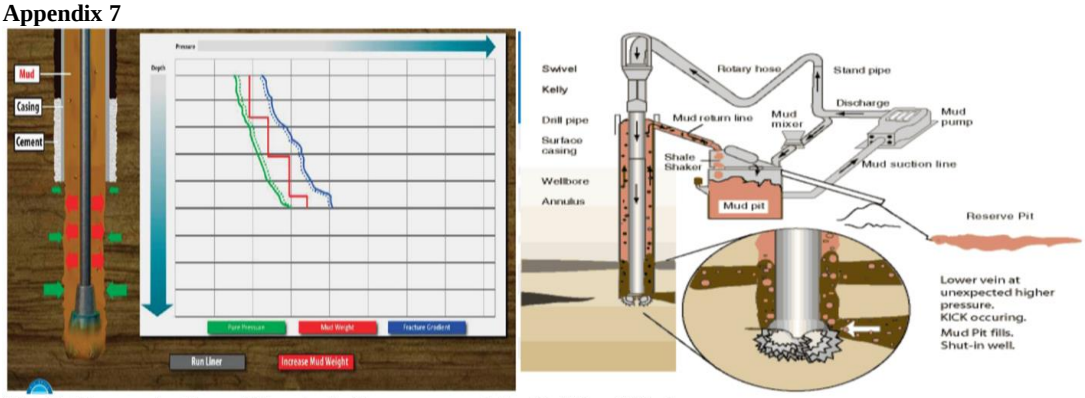


Fig 7: Demonstration of Borehole Pressures and the Drilling Window
Source: (MWB 2011; Bassey 2017)

Appendix 8

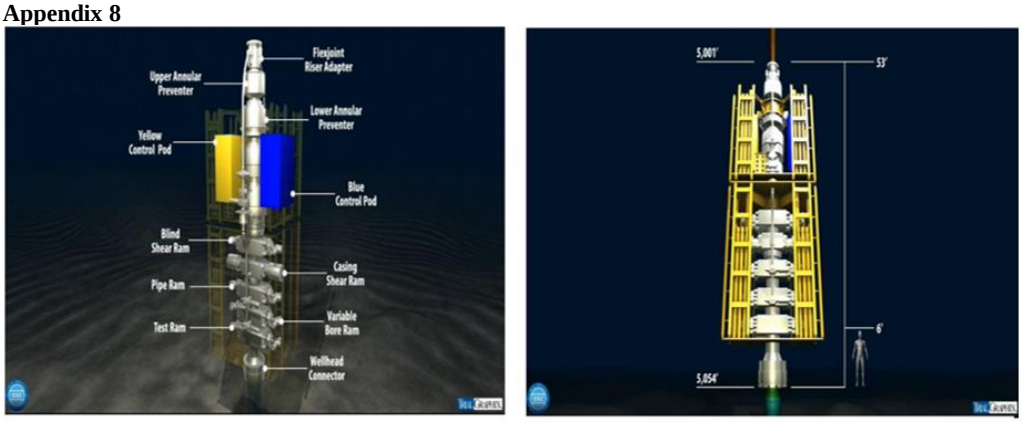
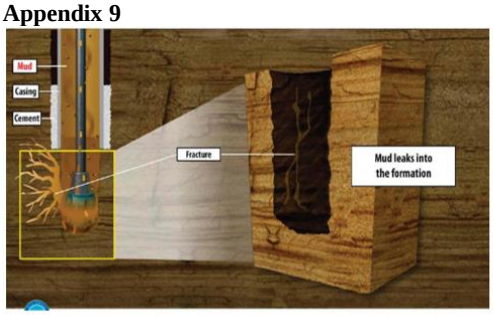
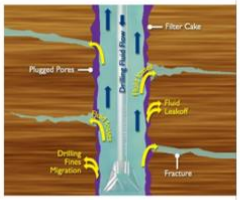


Fig 8: Blow Out Preventer (BOP) and Components Assembly. **Source:** (MWB 2011)

Appendix 9



- Lost circulation can cause the level of mud in the hole to fall as the mud flows into the zone of loss.
- As a result, the hydrostatic balance that provides primary control of a well can change.
- Formation fracture is one of the causes of lost circulation, and heavy mud can fracture a formation
- Caution: The possibility of formation fracture should always be kept in mind when heavy mud is circulated to control formation pressures.



Causes of Lost Circulation

- **Surging** is the increase in borehole pressure caused by downward movement of the drill string.
- The tendency of mud to adhere to drill pipe and to the wall of the hole creates friction as the pipe is moved downward.
- The pressure needed to overcome this friction is related to the movement of mud past the pipe; that is, the faster the fluid is forced to move relative to the pipe, the higher the surge pressure must be.



Swabbing

- The likelihood of swabbing is increased by:
  - pulling the pipe too fast,
  - using mud of high viscosity and high gel strength,
  - having a balled-up bit,
  - having a plugged drill string,
  - having thick wall cake, or
  - having small clearances between the string and the hole.
- Most swabbing occurs when the bit is first moved off bottom.

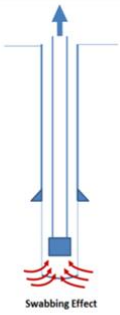


Fig 9: Causes of Lost Circulation. Source: (Bassey 2017a; MWB 2011)

Appendix 10



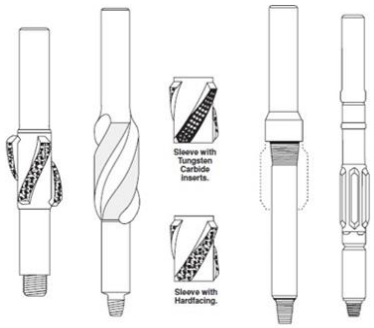


Fig 10: Centralizers and Stabilisers for Casing and Cementing Works
Source: (MWB 2011; Quaife 2017)

Appendix 11

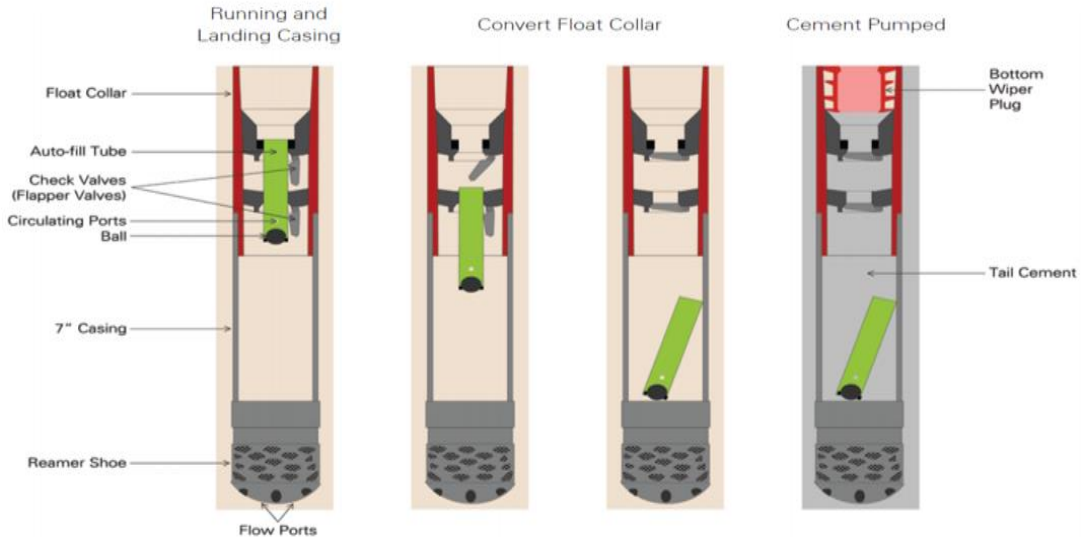


Fig 11 Reamer, floating collar and Shoe Track. **Source:** (MWB 2011)

Appendix 12

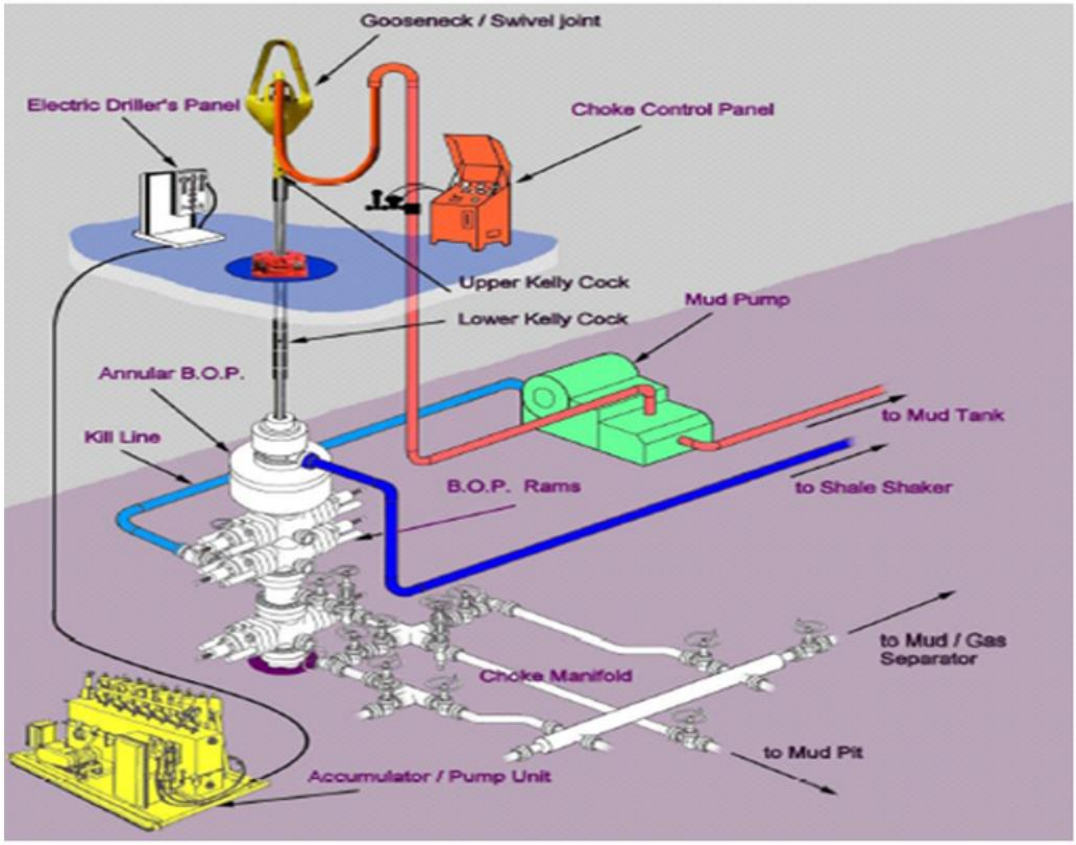


Fig 13: The major well control systems.
Source: (Bassey 2017)

Appendix 13

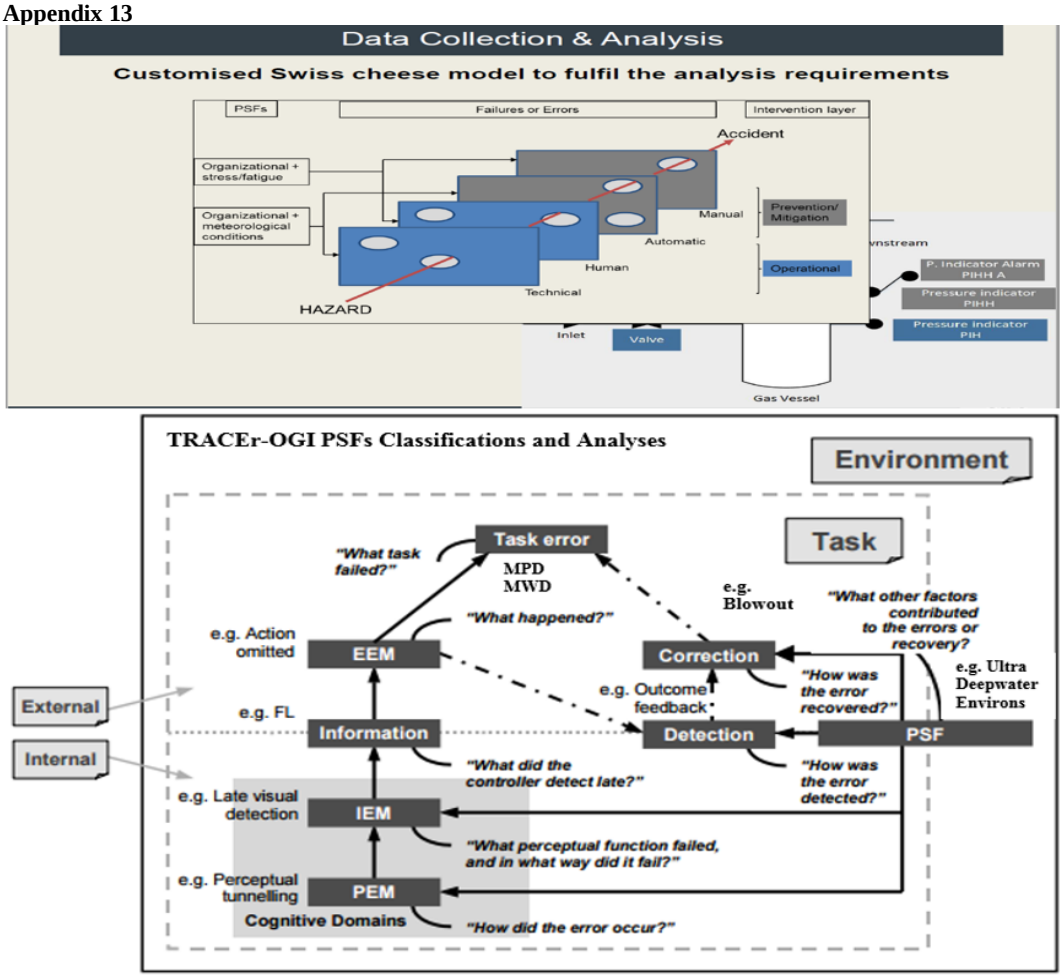


Fig 15: Customised Swiss cheese model and the TRACEr classification systems adapted

Appendix 14

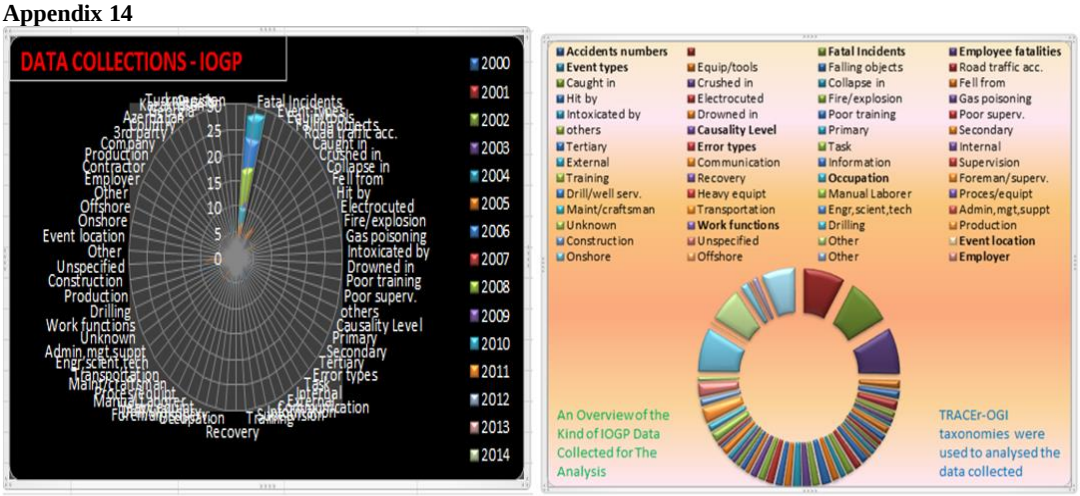


Fig 16: An overview of the kind of data Customised for the model TRACEr-OGI