HUMAN FACTORS IN DEEPWATER DRILLING

A New Approach to Safety and Operational Excellence

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Human Factors in Deepwater Drilling

A New Approach to Safety and Operational Excellence

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ABSTRACT

Deepwater drilling operates high hazardous and complex systems. Technological and operational complexities, harsh environmental conditions, geological uncertainties, and high-pressure flammable fluids are some of the critical factors that pose clear threats towards safe operations and may result in high consequence events, as the Macondo blowout in 2010.

The continuous demand for oil and gas pushes the Oil & Gas industry to explore offshore oil and gas reserves into ever-deeper waters. Indeed, the advances in technologies allow offshore drilling to go into increasingly deeper and farther offshore sites. And each step into deeper waters posed new challenges with increasing danger and complexity.

Such complexity requires the oil worker a great deal of adaption and skilled human intervention to keep drilling operations running efficiently and safely. However, indications show that even after Macondo, the Oil & Gas industry still believes that safe behavior programs are the best approach to safety, inhibiting workers to locally adapt to normal variability and close the gap between the work as imagined and the work as done. For the industry, such adaptations are not only unacceptable but also equal to violations subjected to disciplinary measures. Therefore, meaningful safety interventions are designed to control the behavior of people at the front-line through rigid compliance with rules and regulations. Likewise, safety performance is measured by the number of incidents, mainly personal accidents (e.g., injury rates), since the industry believes that preventing minor high-frequency incidents will also predict and prevent major catastrophic events.

A discrepancy that might be not perceived by the Oil & Gas organizations and may undermine industry efforts to improve safety and operational performance.

The Macondo disaster in 2010 would be expected to act as a wakeup call to the Oil & Gas industry towards a different approach to safety. However, as the empirical data collected by this research suggests, despite its unprecedented magnitude, no fundamental change was observed in the wave of the disaster, as it happened with other high-hazardous industries, which quickly realized the importance of utilizing human factors studies and systems approach to mitigate similar accidents. Indeed, most of the post-Macondo initiatives were limited at improving technical specifications and operational procedures for blowout preventers and capping systems, as well as the development of more stringent regulations.

Therefore, this research was proposed to investigate the safety models and paradigms influencing the current Oil & Gas organizations' approach to safety through the perceptions of its leaders about a recent growing movement discussing the importance of a human factors approach to improving safety in the highly complex systems the industry operates. Furthermore, empirical data collected throughout this work have confirmed relevant theoretical assumptions from the perspective of the Oil & Gas industry. For instance, pieces

of evidence showing the effects of safety as bureaucratic accountability and its consequences were widely observed across the organizations taking part in this research.

Recently, a movement aimed at different approaches to safety is gaining momentum across the industry, mainly driven by Oil & Gas professional associations. However, there is yet an overwhelming predominance of a behavior-based safety approach within the Oil & Gas organizations, confirming the mismatch with the inherent complexity in deepwater drilling. Among the potential reasons for such disconnection, this research identified the hegemony of an Old View thinking, mainly promoted by a powerful safety industry telling Oil & Gas leaders that meaningful safety interventions must target the control of human behavior to prevent accidents.

In its conclusion, this work recommends the implementation of industrywide programs to demystify the New View of human factors among the Oil & Gas organizations and the adoption of further measures to raise the awareness for the importance of the integration of human factors to the processes and operational practices in deepwater drilling.

FORWORD

"The processes and systems involved in producing and distributing oil and gas are highly complex, capital-intensive, and require state-of-the-art technology."

(Business & Economics Research Advisors, 2013)

Drilling for oil and gas has been an integral part of my life for more than three decades. Over this period, from a field-drilling engineer up to several executive positions, I have had the privilege of witnessing most of the outstanding technological developments the industry has experienced in the move from onshore and shallow water operations into deep and ultra-deepwater.

Such developments, however, have brought together a higher level of danger and complexity, making deepwater drilling one of the world's most hazardous activities. Recently, high-profile accidents like the tragic loss of the Deepwater Horizon in 2010 and its subsequent catastrophic oil spill onto the waters of the U.S. Gulf of Mexico just reminded us why the industry must approach safety differently.

In 2014, the organization I work for entered into a Consortium with four other Oil & Gas corporations to develop one of the world's most significant ultra-deepwater projects 200km off the coast of Rio de Janeiro state at the Brazilian pre-salt area.

In the following years, dozens of wells are going to be drilled, completed, and connected to production platforms located on water depths around 2,100m to the seabed. The project represents an immense enterprise from any perspective, either financial or operational. Developing and operating an oil field of this size costs billions of dollars and exposes millions of human-hours to one of the most hazardous working environments.

From the very beginning, the Consortium has realized that this project should be carried out under the highest safety and operational standards, much higher than the usually practiced by the industry so far. It would require a massive effort to bring nothing less than excellence to be a successful undertaking.

After joining the project in 2015, I quickly realized the gap between the size of this challenge and my available repertoire in the field of safety science, particularly in human factors and systems safety.

This thesis exploring Human Factors in Deepwater Drilling is then a natural choice.

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1 INTRODUCTION

1.1. Oil & Gas industry and deepwater drilling

"Ever since its first commercial discovery by the mid-nineteenth century, the quest for oil has been recognized as one of the greatest hazardous and risky activities in the hands of adventurous people in the history of humankind."

(Yergin, 1992)

The Oil &d Gas industry, particularly in the field of well-drilling[1], has always been a high-hazardous enterprise. From the exploration and production of oil and gas to the refining and distribution of their by-products, the entire process involves a significant amount of danger. Oil workers are quite often exposed to highly flammable and hazardous products, toxic gases, massive and powerful equipment, high pressure, and high-temperature environments (SOPHIC, 2019). Indeed, notwithstanding the technological progress the industry has experienced over the years, the issue of catastrophic accidents (fires, explosions, and oil spills) is yet haunting the minds of oil workers, the organizations they work for, and the entire society alike.

However, drilling an oil well is not only dangerous but also a complex process, particularly in deepwater environments. When associated with the danger involving the management of hazardous fluids and pressures towards production efficiency, such complexity makes the industry to operate safety-critical high-risk systems with highly complex and tightly coupling interactions (Perrow, 1999). Moreover, these complex, high-risk systems are acknowledged to be intractable, not fully knowable, semi-measurable, semi-predictable and semi-controllable (Dekker, Bergström, Amer-Wåhlin, & Cilliers, 2013; Hollnagel, 2008, 2012).

Indeed, deepwater drilling usually involves over a dozen different service companies working together in a coordinated distributed activity, each one adhering to stringent around the clock scheduling with a diversity of safety and environmental practices, making the whole process necessary to find and produce oil and gas barely predictable and controllable. Drilling an oil well always carries high levels of operational uncertainty and risk (Suslick, Schiozer, & Rodriguez, 2009). From the uncertainties concerning the geological structure to the existence of reservoir seal[2] or even the presence of hydrocarbons, it requires the oil worker a great deal of adaption and skilled human intervention to keep drilling operations running efficiently and safely (Miles & Randle, 2017).

The dependency of modern society in oil and gas leads to increasing demand for fossil energy, making oil reserves to exhaust in some onshore and near-shore drilling sites (Barreto, 2012). It pushes the industry, no matter the increase in danger and complexity, to gradually explore

[1] The process used by the industry to reach underground reservoirs containing hydrocarbons.
[2] A layer of impermeable rock capping the reservoir necessary to trap an accumulation of hydrocarbons.

more remote areas, mainly offshore, shifting its search for oil and gas into ever-deeper waters. Likewise, the advances in technologies like the development of modern drillships[3] allow offshore drilling to go into increasingly deeper and farther offshore sites, in water depths up to 3,600 meters and over 300 km offshore (Figure 1). Today, according to the American Geosciences Institute (Allison & Mandler, 2018), many of the world's oil and gas reserves lie beneath the oceans, and around 30% of worldwide production comes from offshore.

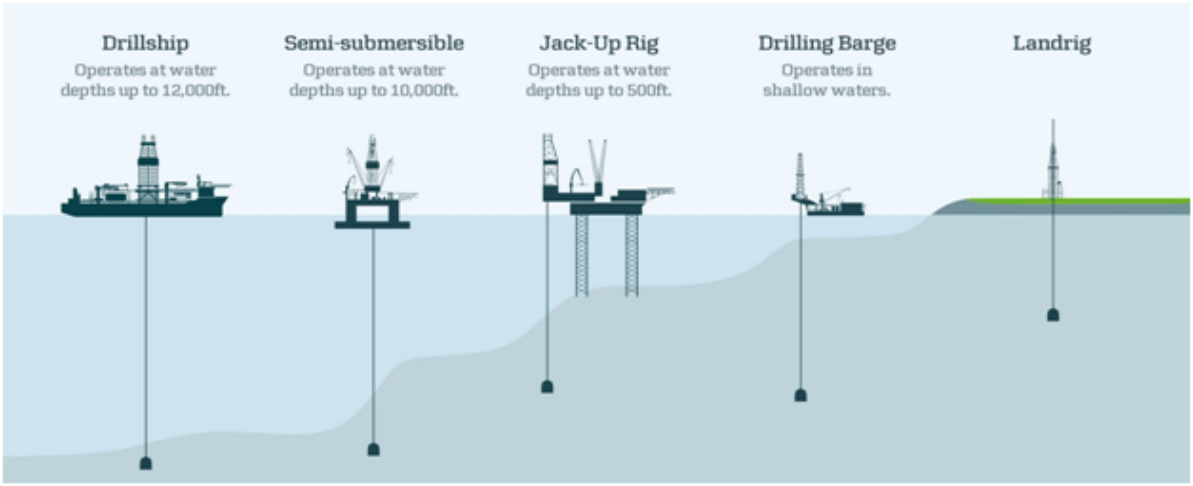

Figure 1 - Diagram with different types of drilling rigs
(Entrance Consulting, 2013)

1.2. The Problem

"Each step into deeper waters posed new and daunting challenges. Blowouts[4], drilling vessel disasters and platform failures often forced engineers back to the drawing board. But the risks never went away."

(NOAA, 2010)

The need for operating in deeper waters requires more sophisticated technology, which makes the drilling process not entirely assimilated and controlled, opening new opportunities for human and organizational errors. In addition, offshore drilling is a capital-intensive business, demanding massive investments, sometimes measured in billions of dollars, increasing pressure for production and efficiency. Moreover, hard living conditions and a myriad of diverse expertise and cultures makes an offshore oil rig what Goffman (1961) defines as "a total institution[5]." Combined with the normal drilling uncertainties, harsher environments, challenging logistics, all these matters play a significant role in increasing complexity and danger.

Even though, the Oil & Gas industry still measures the level of safety performance by the number of adverse outcomes, mainly personal accidents (e.g., injury rates). The lower the numbers, the better. Figure 2 summarizes the evolution of safety performance measured by

[3] Dynamically positioned and self-propelled vessels for offshore drilling.
[4] An uncontrolled release to surface of crude oil and/or gas from an oil or gas well after pressure control systems have failed.
[5] A place with strict regulations of both the residence and work of a large number of people, where they are doing their activities together and cut off from the rest of the society for quite a long period.

the injury frequency rates in the Exploration & Production[6] (E&P) segment, both onshore and offshore, of member companies that voluntarily submitted their figures to the International Association of Oil and Gas Producers[7] (IOGP). Over the years, these numbers with focus on personal incidents and accidents show a consistent decrease, reinforcing a belief among most of the Oil & Gas organizations that they are doing the right thing to improve safety and prevent accidents, even major catastrophes.

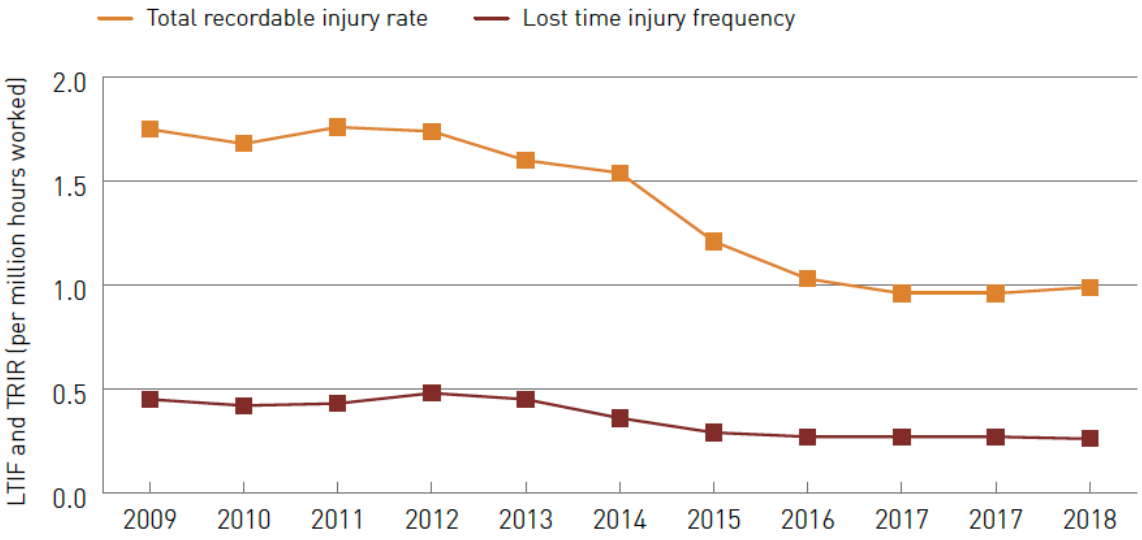

Figure 2 - Lost time injury frequency vs total recordable injury rate (2009-2018) (IOGP, 2019)

The same belief that, in 2010, made the industry to be caught in total surprise by the disaster with the Deepwater Horizon, a drilling rig owned by Transocean and operated by BP in the Gulf of Mexico. As a reminder of how dangerous deepwater operations can be, the Macondo well unexpectedly blew out, destroying the rig, killing 11 workers, and causing a massive oil spill into the waters of the U.S. Gulf of Mexico (BP, 2010; National Commission on the BP Deepwater Horizon Oil Spill and Offshore Drilling, 2011; University of Berkeley California, 2011; Hopkins, 2012). At that time, nobody was prepared for a prompt and effective response to an event of such magnitude (Hopkins, 2012; Melina, 2010). Ironically, right before the disaster, the Deepwater Horizon was celebrating six years without Lost Time Injuries (LTI) and incident-free performance (BP, 2010; Hopkins, 2012; Dekker, 2018) giving both Transocean and BP a false indication that everything was under control. However, as Dekker (2018) reminds, it just confirmed what the literature already knows that minor incidents cannot predict anything and, most of the time, are not even predecessors of the next catastrophe. Such confusion between occupational and system safety is yet present in the Oil & Gas industry (Leveson, 2011; Giuliani et al., 2019). Definitely, there is a strong belief that fighting finger cuts will prevent the next catastrophic accident, making occupational safety to be overemphasized in detriment of process or system safety.

[6] E&P is the process that includes searching and extracting oil and natural gas. It is also known as Upstream.
[7] IOGP is an international association that congregates the majority of the world's top oil and gas producers.

The catastrophic disaster, by far the largest oil spill ever, caused serious socio-political implications and triggered long-standing public questions about offshore exploration and production. Naturally, Macondo, as it happened with other high-hazardous industries in the past should act as a wakeup call to the Oil & Gas industry for the need of approaching safety differently. Indeed, it would be expected Macondo to become the Oil & Gas Tenerife[8] when the commercial aviation industry quickly realized the importance of utilizing human factors studies and systems approach to mitigate similar accidents. However, no fundamental change was observed in the wave of the disaster and most of the post-Macondo initiatives were limited at improving technical specifications and operational procedures for blowout preventers (BOP[9]) and capping systems[10], as well as the development of more stringent regulations.

Nevertheless, more recently, the industry seems to have started to realize the importance of a human factors approach to improve safety in the complex systems it operates. From around 2014 on, a movement mainly driven by Oil & Gas associations like the IOGP and the Society of Petroleum Engineers[11] (SPE), highlighted a critical mismatch between the reality of the industry's increasing complexity and danger, and the way safety had been managed so far. A problem that may undermine the industry's efforts towards safety improvements, and might be even detrimental and prevent the industry from developing its human factors agenda.

1.3. Research question

Therefore, this research was designed to explore how the Oil & Gas industry approaches safety today, particularly after Macondo, and how this movement towards new human factors paradigms is perceived by its leaders as an opportunity to constitute a human factors agenda to improve both safety and operational performance in deepwater drilling.

- ***What are the current accident models and safety paradigms in the deepwater drilling organizations and how are the recent movements towards a different approach to safety influencing the development of a human factors agenda for the Oil & Gas industry?***

As an additional contribution to the field of safety science, this study could also bring empirical foundations from the perspective of the Oil & Gas domain to some theoretical assumptions, mainly premises of the New View of human factors.

[8] A reference to the 1977 terrible air crash disaster in the Canary Islands. There, two jumbo jets collided on the runway, killing 583 people, yet the largest catastrophe in commercial aviation.

[9] A large and heavy device designed to close and control the well to avoid an influx to reach the surface.

[10] A capping stack is a large well closure device developed after the Macondo blowout that connects to the top of the blowout preventer (BOP) and is capable of sealing off a well.

[11] An international association that congregates Oil & Gas industry professional engineers.

2 LITERATURE REVIEW

3.1. Human Factors

Human factors is a field of study that strongly emerged in the late 1970s when the headlines were filled with a series of catastrophes involving socio-technical systems. The size and complexity of those accidents triggered intense scientific debates over the following decades to understand better the role of human factors and, mostly, to seek for explanations about human error in major socio-technical accidents (Dekker, 2019). In summary, human factors is the study of people in systems to understand and improve their performance.

Such discussions involved numerous academic disciplines such as sociology, cognitive psychology, human physiology, ergonomics, engineering, safety and management sciences. Pioneers like Jens Rasmussen, David Woods, Richard Cook, James Reason, and Eric Hollnagel, among many others, proposed new paradigms to the way people should cope with the growing complexity in a fast-developing technological world.

In parallel, these studies unveiled controversies and misconceptions about human error over the last century, bringing to light the existence of two opposite views of human factors, which define the way we understand the role of humans on safety and their contributions to accidents today (Woods et al., 2010; Dekker, 2002, 2014).

Therefore, as a first step to support this work, it is of vital importance to assume the existence of these two distinctive views in the literature of safety sciences (e.g., Dekker, 2002, 2014, 2014a, 2015, 2018, 2019; Hollnagel, 2013, 2014, 2014a; Leveson et al., 2012; Woods et al., 2010). It is also essential to establish the boundaries defining the main premises behind each of these two views to understand which set of paradigms better represents the way the Oil & Gas industry approaches safety today.

3.2. The Old View

This traditional view basically sees human error as the main cause of failure. The unsafe behavior of erratic people compromises an otherwise safe system. This view is known as ‘the Old View’ of human factors (e.g., Cook, Woods, & Miller, 1998; Reason, 2000; Dekker, 2002, 2014; Woods et al., 2010). In the Old View, it is believed that:

> “Complex systems would be fine, were it not for the erratic behavior of some unreliable people (Bad Apples) in it.”
>
> “’Human error’ cause accidents: more than two-thirds of them.”
>
> “Failures come as unpleasant surprises. They are unexpected and do not belong in the system. Failures are introduced to the system through the inherent unreliability of people.”
>
> (Dekker, 2014, p. 1)

In the Old View, the behavior of people is then a problem to control (Dekker, 2014; Woods et al. 2010). The Old View carries a Tayloristic worldview where workers must be kept under strict supervision at all times to ensure they do what they are told to do as the best way to be safe. As Dekker (2019) explains, in the Old View, autonomy and initiative are not only undesirable but strongly discouraged to protect the systems. Hence, any adaptation is seen as a violation to the established rules and procedures, even when following rules is not possible to get the work done. Such 'violations' are often subject to disciplinary actions. Safety is measured by the number of adverse outcomes, which means that the lower the number (incidents, near misses and accidents), the safer the system. Therefore, safety management interventions focus on preventing possible deviations that can make things go wrong, representing the classical safety management paradigm (Reiman et al., 2015).

Conversely, organizations embracing the Old View have to cope with some undesirable and practically inevitable side effects. Dekker (2019) mentions a risk of organizational "blindness to new situations" (p. xv), which may hinder innovation and increase bureaucracy. Moreover, strict control and compliance may disengage people, leading to a continuous growth of bureaucracy and control.

Perhaps one of the most important contributions to sediment the Old View as the backbone of many safety management systems today was the study carried out by Herbert William Heinrich (Heinrich, 1931). His conclusions were published in his seminal book "Industrial Accident Prevention: A Scientific Approach." Heinrich's research produced some of the longest accepted paradigms in safety sciences. His 'domino model' of accident causation, explains an accident as the consequence of a causal chain of events, represented by the dominos, a simple linear model of accident causation. The well-known Reason's 'Swiss Cheese Model' (Reason, 1997), acclaimed by many industries today, has its roots in Heinrich's model. Heinrich also led us to believe that accidents at the workplace are caused either by unsafe acts of people (the vast majority, more than 88% of them) or by mechanical failures, a duality still deep inside the minds of many people today. Furthermore, his 'accident triangle' postulates that there is a mathematical relationship between unsafe acts, minor injuries, and major (fatal) injuries. This concept is the rationale behind most of the organizations' safety interventions over the last century with the firm belief that reducing deviations or minor injuries, the basis of the triangle or pyramid, is the best way to prevent the next major accident. Consequently, such belief makes the absence of adverse events, from minor incidents to major accidents, to be accepted as the ultimate proof of safety, and is the theoretical basis behind fashionable organizational mantras like the 'zero-vision' programs adopted by many industries around the world today (Dekker, 2013).

Moreover, the Old View also sees accidents as a function of carelessness or lack of attention of people (Burnham, 2009), reinforcing the concept of people are a problem to control. The human factor is thought as a set of individual characteristics, the "physical, mental or moral defects" (p. 61) that makes some people predisposed to accidents, the accident-prone people or the 'bad apples' (Dekker, 2014).

All these ideas were fundamental for the development of behaviorist theories that became dominant from 1930s on. Behaviorism has the main objective of influencing or even modifying human behavior to help people to cope with the constraints of their working systems, providing the basis for what we know today as 'Behavior-Based Safety' programs (Dekker, 2014b). Dekker (2019) connects behavior-based safety to modern behavioral 'hearts and minds' programs designed to fix people's moral and mental deficits. Therefore, meaningful intervention on safety using a behavior-based safety approach shall be naturally designed to protect the system from erratic unreliable people.

3.3. The New View

However, the evolution of several scientific disciplines over the last decades has resulted on an emerging New View of human factors and safety, supported by an increased application of complexity theories in safety science (e.g., Rasmussen & Lind, 1981; Woods, 1988; Dekker et al., 2011; Hollnagel, 2012; Reiman et al., 2015). Such distinctive view evolved from what Dekker (2019) defined as the reinvention of human factors in the 1940s when the technological advances in the second world war led to the development of a system thinking approach. This New View, boosted by the researches on human error started by late 1970s, sees human error not as a cause of trouble, but instead as a symptom of system failure (e.g., Cook, Woods, & Miller, 1998; Dekker, 2002, 2014; Hoffman & Woods, 2000; Rasmussen & Batstone, 1989; Reason, 2000; Woods et al., 2010). In summary, the New View argues that:

> "Human error is a symptom of trouble deeper inside the system."
>
> "Safety is not inherent in systems. People have to create safety. The systems themselves are contradictions between multiple goals that people must pursue simultaneously."
>
> "Human error is systematically connected to features of people's tools, tasks, and operating environment. Progress on safety comes from understanding and influencing these connections."
>
> (Dekker, 2014; Woods et al., 2010)

In a move towards a system thinking approach, these researches have profoundly influenced the way safety is perceived today by many high-hazardous industries. Several theories to explain accidents have emerged from this approach. It is worth to mention the Man-Made Disaster Theory (Turner, 1978), Normal Accidents (NA) Theory (Perrow, 1999), the High-Reliability Organizations (HRO) Theory (Rochlin et al., 1987; Weick, & Sutcliffe, 2015), as well Path-Dependency Theories, noteworthily Normalization of Deviance (Vaughan, 1996), Practical Drift (Snook, 2000) and Drift into Failure (Dekker, 2011), among others. All these researches have reinforced the systems approach of the New View of human factors.

The New View assumes that "people do not come to work to do a bad job" (Dekker, 2014, p. xv). Therefore, errors are not the result of 'moral failures' of humans. Rather, people create safety by learning and adapting to contribute to both success and failure. Progress, then, comes from helping people create safety (Woods et al., 2010). In the New View, instead of controlling people, meaningful safety interventions should otherwise harness people to cope

with complexity to achieve success (Rasmussen & Lind, 1981; Woods, 1988; Woods et al., 2010). Hence, safety and accidents alike are both dynamic and emergent properties from complex interactions within the system (Hollnagel & Woods, 2005).

Another perspective to help to establish the differences between these two views of human factors comes from the way safety and accidents are defined and understood. Traditionally, safety is a condition that gives people freedom from harm and is defined as the absence of negatives or a condition where the number of adverse outcomes is as low as possible. Hollnagel (2013) labels this definition as Safety-I. Consequently, the purpose of managing Safety-I is to achieve and maintain that state as a controllable, inherent property of the system. Safety management systems based on Safety-I have a reactive approach since they usually respond when something goes wrong or could go wrong, i.e., when safety is missing or not there (Hollnagel, 2014a). In Safety-I, the goal is to seek and eliminate the causes of failures to improve safety. In summary, reactive safety management systems also embrace the causality credo that adverse outcomes happen when something goes wrong, and such outcomes have causes that can be found and adequately treated, the 'root' causes.

Conversely, Hollnagel (2014) demonstrates that success (things that go right) and failure (things that go wrong) happen in the same way in complex working environments. These different outcomes are the result of the inherent performance variability in everyday work. Hollnagel calls this approach as Safety-II. He goes even further and advocates that improvisations and performance adjustments are crucial for sustaining the desirable acceptable outcomes, even though it may sometimes result in unacceptable outcomes instead.

Safety-I assumes that systems are tractable, meaning they can be fully understood and will behave as anticipated. However, as socio-technical systems evolve, systems and work environments gradually become more complex and intractable, making Safety-I no longer the best approach to safety. In Safety-II, Hollnagel (2013) proposes shifting the focus from things that go wrong to things that go right. With this, safety rather than a state where nothing goes wrong may be defined otherwise as a state where everything goes right, or "the ability to succeed under varying conditions, so that the number of intended and acceptable outcomes in everyday activities is as high as possible" (p. 5). Consequently, in Safety-II, the main goal is to proactively understand why things go right and understand performance adjustments in everyday work, rather than only seek for causes when things go wrong.

Safety-II, like the New View, assumes that everything happens in the same way, regardless of the outcome, which on the other hand reveals a fundamental dilemma at the sharp end. As Dekker (2019) reminds us, adaptations are necessary for complex socio-technical systems, and these adaptations are necessary to close the gap between work-as-imagined and work-as-done. Those who have just a superficial view of the work-as-done tend to underestimate the importance of adaptations and will see them only as deviations or violations. As Dekker (2018) almost poetically elaborates, "They don't see the resilience, the elegant beauty of expertise at

work, the subtle coupling of people's minds to cues and insights deeply embedded in their dynamic environment" (p. 17).

It is precisely the field of study of resilience engineering (Leveson et al., 2012). For Hollnagel (2014), resilience engineering aims at enhancing positive capabilities through the development of models and techniques to identify success promoters and manage them to reinforce their presence in the system (Safety II), instead of treating safety as the absence of certain unwanted elements (Safety-I). Therefore, for resilience engineering, success and failure are the result of the adaptations necessary to cope with the complexity of the real world.

It is for no other reason that resilience engineering has been receiving increase interest from the academic community in recent years, making resilience engineering perspective one of the frontiers of knowledge in the science of accident prevention. As Patriarca & Bergstrom (2017) remark, resilience engineering focuses on helping organizations cope with the complexity of normal work, and helping them to achieve success under varying circumstances.

3.4. Human Factors in the Oil & Gas

“This industry is in its absolute infancy on human factors,” said John Thorogood, a safety consultant to the Oil & Gas industry in an interview with Drilling Contractors magazine (Hsieh, 2014), four years after the Macondo disaster.

In the aftermath of Macondo, the only relevant published work analyzing how human and organizational factors played a crucial role in the disaster was the 2012 Andrew Hopkins’ book “Disastrous Decisions: The Human and Organizational Causes of the Gulf of Mexico Blowout” (Hopkins, 2012).

Despite its importance, no official report has ever connected the Macondo disaster to human factors (Hsieh, 2014). The issue of human factors seemed to be kept dormant for a while until a few years ago. Recently, a movement towards a better understanding of human factors and how its concepts and theories could be implemented in the Oil & Gas industry has gradually levering several kinds of research here and there, mainly from 2014 on. Figure 3 shows the growing number of publications after 2014. Such movement has been mainly driven by Oil & Gas associations like the IOGP and the SPE. The IOGP, for instance, has issued several reports with a focus on human factors quite recently. Although starting in 2005 with an initial focus on safety culture (e.g., IOGP, 2005, 2010, 2013), human factors is gaining momentum more recently (e.g., IOGP, 2011, 2012, 2014, 2014a, IOGP, 2018). Also noteworthy is the series of studies conducted by the SPE from 2014 on (e.g., SPE, 2014, 2018) being the latter the emblematic Technical Report “Getting to Zero and Beyond: The Path Forward - Improving Safety in the Oil and Gas Industry,” which contents are further explored in Chapter 5 - Discussions.

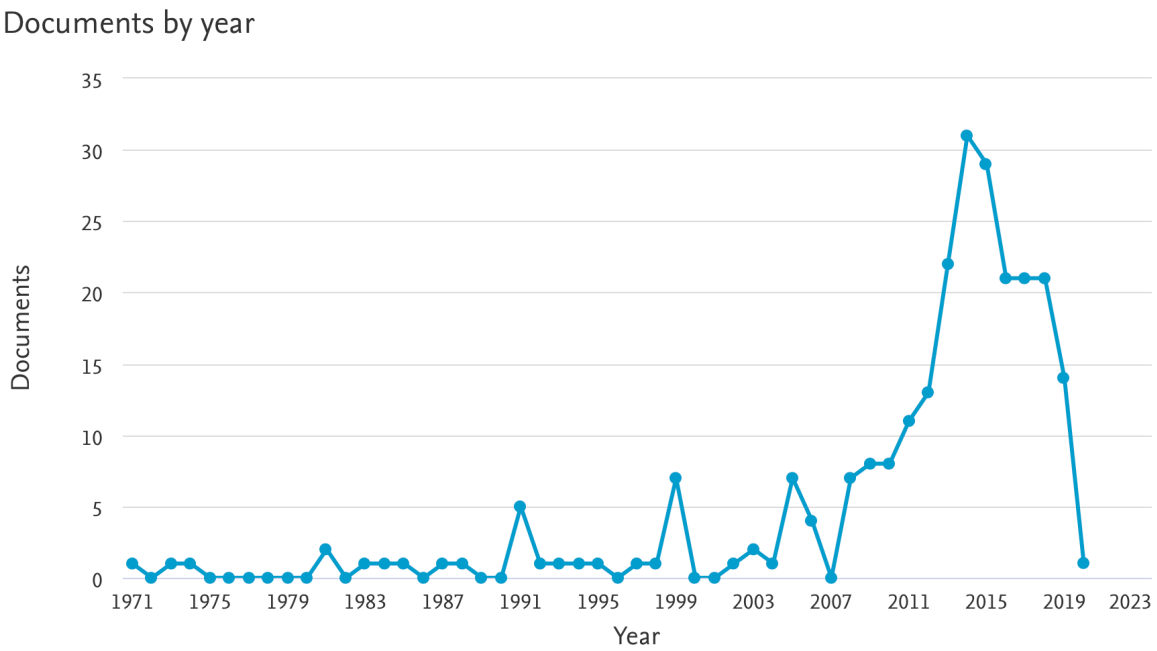

Figure 3 - Documents by year (Human Factors AND deepwater OR drilling - Scopus)

Although yet barely perceived in the way safety is approached by most of the Oil & Gas organizations, such movement towards human factors is gaining momentum and can be observed virtually everywhere within the industry today. Oil & Gas companies are incorporating human factors departments to their organizational structure, scholars are dedicating studies with focus in oil and gas, and research projects like the one sponsoring by my organization (Giuliani et al., 2019) are attracting more and more interest.

3 RESEARCH METHOD

3.1 Introduction

This work conducted an in-depth investigative exploration to capture the current mindset of representative leaders in deepwater drilling. The objective was to identify the main drivers, accident models and safety paradigms behind the perceptions of these key leaders to better understand how the industry approaches safety today. Furthermore, it also aimed to understand how prepared these leaders are to lead the constitution of a safety agenda for the Oil & Gas industry since Macondo and the underlying assumptions that were found in it for the improvement of safety and operational performance in deepwater drilling.

Therefore, considering its primary objective, qualitative design research has been chosen as the best approach to conduct this exploratory investigation, which in this case, was organized in two distinctive, though complementary phases: desk research and action research.

3.2 Desk Research

The first phase was conducted as desk research to characterize the distinctive views of human factors according to the scientific literature. The objective was to be able to establish a clear contrast with the beliefs and practices of the Oil & Gas industry today. This desk research was then developed to:

- Find out pieces of evidence on how the Oil & Gas industry has been working for the constitution of its own Human Factors and Systems Safety agenda since Macondo.
- Surface indications and existing information that help to explain the industry's core assumptions towards safety today that might influence the mindset of the Oil & Gas leaders and the way the industry understands and manages safety.
- Bring some context to the Oil & Gas industry from a historical perspective, revisiting the dilemma of its importance for the society today in against its growing dangers and complexity as a cutting-edge high-tech industry.

This desk research made use of diverse sources of information like reports issued by relevant Oil & Gas associations, e.g., IOGP and SPE (Figure 4); national statistics offices; governmental agencies; newspapers' articles; databases and internal communications of Oil & Gas organizations; training material; norms and procedures; professional journals, official reports, and other previous researches.

	YEAR	REPORT	TITLE
IOGP	2005	REPORT 368	*HUMAN FACTORS. A MEANS OF IMPROVING HSE PERFORMANCE*
	2010	REPORT 435	*SELECTING THE RIGHT TOOLS TO IMPROVE HSE CULTURE*
	2011	REPORT 454	*HUMAN FACTORS ENGINEERING IN PROJECTS*
	2012	REPORT 460	*COGNITIVE ISSUES WITH PROCESS SAFETY*
	2013	REPORT 452	*SHAPING SAFETY CULTURE THROUGH SAFETY LEADERSHIP*
	2014	REPORT 501	*CREW RESOURCE MANAGEMENT*
	2014	REPORT 502	*GUIDELINES FOR IMPLEMENTING WELL OPERATIONS CREW RESOURCE MANAGEMENT TRAINING*
	2014	REPORT 510	*OPERATING MANAGEMENT SYSTEM FRAMEWORK FOR CONTROLLING RISK AND DELIVERING HIGH PERFORMANCE IN THE OIL AND GAS INDUSTRY*
	2018	REPORT 456	*PROCESS SAFETY – RECOMMENDED PRACTICE ON KEY PERFORMANCE INDICATORS*
	2018	REPORT 621	*DEMYSTIFYING HUMAN FACTORS: BUILDING CONFIDENCE IN HUMAN FACTORS INVESTIGATION*
	2018	REPORT 2018s	*SAFETY PERFORMANCE INDICATORS – 2018 DATA*
	2019	REPORT 453	*SAFETY LEADERSHIP IN PRACTICE - A GUIDE FOR MANAGERS*
SPE	2014		*THE HUMAN FACTORS: PROCESS SAFETY AND CULTURE*
	2018		*GETTING TO ZERO AND BEYOND: THE PATH FORWARD. IMPROVING SAFETY IN THE OIL AND GAS INDUSTRY*

Figure 4 - List of IOGP/SPE Reports (2005-2019)

Regarding the latter, it is relevant to recognize the importance of a multidisciplinary research project in Human Factors and Resilience Engineering in Deepwater Operations at the Brazilian pre-salt area. The project is sponsored by my organization's Consortium in a partnership with the Pontifical Catholic University of Rio Grande do Sul state (PUCRS). Throughout the entire project started in 2017, I have represented the Consortium as a mentor and technical facilitator to help the researchers to better understand the language and culture in the domain of deepwater operations.

Likewise, I took part in practically all project meetings. I also supported field researches carried out by different research teams (sociology, resilience engineering, knowledge engineering and management, social service and environment) onboard an offshore drilling rig. The project just completed its first two-year phase and delivered its preliminary findings (Giuliani et al., 2019). Some of the most relevant findings and field observations were also included and duly referenced in this work.

3.3 Action Research

Action research, in a general definition, "is a family of practices of living inquiry that aims, in a great variety of ways, to link practice and ideas in the service of human flourishing" (Reason & Bradbury, 2008, p. 1). In other words, action research is a process of inquiry conducted by and for those acting (Sagor, 2000). In line with the objectives of this research, the primary reason for action research is assisting the actors in improving their actions.

This second phase, then, comprised an action research exercise to scrutinize the current beliefs of some of the main actors in the Oil & Gas industry. The goal was to seek a better understanding through participation and interactions. In order to access different perspectives to make this work as more robust and representative as possible, this phase was structured in three distinctive action research methods:

- Semi-structured qualitative interviews with a selected group of top executives and influencers, representing the full spectrum of organizations usually involved in deepwater drilling;
- Leadership workshops at organizational-level involving managers of three different players in offshore drilling operations, i.e., the operator, the drilling contractor, and the oilfield services contractor; and
- Field observations and interactions with the middle management and crews onboard the drilling rigs.

The main body of data for this research was collected over eight months, starting in March 2019. At the time, I began a series of nine interviews of top leaders in the Oil & Gas industry, mostly Vice Presidents and Directors of Operations, or HSE. I also conducted three two-day workshops with relevant managers with focus on human factors in deepwater operations.

Additionally, we had the opportunity to interact with many front-line workers onboard four drillships under contract with the Consortium over the last three and a half years. These rigs were operated by the same drilling contractors whose top leaders I interviewed for this study. Such observations and interactions were fundamental for this research since they allowed me to crosscheck two different perspectives, the blunt-end represented by the top leaders and managers, and the sharp-end composed by supervisors and crews onboard the rigs.

Therefore, most of the information obtained with the interviews and workshops could be contrasted with field observations as well as other sources like public documents, safety training material and campaigns, public speeches, among others.

3.3.1 Semi-structured qualitative interviews with selected top executives and influencers

Semi-structured interviews as a method for data collection are as flexible as they should be to get deeper insights from participants (Gill et al., 2008; Britten, 1999). To be able to capture different perspectives, various leaders representing the spectrum of organizations involved with deepwater operations were interviewed.

The number of respondents corresponds with the number of these key organizations, which in turn were selected considering either their market share (organizations that run the operations) or importance (regulatory bodies or industry/professional associations). In this regard, a total of nine leaders representing the following segments were interviewed, ranging from Executive Vice Presidents (VP) or Directors (D) to Senior Executive Managers (EM):

- **Three Oil Companies (OP#1-EM, OP#2-VP and OP#3-VP)** – These are the operators, the organizations that usually detain the rights for the exploration and exploitation of oil and gas reserves.
- **Two Drilling Contractors (DC#1-D and DC#2-VP)** – The segment that owns and operates the drilling rigs.
- **One Oilfield Services Company (OS-EM)** – Specialized well services, such as cementing, open-hole logging, drilling fluids, among others required to drill an oil and gas well.

- **One Regulatory Agency (RA-EM)** – The regulator, or regulators depending on the local legislation, represents both the society and the state. It is responsible for setting and enforcing the application of local norms and regulations for the industry.
- **Two Industry Associations (IA#1-D and IA#2-D)** – There are at least two different levels of representativeness in this segment. One level represents the industry itself either internationally or locally. The other level congregates the professionals working in the Oil & Gas industry.

The two different views of human factors, as defined in the literature review (Figure 5), were used as the framework for these interviews.

Old View	New View
"Human error" is the cause of trouble.	*What we call "human error" is a symptom of deeper trouble inside the system.*
"Human error" is a separate category of behavior, to be feared and fought.	*"Human error" is an attribution, a judgement that we make after the fact.*
"Human error" is the target; people's behavior is the problem to control.	*Behavior is systematically connected to features of people's tools, tasks and operating environment.*
"Human error" is something to declare war on. People need to practice perfection.	*"Human error" is information about how people have learned to cope (successfully or not) with complexities and contradictions of real work.*
"Human error" is a simple problem. Once all systems are in place, just get people to pay attention and comply.	*A "human error" problem is at least as complex as the organization that helps create it.*
With tighter procedures, compliance, technology and supervision, we can reduce the "human error" problem.	*With better understanding of the messy details of people's daily work, we can find ways to make it better form them.*
We can, and must, achieve zero errors, zero injuries, and zero accidents.	*We can, and must, enhance the resilience of our people and organization.*

Figure 5 - Old View and New View from 'human error' perspective

Therefore, to be able to capture the current beliefs of these selected leaders, as well as their willingness to incorporate human factors in practice to the existent safety systems, eight open-ended questions were formulated to allow the interviewees to provided broader explanations. These core questions are reproduced below:

1. How important is safety for our business?
2. How do you define success in our business?
3. Why accidents happen in our business?
4. Why humans err in our business?
5. How organizations approach safety in our business?
6. What do you think we should stop doing, keep doing, and start doing in relation to safety in our business?
7. How can human factors be incorporated in practice for safety and operational excellence in our business?
8. What would be the main barriers to make it happen?

3.3.2 Leadership workshops

In parallel, I also organized and coordinated three two-day workshops with a focus on 'Human Factors to Safety and Operational Excellence in Deepwater Drilling.' Each workshop with around 20 participants discussed safety in deepwater drilling from a human factors' perspective. Participants were mostly first-line managers of three different organizations, being one oil company (operator), one drilling contractor, and one oilfield services company. The fundamental goal was to capture their collective views as well as opportunities for improvements regarding safety and operational excellence in complement to the individual perceptions collected with the semi-structured interviews. Both the interviews and the workshops openly addressed the same topics.

The three workshops happened as follows:

- **Drilling Contractor** – Held in March 2019 at the company's headquarters in Houston, TX, USA. Among other relevant participants, there were some board members (COO and senior VPs), HSE Director, Director of Operations Brazil, HSE Manager Brazil, and Rig Managers.
- **Oilfield Services Company** – Held in May 2019 at the company's operational country base in Macaé, RJ, Brazil, with the participation of all service lines' managers in Brazil.
- **Operator** – Held in August 2019 at the company's headquarters in Rio de Janeiro, RJ, Brazil, with relevant executive and first-line managers.

Throughout the workshops, participants were encouraged to engage in group discussions about the topics as they were introduced.

3.3.3 Field observations and interactions

Most of the observations and interactions were captured over the last three and a half years. From June 2016 on, I was designated to work as a coach for improving both human and operational performance on board two latest generation drillships working at the Brazilian pre-salt ultra-deepwater area. Each ship was running around the clock with an embarked crew over 160, working in shifts of 12 hours. Although Brazilian nationals formed most of the crew, people from a diversity of nationalities in a myriad of backgrounds and cultures were also part of the team. Initially, my work as a coach aimed at the improvement of the offshore safety culture based on the principles of high-reliability organizations theory. Gradually, though, such objective evolved to a social experiment with a broader human factors' approach, including aspects of the New View and resilience engineering as well. The experiment was conducted partially in parallel with this research. It could be used to test human factors concepts to help front-line workers and supervisors to better cope with the uncertainties and variabilities characterizing offshore operations. Over this period, I went on board the rigs an average of 7 to 8 times per year in periods varying from 7 to 14 days each. In total, I spent over 300 days onboard or around 3,600 working hours.

Due to these interactions, I considered myself as a privileged insider. This rare opportunity allowed me not only to observe but also take part in the actions and some relevant experiments while they happened.

3.4 Limitations of this Research

The main limitations of action research usually refer to time-consuming and workload. Indeed, as the data collection phase was designed to interview the top leaders from nine different organizations, it took me eight months struggling with their busy agendas as well the following transcriptions to be able to complete the task. In the end, it was my position within the industry that has facilitated the whole process. Likewise, it was of great help to persuade three major corporations for the importance of workshops. The workload was also an issue. It took me months of field interactions as well as organizing workshops. However, again, it was facilitated by the combination of this research project and my routine work and position.

It is noteworthy to recognize that although of great help to conduct this research, my close relationship with some participants, on the other hand, may have affected the outcomes.

Hence, even though the rigor on the selection of the participants, all distinguish leaders and representing as much as possible the different players in the deepwater drilling sector, they comprise just a small sample of the industry leaders. Similarly, field observations and interactions were carried out onboard four different drillships, which represent a small percentage of the total deepwater fleet working for the Oil & Gas industry. Therefore, this thesis results and further interpretations are a mere extrapolation from the views of the participants and my field observations.

Finally, it cannot be ignored that this study may have been influenced by the discussions in Lund over the last two years about the distinctive views of human error and the naturalistic approach of the joint cognitive system school to highly complex systems. Therefore, my personal feelings about the importance of the New View of human factors for the improvement of human and operational performance in highly complex socio-technical systems such as deepwater drilling might be reflected in this work.

3.5 Ethical considerations

The organization I work for and myself, we both regard ethics with great value, defining the boundaries of my research.

As per the Swedish Ethical Review act, there is no reason for obtaining formal approval for my research. Besides, according to my Organization's Code of Ethics, there is no need for formal approval to external written works, including academic work when:

- The organization's name is mentioned in the curriculum or mini-curriculum of the author only.
- Technical and/or scientific works that do not cite the organization do not present internal classified information and are not funded by the company.

- External presentations by the employee on his own initiative, at his own cost, outside working hours, and without being linked to the organization.

Notwithstanding, all the interviews and workshops were conducted upon invitation to be freely accepted at the participant's discretion. The interviewees were duly informed via e-mail of invitation (Appendix 1) about the purpose of the interview and asked for consent. Furthermore, they were informed that any provided information would be treated as classified, and proper care would be taken to avoid mentioning names, both organization or participant's, or any other information in a way the source could be identified.

4 RESULTS

4.1 Introduction

The results collected by this research are organized in this chapter according to the structure of the eight open questions (see Chapter 3 – Research Method). For better comprehension, each question is presented as a specific topic below and followed by some comments to bring context. Moreover, whenever relevant, responses obtained during the interviews are grouped and quoted to preserve fidelity. Summaries from the workshop groups and field-related correlations are also presented under each topic if applicable or offering additional information.

Questions 4.2 to 4.6, were designed to capture the current views of the participants both in the interviews and workshops. In sequence, participants were introduced to the two distinctive views of human factors: a table comparing the Old View and the New View was shown to the interviewees (see Figure 5 – Chapter 3) and a brief presentation to the workshop participants. To instigate their critical thinking, workshop participants had the opportunity to discuss and identify behaviors within their organizations that could exemplify the Old View and the New View. The final questions 4.7 to 4.9 aimed then to assess participant's understandings as well their receptivity of the paradigms proposed by the New View of human factors.

4.2 The importance of safety

This question had the intention to not only explore the importance of safety but also how the industry understands the very meaning of safety.

Interviews – As expected, all key leaders declared to see safety as highly relevant and the number one priority for the success of the Oil & Gas industry, particularly in deepwater drilling operations:

> "Safety is so important that if you do not comply with good safety and environment requirements, you will have revoked your rights as an operator" (OP#1-EM).

> "It is more important than anything else. Safety is everything. After safety, it comes the rest" (OP#3-VP).

> "It is so vital for business. I consider safety is an integral part of our business" (DC#1)

Few leaders, though, more than just recognizing its importance, also associated safety with performance improvement:

> "Safety improves performance…" (DC#2).

> "Safety acts as a framework for the complex activity of deepwater drilling" (RA-EM).

However, one senior leader unveiled a revealing contradiction between the work-as-imagined and the work-as-done:

> "When we observe the speeches, documents, strategies, policies, values, etc., it seems safety is everywhere. But production must keep going. Targets must be achieved. I think this dual will stay in the air forever, or at least for many years" (IA#2-D).

Workshops - Also, as expected, all workshop groups unanimously recognized safety as the number one priority for their organizations today, reinforcing the contradiction revealed by one interviewee and observed at the front-end. The discussions, though, confirmed that participants define safety as the freedom from harm or a situation where nothing goes wrong.

Field Observations - The importance of safety, confirming what has been mentioned by one of the leaders during his interview, is mostly a demonstrated formality. Posters are hanged everywhere onboard the rigs and in the headquarters. As well through internal communications, strategic plans, policies, internal TVs, even websites. However, such safety priority mainly refers to occupational safety, which means preventing people from getting hurt. Likewise, front-line supervisors also seemed to take occupational safety quite seriously, and their number one responsibility. At the front-line, safety is defined as a harmless day or going back home with no injuries. Safety performance, as evidenced by placards in every arrival briefing rooms onboard the rigs and many other facilities, is still measured by the number of days with no 'Lost Time Incidents' and even by the number of free-day hurts. Onboard the drilling rigs, the industry's widespread zero vision is demonstrated via exhortative slogans like 'nobody gets hurt' or 'hold the zero.'

4.3 Definition of success

This question was addressed mainly to the key leaders during the interviews

Interviews - In general, most leaders associated success with incident-free operations. This perception supports the 'zero vision' programs permeating most of the organizations object of this research:

> "We have set a goal towards Zero Fatalities" (OP#2-VP)

> "Our Goal Zero ambition is to achieve no harm and no leaks across all of our operations" (OP#3-VP).

Some also mentioned positive financial results and profit as the definition of success. However, safety and financial results were seen as two distinctive achievements by many, sometimes even opposite to each other. At least three leaders though were able to associate both:

> "Success is defined by how well we can balance all distinctive, sometimes conflicting goals" (DC#1-D).

> "A really successful operation has to delivery what is expected. And it must be safe. A successful operation today must encompass both" (OS-EM).

> "Companies preserving people and environment are the ones that have better financial results" (IA#2-D).

Field Observations – Similarly to the definition of safety, success is understood and defined as a day without incidents, either safety or operational. This 'success' is something measured at the end of each day and ritualistically celebrated as a significant achievement when, for instance, crew and supervisors pray together and congratulate each other for one more incident-free day.

4.4 Why accidents happen?

Interviews - Practically all interviewees associated accidents to some lousy performance of unreliable people:

> "People are doing things automatically, and many times do not perceive changes that open the door for an accident" (OP#1-EM).
>
> "It is the human who causes it somewhere at some point of time" (DC#1-D).
>
> "Group thinking and complacency were major contributing causes of the disaster" (DC#2-VP).
>
> "I think, many times, people get hurt because they do not follow the process" (OS-EM).

It is quite interesting that two interviewees from different organizations apart from each other in time and space mentioned precisely the same human frailty using the same vocabulary. Both described a situation of people doing things without thinking before acting, automatically. It was not a coincidence, however. While interviewing these two leaders at their head offices, I noticed posters almost everywhere, advertising a new safety campaign aiming at teaching people how to stay focused and avoid distractions most of the time using the slogan 'leave the automatic.' It happened that the two organizations hired the same safety consultant, a major multinational company with a robust behavior-based safety program and long working with the Oil & Gas industry, to develop the campaign.

In this regard, a revealing testimony about the mindset of this safety consultancy industry was provided by one of the interviewees, which shows how such fantasist beliefs have become so dogmatically impregnated in the minds of industry leaders and safety management systems everywhere:

> "A person working by a large safety multinational consultant said that going down the stairs without holding the handrail explodes a factory! It means that such a person has no safety culture enough to walk down an ordinary building stair holding the handrail. The same person in a factory in an important activity can make a mistake and trigger a catastrophe" (IA#1-D).

Notwithstanding yet predominantly focused on individual behavior, few answers, on the other hand, remitted to slightly different explanations. The most commonly referred to an abstract concept of safety culture or the different cultures onboard a drilling rig as contributing factors behind accidents:

> "Contractors with different safety culture" (OP#3-VP).

Although none of them unmistakably addressed a system explanation for accidents, at least two interviewees mentioned something beyond the common sense of blaming people. One remembered the issue of 'normalization of deviance' because it was a concept embraced by his organization, emphasizing the importance of people at the sharp-end developing 'chronic unease.' Another, who had recently attended a lecture about the distinctions between the old and the New View of human factors, mentioned with a certain level of understanding the issue of complexity in deepwater drilling as a contributing factor in addition to human errors:

> "There is not enough competence to understand the complexity of all different scenarios. But I would still bet on humans, perhaps because they do not know the extension, the amplitude of the environment they work in" (IA#2-D).

Workshops - Similarly, responses from the workshops also connected accidents to human errors. Like this, the most cited reasons behind accidents were related to human frailties. The most cited were lack of attention or distraction, lack of risk perception, lack of operational discipline or not following procedures, overconfidence and complacency, lack of knowledge or training, rush, shortcuts, and lack of planning. Few groups have diverted from common sense and provided different reasons with a focus on the organization and system such as pressure for results, management, complex environments, unexpected situations, and organizational culture.

Field Observations - Onboard the rigs, however, supervisors and crew have already learned that paying attention is essential, but they know that distraction is not an option, and it is more common than imagined by their managers. Hence, there is an overall discomfort with the impracticability of most of the norms and procedures. It confirmed what was collected in the interviews and workshops, that the current approach on board the rigs is yet strongly focused on people as the main barrier against accidents. The daily routine involves dozens of audits, inspections, safety cards, safety awareness meetings, online normative training sessions - safety as bureaucratic accountability. Therefore, the premises behind the New View were very welcome by front-line workers, who see them as quite obvious.

4.5 Why humans err?

Again, a question specifically addressed to the leadership, both interviewees and workshop participants. Though it may be rhetorical, this question aimed at conceptualized better the current leadership mindset considering the responses obtained so far.

Interviews - Most of the responses focused on individual behaviors at the sharp-end. The reasons behind human errors listed by the participants were very similar to the causes already listed in response to why accidents happen and reinforcing participants' view that humans cause accidents.

One interviewee came with a curious response, though. He cited a lack of responsibility of workers who take risks in a childish behavior to prove their masculinity. Another believes that human error is a question of wrong choices to be fixed with culture. Hence, a Vice President

of Operations, referring to his front-line workers, said that, unfortunately, there will always be 'rot eggs in the basket.'

Workshops – Responses from the workgroups were more objective. They followed the same causes of accidents, as raised in the previous question: lack of awareness, complacency, violations, risk acceptance, or lack of risk perception, overconfidence. Again, few groups had a different approach and tried to produce some systems or organizational causes like business subjectivity or pressure for results.

Field Observations – The working environment onboard an offshore drilling rig is always over pressured. Even though managers and supervisors today do not pressure for results and they used to do until recently, the very nature of the work (e.g., around the clock schedules, heavy-duty tasks, routine re-planning, high costs, and so on) creates pressure. As part of the first phase of a human factors project in deepwater operations conducted by Giuliani et al. (2019), a team of sociologists carried out a comprehensive survey onboard one of the drillships. Among their finding, one, in particular, is quite impressive. The researchers were able to identify at least four distinct groups of offshore workers. The first group comprises the oilmen. The ones that are there because they love what they do. Second, there are the technical, professional people, who are working offshore because of the opportunity to do something aligned to their professional background. The third one is the group of those who hate working offshore, but at least like the money they make, as well the time-off period. Finally, the last group is formed by those that also hate working offshore, but are there because they do not have any other option. This group lives in what psychanalysts referred as a psychic suffering. Whether there is any correlation between these distinctive reasons for working offshore and human adaptability to such a harsh environment is something to be explored further by the researchers in the second phase of the human factors project.

4.6 The industry's approach to safety

This question was formulated with the primary objective of characterizing the current mental models and paradigms inside the minds of the Oil & Gas leaders and the organizations they represent.

Interviews - The responses overwhelmingly indicated that all the organizations have a robust retributive approach to safety based on the belief that operational discipline, meaning strict compliance to rules and procedures, is the best way to guarantee safety. Invariably, they are focused on controlling people's behavior by all means. Among them were prescriptive procedures, routine safety audits, observation cards, rewards and punishments, and even video monitoring. Therefore, compliance was mentioned by most leaders to explain, in short, how their organizations approach safety.

Almost all interviewees also mentioned that their organizations do not tolerate any deviations from their rules and procedures:

> “Then, our approach is punitive for an intentional deviation or negligence. We cannot be complacent with lenience and laziness. We cannot get away from this principle” (OP#1).
>
> “Any critical deviation is investigated. It is where we seek the root causes to prevent repetition. When we identify a negligent or deliberate deviation, the way is punishment” (OP#1-EM).
>
> “If someone consciously does not follow a rule, it will be a violation we do not tolerate. We must be careful in not give then a free pass to do whatever they want” (OP#2-VP).
>
> “In summary, culture, training, and discipline” (OP#3-VP).
>
> “Operational discipline and strict compliance with rules and regulations” (DC#2-VP).
>
> “My organization believes that compliance with rules and procedures is enough to guarantee a safe workplace” (OS-EM).

For a better understanding, it was also questioned what happens if someone breaks the rules, to leave no doubts about the real meaning behind their previous answers. The result, even though expected, was quite astonishing:

> “Then, our approach is punitive for an intentional deviation or negligence” (OP#1-EM).
>
> “If you choose not to follow the rule, you choose not to work for us. Then you will think twice” (OP#3-VP).
>
> “I think there is very much a culture of punishment. If you commit a mistake, you must be punished” (IA#1-D).

Another relevant set of responses touched the issue of the confusion between occupational safety and process (or system) safety. Many leaders manifested their concerns with their organizations devoting most of their safety efforts to occupational safety with the belief that preventing injuries to workers by controlling human behavior it would automatically prevent major accidents:

> "The fact we pay attention to occupational safety does not mean that we mitigate the risk of process accidents. Occupational safety is indeed important; but process safety has to have a captive slot in the company” (OP#1-EM).
>
> "Occupational safety is indeed important, but process safety has to have a captive slot in the company" (OP#2-VP).
>
> “We simply forget there is a high risk of fire and explosions in what we do” (OP#3-VP).
>
> "There is a big difference between occupational safety and process safety. For instance, in the Macondo case, on the very days before the accident, they were celebrating many years without LTIs. Our safety KPIs[12] are mainly reflecting occupational safety aspects, and are very little focused on the issues that could prevent large accidents” (RA-EM).

[12] Key Performance Indicators.

Many leaders also mentioned the growing use of automation and digital technologies to improve safety on board. Among other aspects, they commented about the development of human-machine engineering with the use of sensors and cameras to safeguard people at the drilling deck and improved remote operations capabilities to allow remote operations and reduce people on board the rig.

Workshops - Likewise, workshop groups confirmed what the top leaders indicated in the interviews. Most cited responses were a reactive approach, compliance, blame culture, focus on adverse events, disciplinary actions, safety campaigns, excess of bureaucracy, among others. Besides, many managers mentioned some rituals adopted by their organizations as a means to get their commitment to safety behavior. Amazingly, workers are demanded to formally swear it before their superiors or sign a document stating their promise to behave safely.

Field Observations - The use of automation and digital technologies for improving safety and efficiency is part of the history of deepwater drilling. Today, most of the drill floor repetitive hazard operations, for instance, are carried out by robot-type equipment controlled by the driller and the assistant driller from cyberbases[13]. However, some latest initiatives may be counterproductive. One, as mentioned with pride and more than once during the interviews and workshops, is the use of digital cameras and broadbands to allow online control from onshore over the workers at the front line. Though the leadership demonstrated such enthusiasm with this possibility of online behavioral supervision, a modern type of digital 'panopticon'[14], virtually every worker on board the rig, manifested their discomfort with this additional control. Foucault (1977), for instance, dedicates an entire chapter to 'panopticism' in his book "Discipline and Punish." Workers on board the rigs, although demonstrating their concern with it, seem to be resigned with the situation. For instance, during a short seminar about human factors with the front-line leaders I conducted onboard one of the drillships, one supervisor responded in short when questioned about his organization's safety culture, "That is easy. It is fear-driven," which said a lot about the way his organization approached safety and confirms the retributive approach to safety mentioned by many leaders across the interviews.

4.7 What should we stop, keep or start doing differently?

This question explored interviewees and the workshop participants' level of understanding of the two different views of human factors as they were introduced to them. More importantly, it aimed to measure their willingness to start building a human factors agenda for the Oil & Gas industry. As expected, it resulted in a myriad of responses.

[13] Workstation chairs with drilling equipment command system enclosed in a driller's cabin on the drill floor. It includes joysticks and keypads dynamically tied to a set of computer screens, replacing the older system of gauges, lights, and switches.

[14] A type of institutional building and a system of control designed by the English philosopher and social theorist Jeremy Bentham in the 18th century to easily control all inmates in prison by a single guard from a tower located in the center of the building.

Interviews - A subject mentioned by many participants is the need for simplification to reduce bureaucracy:

> "I am proposing a sort of simplification in safety. Simplify our procedures. Simplify our procedures. They must be revised by the front-line workers to define which instruction is good and which has no meaning or is just bureaucracy" (OP#2-VP)
>
> "Making a step-by-step procedure for all critical activities. From the step-by-step procedure, we will create a one or two-page checklist" (DC#1-D).
>
> "Revise procedures and make them simpler and easier to follow. Strict procedures remove freedom from front-end workers to adapt to unexpected circumstances" (OS-EM).
>
> "Because the procedures are too complex. Many people see a procedure as a general guide, but not applicable many times because the reality is much more complex and variable than that" (OS-EM).
>
> "Simplifying the process is a key factor for operational safety" (RA-EM).

One leader made an intriguing comment when suggesting we should stop blaming people for undesirable outcomes:

> “Allow honest error. The honest error should not be punished” (OP#2-VP).

Other suggestions were related to the need for enhancing communication, revising the way people are selected and trained, as well as recognizing the importance of creating a more collaborative environment among the operators:

> “We must be much more disciplined in the selection of who works for us” (OP#3-VP)
>
> “There is a need for promoting a much more collaborative environment with the operators” (OP#3-VP).
>
> “We always choose the best roustabout and put them in the crane and miss that opportunity to select the right people for the right job” (DC#1-D).

At least one VP Operations mentioned something that can be linked to the concept of just culture:

> “Set the expectations, draw and maintain the line between acceptable and unacceptable behaviors” (DC#2-VP).

Workshops - Probably thanks to no-time constraints, which allowed longer group discussions, workshops resulted much more prolific and objective on their responses. So, for better understanding, their most relevant responses are organized on Figure 6 below:

STOP	KEEP	START
• Blaming people • Excessive compliance • Too prescriptive procedures • Associating failures with people • Pyramid concept • Behavioral audits • Main focus on occupational safety • Reduce bureaucracy • De-emphasize lagging indicators • Ambiguous expectations • Overwhelming system with safety audits • Overloading supervisors • Reactive - focus only on what goes wrong • Old View of the leadership and organizational culture	• Leadership meeting • Cooperative environment • Training • Stop Work Authority • Collaborative meetings • Task Planning • Risk assessment • Leadership engagement • Hazard hunt / identification • Continue relationship between companies • Good practices of job planning • 5 key expectation • Continue improvement efforts	• Debrief success cases • Review training model • Learning teams • Communication protocol • Shift from focus on individuals to focus on system • Automation opportunities in engineering processes • Leadership engagement to operational reality • Team building / Promote people engagement • Simplify procedures: focus in HF • Involve people in execution of work • Change communication • Investigation to learn • Review procedures with focus in HF • HF champions to spread the word • Develop leading indicators • Build-up trust and collaborative environment

Figure 6 - Workshop Summary - What stop, keep, and start doing

4.8 Incorporating human factors in practice

Participants, both in the interviews and the workshops, were instilled to provide some ways to incorporate human factors in practice to the existent safety management systems. Their contributions have provided elements to draw a pathway for the development of a human factors agenda for the Oil & Gas industry.

One of the most cited points by virtually all participants, no matter their roles in the field of deepwater drilling, was the imperative need for integration and collaboration. Integration not only among the operators, but also with the regulators, other industries, and the academia as well:

> "Safety is like commodity. Safety cannot be taken as a competitive asset" (OP#2-VP).
>
> "Collaboration. To get together. Get closer to aviation" (OP#3-VP).
>
> "Every drilling contractor and every operator should follow the same safety management system" (DC#1-D).
>
> "Other aspect that can also evolve well for this improvement is the integration of the regulation" (RA-EM).
>
> "Joining efforts and putting the regulator working together with the academy may bring benefits of evolution in operational safety" (IA#2-D).

Another topic seen as of great importance by many leaders was the development of non-technical skills, particularly in safety leadership:

> "The issue of leadership is one of the key points" (OP#2-VP).

"Safety leadership questions if the OIM[15] care for everyone on board the same way he cares for himself" (OP#3-VP).

"Good leadership. Absence of arrogance" (DC#2-VP).

"I think we should organize this knowledge about human factors. Perhaps creating a program to form experts in human factors, master and PhD programs" (IA#1-D).

Once again, many leaders demonstrated here their concerns with the confusion between occupational and process safety:

"Why so many things fail at the same time leading to a catastrophe?" (OP#1-EM)

"I believe human factors shall be part of a more comprehensive approach, including process accidents, where the safety management system plays a significant role" (OP#2-VP).

"Developing leading indicators to identify or anticipate eventual operational safety deviation that may lead to big accidents" (IA#1-D).

The role of the regulator was also mentioned as a vital factor to help the introduction of a distinctive approach to safety:

"The regulator in Brazil has a different approach, and instead of issuing prescriptive rules and regulations, it has an approach of defining performance goals to be taken by the oil companies as an encouragement to freely improve their performance" (RA-EM).

"But I see ANP[16] trying to change this. ANP has today a much more collaborative posture of exchanging information, best practices, promoting discussions with the industry instead of just finding and error, and punishing you" (IA#1-D)

Finally, perhaps because of the introduction of other human factors paradigms during the interviews and group discussions over the workshops, different but quite exciting responses demonstrate what these leaders are willing to do towards a new safety approach:

"I will look at how I can change the level of trust" (OP#1-EM).

"This issue of human factor is a complement to help us to understand this portrait of seeking a safer work, understanding people, bringing more satisfaction, higher inclusion of human beings" (OP#1-EM).

"We can always increase trust" (OP#2-VP)

"Our industry is becoming more rigid because this is always the easiest approach. We must develop the ability to be more flexible" (DC#1-D).

[15] Offshore Installation Manager is the most senior manager onboard an offshore platform.

[16] ANP (Agência Nacional de Petróleo, Gás Natural e Biocombustíveis) is the Brazilian National Petroleum Agency. The regulator for the Oil & Gas industry in Brazil.

"To change the perception of how we can reduce human error by design it would require a lot of momentum and push from various stakeholders like oil companies, drilling contractors, equipment manufacturers, all of them" (DC#1-D).

"Systems to be not too detailed but leaving room for flexibility" (DC#1-D).

"The idea of considering the human being as an equipment with an intrinsic reliability is an idea that do not take the best human characteristics" (RA-EM).

"One is the issue of resilience itself and how the system, including the human being as a central part, will react to certain risks" (RA-EM).

4.9 Barriers

A final question was designed to identify the main barriers to constitute a human factors agenda for the Oil & Gas industry. This approach, though, tried to make explicit the main hurdles that might prevent or even barrier off a move towards a human factors approach to safety.

Following the same openness that characterized the responses so far, participants were then able to provide remarkable information once again.

Interviews - On this regard, most leaders recognized that Oil & Gas organizations are quite an individualist, which may undermine integration, collaboration, and standardization:

"Distinctive views are difficult to deal with" (OP#1-EM).

"Oil companies are self-referenced. Each one has its own standard" (OP#2-VP).

"There is no more traditional, old-style industry than the oil and gas" (OP#2-VP).

"Each one has its own business. Oil companies are not integrated" (OP#3-VP).

"This has to be driven industry-wise, which is not an easy task" (DC#1-D).

"There is a big gap between different forums in the oil and gas industry. I felt that better interaction is missing" (IA#1-D).

"Besides, there is no integration. Each company believes it has a robust safety structure and does not discuss safety improvements to each other" (IA#1-D).

Many participants also mentioned the issue of over-regulation with a focus on compliance. One interviewee with extensive international practice shared his extensive experience with rigs operating in a different area. Rigs operating in environments with lesser rigid regulations like Africa were the ones showing the best safety records. Conversely, rigs operating in places with stringent rules and strict control from outside authorities like the North Sea presented the worst results. "It is quite a paradox," he said. "Africa probably may have the right level of procedure and flexibility, and Norway has gone too much towards the procedure, offering very little flexibility for people to do anything different. Compliance may not result in better safety, but the opposite," he added.

Some leaders mentioned the adverse side effects of bureaucracy and strict compliance adopted by many Oil & Gas organizations as the way to improve safety:

> "This kind of line of compliance first generates a problem because it refrains, limits the development of new technologies and new operational safety systems on the one hand and the second point, in my opinion, is even worse because it is a cultural matter. From the moment this line is established, we know that culturally the operator, instead of challenging itself to enhance its management system more and more independently, it will stop at that line defined by the regulator" (RA-EM).

> "We see many companies just doing things towards safety as a response to a contractual demand" (IA#1-D).

> "From the moment a regulator of a high technological activity becomes highly prescriptive, it establishes one line of action from which… below that, you cannot go. It inhibits improvement" (IA#2-D).

Nevertheless, in the same line of thinking, some leaders, particularly from drilling contractors and oilfield services companies, manifested their discomfort with what they call an undue interference in their safety management systems. They explicitly referred to the clients, the oil companies, as the main problem, more than the regulators:

> "Compliance is imposed today by both the client and the regulator" (DC#1-D)

> "Operators don't know how to manage people. There is a lack of proper translation of their thoughts and demands into the operational world"" (DC#2-VP).

Another relevant aspect is the overall complaint that human factors is a quite difficult concept to understand when compared to the simplicity of the compliance to rules and procedures:

> "The biggest challenge is how to translate them through multiple layers of management down to the front-line workers" (OP#2-VP).

> "Compliance is easier to implement, easier to convince other people to use, or to convince the authorities. Easier to convince the wider stakeholder" (DC#1-D).

> "It seems to be something coming from people that do not know the reality of deepwater drilling" (DC#2-VP).

> "There was a great resistance against the apparent no blame concept in the systems thinking" (DC#2-VP).

> "Several drilling contractors struggled against that concept initially" (DC#2-VP).

> "I am afraid our people on the rig are not able to understand these human factor ideas" (DC#2-VP).

> "For many companies, it is unacceptable not having prescriptive rules to simply comply with" (RA-EM).

> "We are well-prepared engineers, but the person at the front line with tools on hand, which education he has?" (OP#3-VP)

As expressed by many interviewees, such concerns may be a consequence of an industrywide lack of knowledge about human factors and systems thinking:

> "There is a great disparity of knowledge in the oil industry" (IA#1-D).
>
> "There is a lot of people discussing human factors by guessing. Human factors are now fashion. As well as the safety culture. I think we cannot keep discussing these issues simply by guessing" (IA#2-D).

As a final remark, something that reinforces the contradiction of safety as the number one priority. Many senior leaders raised concerns regarding the lack of operational experience of some managers reaching high positions without the necessary experience, which might be blurring a better view over the reality of the operational world and enlarging the gap between the work-as-imagined and the work-as-done:

> "I see here in high-level positions, people with a long time with the industry but with limited knowledge about the reality of the operational world" (OP#2-VP).
>
> "We see operations managers extremely young, with all due respect to the young people, but they have little knowledge about the greatness of the issues they are dealing with" (OP#3-VP).
>
> "They do not have enough knowledge for creating a safer environment" (OS-EM).

Workshops – Again, the responses collected from the workgroups were a bit more objective. Among the main reasons, the most cited were reluctance of the leadership, cultural inertia, retributive legislation, regulatory demands, lack of integration, organizational culture in the Old View, difficult to sell upwards (cost x benefit x risk).

4.10 Macondo

Although not directly questioned during the interviews and workshops, the issue of the Deepwater Horizon disaster naturally emerged as a recurrent topic all across this research, particularly during the interviews with the top leaders. The general impression expressed by many leaders is that Macondo, although a significant milestone for the industry, has reflected mainly in more stringent norms and procedural bureaucracy:

> "There was an impact on regulations, but the culture was much less affected. The shortcut, the issue of placing profitability ahead of safety, weights more in the mindset of many companies yet" (OP#2-VP).
>
> "Deepwater Horizon could have brought many lessons to be learned, but I see almost no one talking about it" (DC#1-D).
>
> "Unfortunately, I think that Deepwater Horizon did not light up the safety alert. I think it had a small contribution" (IA#1-D).

Field Observations – Conversely, what is observed everywhere in the industry today tells otherwise that Macondo is not only still alive in the minds of most of the oil workers at the front end, but seems to be one of the main drivers boosting the construction of a human factors agenda specifically for the Oil & Gas industry. Onboard the rigs, for instance, Macondo is often mentioned as a wake-up call for the need to do safety differently. Hence, over the period working onboard the rigs, Macondo was a key element, from a perspective of human and organizational factors, to attract even the most reluctant middle-manager, supervisor or worker to the concepts proposed by the New View of human factors.

Leaders' perception of the importance of Macondo may have its origins from the fact that initially, Macondo did not cause the impact as expected by the industry. Indeed, lessons learned from Macondo have produced limited practical changes in the way the industry approaches safety so far. However, though yet not producing visible structural changes, several initiatives discussing the importance of human factors in the Oil & Gas industry are being observed more recently, particularly over the last five years. This topic is further explored in Chapter 5 – Discussions.

5 DISCUSSIONS

5.1 Introduction

In the preceding chapters 3 and 4, this work sets the boundaries between the two distinct views of human factors and consolidates the information obtained from both the interviews and the workshops, as well from my field observations as a privileged insider onboard the drilling rigs to support the discussions as driven by the research question.

"What are the current accident models and safety paradigms in the deepwater drilling organizations and how are the recent movements towards a different approach to safety influencing the development of a human factors agenda for the Oil & Gas industry?"

5.2 Accident models and safety paradigms

First, it is essential to remark that safety, as unanimously expressed by the leadership object of this research, is seen as highly relevant and the number one priority for the future of the Oil & Gas industry. Indeed, safety is a genuine concern shared by virtually everyone in the industry at both organizational and individual levels, either front-line workers, middle managers or top leaders. Hence, safety is understood as the freedom from harm or a condition where nothing goes wrong, or Safety-I as defined by Hollnagel (2013).

However, behavior-based safety is the dominant approach within the Oil & Gas organizations. Consequently, safe behavior programs are overwhelmingly prevalent across the industry. Following the old view of human factors, linear accident models are accepted by most of the Oil & Gas leaders today as the ultimate representation of accident causation. The "domino" model (Heinrich, 1931) and the "Swiss Cheese Model" (Reason, 1997) are both universally accepted across the industry as the paramount explanation for the human contribution to accidents. Linear models, however, carry the risk of excessive simplification in a complex world, which frequently results in less effective ways to improve safety performance. Usual interventions are then limited to more training and compliance to procedures as a reaction to adverse outcomes. Therefore, other contributing factors to accidents such as competing goals, unaccountable interactions, and unpredictable outcomes, among many others, as proposed by the new view, are often solemnly ignored by most of the Oil & Gas organizations.

Moreover, there is also a credo in safety pyramids and triangles (Heinrich, 1931; Bird, Clark & Germain, 2012), as strong as the linear model of accident causation. For virtually all organizations in this industry, the direct relationship between minor deviations and the next disaster seems to be accepted as a dogma. This belief is so strong that even after Macondo most of the efforts towards safety across the Oil & Gas industry still focus on controlling people's unsafe acts and deviations, the basis of the Pyramid, to prevent the next catastrophe. For instance, in an Oil and Gas Conference held in Denmark in 2018 with the motto "face the facts," Dekker (2018a), for the astonishment of an audience of Oil & Gas leaders, showed the 'fact' that, on the contrary, studies had demonstrated there is no scientific evidence of a

meaningful relationship between minor injuries/incidents and fatalities. Actually, he continues, if there is any relationship, it shows otherwise that a large number of reported incidents corresponds with lower fatalities. The literature already knows that minor incidents do not predict anything or, most of the time, are not even predecessors of the next Macondo (Saloniemi & Oksanen, 1998; Storkersen, Antonsen, & Kongsvik, 2016; Dekker, 2018a, citing Barnett & Wang, 2000).

As declared by many leaders across this research, most of the industry's safety management systems are still impregnated with a culture of command and control. Such culture, as in the Old View, relies on administrative tools like prescriptive procedures, behavioral audits, safety cards, training reinforcements, and disciplinary measures to keep people's behavior under strict control as the main drives to guarantee safe operations.

As a consequence, front-line supervisors and safety people alike are always overloaded with the enormous bureaucracy created by this culture of control. For instance, one OIM once told me a story. He was uncomfortable with the enormous quantity of safety audits his drillship was being submitted every year either by his organization's requirements, clients, regulatory agency, or any other government body. Seeing no gains with those audits, he decided to compute the numbers and grasped the astonishing number of 275 audits per year! Definitely, doing more of the same may have exceeded any reasonable logic. The industry seems to have reached its 'sweet spot' (Dekker, 2018), a point from where more rules do not necessarily bring more safety. In the sweet spot, there is a balance between what Amalberti (2013) calls 'controlled safety' imposed by regulations and procedures, and 'managed safety' based on the expertise and experience of workers. Indeed, over the last years, safety indicators in the Oil & Gas industry, measured by injuries and fatalities frequency rates, have reached a plateau (see Figure 2 – Chapter 1), suggesting that doing more of the same have had little or no effect on safety performance.

Such a condition may explain why many leaders have demonstrated a visible discomfort with this traditional approach to safety during the interviews and workshops. They revealed a blurring feeling that something else should be done. Moreover, many leaders have reported that such a sort of behavior-based approach is so embedded deep inside most of the giant Oil & Gas corporations today that they see no way to walk around towards different approaches to safety. It seems to be something far beyond their capacity to fight for. This discomfort, however, is a good indication that many leaders are already awaking for the need to incorporate new paradigms to the existent safety practices in their organizations.

Apparently, though, there is considerable inertia preventing the industry as a whole to move the same way its leaders would individually do. It makes these leaders intuitive feelings to be engulfed by the current organizational culture. After all, an industry that, even after Macondo, still measures the level of safety performance by bureaucratically counting the number of minor deviations, unsafe acts and occupational accidents, may see no need for a change and might be quite comfortable with the decreasing trend of LTIs observed over the last years. This comfort, though, may create a false impression that the industry is doing the right things to improve safety. Dekker (2018) goes even further when he says that recent studies suggest

this ritualism in the investigation of minor incidents might be a symptom of alienation of the limits of control over organizations' technologies, operations, and processes. For the industry, it is just a matter of keep doing what it always did, i.e., controlling attitudes and behaviors of people to achieve the so desired goal zero. Amazingly, a zero that was held over six years by the Deepwater Horizon until the Macondo blowout (BP, 2010; Hopkins, 2012). Definitely, the practices and processes as well the sociological aspects that decisively contributed to the Macondo disaster are still alive and very present in the Oil & Gas industry today.

Three main reasons might explain this apparent mismatch between the industry's organizational culture and the feelings expressed by many leaders, as observed throughout this research:

Lack of repertoire

The vast majority of the interviewees, workshop participants, and front-line workers have demonstrated little knowledge about the role of humans on safety and accidents beyond the traditional paradigms represented by the Old View of human factors. Most of them have learned that humans cause accidents and, therefore, must be controlled by all means to protect the system. Hence, they have been told that root causes can be found and adequately blocked to avoid recurrence; that minor deviation cannot be tolerated in order to prevent the next catastrophe; compliance to rules and prescriptive procedures is the best way to guarantee safety. Such a limited repertoire may also explain this widespread confusion yet observed in the Oil & Gas industry between occupational and process safety. Hence, without a certain level of repertoire, it will be tough for these leaders to overcome that powerful industrywide inertia to start moving towards the constitution of a human factors agenda.

It is intriguing though that being around for at least twenty years, most leaders we have had contact have never heard about the concepts that constitute the New View of human factors and system thinking. The few ones who demonstrated to know something about the New View manifested their concerns that its concepts, in contrast with the simplicity of the traditional practices, are too complicated, too academic to be translated into practical tools to front-line workers. Indeed, concepts dealing with intangible ideas like sociology or cognitive psychology can easily be seen as too abstract and distant for an industry like deepwater drilling that is mostly driven by practical engineering mindsets. Some others are afraid that the adoption of the New View ideas would bring the risk of introducing an unacceptable *'no blame culture'* into their organizations. As evidence of a lack of repertoire behind these concerns, a Vice President of an organization object of this research, after attending one of the workshops, expressed his relief by finally understand that 'no blame' and a system view do not mean impunity.

From a more optimistic perspective, however, this research also brings to light that most of the leaders are open to approach safety differently. Such willingness to at least getting to know different safety paradigms could be observed during the interviews and, particularly, the workshops across this research. Participants started to change their suspicious and reactive minds after appropriately been introduced to the real meaning of the New View of human factors. Reactions initially varied from surprise and discomfort to acceptance and even

some enthusiasm at the end of the workshops. It means that a better repertoire of knowledge will make these leaders capable enough to lead this journey towards the constitution of a human factors agenda for the Oil & Gas industry.

A culture of compliance in a world of complexity

As several indications also demonstrate, there is a strong belief among the Oil & Gas leaders that because of the high risks involved in deepwater drilling, safety must be managed through strict compliance to rules and procedures, no matter the complexity. Any flexibility is too risky, they think. Common sense is that every possible measure shall be put in place to prevent human errors and their consequent undesirable outcomes.

Therefore, most of the safety management systems in the Oil & Gas industry rely on safe behavior programs, compliance, and operational discipline to ensure safe operations. However, complexity requires systems to develop adaptive capacities to cope with their normal performance variability (Hollnagel, 2012). Dekker (2018) argues that compliance with rules and prescriptive procedures sometimes may otherwise increase risk. It should be much evident, he continues, that compliance does not deal well with novelty, complexity, and uncertainty, not coincidently three of the main characteristics of deepwater drilling. As Dekker (2014) explains, such characteristics require adaptive responses, experimentations as small incremental steps away from the original rules to adjust procedures to the circumstances and cope better with the scarcity of resources and multiple, sometimes conflicting goals. Actually, these concepts are far to be evident to many leaders in the Oil & Gas industry. As this research demonstrates, the industry is yet profoundly immersed in Old View paradigms. Telling the Oil & Gas leaders, as proposed by the New View and resilience engineering, that performance must be continually adjusted. That success and failure are the results of adaptations necessary to cope with the complexity of the real world, are often seen as weird ideas from well-intentioned academic people who know nothing about the hazards and risks onboard a drilling rig. These concepts, contrarywise, are quite hard to be assimilated by an industry that apparently sees its operations as so hazardous and risky that normal adaptations usually equal to unacceptable deviations or violations.

It is convincing evidence that the complexity present in its systems, particularly in deepwater drilling, might be either not recognized or not fully understood by the Oil & Gas industry. Even though drilling an oil well will always depend on the natural resilience already existent in the system. Indeed, adaptations and improvisations have been the reality of the operational world at any drilling rig ever since the first oil well was drilled by the mid 19th century. However, because sometimes operators can fail to adapt procedures when necessary or attempt procedural adaptations that may fail, Dekker (2003) recommends that organizations should invest in their understanding of the gap between procedures and practice to help effectively developing operators' skills at adapting. As observed by Reiman et al. (2015), "adaptation is a vital feature of complex safety-critical systems, but it can also be the cause of system failure" (p. 84). Therefore, to improve both safety and operational performance, meaningful safety interventions in deepwater drilling, rather than merely controlling people, should focus on harnessing them to cope better with the complexity of the systems they operate. In other

words, the adoption of modern concepts of human factors and systems safety is critical to help the industry to understand how its operations succeed and fail, and to cope better with those hazardous and complex systems it operates. Otherwise, sooner or later, either it will be quite difficult if not impossible to drill a deepwater well, or every single front-line worker will be labeled as a violator.

Furthermore, many leaders maybe not even perceiving the growing gap between the high complexity in deepwater drilling and the way safety is approached by the industry today. In the operational world, particularly involving high-hazardous activities, like in the deepwater drilling, safety is a social construct and cannot be understood as merely a matter of efficient management to avoid risks or errors (Rochlin, 1999). Such apparent blindness may undermine the industry's efforts to develop a human factors agenda for the Oil & Gas industry. Indeed, for an industry yet relying on the old paradigms of blaming individual components, mainly human errors, to explain systems failures, it might be too complicated to digest a concept like complexity theory suggesting performance as "an emergent property, the result of complex interactions and relationships" (Dekker et al., 2011, p. 939).

The influence of a powerful safety consultancy industry

The two reasons above certainly did not come out of the blue. There must be additional explanations for this mismatch between the way this industry currently approaches safety and the complexity of deepwater drilling operations. Throughout this research, though, it was not difficult to find everywhere safe behavior programs in the form of training material, textbooks, posters, or slogans, all of them full of pyramids, linear causality models, and statistics showing huge percentages of human errors as primary contributors to accidents. All of them developed by safety consultancy companies. Indeed, a powerful behavior-based safety industry is well established deep inside the Oil & Gas organizations, at least in the organizations objects of this research. This safety industry, preaching Old View mantras, may be behind this strong belief by telling the Oil & Gas industry that humans are the leading cause of accidents and, therefore, front-line workers must be kept under rigorous control through the safe behavior programs, tools, and campaigns they sell. Dekker (2018) has already adverted about these behavioral safety and safety culture consultancies spreading the message of behavior control and compliance as the most reliable way to achieve safety.

Pieces of evidence captured across this research show that, perhaps, such a behavioral-based safety industry might be merely telling Oil & Gas leaders what they want to hear. As Schulman (2013) elaborates, business leaders, under the pressure of their various stakeholders, often tend to look for short term solutions. They are "convinced that simply pursuing a policy of tighter controls and stiffer penalties for front-line operators will provide the ultimate solution to their problems" (p. vii). And it is precisely what this safety industry promises. It might sound like music. This safety industry seems to be in a constant renovation to sustain such promise indefinitely credible to keep convincing its customers to try harder and harder the same interventions to improve safety. For instance, over this research, contemporary fashionable terms like 'safety culture' and, more recently, 'human factors' have been found incorporated to repaginated behavior-based brochures and training material. One of the Oil & Gas

organizations objects of this research, for instance, has recently launched an ambitious campaign developed to reach its entire workforce, including sub-contractors, of over 100,000 employees. Designed by a multinational behavior-based safety consultant, this campaign aimed at training every single employee in what they believe to be 'human factors.' I had the opportunity to check its contents. Not surprisingly, the whole campaign is just more of the same. It merely reinforces human frailties (e.g., lack of risk perception, distraction, or complacency) to help people to avoid human errors. Undoubtedly, the improvement of attitudes and behaviors obviously constitutes an essential component of any safety management system. However, such an approach cannot be the only, not even the most critical component at all of any comprehensive safety system.

However, once these safety consultants apparently detain a monopoly of safety knowledge within the industry, everything they say is often taken as the very expression of the truth. It may explain, by the way, the limited repertoire demonstrated by many leaders during the interviews and the workshops alike. Also, why these leaders, despite the excellent reception expressed across this research, seemed to have no idea about different and perhaps more effective ways to approach safety for accident prevention.

On the other hand, a positive finding from this research was the enthusiastic receptivity demonstrated by many leaders either in the interviews or in the workshops, as well the crews onboard the rigs, regarding the paradigms proposed by the New View and systems approach. It is a good indication that it might be just a matter of developing ways to highlight the relevance of human factors to drilling operations to have these leaders effectively driving the efforts to develop a human factors agenda for the Oil & Gas industry.

5.3 The development of a human factors agenda for the Oil & Gas industry

Discussions addressing the issue of human factors in the Oil & Gas industry have started years before the Macondo disaster. In 1992, in an IADC conference in Houston, the issue of human factors in well control incidents was approached for the first time (Thorogood et al., 2015). However, the first moves towards a system view begin yet as a consequence of the Piper Alpha disaster in 1988. For instance, at the beginning of the 2000s, a major multinational Oil & Gas organization sponsored a research project to improve its safety culture (Hudson, 2007). The research, using principles of the HRO theory (Rochlin et al., 1987; Weick & Sutcliffe, 2015) as a framework, resulted in a model for the implementation of a safety culture in large organizations. However, its implementation, as Hudson reports, had some difficulties. For instance, HRO principles did not go well with the organization's long-rooted culture of command and control, which made many managers quite challenging to convince that control should be otherwise dispersed. They simply did not understand why strict compliance to rules and procedures is not only difficult to follow but mainly very much ineffective in the complex systems they operate. Even though, after been adopted by the IOGP, this model has become a reference for the Oil & Gas industry. As captured by this research, the problems Hudson observed in that particular organization shall be pretty much similar across the industry today. Perhaps Hopkins (2014) is right when he advocates that "Oil and gas companies will never be

‘High-Reliability Organizations’ if they rely on campaigns to change hearts and minds on the operational frontline. Instead, they must identify the obvious precursors to catastrophe and get serious about eliminating them – led firmly from the top.”

The same major multinational, with the best of the intentions, in 2009, one year before Macondo, launched another program, called ‘life-saving rules,’ developed from statistical research over previous accident reports, to reduce fatalities and severe incidents within the organization. A dozen rules, the life-saving rules, were defined to prevent severe personal accidents allegedly. Such rules should be used to improve worker’s awareness of risk. Actually, those rules, no matter their good intentions and the results in the short term, are used as another instrument of behavior control. In an evident conflict to the safety culture program launched a few years earlier, breaking any of such rules would be subject to disciplinary consequences, even dismissal. As mentioned by one of the leaders I interviewed: “anybody who decides not to follow the rule also decided not to work for my organization.” The IOGP also adopted the program as a model for the entire industry. Sometimes with different names like golden-rules or life-rules, it has quickly become another mantra among almost every organization in the industry today. These rules have become so entrenched inside the industry, that it would be difficult for leaders and managers to accept different approaches to safety.

So, in 2010, the catastrophic consequences of the Macondo disaster were expected to be enough to act as a catalyst to finally wake up the Oil & Gas industry for the urgent need to develop its own human factors agenda. Perhaps, a good start would be looking outwards to learn from the experience of other industries with different approaches to safety like commercial aviation and nuclear power plants. Surprisingly, though, many leaders in this research expressed their perceptions that Macondo had a limited impact on the safety culture among the Oil & Gas organizations as it would be expected. They argued that most of the post-Macondo initiatives were limited at improving technical specifications and operational procedures for blowout preventers (BOP) and capping systems, as well as the development of more stringent regulations with increasing compliance demands, overstressing an already complex activity. Actually, these initiatives, all aiming at reinforcing the physical or procedural barriers that failed at the time of the disaster, merely followed the linear model of accident causation widely accepted by the industry, particularly the swiss cheese model (Reason, 1997) and its layers of defense. Indeed, all the causes of the blowout collected by the official investigations could be easily seen in hindsight as a sequence of events, breaches of such layers of defense (BP, 2010; Hopkins, 2012), starting with the failure of the cement barrier all the way up to the blowout preventer not sealing the well. It would then be just a matter of fix whatever went wrong or did not work as expected, the existent ‘holes’ on the layers of defense. This model of accident causation as a sequence of events, though, tend to focus on more proximal causes and the last moments right before the accident, leaving untouched numerous, and perhaps more significant, organizational and human factors that have contributed to the outcome.

However, several pieces of evidence collected over this research show that Macondo, after that initial period of apparent dormancy, is gradually becoming more and more an important milestone for the industry. For instance, it has triggered so many studies and initiatives more recently that it is now almost rivaling Piper Alpha, perhaps yet the most studied accident in the history of offshore operations.

Notwithstanding, there is still much to explore and learn from Macondo. In this regard, crucial questions about the disaster have been barely addressed and are yet to be further investigated by the Oil & Gas industry. For instance, how such a catastrophic accident could have happened on a drilling rig with such an outstanding safety performance like the Deepwater Horizon? Why did nobody even notice the probably thousands of indications over the years that such a disaster could happen? Questions like these are yet to respond. Perhaps the industry was so shocked by Macondo that it might have become hard to believe or did not want to believe that an apparent perfect safety system suddenly failed so miserably. After all, it should be expected, based on that so believed pyramids and triangles, that an accident like Macondo would be virtually impossible to happen. As questioned by one top leader, why so many things fail at the same time leading to a catastrophe? Probably, the Oil & Gas industry does not understand yet why complex organizations fail. It would explain the post-Macondo stunning reaction. It could be just a natural consequence of an industry suffering from that alienation mentioned by Dekker (2018) and still reluctant to realize that perhaps it had exceeded the limits of control of the technologies and processes it operates.

It may also explain why we still see in deepwater operations an overwhelming preoccupation with minor high-frequency low-potential personal incidents in detriment of less frequent high-potential systems incidents like Macondo (Leveson, 2011; Giuliani et al., 2019). For instance, recently, while I was on board a drillship owned by one of the largest deepwater drilling contractors in the world, one safety alert came in from its headquarters to be obligatorily shared with the entire crew at the routine pre-tour meetings. The objective was to reinforce the worker's awareness of safety. At least that was the belief of that big corporation's leadership. Amazingly, the incident was nothing else than a first aid case, a minor injury suffered by an employee who had hurt his elbow on another rig elsewhere in the world. Ironically, at the same time, drilling operations were facing some unexpected problems, and everybody on board was actually much more concerned about understanding and resolved those problems with the well. Issues that were not even mentioned at that same meeting. It is an excellent example of this industry's disconnection from the real dangers involving deepwater drilling, a concern clearly expressed by many leaders across this research.

Auspiciously, though, most of these questions and concerns are now finally being addressed today. Recent movements in the Oil & Gas industry towards a better understanding of the importance of human factors and its complex socio-technical systems, particularly in deepwater drilling operations, are now being the subject of several relevant academic and technical studies to explore possibilities for a different approach to safety from a human factors perspective. Such movements are being driven mostly by professional and industry

associations like the SPE and the IOGP. They are also attracting the attention of a large number of most of the relevant stakeholders like the operators and the regulators, as well the academia and independent safety professionals. It seems the industry is, at last, embarking on the same journey of other high-hazard and highly technical industries. In fact, these industries, especially commercial aviation, are benchmarking the Oil & Gas industry, as exemplified in several publications by the IOGP, including a major focus on non-technical skills like the CRM programs. IOGP has also launched a series of publications regarding process safety and human factors over the years following Macondo (e.g., IOGP, 2011, 2012, 2014, 2014a).

Indeed, other countless initiatives are popping up all over the industry and are trying to push the Oil & Gas industry towards the incorporation of human factors and a system view into its current safety practices. But it is just the beginning of a long journey yet to go through. Human factors, as demonstrated by this research, is still quite a mysterious concept for most of the Oil & Gas leaders. That is why, Chris Hawkes, the HSE Director of the IOGP, in a speech at the 2018 SPE International Conference held in Abu Dhabi, tried to demystify human factors to an audience of Oil & Gas leaders and safety professionals. “Human factors is an essential part of our business,” he said, also emphasizing the importance of building “resilient systems” and recognizing that “human error is due to faults in the system.” Following his speech, IOGP also published report 621, “Demystifying Human Factors: Building confidence in human factors investigation” (IOGP, 2018).

Furthermore, the SPE has been publishing a series of reports (e.g., SPE, 2014, 2018), mainly proposing ways to develop a human factors agenda specific to the Oil & Gas industry. The most recent, though, yet reflects this confusion between the two distinctive views of human factors. In one of its latest technical reports (SPE, 2018), the SPE proposes a way forward to improve safety in the Oil & Gas industry. The Report summarizes a series of global sessions facilitated by the SPE between 2009 and 2016 “to develop ideas for the advancement of health, safety, and the environment (HSE) in the industry” (p. 1). With the title “Getting to Zero and Beyond: The Path Forward. Improving Safety in the Oil and Gas Industry,” the Report, developed by a group of well-recognized professionals, although yet insisting on the zero-vision speech, represents, on the other hand, a significant advance towards a better understanding about the concepts of the New View of human factors. The Report brings up the current approach to safety and how this approach has evolved over the last ten years. It also identifies opportunities for improvement to help the industry to go even further. In this regard, the Report dedicates an entire chapter, “It’s All About Us: Human Factors,” to explain the importance of human factors as an indispensable element for the development of a new safety agenda for the Oil & Gas industry. However, the Report was received with some criticism by safety consultants working with the Oil & Gas industry. For instance, one of these consultants argues in the Report’s afterword section that a discussion of such magnitude should include current modern-thought leaders in human factors. He misses some essential human factors concepts like the notions of ‘Safety-I vs. Safety-II’ and ‘work-as-imagined’ vs. ‘work-as-done,’ resilience engineering, or the issue of safety as an emergent property of

complex systems. Nevertheless, this Report undoubtedly summarizes well the industry's attempts on new approaches to safety, representing a crucial step for the constitution of a human factors agenda for the Oil & Gas industry.

Indeed, all these movements have started yielding fruits. A good example comes from the impressive ever-growing number of sessions dedicated to the discussion of human factors at many of the most important Oil & Gas conferences. Also, the number of events specifically designed to discuss the issue of human factors is escalating in the Oil & Gas and energy sectors like for instance, the upcoming 2020 IADC Human Performance Conference, to be held in Rio de Janeiro, Brazil, among many others.

Likewise, significant breakthroughs are emerging everywhere in the Oil & Gas industry at speed never seen before. In one of them, Dave Payne, Vice President Health, Environment, and Safety for Chevron, a major Oil & Gas company, reported in a recent article published by the SPE, how his organization is now embracing the concepts of the New View of human factors (Payne, 2019). While telling a story about one offshore worker who had been dismissed because he had put his hand on a load against one of the company's golden rules, Payne advocates that learning, more than punishment, drives safety. His organization, he continues, is in a transition from the old culture of 'blame and punish' to a different culture of 'learn and improve,' which deals much better with the issue of complexity. It recognizes that people make mistakes, even though almost everybody comes to work with positive intents, which would be one of the paramount principles of the New View, except for the word *'almost'* he uses, perhaps still believing in 'bad apples.' It denotes a bit of hesitation towards the New View and confirms that his organization is indeed in a transition. Payne also emphasizes that learning cannot live well with punishment. Finally, he mentions their experience with learning teams and the importance of a different leadership approach, able to trust people and to be open to listening to them, regardless of how bad the news may be.

In another article also published by the SPE, Feder (2019) reports a recent presentation addressed by Sandra Adkins, safety advisor for BP, to the 2019 IADC Health, Safety, Environment & Training Conference, held in Houston. There, she explained how BP is now integrating human factors into its systems and helping its people to think safety differently. She also mentioned the work BP is conducting together with other two major deepwater players, Chevron and Shell, to share best practices to make human factors sustainable and integrate it into their organizations. The principles supporting this work are very much in line with the New View.

Such engagements with the concepts of the New View of human factors are, to my knowledge, the first concrete moves of giant Oil & Gas corporations towards the New View of human factors. Although yet not the predominant view among the industry, these examples are promising and represent a clear evidence that the Oil & Gas industry is moving fast towards the comprehension of human factors and system safety and the importance of developing a safety agenda for the integration of human factors in practice to the processes and complex systems it operates.

5.4 Empirical Foundations for Theoretical Assumptions

Over the last years, some theoretical assumptions have gained the forefront of safety sciences debates. This research was also able to collect several empirical evidences confirming, from the perspective of the Oil & Gas industry, many of these assumptions such as the bureaucratization of safety (e.g., Dekker, 2014b, 2018, 2019; Rae & Provan, 2019) and its influences on a process of alienation (e.g., Andersen et al., 2017; Dekker, 2018) and the gradual acceptance of risk (e.g., Starbuck & Milliken, 1988; Vaughan, 1996; Snook, 2000; Dekker, 2011; Woods, 2012).

Bureaucratization of safety

The issue of growing bureaucracy and its adverse impact on the way safety is managed by Oil & Gas organizations was by far the leading topic across this research, and a major concern expressed not only by top leaders and managers but mostly by front-line supervisors and operators. The Oil & Gas industry, as demonstrated, with the strong belief that human error is the leading cause of accidents, relies on safe behavior programs to fix or at least control human behavior as the best way to protect its high-hazardous systems. This behavior-based approach, promoting an imperative need of keeping people under strict control, plays a significant role in the increasing bureaucracy observed in most of the organizations' safety management systems today.

On the one hand, safety bureaucracy up to certain limits promotes accountability for safety performance, when managers and supervisors are encouraged to care about those they are responsible for. It has resulted in a reduction of harm, measured by the number of occupational incidents and an increasing level of standardization and better safety management controls across the industry (Dekker, 2014b).

On the other hand, though, bureaucratization causes a lot of adverse side effects as it was easily perceived today in the Oil & Gas industry. Audits after audits, safety reports and countless statistics are overloading front-line leaders and have become the routine onboard the drilling rigs. It is not difficult to realize how such a bureaucratic approach results in primary, critical duties quite often being left aside in favor of this growing bureaucracy, sometimes increasing risk instead of reducing it. Oil company representatives and drilling engineers onboard the rigs, supposed to be caring of the well, now have to spend much of their time doing behavioral safety audits or hunting deviations to comply with the safety rules. Worse, all such bureaucratic safety activities provide organizations confidence that they are doing the right things. In the end, however, this increasing bureaucracy seems to have much more to do with "organizations to limit their legal liability risk resulting from a safety incident or non-compliance" (Rae & Provan, 2019).

Hence, as Dekker (2014b) adverts, bureaucratization reduces safety initiatives and hinders innovation, diversity, and creativity. It was evidenced by several leaders over the interviews and workshops mentioning organizations just doing what is requested by the regulator or contractual requirements. Even worse, many organizations do not know what to do without prescriptive rules to simply comply with. Bureaucratic accountability also promotes what

Dekker (2015) calls ‘numbers game,’ with entire safety departments struggling to show positive statistics as evidence of safety. Modern drillships today may have up to six safety officers permanently onboard, mainly to take care of the overwhelming bureaucracy. It is a bureaucracy that brings the impression that risks are under control, which can result in organizations’ blindness to unexpected events. It was what happened in Macondo when a safety system full of rules and procedures bureaucratically developed and enforced by those far away from the reality of the operational world was not able to anticipate the tragic outcome.

A process of alienation

The behavior-based safety and its rigid demand for compliance with rules and procedures can make people follow them regardless of the effects they produce mindlessly. It creates a kind of organizational ritualism (Andersen et al., 2017). Ritualism that, for instance, could be found in the process behind NASA's decision to launch the Challenger space shuttle (Vaughan, 1996) and was also present in the decision-making process in the Macondo blowout. In both cases, the tragic consequences were not the result of an individual fault but rather resulted from the organizational cultures, full of bureaucratic rituals. Indeed, many organizations in the Oil & Gas industry, following what Dekker (2019) describes as “a religious conversion ritual” (p. 113), formally demand their workers to ritualistically commit to working safely, either being obliged to swear it before their superiors or sign formal statements promising to behave safely.

On the organizational level, these bureaucratic rituals may lead to a process of alienation. The bureaucratic framework of stringent regulations and a culture of compliance characterizing the Oil & Gas industry brings together a sensation that all risks associated with its complex processes and high-technologies are also under control. Examples are everywhere: the outstanding number of safety audits, formal agreements with promises to behavior safely, safety campaigns and training programs evoking moral engagement, safety signs virtually everywhere warning people to pay attention, to be careful, slogans such as ‘safety first,’ ‘nobody gets hurt,’ or ‘hold the zero.' And the industrywide venerated ‘zero-vision,’ a sort of “western salvation narrative” (Dekker et al., 2016, p. 219), where the world would be free of suffering. They are all examples of ritualism deep inside the industry that, conversely, may lead to a disengagement from the reality of the real dangers of the operational world (e.g., blowouts, massive oil spills, heavy fires, and explosions). An alienation that led the industry to believe that an accident like Macondo would never happen, which, even though, seems to be strongly present in the organizational culture of most of the Oil & Gas organizations in deepwater drilling yet.

Gradual acceptance of risk

As discussed, the bureaucratization of safety produces lots of positive numbers. It gives the deepwater industry the alienating overconfidence that higher risks associated with the processes and technologies it operates are also under control. Such overconfidence not rarely leads many deepwater operators to speed up the process of moving technologies and

processes from the experimental stage into an operational stage. The obvious consequence is an ever-growing increase in risks.

This alienation to the real risks (e.g., blowouts and massive oil spills) received another contribution from 2014 on, when the Oil & Gas industry was shocked by an unprecedented drop in the oil prices, almost by half from 2014 to 2015 (Figure 7).

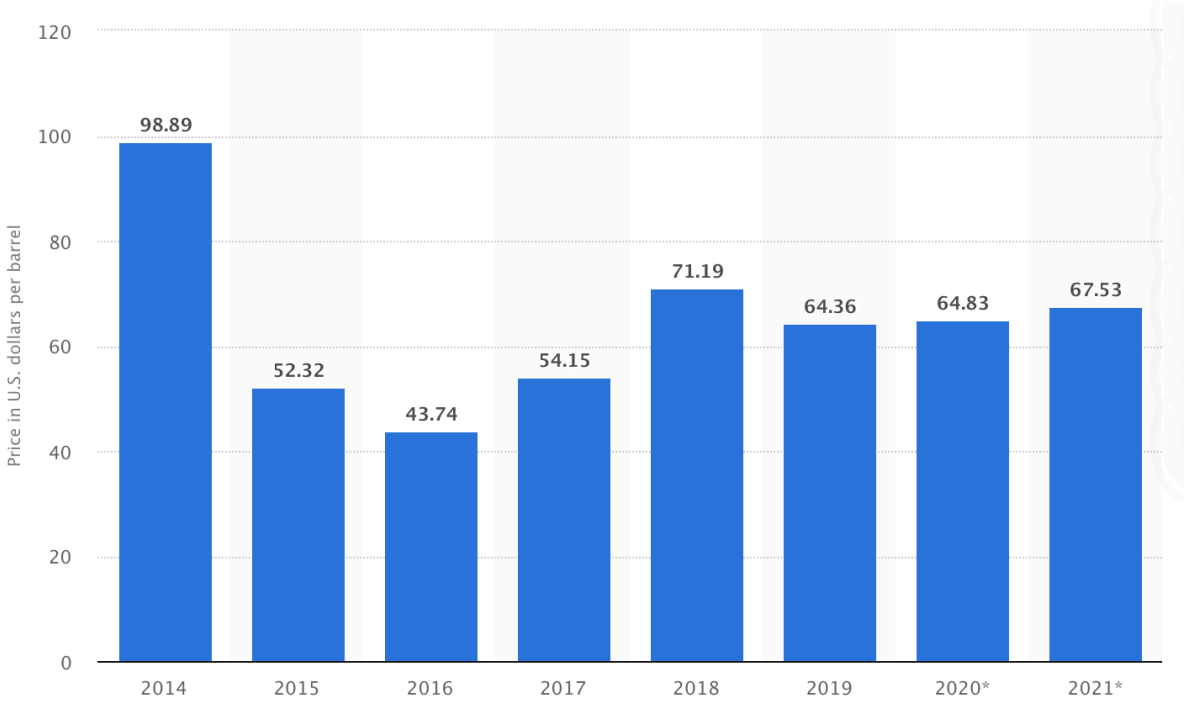

Figure 7 - Brent Crude oil prices from 2014 to 2021 (in U.S. dollars per barrel)

Lower oil prices are critical for the deepwater industry, known to be very expensive and highly capital-intensive. Oil & Gas organizations were forced to quickly learn how to cope with the pressure to be faster, better, and cheaper to survive, similarly to what happened to NASA at the beginning of the 1990s and its FBC policy (Woods, 2012).

As a consequence, cost 'optimization' programs are widely adopted across the industry today, pushing the technological boundaries even further to help the deepwater business to stay competitive. In this regard, many leaders across this research have expressed their concerns with the replacement of experienced operators and even top operational managers by young professionals without the necessary experience to make critical decisions, probably influenced by the need to reduce costs. A contradiction with the declared credo that safety is the number one priority. Therefore, safety-risk assessments may easily drift to financial-risk assessments, resulting in many authorized deviations from standard to keep the operation on, making higher risks to be gradually accepted. It is similar to what Hopkins (2012) identified as organizational factors contributing to the Macondo blowout. With increasing risks, unexpected incidents (e.g., heavy mud losses and minor well control incidents), though not as serious as Macondo, are quite frequent and tolerated as normal outcomes that are believed to be adequately managed by the systems in place.

5.5 Further steps

Although with no visible structural changes yet, a movement towards the integration of human factors has already begun and it is gaining more and more momentum and attracting the attention of representative players in the Oil & Gas industry, like major oil corporations, industry and professional associations, drilling contractors, regulators, and the academia as well. The industry is indeed experienced a transformational process with a growing number of publications, journal articles, and important events focused on human factors in the Oil & Gas industry.

It is just the beginning, however. Further steps, as this research indicates, shall include key and more practical initiatives:

- Developing industrywide programs to stimulate deepwater drilling organizations to recognize its inherent complexity and understand why safety must be approached differently in complex socio-technical systems to cope better with the high-tech technologies and processes it operates.
- Fostering the integration of all major players in the field of deepwater drilling, mainly the operators, to establish undisputable industrywide standards and practices, in close collaboration with drilling contractors, oilfield services companies, manufacturers, professional associations, regulators, and the academia as well.
- Learning from the experience of other industries, such as commercial aviation, about the application of human factors and system thinking for the transposition of their best practices and human factors tools into the process of deepwater drilling.
- De-emphasizing the Old View approach to safety, mostly influenced by a powerful behavior-based industry and materialized with the massive adoption of safe behavior programs across the Oil & Gas industry, and promoting an open discussion about different safety approaches, mainly with the introduction of the paradigms proposed by the New View of human factors.
- Reviewing training programs to shift the focus from compliance to legal and regulatory demands only to reinforcing task-based training and to developing soft-skills to improve people's ability to adapt and cope better with the inherent complexity of deepwater drilling operations.
- Establishing a cross-company collaborative environment with open access to lessons learned from incidents and significant accidents to implement a culture of organizational learning across the industry, including international legal agreements, as it happens in the commercial aviation.
- Reinforcing the focus on process, system safety, and developing specific leading indicators to prevent major catastrophic accidents, while de-emphasizing occupational safety and its lagging indicators as the way safety performance is measured today.

6 CONCLUSION

This research has demonstrated that even though the high-hazardous and complex systems the Oil & Gas industry operates, accidents are still believed by many leaders to be the consequence of a chain of events, a simple linear model of accident causation. Failures are yet explained by the old paradigms of blaming individual components, being human error the leading cause of accidents. Therefore, safety systems across the industry are designed to control human behavior through strict compliance with rules and procedures.

As strong evidence that Macondo has produced no fundamental changes in the way the industry approaches safety, the overwhelming predominance of a behavior-based safety approach across the industry reveals a disconnection with the inherent complexity it operates, particularly in deepwater drilling. This approach to safety, with the main focus on occupational safety in detriment of system safety, a confusion alerted by Leveson (2011) after the Macondo blowout, is yet widespread within the Oil & Gas industry.

As discussed in this work, such Old View thinking that sees necessary adaptations equal to violations does not deal well with the complexity, particularly in deepwater drilling, where adaptations and improvisations are the reality of the operational world at any offshore rig. Indeed, the issue of complexity seems to be not fully understood by most of the organizations and their leaders across the industry. Sometimes not even recognized.

However, such confusion is not only caused by the reluctance of top leaders and managers to approach safety differently. Inversely, many leaders have expressed their feelings that the traditional approach to safety might be no longer suffice, not even be the most appropriate to deal with the growing challenges of an industry in the continual development of cutting-edge technologies. It is indeed an incompatibility becoming more and more evident with the unstoppable growth in bureaucracy with no visible safety improvements. The positive receptivity of the New View paradigms by the leadership across the interviews and workshops indicated that it might be just a matter of lack of knowledge about the existence of different alternatives to the safe behavior programs these leaders have been taught ever since.

Consequently, many leaders yet see human factors as a mysterious abstract concept, too academic to be translated into practical tools that can be applied in day-to-day operations. Therefore, any meaningful move towards the constitution of a human factors' agenda for the Oil & Gas industry should first start demystifying the New View of human factors among the Oil & Gas organizations and raise an industrywide awareness for the importance of its integration to the current management systems and operational practices in deepwater drilling.

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APPENDICES

Appendix 1 - e-mail of invitation

Dear Mr./Ms.

My name is José Carlos Bruno, a master student in Human Factors and Systems Safety @ Lund University in Sweden and with a background in petroleum engineering, particularly in offshore drilling.

Currently, I am conducting a research project for my master's thesis, which aims at to explore how Human Factors, as a scientific discipline, could help the oil & gas industry as a whole and deepwater drilling in particular to improve both safety and operational excellence.

However, as an initial step for this research, it is essential to understand the current beliefs of representative leaders in our business, to evaluate better how such beliefs impact the way oil & gas organizations approach safety today.

To be able to do so, I have selected a group of leaders to interview within the key players in the offshore drilling in the Brazilian pre-salt (operators, drilling contractors, field services contractors, regulators/government, and professional associations). Such a distinguished group of top leaders should provide a broad overview of this subject as more robust and accurate as possible.

In this regard, I believe you and your organization are a natural choice to take part in this research as a key representative of the (to be added) group.

The idea is to carry out a semi-structured interview with you, as one of your organization's top executives, to get your thoughts on this matter. The interview shall take from around one hour to no more than two hours of your time.

Since it aims to support academic research, every information will be treated as classified information. It shall not be disclosed in any way the source or your organization could be identified. Notwithstanding, the interview will be recorded and a transcript for the purpose of accuracy and fidelity. The transcriptions will be at your disposal as you wish.

Please, let me know if you agree on taking part in this research project and, in case of an affirmative answer, your availability by indicating the best time and place at your convenience, and I will do my best to match it.

Thanks in advance and best regards,

José Carlos Bruno

Master's student in Human Factors and Systems Safety
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