وزارة التعليـــم العالـــي و الـبحــث العلمـــــــي

MINISTRY OF **H**IGHER **E**DUCATION AND **S**CIENTIFIC **R**ESEARCH

UNIVERSITÉ **K**ASDI **M**ERBAH-**O**UARGLA

جامعـــة قاصدي مرباح ورقلة

Institut de **T**echnologie

معهد التـكنــولــوجيـــا

Département : **G**énie **A**ppliqué

قسم : الهندسـة التطبيـقيـة

Dissertation submitted to obtain the diploma of

Master's degree in science

No.Ref.: July 2024

Submitted to the department of **Applied Sciences**

Field	:	Science and Technology
Major	:	Quality, Health, Safety & Environment

Realized By :

Assala Dob & Mohamed Lamine Bennouna

Title

"Integration of Artificial Intelligence in Proactive Safety Analytics for Oil and Gas Operations-A case study of SLB"

Presented on 9th of June before the examination committee consisting of:

M. Boubakeur ROUABAH	at University of Ouargla	President
M. Mohammed Abd Elbasset MAHBOUB	at University of Ouargla	Thesis Supervisor
M. Hamza DJEGHOUBI	at University of Ouargla	Examiner

Acknowledgment

We would like to extend our gratitude to all those who contributed to succession of this dissertation our colleagues, supervisors, mentors, friends and families.

A heartful thank you to our supervisor Mr.Mahboub who has been an inspiration and an experienced guide for this study, his dedication and commitment allowed us to set a clear plan and respect the time frames. we would also like to thank our mentors and supervisors in the professional world, Lounes Arabi, Mansour Abderrahmane, Aissa Achou -Schlumberger HSE managers and experts- who have provided us with the knowledge and the on-site opportunities to understand and study our data in real life. they have opened various doors toward continuous learning and corporate practices.

Additionally, our families and friends have been quite the support and the mental barrier that kept us consistent with our actions to achieve our goals of this thesis. Their love, patience and belief have been the source of our motivation.

Finally, I acknowledge the financial and resources support provided by the university of Kasdi Merbah Ouargla (UKMO) and SLB which made this research possible.

Thank you to everyone who has been part of this hard work, thank you for all the effort no matter how big or small, your contribution is the key element and the core of our study.

Ouargla, on 24 /05 /2024

Dedication

This dissertation is dedicated to all the people who have helped us in every step of the way, who inspired us to pursue and to strive for excellency, those who supported us in our academic journey.

To our families, their love and encouragement has been the light at the end of the tunnel, many thanks for always keeping us motivated and committed to our studies. A huge thanks for their mental, financial and physical support that they have provided us during this journey. they will always be the reason and the motivation of our success.

To our friends, all the great moment and laughter spent with them has lifted our spirit, our motivation is to make them proud. They have been supportive every step of the way and for that we are beyond grateful.

To our mentors and professors, their tireless dedication to shaping every student's path with knowledge, wisdom, and guidance is the most humanistic task on earth. They have shaped our growth to strive for excellence and perfection. All our future achievements and what we become in the future are because of their collective dedication and effort.

Table of Contents

List of figures

List of tables

List of Acronyms and Symbols

Acronyms

AARM	Automotive Accidents Rate per Mileage
AI	Artificial Intelligence
AR	Augmented Reality
BP	British Petroleum
CCUS	Carbon capture, utilization, and storage
CMS	Catastrophic, Major, Serious
ERG	Employee Resource Group
FAR	Fatality Rate
FIR	Fatality Incident Rate
HSE	Health, Safety and Environment
IOC	International Oil Company
IOGP	International Association of Oil & Gas Producers
JV	Joint Venture
MWD	Measurement While Drilling
NAF	North Africa
NEST	New Employee Safety Training
NOC	National Oil Company
O&G	Oil and Gas
PS	Production System
Q	Quarter
RP	Reservoir Performance
SLB	Schlumberger
TES	Total Energy Supply
TRIF	Total Recordable Injury Frequency
TRIR	Total Recordable Injury Rate
VP	Vice President
VR	Virtual Reality
WEC	Well Construction

GENERAL INTRODUCTION

In the past couple decades, Artificial intelligence (AI) has contributed significantly to reshaping the major industries and sectors in the world, taking a huge leap from tech to finance to economies to energy, and societies at large. With its ability to surpass human intelligence and reduces human error for various reasons such as complete complex tasks, where a minor human error could have significant consequences. AI has been spreading rapidly in various domains across the globe, for some it has become an essential part for innovation, productivity, and performance.

Acknowledging the Health, safety, and environment to be the core element of success of majority of industries, it has always been a serious topic and considerable commitment especially for oil and gas companies, where safety is considered part of their identity, decision making and policy of living. The earnest focus on safety allows major sectors to invest on the quality of safety performances and reduction of incidents, artificial intelligence plays a pivotal role in this endeavor. Through the implementation of AI based solutions, industries can eliminate human error, facilitate risk analysis and adopt proactive risk management strategies. It also allows to evaluate the accidents trend with the aim of anticipating life threatening consequences.

This dissertation aims to study the artificial intelligence implementation in the oil and gas sector with primary focus on enhancing individual, environment, and asset safety. Assess the level of implementation in different areas and evaluate its contribution and efficiency to the reduction of industrial accidents. We also present three possible futures that illustrate how artificial intelligence will develop in the oil and gas sector and how it will likely affect safety protocols over the course of the next five, ten, and twenty years. SLB, historically called Schlumberger, an oil and gas service company transitioning to a technology company that drives innovation has been selected for the case study. an in-depth study of SLB’s AI initiatives and their impact of the safety performance on the company and the oil and gas sector in Algeria.

This study seeks to highlight the opportunities, challenges, and implications of workplace safety associated with the adoption of AI technologies in these critical sectors. Methodologically, the study put into action different methods approach, combining qualitative analysis of the sector practices and case studies with quantitative assessments of AI implementation levels and safety results. A thorough analysis of accidents variation and trend in the oil and gas sector at a large and SLB as a case study.

In conclusion, this study will allow the reader to quantify the impact of Artificial Intelligence on the quality, health, safety and environment of industrial operations in the oil and gas industry in Algeria and understand the trend of incidents in relation with human error vs Computer. Additionally, it provides different solutions and recommendations of improving AI integration and best practices in the oil and gas sector.

Problematic:

How can Artificial Intelligence be integrated in predictive safety analytics to effectively enhance safety management in the oil and gas industry, and what are the key factors influencing its successful implementation?

Hypothesis:

- The integration of AI in predictive safety analytics significantly reduces the occurrence of safety incidents in the oil and gas industry.
- The quality and comprehensiveness of data available to AI systems are critical factors that influence the effectiveness of AI in enhancing safety performance.
- The integration of AI in predictive safety analytics faces significant challenges related to system interoperability, organizational readiness, and regulatory compliance.

Objective:

- To evaluate the impact of AI integration on the frequency and severity of safety incidents in the oil and gas industry.
- To assess the role of data quality and availability in the performance of AI-driven predictive safety analytics.
- To identify and analyze the main challenges and barriers to the successful implementation of AI.
- To propose a predictive safety analytics-based AI model that would enhance safety management systems in the oil and gas sector.

CHAPTER 01 :

INTRODUCTION TO ARTIFICIAL INTELLIGENCE

INTRODUCTION TO ARTIFICIAL INTELLIGENCE

1.1. Introduction:

Artificial Intelligence (AI) has rapidly evolved from a theoretical concept to a transformative technology that permeates various sectors of modern society including healthcare, finance and oil and gas..., Rooted in the pursuit of creating machines that can simulate human intelligence, AI encompasses a wide array of subfields, including machine learning, neural networks, natural language processing, and computer vision. This chapter aims to provide a foundational understanding of AI, tracing its historical development, defining key concepts, and exploring its diverse applications. By examining the theoretical underpinnings and practical implementations of AI, this chapter sets the stage for a deeper exploration of how AI techniques can be leveraged to enhance safety analytics within the oil and gas industry.

1.2. Understanding Artificial Intelligence

AI is a branch of computer science that focuses on creating systems capable of performing tasks that typically require human intelligence. These tasks include learning from experience, recognizing patterns, understanding natural language, making decisions, and solving problems. AI systems leverage algorithms and models to process and analyze large amounts of data, enabling them to perform complex functions autonomously or assistively. The ultimate goal of AI is to develop machines that can emulate human cognitive processes, offering capabilities such as reasoning, perception, and decision-making in various applications, from everyday personal assistants to advanced industrial automation. [1]

1.2.1. Types of AI

a. Weak or Narrow AI:

The most used type of AI which are designed for specific tasks and have a narrow set of instructions with no thinking capabilities, able to provide a narrow output for a pre-defined set of data (input).

Examples: personal assistance (Siri, Alexa…), image recognition software, IBM's Watson supercomputer.

b. General AI

Stands for the AI that can reach and exceed the human intelligence so that "it has the ability to reason, plan, solve problems, think abstractly, comprehend complex ideas, learn quickly, and learn from experience", this type of AI is under study that researchers and scientists are hoping to achieve this level of intelligence in the near future.

c. Strong AI

An advanced level of intelligence that can surpass the best human brain in every possible way including scientific creativity, general wisdom and social skills. This type of AI is considered as high threat to the society by so many scientists, but this consideration didn't hold the scientists from the dream of discovering possible ways to reach this kind of intelligence.

1.2.2. Machine Learning (ML):

The most well-known and wide spread used domain, the aim of ML is to develop models and complex algorithms that allow machines to learn (train) from input set of data and make decisions or predictions as outputs, the more data and inputs are provided the more perfect inputs are given by the model. [1]

It is used in various fields as examples: healthcare (diagnosis and prognosis), finance (fraud detection), and Natural Language Processing (chatbots and language translation).

a. Supervised Learning:

Using training data that has been labeled by a supervisor which is human in order to train the model, although getting sufficient labeled data can be hard, expensive and time-consuming supervised learning has incredible performance. [1]

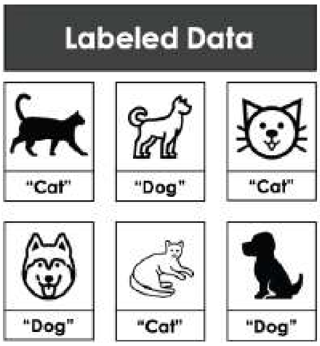


Figure 1.1. Labeled data

b. *Unsupervised Learning:*

The model train itself with no intervention from the human factor, it provided with neither labeled nor classified data as the input so the algorithm tries to identify the similarities among the given data and solve the given problem by figuring out the appropriate output.

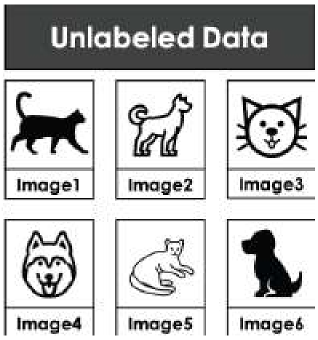


Figure 1.2 Unlabeled data

a. *Reinforcement learning:*

It is a feedback and based learning that the model is trained by applying a rewarding system in case of right action and would have a penalty in case of wrong ones, the model's algorithm tries to gain the maximum amount possible of rewards by learning from its own previous choices and actions which make regression as a self-learning method. [2]

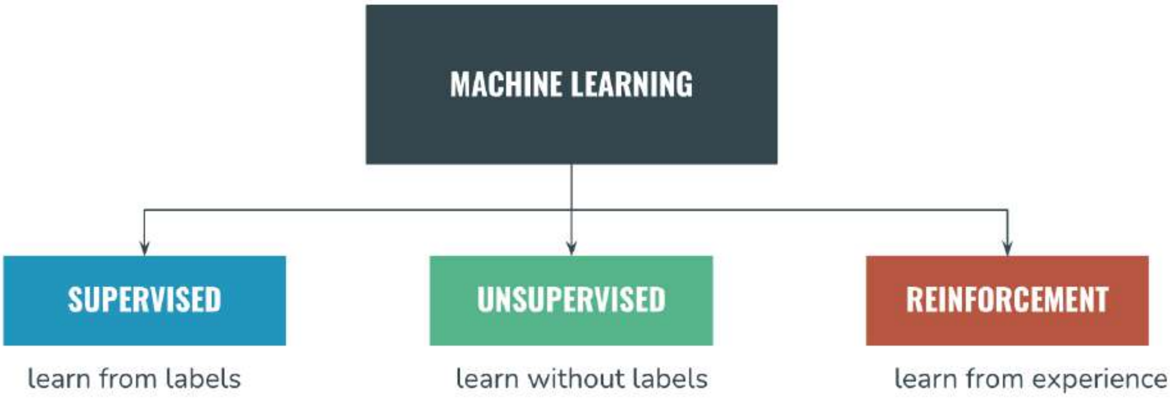


Figure 1.3. Machine learning and its types

1.2.3. Deep Learning:

Deep Learning is a subset of machine learning that involves training artificial neural networks with multiple layers to automatically learn and extract features from data. Unlike traditional machine learning algorithms that require manual feature extraction, deep learning models, particularly deep neural networks, are capable of hierarchical feature learning. This means that they can learn increasingly abstract representations of the data at each successive layer, enabling them to handle complex tasks such as image and speech recognition, natural language processing, and autonomous driving. **[3]**

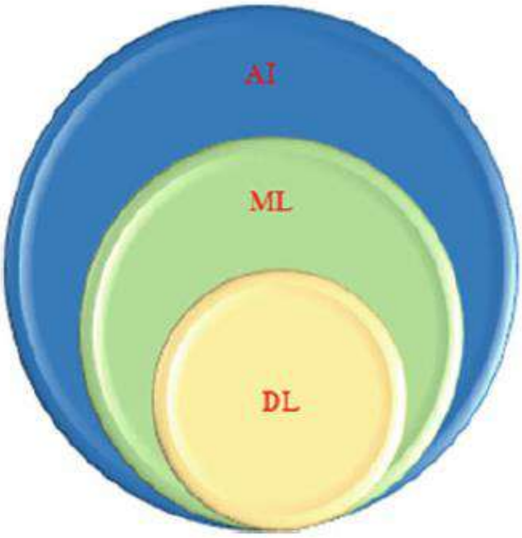


Figure 1.4 the relation between AI, ML and DL

1.3. Historical Overview of AI Development:

Having intelligent machines was a dream of humanity for ages, to live along with machines that can do human jobs with the same accuracy and it can even exceed the human performances making our lives much easier, but the term Artificial Intelligence as we know it have passed through several stages and developments across the history to be as efficient as it is now, as follows the journey of AI until the present time:

1940s-1950s: The Dawn of AI

- 1943: Warren McCulloch and Walter Pitts develop a mathematical model for neural networks, laying the groundwork for AI.
- 1950: Alan Turing publishes "Computing Machinery and Intelligence," proposing the Turing Test as a criterion for machine intelligence.

- 1956: The term "Artificial Intelligence" is coined by John McCarthy during the Dartmouth Conference, which is considered the birth of AI as a field.
- 1960s-1970s: Early Development and Optimism.
- 1966: Joseph Weizenbaum creates ELIZA, one of the first chatbots, demonstrating natural language processing.
- 1970: The first expert system, DENDRAL, is developed at Stanford University to analyze chemical compounds.
- 1972: MYCIN, another expert system, is developed for medical diagnosis and treatment recommendations.

1980s: The AI Winter

The AI field faces setbacks due to unfulfilled promises and limitations in computing power, leading to reduced funding and interest, a period known as the "AI Winter."

1990s-2000s: Resurgence and New Approaches

- 1997: IBM's Deep Blue defeats world chess champion Garry Kasparov, showcasing the potential of AI in strategic games.
- 2000: AI applications expand into diverse fields such as finance, healthcare, and robotics, fueled by advances in machine learning and data availability.

2010s - Present: The Rise of Deep Learning and AI Ubiquity

- 2011: IBM's Watson wins Jeopardy! against human champions, demonstrating advanced natural language processing and information retrieval.2012: The deep learning breakthrough occurs with Alex Net's success in the ImageNet competition, leading to rapid advancements in image and speech recognition.
- 2016: Google DeepMind's AlphaGo defeats Go champion Lee Sedol, highlighting the progress in reinforcement learning and complex decision-making.
- 2018-Present: AI technologies like autonomous vehicles, voice assistants, and advanced recommendation systems become integrated into everyday life, driven by continued advancements in machine learning and neural networks.

  [4]

1.4. Key Concepts and Terminologies:

a. *Natural Language Processing (NLP)*

This domain aims to facilitate the communication between the computer and human language, that allows them to understand, interpret and generate human language so it is the interaction between human and computers in a smart way. [1]

Examples: Google translator, spell check, chat bots.

b. *Robotics*

One of AI's domains that focuses on creating machines that obeys humans' instructions, it is basically the integration between AI and physical machines these robots are getting to be more and more focused on so that currently robots that are used in: the industry, restaurants, medical surgeries and health care car are all classified under this domain. [1]

c. *Expert systems*

Systems that have the ability to create solutions and decisions based on the data present in the knowledge base with experts' guidance for the purpose of replicating the decision making of human experts, in other words they are computers that solve complex problems with knowledge and intelligence. [1]

d. *Computer vision:*

Computer vision is a field of artificial intelligence that enables computers and systems to interpret and understand visual information from the world, such as images, videos, and other visual inputs. By leveraging algorithms and models, computer vision systems can automate tasks that the human visual system performs, such as object detection, image classification, facial recognition, and scene reconstruction. The primary goal of computer vision is to develop techniques that allow computers to process, analyze, and make sense of visual data, ultimately enabling them to make decisions and take actions based on that data. [5]

e. *Neural networks:*

A widely used domain which stands for the representation of data and algorithms in form of human neural. It formed basically from algorithms that mimic the human brain in order to understand the relationships between the data. [1]

It is used in many processes such as: face recognition and image recognition in medical diagnosis.

f. *Algorithm:*

A set of chained instructions that a computer can understand follows to perform a specific task, in other words it's the language that bond the relation human-machine so computer can understand what human want. [3]

g. *Data:*

The raw information used to train and test AI models.

h. *Training Data:*

Labeled data used to teach an AI model how to recognize patterns and make predictions.

i. *Testing Data:*

Unlabeled data used to evaluate the performance of an AI model on unseen examples.

1.5. Applications and Impact of AI Across Industries:

- Healthcare:

AI has the potential to help the diagnostic procedures and medical decisions, helping doctors to discover cancers and virus infections and many other dangerous diseases in their early stages by analyzing several images in a record of time to facilitate the treatment process and avoid any future complications Example: IBM's Watson AI system, which helps analyze medical images and create treatment plans. [6]

- Finance:

The uses of AI for fraud detection and risk management improvement, Example: the usage of AI to analyze financial data and predict market developments. [6]

- Transport:

AI is used in transport sector to develop self-driving vehicles, as in Tesla and Waymo using computer to recognize the environment, read traffic signs and control vehicle movements and decide the next move depending the data collected and their processing using algorithms that it is programmed with all to insure safe self-driving cars. [6]

- energy sector:

One of the most targeted industrial uses of AI is the optimization of energy consumption and improve the efficiency of renewable energies thus AI would be a huge factor for companies that are willing to be more and more environmentally friendly to ensure the best use of energy resources with no losses, Example: AI-controlled systems can predict power consumption and improve network control to maximize energy efficiency. [6]

- Manufacturing:

AI is used in manufacturing industries to optimize equipment performance reducing downtime, and improving production efficiency, Examples: Companies like General Electric and Siemens utilize ML-based predictive maintenance solutions to monitor industrial machinery and prevent breakdowns. [7]

1.6. AI challenges and limitations:

AI has a numerous beneficial impact and has become a powerful tool for several industries and through our daily lives, even so this doesn't change the fact that AI in nowadays is facing some challenges and limitations that holds it from reaching its perfect form:

a. Data quality and availability:

AI models generally requires a huge data with a high quality in order to work efficiently [1] and give the most accurate results, outputs and prediction results rely deeply on the number and quality of data which are most of times hard to obtain

b. AI adaptability:

In reinforcement learning the decisions are based on the previous decisions and experiences only the model has no ability to provide new behaviors when experiencing new situations. [2]

c. Lack of transparency and explainability

Lack of transparency and explainability is another AI's issue that sometimes it is difficult to understand how it jumped into certain results without clear vision or explanation of how it has been obtained it generally happens in machine learning, this can be crucial in cases of healthcare and finance. [8]

d. Generalization and transfer learning;

AI models often struggle to generalize from training data to real-world scenario, and due to absence of common sense of AI models it would be facing hard times analyzing real world situations causing accuracy decrease. [5]

e. Security concerns

One of the biggest concerns when implementing an AI model is how much safe is it companies are concerned that their sensitive data would be in danger of being shared or hacked causing operational critical changes as a result of sharing it for the learning process of the ai model [5]

f. Ethical concerns:

The rapid development of AI the desire of companies to adopt such technologies built a huge concern in the matter of job replacement and job displacement, putting workers under pressure of being replaced by robots in the near future that can do their jobs as efficient as theirs and it can even exceed their performance with lower cost. [9]

1.7. Conclusion

In summary, Artificial Intelligence (AI) has transitioned from a theoretical idea to a transformative force across multiple industries, including healthcare, finance, and notably, the oil and gas sector. This chapter has provided a foundational understanding of AI, charting its historical evolution, defining its core concepts, and exploring its varied applications. By delving into the theoretical frameworks and practical implementations of AI, we have laid the groundwork for a deeper exploration of its potential to revolutionize safety analytics within the oil and gas industry. The subsequent chapters will build on this foundation, illustrating how AI techniques can be strategically applied to enhance operational efficiency, mitigate risks, and drive innovation in one of the world's most critical industries. As AI continues to advance, its integration within the oil and gas sector promises to unlock new levels of safety, productivity, and sustainability, paving the way for a more secure and efficient energy future.

CHAPTER 02:

AI In The Oil And Gas Industry

AI IN THE OIL AND GAS INDUSTRY

2.1. Introduction:

The integration of Artificial Intelligence (AI) into the oil and gas industry marks a significant evolution in how these critical resources are explored, extracted, and managed. AI technologies, encompassing machine learning, predictive analytics, and advanced data processing, offer unprecedented opportunities to enhance operational efficiency, safety, and profitability. This chapter explores the transformative impact of AI on the oil and gas sector, detailing its applications across upstream, midstream, and downstream operations. From optimizing drilling processes and predictive maintenance of equipment to improving supply chain logistics and ensuring environmental compliance, AI-driven solutions are reshaping traditional practices. By leveraging vast amounts of data generated in the industry, AI enables more informed decision-making, reduces risks, and minimizes operational costs. This chapter aims to provide a comprehensive overview of AI applications in the oil and gas industry. Through this exploration, we will understand how AI is not only addressing existing challenges but also paving the way for innovative approaches to resource management and sustainability in the oil and gas sector.

2.2. Overview of the oil and gas sector

The oil and gas sector represents the bone of the world's economy, serving as the primary energy provider to various global industries such as transportation, electricity, cooling, and heating...etc. These industries are largely dependent on the utilization of O&G due to its high performance and stability. Oil and gas extraction includes divers and complex activities of exploration, drilling, refining, transportation, and production, with operations spanning across the globe. [10]

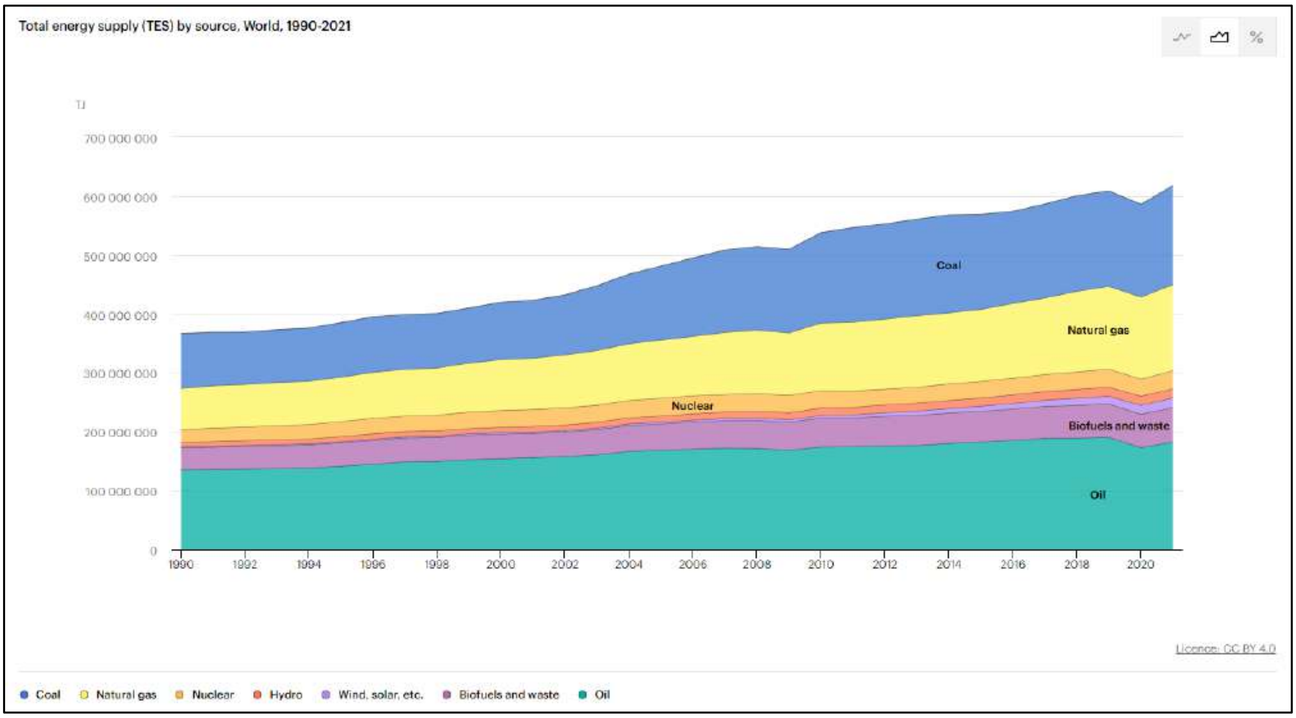


Figure 2. 1. Total energy supply by source (TES)

The main focus of the oil and gas sector is the extraction and production of hydrocarbons, mainly gas and crude oil from reservoirs, in Algeria major activities are performed onshore. these materials eventually serve to create various petroleum products which support modern industries with fuel, diesel, gasoline and petrochemicals.

A wide variety of entities, such as independent producers of gas and oil, infrastructure suppliers, service providers, national and international oil companies, and independent oil and gas producers, define the business. Global operators, IOCs like ExxonMobil, Shell, and Chevron are involved in every step of the oil and gas value chain, from production and refining to marketing and exploration. On the other hand, most of the oil and gas reserves in nations like Saudi Arabia, Russia, and Iran are controlled by NOCs, which are state-owned companies. As demonstrated in the table below from the company's global market journal showcases the ranking of major oil and gas companies by market capital and revenue.

Table 2. 1. List of Major Players in the Oil and Gas Industry per market cap

Rank	logo	Name	Market cap	Price $	Price 30 days	country
1		Saudi Aramco	$1.933 T	$7.99		Saudi Arabia
2		Exxon Mobil	$509.19 B	$113.51		United States
3		Chevron	$289.23 B	$156.94		United States
4		PetroChina	$245.05 B	$1.37		China
5		Shell	$226.50 B	$70.37		United Kingdom
6		TotalEnergies	$166.52 B	$70.50		France
7		ConocoPhillips	$137.59 B	$117.65		United States
8		CNOOC	$121.35 B	$2.46		China
9		BP	$104.01 B	$36.42		United Kingdom
10		Sinopec	$101.91 B	$0.88		China
11		Petrobras	$96.10 B	$14.89		Brazil
12		TAQA	$84.49 B	$0.75		United Arab Emirates
13		Southern Company	$84.37 B	$77.17		United States
14		Equinor	$83.47 B	$28.53		Norway
15		Canadian Natural Resources	$80.78 B	$75.37		Canada
16		Duke Energy	$78.55 B	$101.79		United States
17		Enbridge	$76.74 B	$35.97		Canada
18		EOG Resources	$71.28 B	$124.03		United States
19		Rosneft	$69.35 B	$6.57		Russia
20		Schlumberger	$66.20 B	$46.32		United States

[11]

For Algeria, Sonatrach is the official state owned oil company that controls the industry within the country, Sonatrach has made several partnership with international oil companies (IOC's) such as BP , Oxy ,ENI ,Equinor ..etc, These partnerships are referred to as "Groupments". These collaborations encompass in various regions within south Algeria, including In Salah, In Amenas, and Hassi Berkine , Hassi Messaoud ..etc. it aims to leverage the company's performance and production capabilities. Furthermore, joint ventures like JV Gas and Groupement Berkine support technological innovation and sustainable development within the Algerian oil and gas industry while strengthening Sonatrach's position in the global energy market.

2.2.1. History of oil

The American Petroleum Institute states that "the usefulness of hydrocarbons to humankind is as old as history" due to the long history of petroleum's utility to humanity. Humans used crude oil for a variety of reasons back in antiquity. For instance, historical for water repellent, man used crude petroleum. In other words, they employed petroleum as a material or substance to stop water from getting into unwanted areas. Additionally, because petroleum is sticky, early humans utilized it to tie objects together. Petroleum was used for a variety of purposes by the Egyptians, Mesopotamians, and Sumerians five thousand years ago. [12]

2.3. The oil and gas activities:

The oil and gas industry can be categorized into three main sections of major activities, upstream, midstream and downstream.

2.3.1. Upstream Fundamentals

The upstream sector the early stage of O&G operations, it includes searching for potential wells, crude oil and natural gas, drilling and bring raw material to the surface. [13]

Companies can be categorized by value chain management as below: [14]

2.3.1.1. Drilling Contractor business

A business that leases its drilling rigs to operators in order to drill wells. Such as NABORS, Patterson UTI. [14]

2.3.1.2. Integrated gas and oil corporation

A business that conducts both downstream and upstream activities, Saudi Aramco, ExxonMobil, Shell, Chevron are few examples. [14]

2.3.1.3. Independent oil and gas corporation

A business that operates exclusively in the upstream or downstream sectors. Such as, Murphy Oil, Phillips 66, Anadarko petroleum and ConocoPhillips. [14]

2.3.1.4. Oil service companies

An organization that provides equipment, services to the oil and gas sector, typically a mix of human resources, tools, and services. As an example, Schlumberger (Slb), Halliburton, Baker Hughes.

2.3.1.5. Petroleum equipment producers

A contractor company that sells and distributes equipment to the oil and gas sector. ABB, Simens and Schneider Electric are a few examples.

2.3.1.6. Key products

- Crude oil.
- Natural gas.

2.3.2. Mid stream fundamentals :

The stage that deals with the transportation and storage of the petroleum products, natural gas (LNG) using pipelines, tankers, rail, and trucks, this stage plays a crucial as a link between upstream and downstream phases ensuring that O&G products are safely and efficiently delivered from production sites to the refinery stations and the end costumers. And thanks to storing facilities (tanks) that ensure to make the hydrocarbons being transported in best quality.

2.3.2.1. Key products:

- The safe and efficient transportation of crude oil and LNG.

2.3.3. Down Stream Fundamentals

The processing, purification, and marketing of products made from natural gas and crude oil, as well as the refining of petroleum crude oil, are all included in the downstream sector. Products including gasoline, kerosene, jet fuel, diesel oil, heating oil, fuel oils, lubricants, waxes, asphalt, natural gas, liquefied petroleum gas (LPG), naphtha, and other petrochemicals are among the goods that the downstream sector offers to consumers.

Midstream operations are seen as a component of the downstream sector and are frequently included in the downstream category.

2.3.3.1. Key products:

- Refined fuels (Gasoline, Diesel, Jet fuel, Heating oil).

- Liquefied petroleum gas (LPG).
- Petrochemicals (Plastics, Synthetic fibers, Medicines and pharmaceuticals, Fertilizers, Solvents and coatings)

2.3.4. Industry trends & Challenges

The international association of oil and gas producers has been collecting safety events from its members and their contractor companies globally since 1985, which is considered the largest data base for safety performance indicators in the exploration and production industry. The yearly report represents the number of fatalities, accidents and high potential risk events reported by region, , function , risks . in 2022 IOGP reported a rate of 1.28 fatality rate (FAR) which is 71% higher than the year before.

2.3.4.1. Fatality Rate and fatal incidents [FAR, FIR]

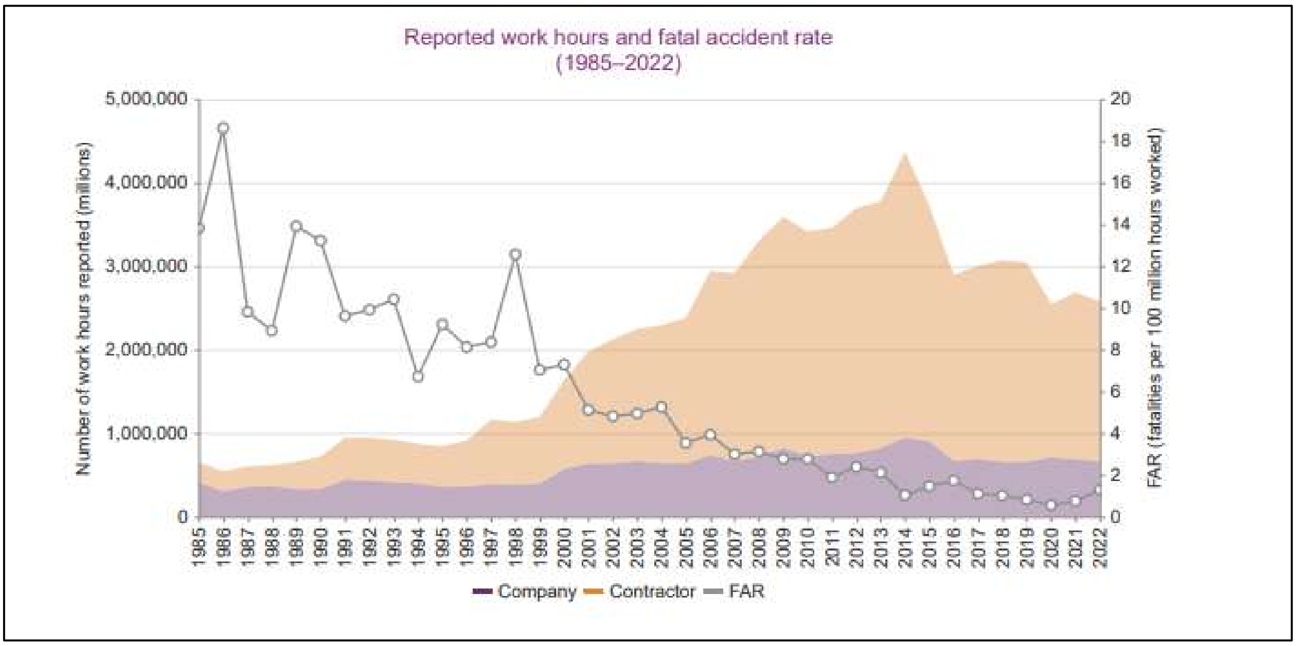


Figure 2. 2. . Reported work and fatal accident rate (1985-2022)

The number of fatalities has grown from 20 in 2021 to 33 in 2022, against the backdrop of a reported 4% decrease in labor hours. 29 distinct incidences resulted in the 33 fatalities. As a result, the fatal accident rate (1.28) is 71% greater than it was in the previous year (0.75). The FARs for the contractor and the company are 1.62 and 0.30, respectively.

The equivalent FARs for onshore and offshore are 1.27 and 1.29.

Every recorded fatal event has a cause and a work activity assigned to it. Regarding the cause, occurrences classified as "Struck by (not dropped object)" accounted for 18% of the reported fatalities in 2022 (6 fatalities in 6 unique instances).

'Dropped objects' fatalities also accounted for 18% of the total fatalities, with 6 fatalities from 6 instances.

Nonetheless, during the past ten years, the fatality reported rate has dramatically dropped from 2000 to the present, with a FAR range of {16–20} to {0–2}. [15]

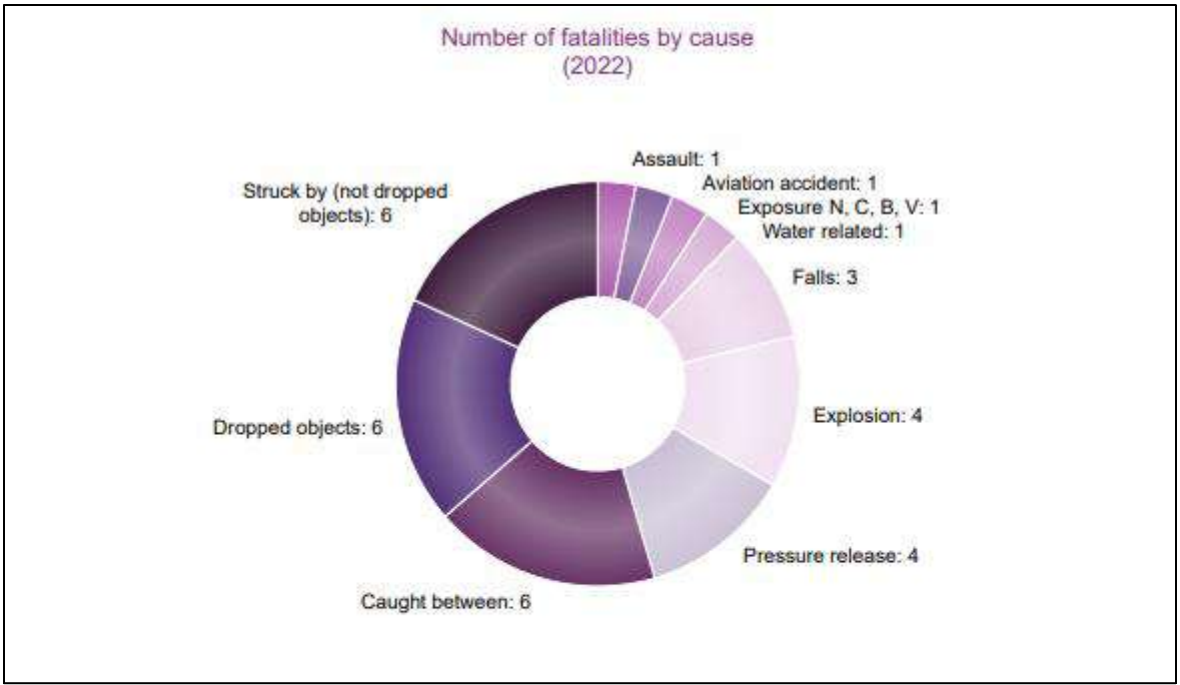


Figure 2. 3. Number of fatalities by cause (IOGP 2022)

Concerning the Activity, incidents classified as "Drilling, workover, well operations" accounted for 27% of the recorded fatalities in 2022 (9 fatalities in 8 unique incidents).

Fifteen percent of the deaths were related to "Production operations," with five deaths occurring in four distinct incidents.

The 'Lifting, crane, rigging, deck operations' activity recorded 4 fatalities in 4 distinct events, whereas the 'Construction, commissioning, decommissioning' activity reported 4 fatalities in 3 separate incidents. [15]

The above figure (3) represents the number of fatalities by activity according to IOGP annual report of 2022, comparing to other years the number of fatalities has decreased however the cause of accidents remain a challenge in the industry. In other hands Drilling and production still report the highest rate of fatalities in the industry due to its challenging nature

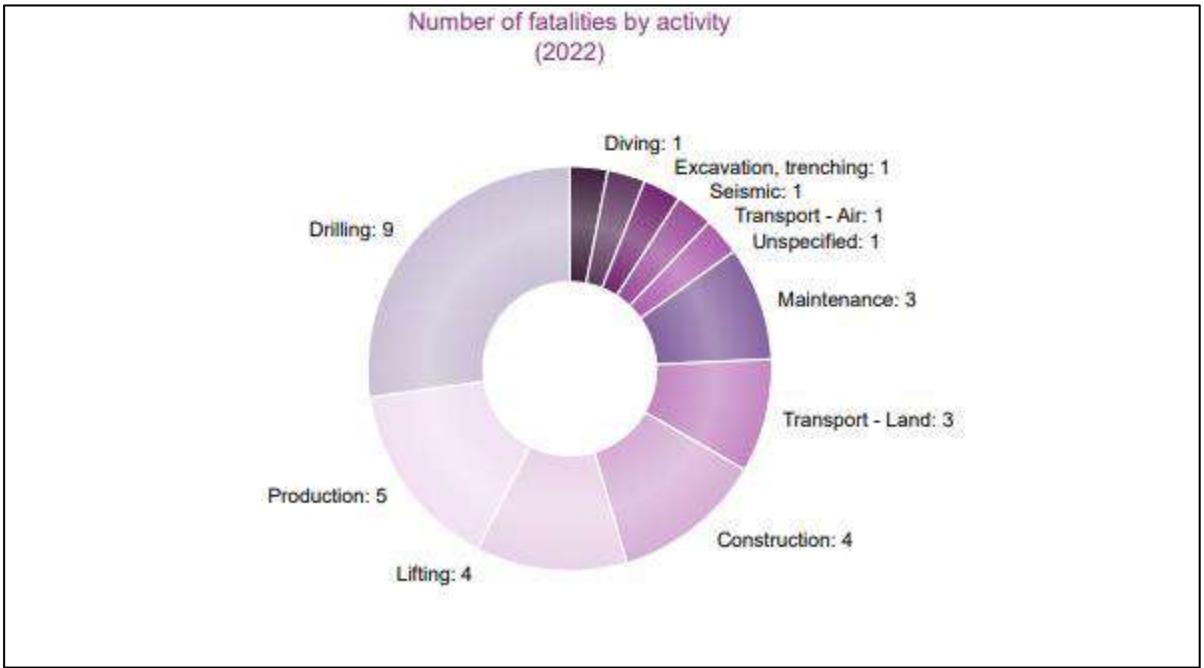


Figure 2. 4. Number of fatalities by activity

Although the IOGP has reported an increase in FIR and FAR however comparing to 10 years earlier the rate has decreased significantly, for example the below chart represents the accident rate by cause of the past 10 years where the main cause “Caught in ,under or between” has reported more fatality rates in 2018 and 2019 than in 2022 and 2021.

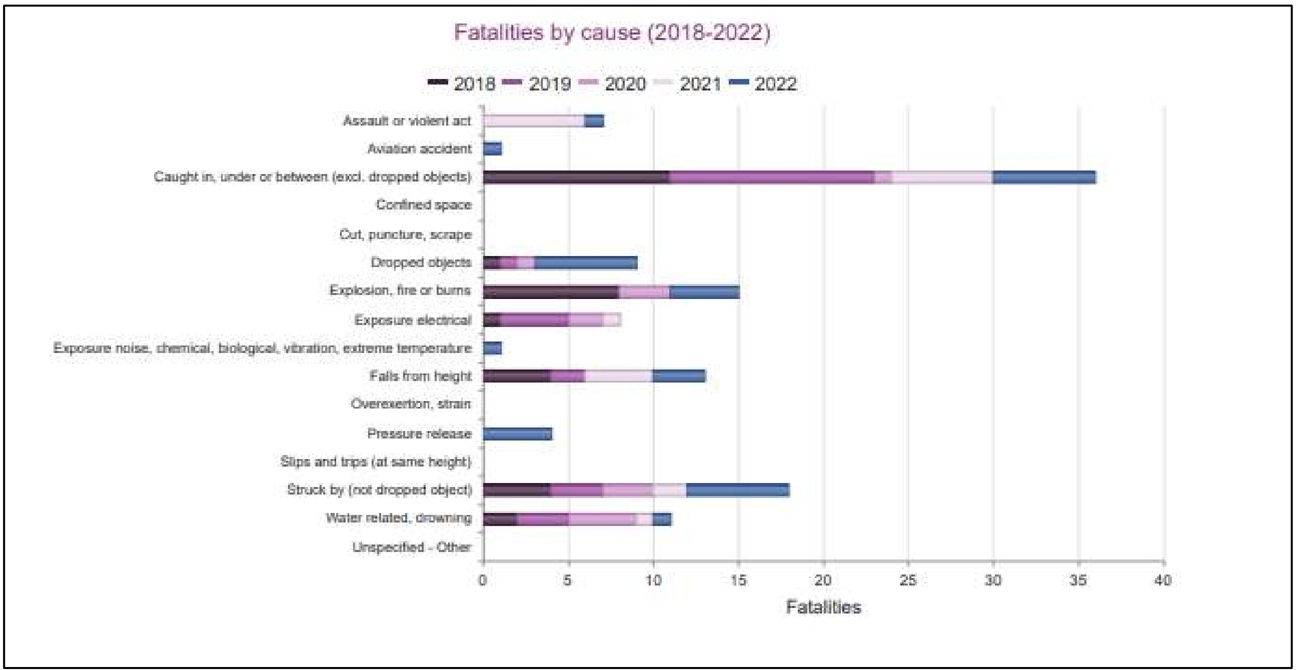


Figure 2. 5. Fatality Rate by Cause (2018-2022) IOGP

2.3.4.2. Total Recordable Injury Rate [TRIR]

Even while the industry's primary goal is to eliminate fatalities, injury rates are still a major concern in modern businesses; the zero-incident mentality is used in many sectors, nations, and organizations. more especially in the oil and gas sector, the IOGP reported in 2022 a rate of 0.78 total recordable injury rate out of 2,535 million hours worked. moreover, while this represents 28 % increase from 2021 but it also represents a significant decrease for the 10 past years data. [15]

The total recordable injury rate is calculated based on number of declarable accidents that caused human injury divided by yearly manhour recorded. The injury rate still affects the oil and gas industry due to human, financial, time consequences associated with it. which is the purpose on why companies invest in keeping people safe and sound.

$$TRIR = \frac{Total\ Recordable\ injury\ number\ * 1000000}{Total\ Manhour}$$

2.3.4.3. Causal Factor

In 2010, IOGP started keeping track of the causative elements. Users can now compare data on this issue across the last 12 years.

As part of the IOGP user guide, the Member Companies received a glossary and an IOGP list of causal elements to help standardize the answer. There are two sections to the list of causal factors:

People (Acts) classifications typically deal with either an individual's acts or necessary actions that are either not completed at all or are conducted improperly. There are four main categories for actions, and each major category has a subcategory with more specific information.

Process (Conditions) classifications typically involve an organizational feature or physical hazard that is outside the individual's control. There are five main classification categories, and each major category has a subcategory with more specific information.

2.4. AI in the Oil and Gas Sector

Artificial Intelligence (AI) integration has become a transformational force in the oil and gas business, transforming operations, increasing efficiency, and streamlining decision-making processes [16] [17]. AI technologies are revolutionizing every aspect of the business, from production and exploration to distribution and refining, with the potential to achieve never-before-seen levels of sustainability, safety, and productivity. Oil and gas companies are now gaining the ability to derive deeper insights from intricate datasets using AI-driven solutions, which facilitate predictive analytics that optimize exploration and production procedures [18] . nevertheless, management is being revolutionized by advanced algorithms and machine learning approaches, which enable predictive maintenance and real-time monitoring of vital infrastructure [19].

2.4.1. AI-aided exploration:

A series of procedures known as "exploration of oil and gas reserves" yields a 3D geological model of an oil/gas field or reservoir. The operations comprise data processing from the studies and geophysical and petrophysical research. The usual components of geophysical and petrophysical research are:

1) well logging.

2) reservoir-scale seismic surveying.

3) digital core analysis.

and in certain extremely rare circumstances, lab core analysis.

A collection of sensor records known as seismic traces are the result of seismic surveying. The traces are time series that show the elastic wave strength that is reflected from boundaries that separate different subsurface formation layers and is started by a vibrator at the surface. After putting these recorded time series through a unique reconstruction method along with the spatial coordinates of the vibrator and accompanying sensors, noisy 3D pictures are produced that show some of the reflecting borders. Reconstruction is largely done offline because of the high-performance computation requirements. Studies with an AI focus seek to expedite this phase.

2.4.2. Increasing efficiency and productivity:

Preventing downtime and equipment failure will significantly increase the productivity rate as a result of less lost time in equipment maintenance and providing a real time performance check that would help expertise to look for solutions to increase the equipment yield and to be more efficient.

AI systems can play an impactful role in drilling operations monitoring and adjusting drilling parameters in real-time, optimizing the drilling bit speed, pressure and direction and this is all thanks to AI that can analyze the geological data and predict reservoir behavior to finally figure the best way to increase drilling efficiency and reduce the operational risks including catastrophic equipment failure. [7]

2.4.3. Algorithms used in oil and gas

The two main approaches propelling AI developments in the upstream and larger oil and gas sectors are classical machine learning and deep learning. These methods work well for tasks involving regression, grouping, and classification. But machine learning and deep learning algorithms are black-box systems without any clear formulas explaining their internal workings or decision-making logic. Rather, they rely on complex multidimensional algebraic expressions, called "training," where the coefficients are adjusted to fit input-output data. These algorithms can derive new insights from fresh inputs once they have been trained on preexisting data.

Furthermore, hybrid modeling—which combines machine learning algorithms with physics-based models—is becoming more and more popular in industrial contexts. There are two types of hybrid models: data-dominated and physics-dominated. In data-dominated models, physics-driven models provide enormous amounts of training data, supplementing real-life data to aid in the comprehension and problem-solving of machine learning models. In physics-dominated models, machine learning refines equation coefficients to real-world data.

In addition, cutting edge AI planning apps are starting to appear in the oil and gas sector. These applications use optimization and machine learning methods to plan actions with the goal of reaching predetermined targets. Usually, intelligent agents, unmanned vehicles, and autonomous robots carry out these tasks.

2.4.4. Leveraging safety:

AI has the ability to predict and prevent potential accidents, it can analyze and identify patterns to figure where the next accident would potentially occur depending on equipment failure analyses and what are the possible consequences that might be as a result of that failure on the workers, environment and nearby areas and even for the equipment itself to launch immediate preventive actions. work related accidents are not fully occur due to equipment failure it can be in form of human mistakes, machine learning and computer visions are applied to track and monitor employee behavior, ensuring that employees are respecting the proper safety protocols, so that in case if an employee is displaying an unsafe behavior or not using the appropriate safety gears, these AI systems will alert the managemental sides to intervene and take the necessary precautions.

Sensor technology is also used to detect pipeline leaks with an assessment to their severity, leaks detection using sensors would improve significantly the workplace safety as well as an impactful decrease of environmental bills. Rachid et al developed a smart wireless sensor network to detect leaks in pipelines and assess their severity, these sensors can detect leakage through their “magnitude via negative pressure waves in the pipeline detected by sensor nodes”. [20]

preventing employees from the exposure to toxic and hazardous substances and flammable gases would be much easier when spill detection is fast and the intervention is immediate using sensor technologies, these technologies are able to detect the exact position of leaks, the type of the product to make it much easier compared to the traditional methods that requires a serious amount of time to detect leaks and the exact place that most of times it would be too late and hard to intervene. [7]

2.5. Conclusion

To summarize, the integration of Artificial Intelligence (AI) in the oil and gas industry represents a critical turning point that has the capacity to completely transform current methods and redefine operational excellence. AI is incredibly versatile and may be used for a wide range of tasks, including as streamlining exploration and production workflows, predicting maintenance needs, and optimizing asset management. Artificial intelligence (AI) has primarily been used to improve performance and operational efficiency, but it also plays a critical role in supporting industry safety protocols. As we go on to the next chapter, we'll be delving deeper into the critical role artificial intelligence plays in improving safety in the oil and gas industry. Come explore with us the cutting-edge approaches and revolutionary possibilities of AI in guaranteeing worker well-being.

CHAPTER 03

The Role Of AI In Safety Enhancement

THE ROLE OF AI IN SAFETY ENHANCEMENT

3.1. Introduction

Artificial intelligence (AI) has been used more and more by the oil and gas sector in recent years to improve safety procedures and reduce operational hazards. Through the provision of real-time monitoring, predictive analytics, and decision support tools, the integration of AI technology presents the potential to completely transform safety management. This chapter explores the critical role artificial intelligence (AI) plays in improving safety in the oil and gas industry, emphasizing its uses, advantages, difficulties, and potential. Our study is mainly focused on the oil and gas industry with a case study from SLB a well-known large sized company in the oil and gas who, like many others, have been inventing in technological advancement in all its operations including safety performance.

3.2. Introduction to SLB (Schlumberger)

SLB, also known as Schlumberger, is an American oil service company [21] [22] founded in 1926 by two brothers Conard and Marcel Schlumberger. Schlumberger started with wireline and continued to expand its operations until it became worldwide billion dollars company.

The Schlumberger brothers had conducted geophysical surveys in the United States, the Democratic Republic of the Congo, South Africa, Canada, Serbia, and Romania, among other nations. In 1927, the newly established business recorded the first electrical resistivity well log in Merkwiller-Pechelbronn, France, and went on to sell electrical-measurement mapping services. The business grew swiftly, drilling its first well in the United States in Kern County, California, in 1929. Schlumberger Well Surveying Corporation was established in Houston in 1934. In 2022 Schlumberger not only changed its name and logo but it has also changed its vision and mission in the oil and gas market and the planet.

Today SLB faces the world's greatest balancing act- providing reliable, accessible, and affordable energy to meet growing demand, while rapidly decarbonizing for a sustainable future. This challenge requires a balance of energy affordability, energy security and sustainability. It requires a balance of innovation and decarbonization in the oil and gas industry as well as clean energy solutions. It requires a balanced energy mix for a balanced planet. Slb is committed to moving farther and faster in facilitating the world's energy needs today and forging the road ahead for the energy transition. It's a bold challenge -like its new branding color- but the legacy of their people, technology and performance are the equation to help answer this challenge.

SLB has consistently advanced engineering and technology in the oil and gas industry since its founding. Numerous ground-breaking inventions, such as the development of sophisticated drilling technologies, seismic exploration techniques, and the wireline logging technique, have left a lasting legacy for the corporation. Not only have these developments changed the face of the industry, but they have also been crucial in opening up new avenues for global oil and gas production and exploration.

Schlumberger is unwavering in its dedication to innovation, quality, and sustainability as it forges ahead in the twenty-first century. Schlumberger has a long history of technological innovation and is well-positioned to influence the oil and gas sector going ahead thanks to its innovative approach to meeting the problems presented by the current energy landscape.

3.2.1. SLB Culture and Values

« Together, we create amazing technology that unlocks access to energy for benefit of all" This is what Slb considers the motto and the purpose of its businesses as shared in their main Hub page, SLB encourages its employees to work together to create industry-changing technology that unlocks cleaner, safer access to energy for all communities.

Just as SLB purpose offers a clear direct path for the future, so do the three main values the company cherishes, People, Technology, and performance. These values continue to be the cultural compass of the company.

figure 3. 1. Introduction to SLB

3.2.1.1. People

Slb have set commitments through policies and code of conduct to ensure people Safety, Inclusivity and respect of work and personal life. Slb has more than 99,000 global team members, over 100 operating countries and 17,000 members across four SLB identity and experience employee resource groups (ERG's) such as connect women, Sustainability...etc.

figure 3. 2. World map of SLB people

3.2.1.2. Technology

As shared in the company overview, SLB consider itself a pioneer for innovation and technology, they believe with the experiment learning and growth comes, which is why SLB has invested creation of >70 Global technology centers with 150 new technologies introduced across the portfolio over the past three years. And about 10,000 publications in the past decade have been published by SLB employees.

figure 3. 3. Picture of the latest SLB Technology

3.2.1.3. Performance

SLB Transition technologies assisted in preventing 700Kt of CO_2 emissions in 2022, which is the same as taking 160,00 automobiles off the road. Comparatively, it has been placed in the top 10% of the energy sector for cyber security performance in terms of safety. 2022 TRIF was well below the IOGP industry average and the lowest in SLB's history.

Additionally, it experienced a notable 14.4% activity upturn, resulting in 28 billion dollars in revenue—a 23% increase year over year. In addition to maintaining its profitability, SLB has made environmental and climate action a priority.

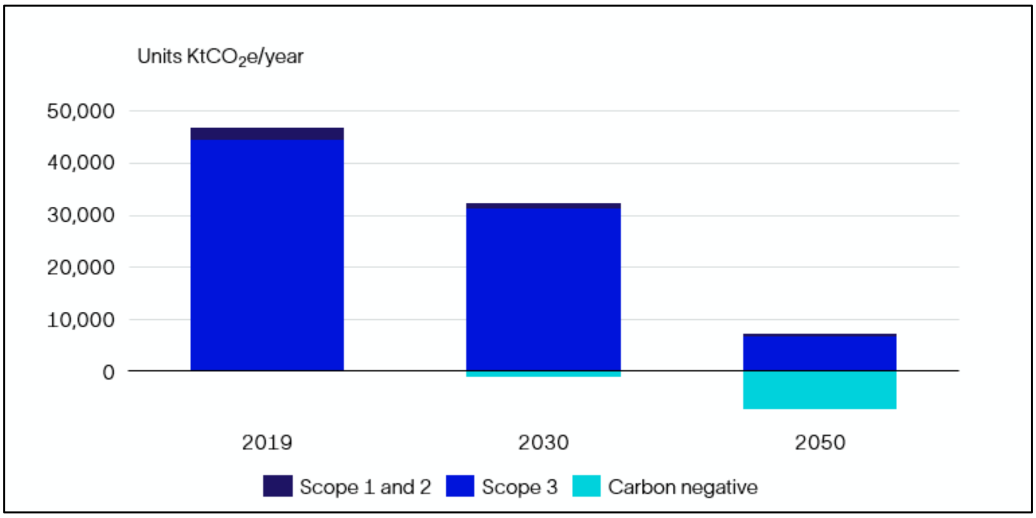


figure 3. 4. SLB Net-Zero Emissions Objective

3.2.2. Company Business Area

3.2.2.1. Core

Schlumberger (SLB) provides comprehensive services for both the upstream and downstream sectors of the oil and gas industry. These services encompass well completion, geological surveys, drilling services, reservoir assessment, and the collection and processing of seismic data. Leveraging cutting-edge technology and extensive expertise, SLB optimizes hydrocarbon recovery and enhances production efficiency.

a. Production Systems (PS)

The Production Systems division focuses on various aspects of oil and gas production, offering solutions that cover:

Artificial Lift Systems: Technologies to enhance oil recovery from wells.

Completions: Services to prepare wells for production.

Midstream Solutions: Infrastructure and services for transporting oil and gas.

Subsea Systems: Equipment and services for offshore oil and gas production.

Surface Systems and Valves: Equipment for surface-level operations and control.

b. Reservoir Performance (RP)

In regions like Algeria, SLB is well-known for its Reservoir Performance division, which provides:

Evaluation: Comprehensive analysis of reservoir properties and potential.

Intervention: Techniques to enhance or restore well performance.

Stimulation: Methods to increase the flow of hydrocarbons from the reservoir.

c. Well Construction (WEC)

The Well Construction division encompasses all aspects of drilling, including:

Drilling Services: Advanced techniques and technologies for efficient drilling operations.

Equipment: High-quality tools and machinery for drilling.

Fluids: Specialized fluids used during drilling to improve efficiency and safety.

Measurement While Drilling (MWD): Real-time data collection to guide drilling operations.

3.2.2.2. ***Digital***

Connecting people, ideas, and data to the newest digital technology is a critical function of the Digital and Integration division, which boosts productivity and creativity in everything from project management to corporate operations. The business lines included in this division are as follows:

- Asset Performance Solutions
- Digital Operations Solutions
- Digital Subsurface Solutions
- Exploration Data
- Integrated Well Construction

3.2.3. New Energy

Schlumberger (SLB) recognizes itself as a leader in renewable energy and industrial decarbonization technology worldwide. The corporation has made strategic investments in the following five industries as part of its commitment to advancing sustainable energy solutions:

- Carbon Solutions: Developing technologies for carbon capture, utilization, and storage (CCUS) to reduce greenhouse gas emissions.

- Critical Minerals: Ensuring the supply of essential minerals needed for clean energy technologies and battery production.
- Geothermal and Geoenergy: Harnessing the earth's natural heat for sustainable energy production and exploring innovative geoenergy solutions [23].
- Low-Carbon Hydrogen: Promoting the production and utilization of hydrogen as a clean fuel alternative to reduce carbon footprints.
- Stationary Energy Storage: Advancing energy storage technologies to enhance the reliability and efficiency of renewable energy systems.

With these programs, SLB hopes to accelerate the shift to a low-carbon future by utilizing its global network and technological know-how to assist in the creation of sustainable energy infrastructures.

3.3. Corporate Structure-Leadership

figure 3. 5. SLB Executive Leadership Team

Since August of 2019, Olivier Le Peuch has served as Schlumberger's CEO. Le Peuch has worked at SLB for more than thirty years. During that time, he has held a number of leadership roles on several continents and made a substantial contribution to the company's expansion and technological innovations.

Le Peuch's leadership is distinguished by a strong emphasis on sustainability, digital transformation, and innovation. Under his direction, SLB has stepped up its digital activities and integrated state-of-the-art technology into its business processes to increase productivity and provide clients with better value. Along with emphasizing the shift to clean energy and sustainable behaviors, his strategic vision supports international efforts to tackle climate change.

The executive management group and board of directors of SLB are made up of seasoned experts with a range of expertise in business, technology, and energy. Together, they drive the organization toward its strategic goals while maintaining strong governance and long-term viability.

3.4. Safety practices and innovation at SLB

During alternance internship of two years at SLB we have been able to explore the various safety practices it adapted in its sites to ensure the safety of everyone involved, employees, contractors and even 3rd parties. One that particularly stands out is the QUEST, a software that goes decades ago initially introduced to report different safety inputs such as hazardous situations, Accidents, audits and inspections and other HSE relevant report types. We believe QUEST is the first step that SLB took toward introducing AI into safety , as it stores a huge amount of data , treats and delivers accurate and detailed report.

3.5. Real time monitoring and hazard detection

To ensure safety, efficiency, and productivity in today's fast-paced and constantly changing industrial scene, it is imperative to have the ability to quickly identify dangers and monitor operations in real-time. Systems for real-time monitoring continuously supervise processes, making it possible to see possible problems early on and take appropriate action. By facilitating quick modifications and optimizations, this proactive strategy not only reduces risks and avoids accidents but also improves operational performance.

In order to collect and analyze data instantly, real-time monitoring makes use of cutting-edge technology including sensors, Internet of Things (IoT) devices, and data analytics platforms. Numerous characteristics, including as worker safety metrics, equipment performance, and ambient variables, can be monitored by these systems. Organizations can obtain important insights into their operations by consistently gathering and analyzing this data, seeing trends and abnormalities that might point to possible risks.

A key component of real-time monitoring is hazard detection, which includes a range of methods to identify and reduce risks before they become significant incidents. This involves using machine learning algorithms to identify departures from standard operating procedures, automated alarm systems to warn staff members of impending threats, and predictive analytics to anticipate potential problems. Through the integration of these technologies, businesses may establish a strong safety net that safeguards their personnel and property.

Real-time monitoring and hazard detection have a wide range of applications in many different industries, including manufacturing, oil and gas, construction, and healthcare. For example, real-time monitoring in manufacturing can lower maintenance costs and downtime by identifying early indicators of wear and tear and preventing equipment faults. It can assist in locating leaks or pressure fluctuations in the oil and gas industry that might cause disastrous incidents. Similar to this, it can guarantee that safety procedures are properly followed in construction, which lowers the possibility of mishaps on the job site.

Furthermore, as many businesses are subject to strict safety and environmental regulations, the deployment of real-time monitoring systems aids in regulatory compliance. Organizations may make sure they comply with these regulations, reduce penalties, and improve their image for dependability and safety by keeping a close eye on their operations.

We will go more deeply into the tools and techniques used in SLB's real-time monitoring and danger detection in this part. We'll look at the most recent developments, industry best practices, and case studies that demonstrate how these platforms may change people's lives. Gaining an understanding of the complexities involved in danger detection and real-time monitoring will enable you to apply these tactics in an efficient and safer manner.

3.5.1. Digital Workshop

Digital Workshop is a first-of-its-kind software application program, developed by Operations System and Information Technology (OS&IT) organization in support of Technology Lifecycle Management (TLM) digital performance ambitions, that uses camera analytics and AI to keep people in SLB facilities safe. It has been deployed in five locations and has shown promise as an effective coaching tool that helps detect, analyze, and raise alarm for non-compliances during high-risk activities like actions related to personal protective equipment (PPE), mechanical lifting, zone intrusion, and housekeeping. Specific incidents or general health, safety, and environmental (HSE) insights can serve as powerful coaching moments that can modify unsafe behaviors leading to a decrease in total recordable injury frequency (TRIF) and catastrophic, major, and serious (CMS) incidents.

Since its inception, there have been over 2600 notifications of non-compliances generated and almost 250 recorded coaching moments.

"Digital Workshop is the start of a new era in innovation to keep our people safe," says Vice President of TLM Tamer Shoukry. "HSE is the first value driver for TLM. In this time of growth, it is particularly important to use technological advancements in AI for the benefit of our people's safety, especially our trainees and newcomers."

Although its current usage is in TLM locations, the technology can be easily scaled for manufacturing centers, field operations locations, testing facilities, customer sites, or anywhere high-risk activities are conducted.

Digital Workshop is one of many applications within SLB first started as a platform designed to optimize asset management and maintenance however, its capabilities and functionalities have transcended beyond equipment to include workplace and workforce.

One of the newer applications, Digital Workshop uses camera feeds and business systems data used in our facilities and applies machine learning algorithms to recognize activities, risks, and unsafe behaviors in the workplace. When a non-compliance occurs, it generates notifications to bring awareness and encourage intervention to help prevent incidents.

The notifications generated are posted in the application where users can view, acknowledge, and give feedback to the analytics team on the accuracy to help improve the machine learning models. A mobile version of the application has also been developed where notifications can be accessed and reviewed on a mobile phone.

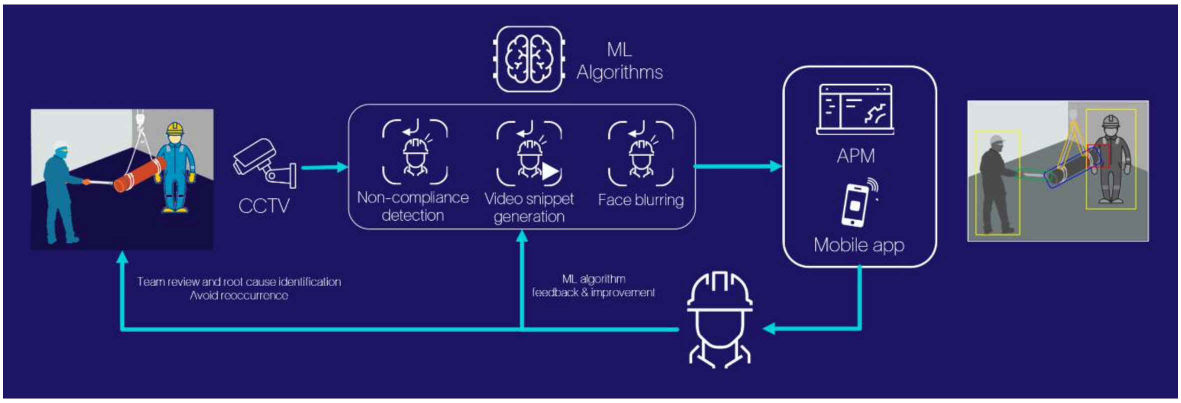


figure 3. 6. Notification Workflow

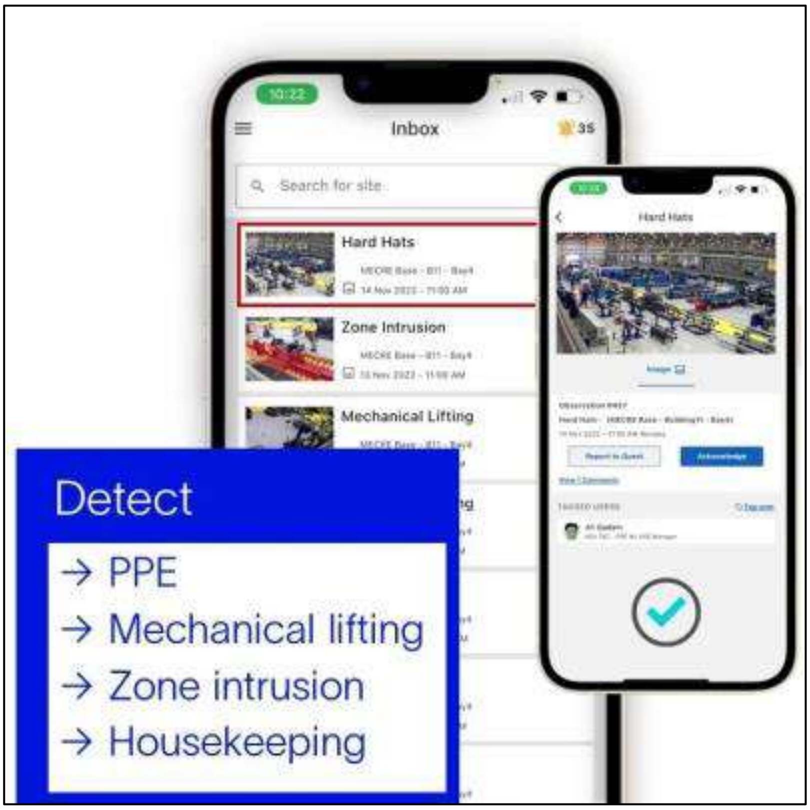


figure 3. 7. HSE non-compliances detected by

3.5.1.1. The importance of Digital workshop

"We are safe" is one of the nine behaviors in our culture framework that make us who we are—unique people who develop and deploy pioneering technology that drives performance. TLM are committed to living the cultural evolution, the function partnered with HSE and OS&IT to explore how AI and digital solutions can enhance the company's HSE performance. Digital Workshop is one of the tools that has been developed to achieve exactly that!

"We are a technology company, and I am so happy to partner with TLM on the Digital Workshop in utilizing cutting-edge, AI-assisted capability to enhance our safety," says VP HSE and Facility Management Devan Raj. "The insights our teams on the ground will gain should be used as a coaching tool and a nudge to improve the ergonomics of our workspaces. We should embrace this technology to help us… keep our people SLB Safe!"

3.5.1.2. Results

a. ***Incident & Injuries Reduction***

Table 3. 1. 2021-2024 HSE Performance Results IOGP

2021 - 2024	Q1 2021	Q2 2021	Q3 2021	Q4 2021	Q1 2022	Q2 2022	Q3 2022	Q4 2022	Q1 2023
Industry Recognised (OGP) - Occupational Injuries									
Fatalities (Total fatalities in fatal incidents)	0	0	0	0	0	1	0	0	0
FAR	0	0	0	0	0	13.64	0	0	0
Total Permanent Impairment Occupational Injuries (PI)	0	0	0	0	0	2	0	0	0
FPI - Fatalities and Permanent Impairment Occupational Injuries	0	0	0	0	0	3	0	0	0
FPIR - Fatal and Permanent Impairment Rate Injuries (FPI/100,000,000)	0	0	0	0	0	40.91	0	0	0
LWDC - Lost Work Days Cases	4	2	2	2	1	3	0	0	0
LD - Lost Days	83	23	23	44	3	325	0	0	0
RWDC - Restricted Work Day Cases	0	0	0	0	0	0	0	0	0
RD - Restricted Days	26	14	0	0	0	111	0	0	0
TDL - Total Days Lost (LD + RD)	109	37	23	44	3	436	0	0	0
MC - Medical Treatment Cases	0	1	0	0	1	0	0	0	0
FAC - First Aid Cases	11	3	8	8	0	4	3	3	0
(LD + RD)/(LWDC + RWDC)	27.25	18.5	11.5	22	3	145.33	0	0	0
(LWDC + RWDC)/(MC)	0	0	0	0	0	0	0	0	0
LTI - Lost Time Occupational Injuries (fatalities + LWDC)	4	2	2	2	1	4	0	0	0
TRI - Total Recordable Occupational Injuries (fatalities + LWDC + RWDC + MC)	4	3	2	2	2	4	0	0	0
TRI (Contractor) - Total Recordable Occ Injuries (Contractor fatalities + LWDC + RWDC + MC)	1	1	0	1	1	2	0	0	0
TRI (Employee) - Total Recordable Occ Injuries (Employee fatalities + LWDC + RWDC + MC)	3	2	2	1	1	2	0	0	0

LTIF - Lost Time Occupational Injury Frequency (LTI/1,000,000 manhours)	0.54	0.27	0.28	0.27	0.14	0.55	0	0	0
LWDCF - Lost Work Days Case Freq (LWDC/1,000,000 manhours)	0.54	0.27	0.28	0.27	0.14	0.41	0	0	0
TRIF - Total Recordable Occupational Injuries per 1,000,000 wrkhours (TRI/1,000,000 work hours)	0.54	0.41	0.28	0.27	0.27	0.55	0	0	0
TRIF (Contractor) – Total Rec Occ Injuries per 1000000 wrkhrs (Contractor TRI/1000000 wrkhrs)	0.29	0.28	0	0.29	0.3	0.6	0	0	0
TRIF (Employee) - Total Rec. Occ Injuries per 1000000 wrkhrs (Employee TRI/1000000 wrkhrs)	0.75	0.53	0.54	0.26	0.25	0.5	0	0	0
Estimated Losses in $K - Lost Time Occupational Injuries	301	34	13	132	9	1,197	0	0	0
General HSE Events									
Catastrophic	0	0	0	0	0	1	0	0	0
Major	0	0	0	0	0	0	0	0	0
Serious	8	7	4	2	3	7	1	3	4
Light	23	17	22	12	7	11	10	5	10

The results of the Health, Safety, and Environment (HSE) performance after the installation of hazard detection and real-time monitoring systems are shown in the above table (Digital Workshop). It's crucial to remember that, although these findings represent safety performance throughout the deployment country, the investigation was mainly concerned with facilities and workshops. The study purposefully excluded field locations in order to protect customer privacy and safeguard sensitive data. Furthermore, the data shows a notable decrease in injuries and accidents when compared to quarters prior to the implementation of these safety measures. The below graph demonstrates the trend of TRIF and CMS reported before and after the deployment, Q2 2023, zero accident were reported.

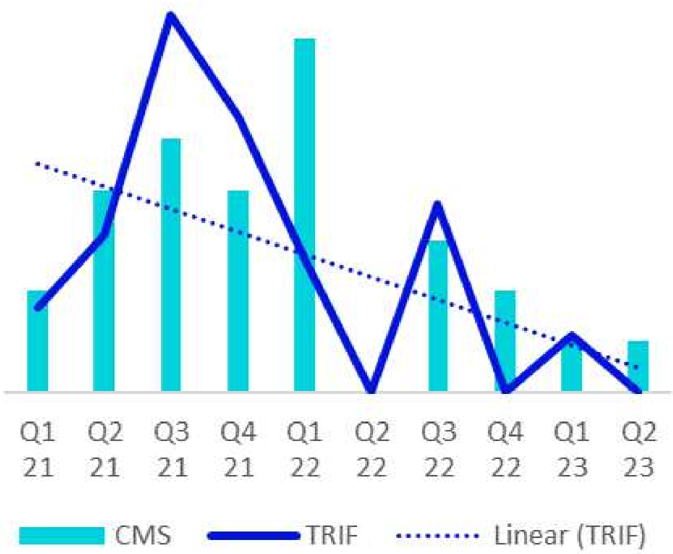


figure 3. 8. 2021-2024 TRIF &CMS Rate

b. Notification and surveillance

A total of 2674 non-compliance notifications were reported demonstrating the effectiveness of the system in quickly detecting and resolving such problems. Furthermore 247 coaching moments were conducted demonstrating proactive actions taken for a safer culture and operation.

A crucial component of the monitoring improvements was the deployment of 200 cameras in strategic operating zones. These cameras cover a large area, making it possible to monitor continuously and react quickly to any abnormalities. The incorporation of surveillance technology has demonstrated a crucial role in upholding a secure and obedient work environment, enabling preemptive measures and alleviating any hazards.

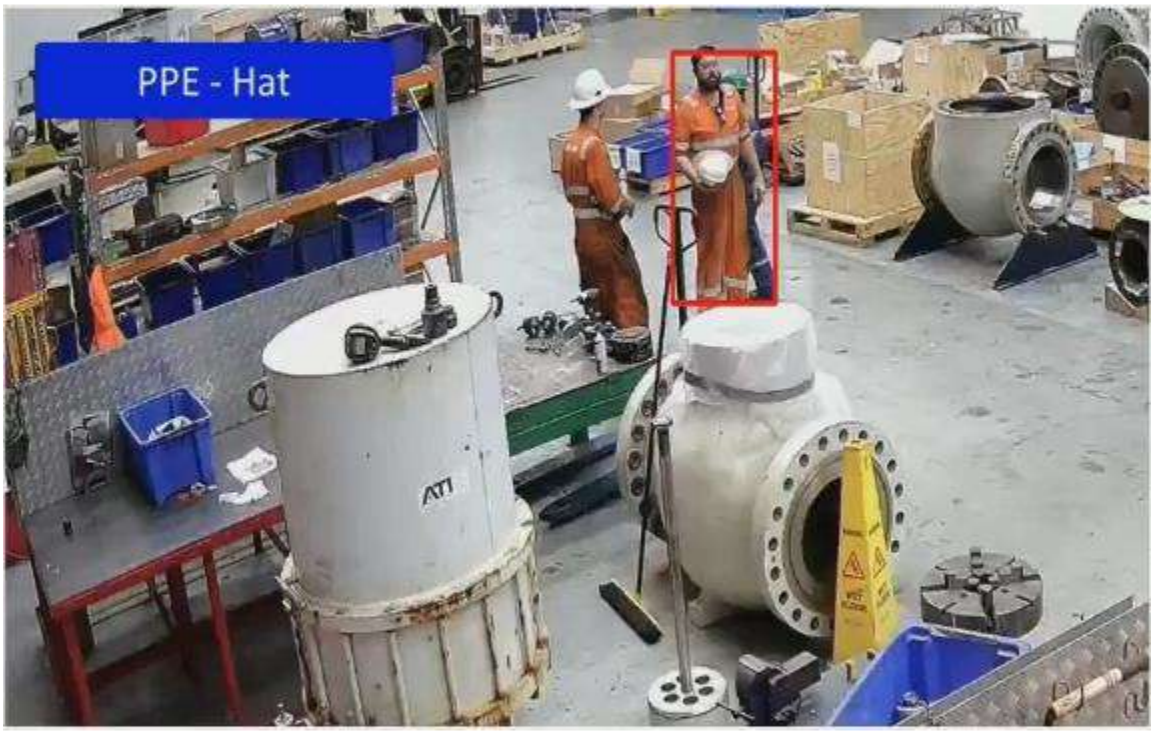


figure 3. 9. Footage taken by Digital Workshop Camera

c. *Financial Savings*

Preventing accidents not only protects workers but also lessens the financial burden of damages and liability. This section explores how to put strong safety procedures into place with the goal of reducing accidents, downtime, and expenses. Organizations that prioritize safety efforts can protect their workers and save a significant amount of money by lowering accident-related costs.

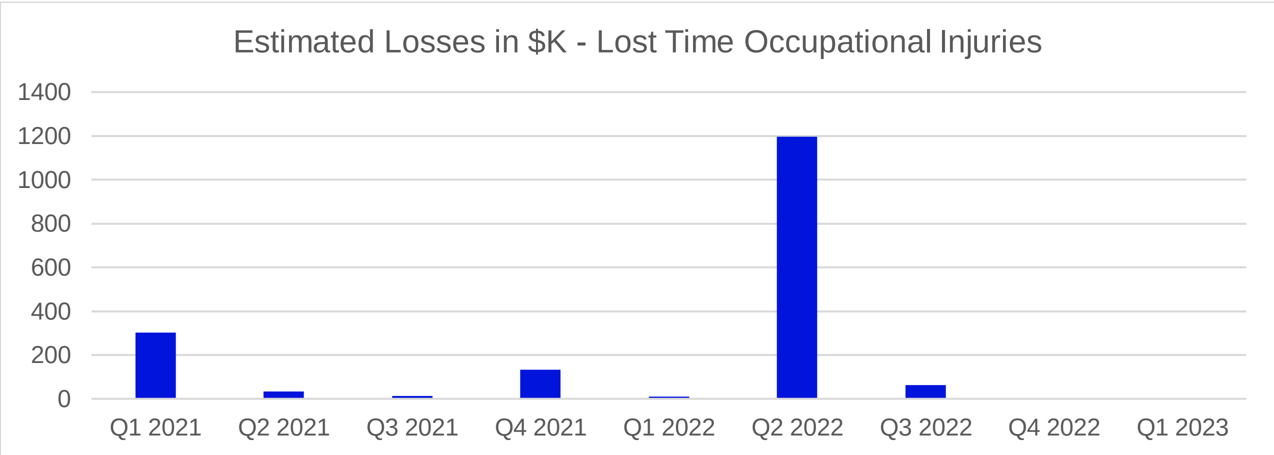


figure 3. 10. Estimated Losses in $K 2021 to 2023

3.6. Autonomous systems and robotics

Multiple types of robots with various sensors (payloads) enable acquiring data, including photographs, from diverse locations without disrupting operations, while minimizing personnel exposure to hazardous locations and confined spaces. Different sensors can acquire data simultaneously and data collection is more consistent. Robots are immune to the tedium of repetitive tasks that can lead to human errors.

SLB has developed its own autonomous robot used in rigs and well sites to visually analyze hazards and act upon it, whether the concern is equipment and processes, data quantification or interpretation or reducing carbon footprint, the autonomous is a solution for inspection, collection of visual thermal and acoustic data including hazardous atmosphere measurement, the robot also provides real time digital twin on facilities at any time of the day.

figure 3. 11. SLB Autonomous Robot

The above figure shows two robots deployed in SLB facilities (Rigs) with approval from client representatives, the robot are equipped with a suit of sensors and capabilities that allow it to:

a. Visual Hazard Analysis

The robot analyzes visual thermal and acoustic data of hazardous atmospheres, study the air , the anatomy , and shape recognitions to collect data to ensure comprehensive monitoring of the environment

b. Data Quantification and Interpretation

The robot is able to quantify data and parameters of several critical operations with actionable insight. Including monitoring of equipment and abnormalities

c. Carbon Footprint Reduction

The robot contributes to lowering the overall carbon footprint of operations by assisting in the reduction of human intervention during inspections and data collecting.

d. Real-Time Digital Twin

The autonomous robot from SLB is unique in that it can provide a real-time digital twin of the facilities. This digital twin improves operational visibility and decision-making by providing a live, virtual representation of the physical site that is available at all times.

3.6.1.2. ***Advantages of robots in industrial environment***

a. Minimizing Personnel Exposure

Robots can navigate dangerous environments where humans would be at risk, such as hot spots, toxic gas rooms, or cramped quarters. This lowers the risk of mishaps and health problems for employees.

b. Enhanced Data Consistency

Multiple sensor-equipped robots (such as those with cameras, thermal imagers, acoustic sensors, and chemical detectors) can collect large amounts of data during a single mission. This guarantees the consistency and dependability of the data gathered, enabling improved analysis and decision-making.

c. Repetitive Task Efficiency

Robots do not get tired or bored -Like humans – they are perfect for carrying out monotonous jobs that require consistency and resilience which lowers the likelihood of human error and human risk exposure.

d. Simultaneous Data Acquisition

Robots' capacity to carry a variety of sensors makes it possible to collect multiple kinds of data at once. For instance, one robot is able to simultaneously record thermal data, acoustic signals, visual images, and atmospheric measurements. A more thorough grasp of the monitored environment is offered by this integrated approach.

3.7. Workforce training and simulation

The way industries approach safety training is changing as a result of the incorporation of Artificial Intelligence (AI) into simulation and worker training programs. Businesses may develop individualized, dynamic, and realistic training programs that better equip staff for real-world situations by utilizing AI. This chapter examines how cutting-edge simulation technology and training approaches are using AI to improve safety.

3.7.1. Virtual Reality (VR) and Augmented Reality (AR)

"We have developed immersive training environments through the use of AI-powered Virtual Reality (VR) and Augmented Reality (AR) technology. These platforms allow workers to practice safety and emergency measures in virtual environments that closely mimic their real workplaces. In the last two years, we have successfully incorporated virtual reality technology into our New Employee Safety Training (NEST), an induction program for new hires that focuses on health, safety, and the environment (HSE). VR modules are included into this extensive three-day safety training, which is enhanced with a gamified application for danger detection situated in an authentic SLB workshop setting. By using this creative strategy, we have effectively conducted 48 NEST training sessions, involving almost 200 participants, including SLB staff members, contractors, and third-party workers. The input gathered through post-session assessment forms offers insightful information about. Below chart represents 67% class effectiveness as per individual feedback.

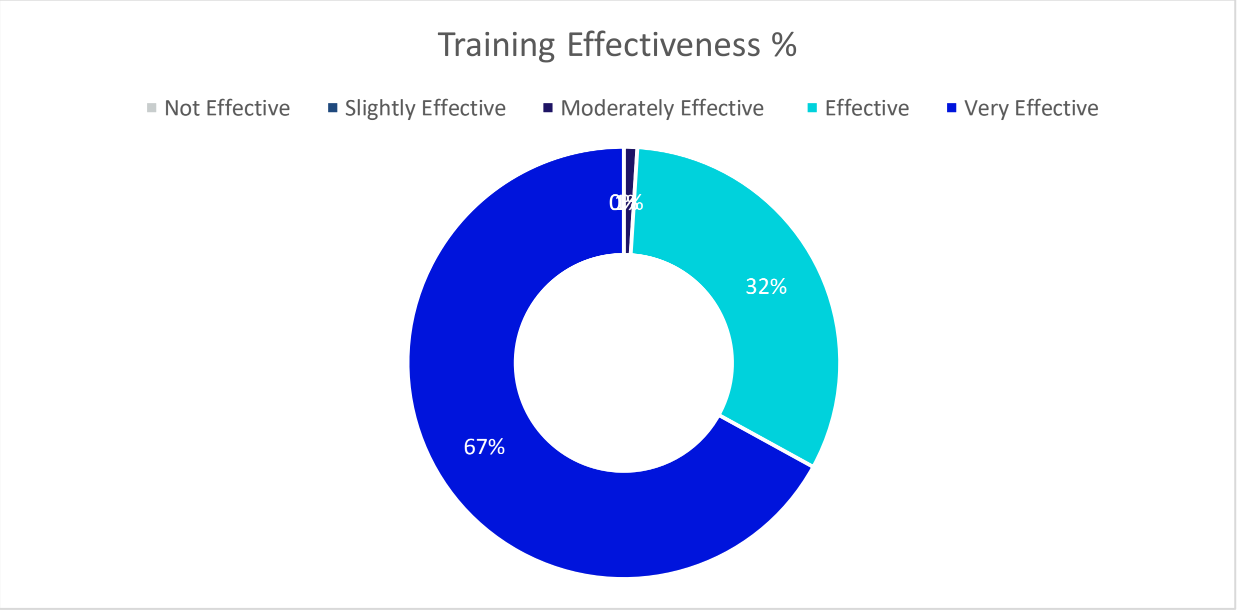


figure 3. 12. Training Effectiveness %

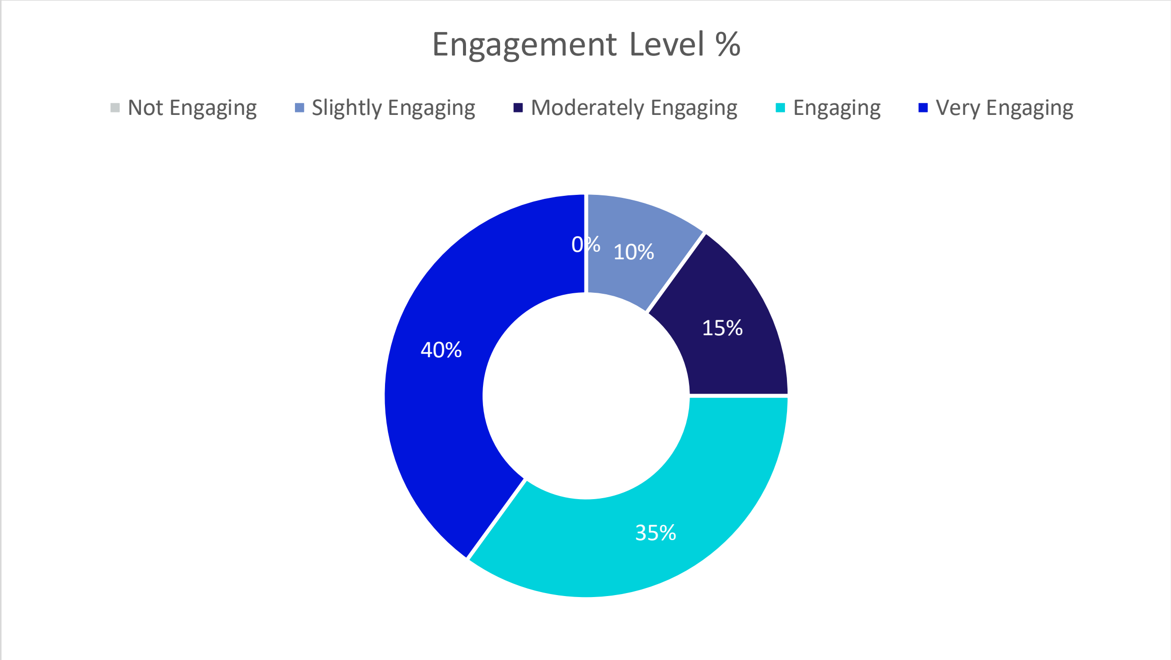


figure 3. 13. Engagement Level %

Individual feedback obtained via Microsoft Forms and handout sheets indicates that training courses utilizing Virtual Reality (VR) technology have proven to be remarkably beneficial, as evidenced by a reported 67% of participants. Furthermore, the degree of participation approached 40%, as evidenced by the high scores of "Very Engaging" and "Very Effective." Remarkably, just 10% of participants said they were not very successful or engaged. These results validate the effectiveness and significance of incorporating virtual reality (VR) into workforce training, especially in companies that place a high value on hiring younger workers, including millennials and Gen Z.

These instructional techniques provide a special fusion of amusement and knowledge, making learning entertaining as well as educational. Additionally, they give participants access to a multitude of material, which promotes improved understanding and retention. This demonstrates how VR-integrated training has the power to transform educational opportunities and produce significant results in contemporary work settings.

3.8. Conclusion:

In conclusion, the integration of Artificial Intelligence (AI) into the oil and gas sector has proven to be a game-changer for enhancing safety procedures and mitigating operational hazards. This chapter has highlighted the transformative potential of AI through real-time monitoring, predictive analytics, and decision support tools, showcasing its critical role in safety management. By focusing on the advancements and implementations at SLB, we have demonstrated how AI can significantly improve safety performance. The insights gained from this case study underscore the advantages, challenges, and future potential of AI in revolutionizing safety practices within the industry, paving the way for a safer and more efficient operational environment.

CHAPTER 04

IMPLEMENTATION OF AI MODEL IN PREDICTIVE SAFETY ANALYTICS

IMPLEMENTATION OF AI MODEL IN PREDICTIVE SAFETY ANALYTICS

4.1. Introduction

Having the ability to forecast future events is a dream of any human being, and with the application of predictive analytics this dream can come close to be real more than ever, predictive analytics is a branch of advanced analytics that utilizes statistical algorithms, machine learning techniques, and historical data to make predictions about future events. It involves analyzing current and historical data to identify patterns and trends, which can then be used to forecast future outcomes and behaviors.

This chapter highlights the application of predictive analytics in workplace safety with several theoretical aspects and proposed AI risk predictive based app and its functionality.

4.2. Predictive safety analytics:

Predictive safety analytics is an advanced approach that gathers all of the advanced data analytics, machine learning, and artificial intelligence to predict and identify mitigation measures for potential risks before they occur. Its prediction comes as a result of analyzing historical and real-time data, predictive safety analytics can identify patterns and trends that may indicate future safety issues, allowing organizations to take proactive measures to prevent accidents and enhance overall safety, This proactive strategy is transforming industries, particularly those with high-risk operations like oil and gas, manufacturing, and construction. [24] [25]

4.2.1. Key components of predictive safety analytics:

4.2.1.1. Data Collection and Integration:

Data collection is the first step of unlocking the power of data involves gathering information from various sources including include historical data, sensors, surveys, public records, purchased datasets or even a real time inspection…, and then merge them into a consistent format and structure (cohesive dataset), which then can be used for analysis and model building. [26]

This process is so important to take sure it is well done because:

- Integrating data from multiple sources provides a clear view needed by the model to provide more accurate and efficient analysis.
- Proper integration processes ensure that data is consistent, reliable and with the good quality needed to achieve better model performance and insights.
- Easier access to all relevant data in one place increases the efficiency of the analytical process and give a holistic view for the model to provide more accurate and efficient decisions.

4.2.1.2. Data Preprocessing and Cleaning:

Before the analysis process takes place, data must be prepared (pre-processed), this step aims to transform raw data into usable clean the data and search for any inconsistencies, errors (typos, incorrect entries, out-of-range values), and noise (duplicates removal) and remove them [26], it is considered as one of the most important steps due to the crucial role that it plays for increasing the efficiency and reliability of the prediction model because this process:

- will assure accurate and reliable predictions and reduce the possibility of false predictions because of the cleaned and well pre-processed data.
- As previously mentioned, one of AI biggest and crucial challenges is to provide the model high quality data which can be secured with data preprocessing that allows the elimination of any unnecessary and low-quality data enhancing the integrity and consistency of the data.
- Provides a better visualization of data patterns which allow the model to give the best processing results.

4.2.1.3. Advanced Analytics and Machine Learning:

Advanced analytics stands for the sophisticated technics that goes beyond traditional basic data analysis methods to extract insights and make predictions, by using algorithms, artificial intelligence and statistical models to identify patterns, trends and relationships within complex datasets. It is basically divided into3 main concepts:

a. Descriptive analytics:

The aim of this concept is to understand what has happened in the past by exploiting the data provided such as incident reports.

b. *Predictive analytics:*

This concept has the ability to predict and forecast what possibly can happen by analyzing the patterns and trends of the historical data (incident reports, scenarios, real-time inspections)

c. *Perspective analytics:*

The concept that provides recommended actions (preventive and protective measures) to achieve the required results in shape of risk mitigation and elimination as in our case study.

All of the previous technics requires a machine learning model that is trained to identify patterns and correlations associated with the safety records such as incidents, scenarios and real-time data

4.2.1.4. ***Predictive Modeling:***

The realization phase of the model, prediction modeling is a process used in data science and machine learning came in the creation purpose of models that using historical data such as anomaly detection, time series analysis, and predictive maintenance to help the model forecast future incidents.

After collecting, cleaning and preprocessing the data, the model passes through the following:

a. *Model Selection:*

Choosing an appropriate modeling technique based on the data and the prediction goal. [27]

b. *Model Training:*

Fitting the chosen model to the data. The model learns the relationships between variables and their impact on the predicted outcome. [1]

c. *Model Evaluation:*

Assessing the model's performance on unseen data. This ensures the model generalizes well and avoids overfitting (performing well on training data but poorly on new data).

d. *Model Deployment:*

Once a model demonstrates good performance, it can be used to make predictions on new data points.

4.2.1.5. ***Risk Assessment and Mitigation:***

Assessing the likelihood and impact of predicted safety incidents.

Implementing preventive measures and safety protocols to mitigate identified risks.

Predictive safety analytics systems often include real-time monitoring capabilities that continuously analyze data streams to detect early warning signs of potential safety issues. Alerts are generated to prompt timely intervention.

The model now after been well trained it now has to work in a real situations predicting possible incidents and detecting safety issues and identify possible risks with assessing their severity and occurrence possibility and provide actionable decisions with preventive measures and safety mitigation protocols to the administrative stuff to ensure to make sure that neither employees nor equipements are exposed to these risks.

4.2.1.6. Proactive Intervention:

Deploying real-time monitoring systems that provide continuous surveillance of operations, this system is able to intervene in case of any anomaly detected, this intervention comes inform of alerts, sending notifications, starting the intervention measures (auto extinguishers in case of fire, ventilation in case of toxic gases presence or in confined space works…), enabling timely interventions and predicting accident occurrence would decrease significantly the numbers of incidents in workplace.

4.3. The implementation of AI model:

The proposed app makes it simple for users to report dangerous circumstances they come across at work. Employees may properly document dangers by capturing pertinent information, including images and descriptions, using an interface that is easy to use.

The architectural design includes centralized data storage, ensuring that all hazard reports are securely stored and accessible to authorized personnel. This centralized approach facilitates data analysis and reporting, enabling organizations to identify trends and prioritize safety initiatives.

The app's predictive analytics tool, which uses AI to analyze user-submitted data and produce prediction reports, is one of its standout features. Through the examination of past data and the identification of patterns and trends, the app is able to forecast possible hazards and suggest preemptive actions to reduce them. This predictive capacity promotes a proactive risk management culture in addition to improving the organization's capacity to anticipate and handle safety issues before they arise.

In summary, the Hazardous Situation Reporting App represents a significant step forward in workplace safety management. By providing a centralized platform for hazard reporting, leveraging predictive analytics, and prioritizing scalability and usability, the app empowers organizations to proactively identify and mitigate workplace hazards, ultimately creating safer and healthier work environments for all stakeholders involved.

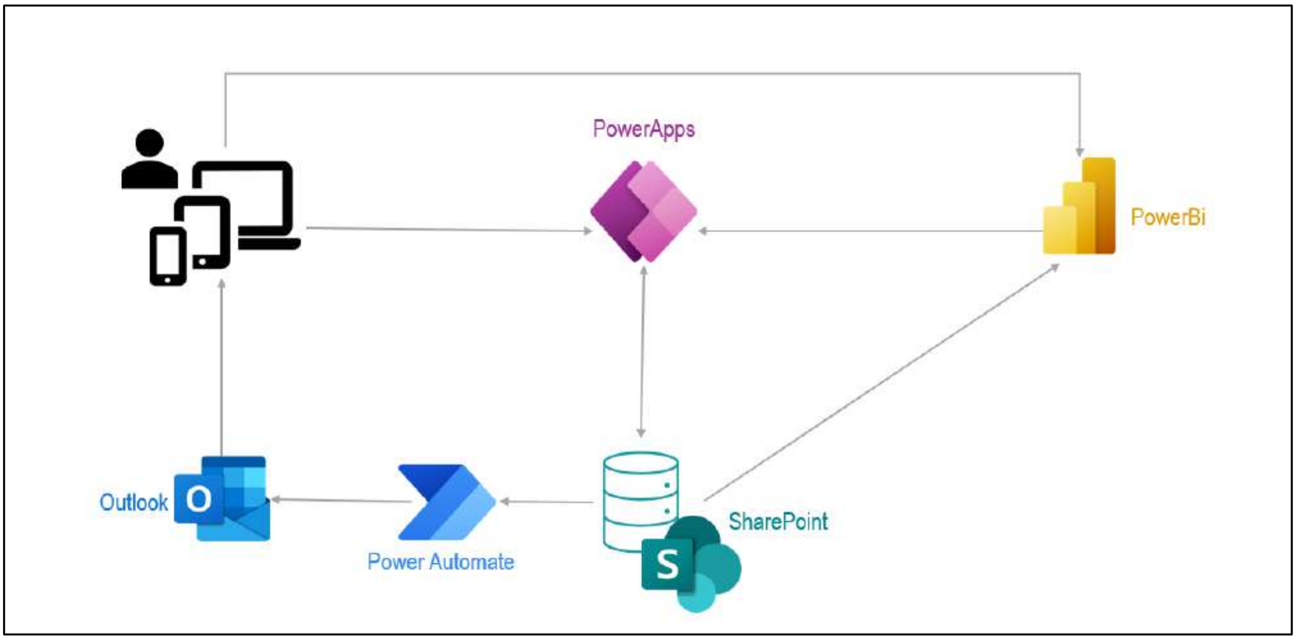


Figure 4. 1. Hazardous Situation Reporting App Architecture

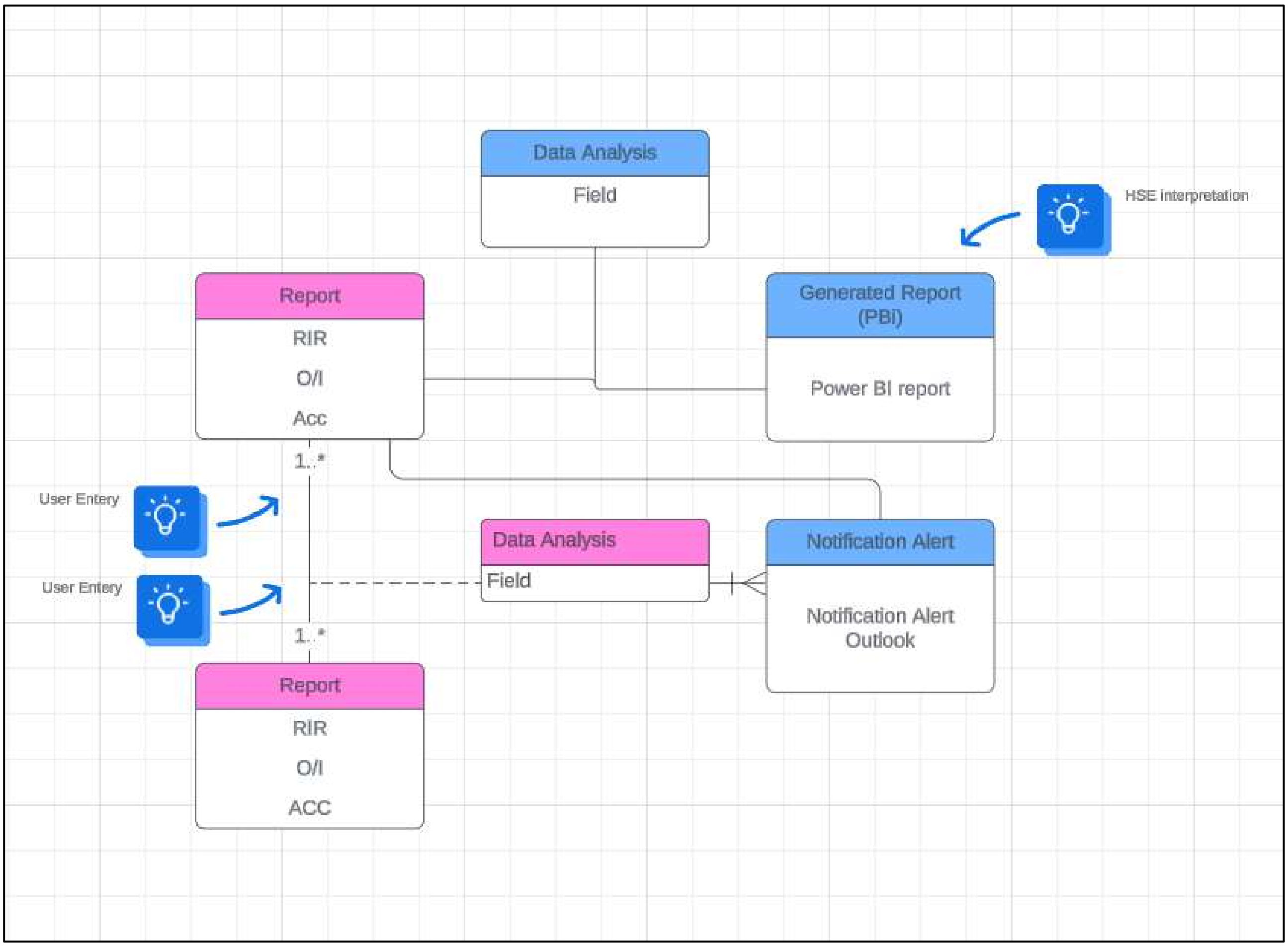


Figure 4. 2. App Wireframe

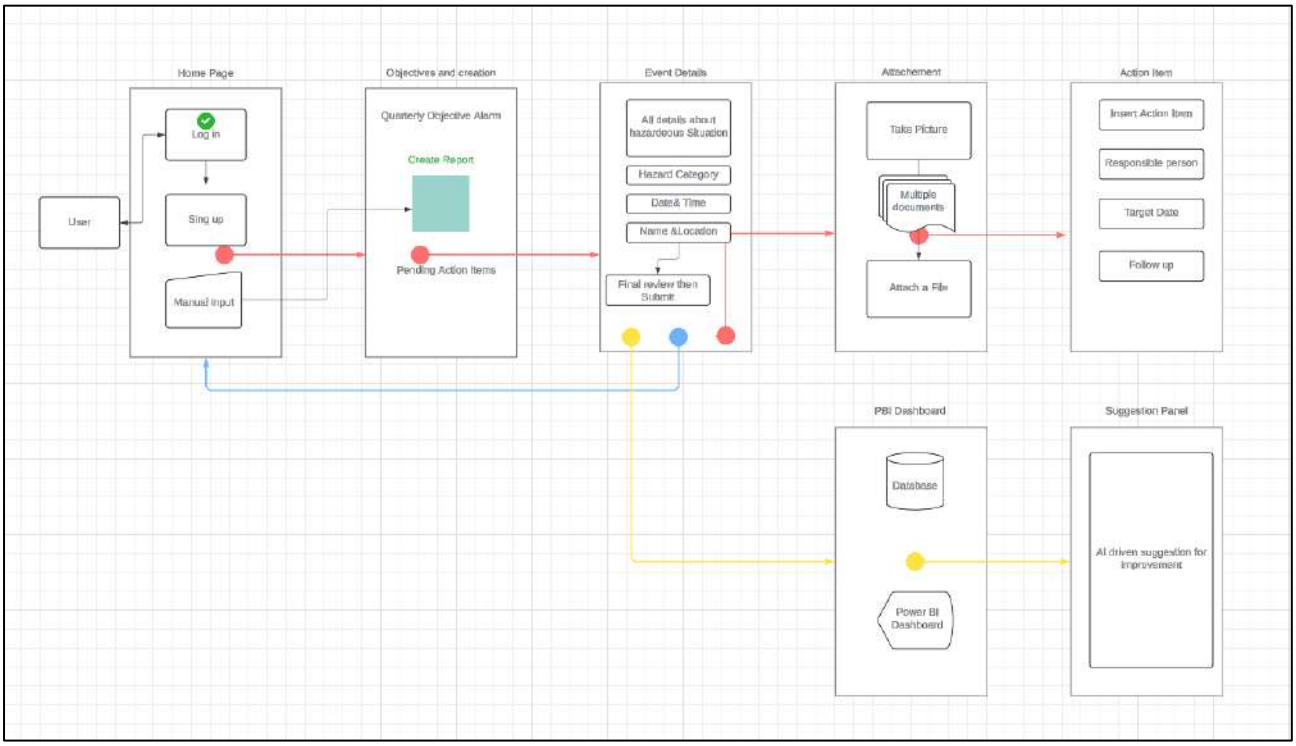


Figure 4. 3. App Wire Frame Details

4.4. The Future of Safety

As AI continues to lead and reshape various industries, workplace safety stands at the frontline of its core advancement this prognosticative study showcases the trajectory of risk management within the next five, ten and twenty years from now with the main focus on Machine learning, AI integration technologies. This analysis seeks to predict the future landscape of workplace safety and answer the questions the most commonly used in all industries, will AI replace us? and for safety industry more specifically, will AI replace HSE officers, Advisors, specialists?

In Five year projection, the integration of machine learning and AI in safety systems is anticipated to become increasingly high .In the future, AI-powered hazard management systems will develop to provide predictive analytics and real-time monitoring, allowing businesses to proactively detect and reduce risks. Large volumes of data will be continuously analyzed by machine learning algorithms, which will look for patterns and trends to forecast possible safety problems before they happen. By enabling companies to more effectively anticipate hazards and avert accidents, this predictive capability will transform safety management procedures.

In ten year projection, AI is expected to reach maturity with advanced technologies and various autonomous robotics that reduces human error and human exposure at a large. In addition to analyzing past data, these AI-powered systems will collect real-time data from the workplace by utilizing cutting-edge technologies like wearables, sensor networks, and IoT devices. Additionally, AI-driven virtual assistants and augmented reality tools will provide personalized safety guidance to workers, further enhancing safety awareness and compliance.

In twenty year projection, AI is presumed to transform the concept of workplace safety launching an era of AI powered technologies fully able to recognize and react to safety risks on their own without human assistance, AI powered systems will carry out routine inspections, monitor hazards, carry out emergency response plans through the integration of robotics, drones, autonomous vehicles...etc.

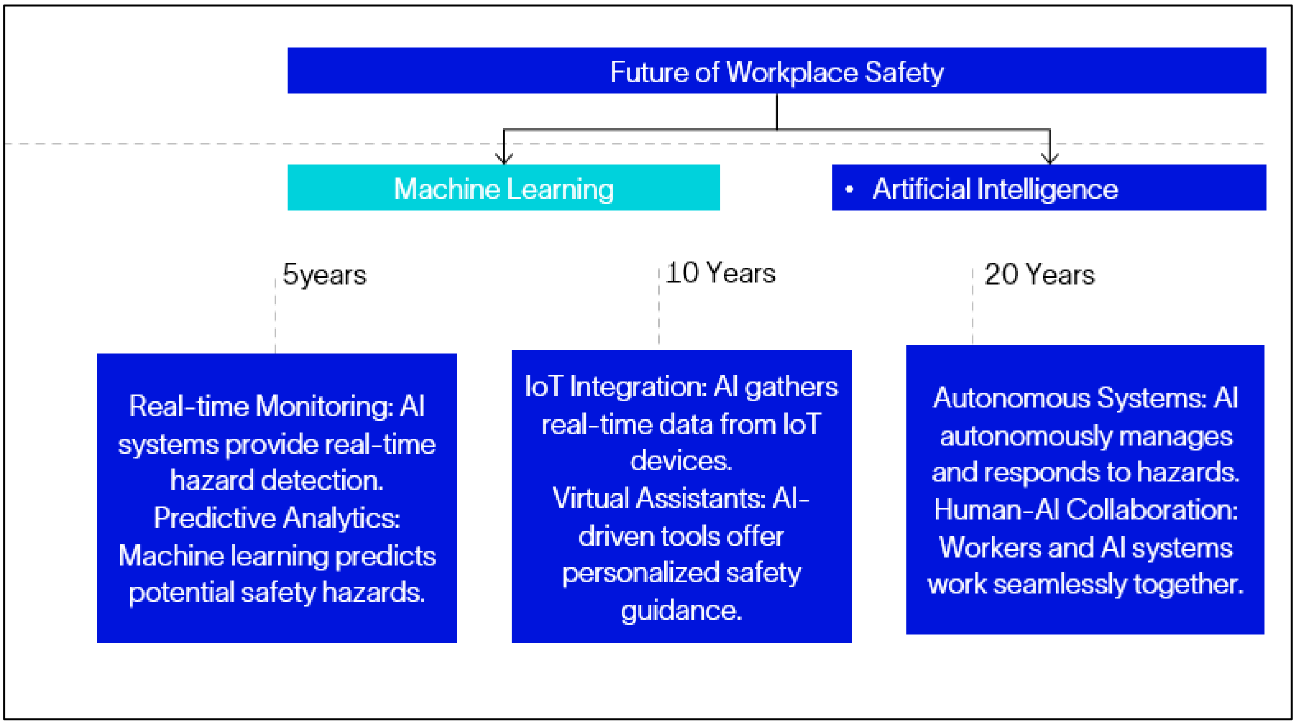


Figure 5 Future of Workplace Safety

4.5. Conclusion:

In conclusion, the integration of AI hold a transformative future toward minimization of risks and workplace accidents and has potential to completely change the risk management procedures for a safer , healthier workplace.

GENERAL CONCLUSION

This dissertation has delved into the transformative potential of Artificial Intelligence (AI) for enhancing safety in the oil and gas industry. We explored how AI can eliminate human error, facilitate proactive risk management, and potential anticipate hazards, ultimately leading to a safer work environment for individuals, improved environmental protection, and asset security.

By analyzing the implementation of AI in different areas and its impact specially on – Schlumberger (SLB) – this research provides valuable insights into the current state and future trajectory of AI-driven safety practices.

Looking ahead, the three potential futures outlined offer a glimpse into how AI will likely reshape safety protocols within the next two decades. Understanding these possibilities, along with the opportunities, challenges, and ethical considerations presented by AI adoption, will be critical for navigating this technological shift effectively.

This study serves not only to quantify the impact of AI on safety in the Algerian oil and gas sector but also to provide actionable recommendations for improving AI integration. By fostering a collaborative approach between industry leaders, technology developers, and policymakers, we can ensure that AI becomes a powerful force for maximizing safety and minimizing risks in the oil and gas sector, not just in Algeria, but globally.

In conclusion, this research paves the way for further exploration and implementation of AI solutions that prioritize the well-being of workers, the environment, and the overall sustainability of the oil and gas industry.

Annex A Training Evaluation and Feedback Form

Schlumberger
Training Evaluation and Feedback

Training Program Evaluation

We would appreciate your comments regarding this training program.

Circle the appropriate response.	Very Satisfied		Satisfied		Very Dissatisfied
1. Please rate the instructor's presentation	5	4	3	2	1
2. Instructor was well organized	5	4	3	2	1
3. Instructor generated interest And made class stimulating	5	4	3	2	1
4. Instructor's knowledge or skill In the subject area	5	4	3	2	1
5. Please indicate your overall rating of the class	5	4	3	2	1
6. Rate the usefulness of the class for your personal use	5	4	3	2	1

7. The length of the class was: ☐ Too short ☐ Too long ☐ Okay

8. List skills or information learned in this program that you can apply in your workplace.

____

____

____

9. To you, what topics were of
Most value: ______________________________

____

Least Value: ______________________________

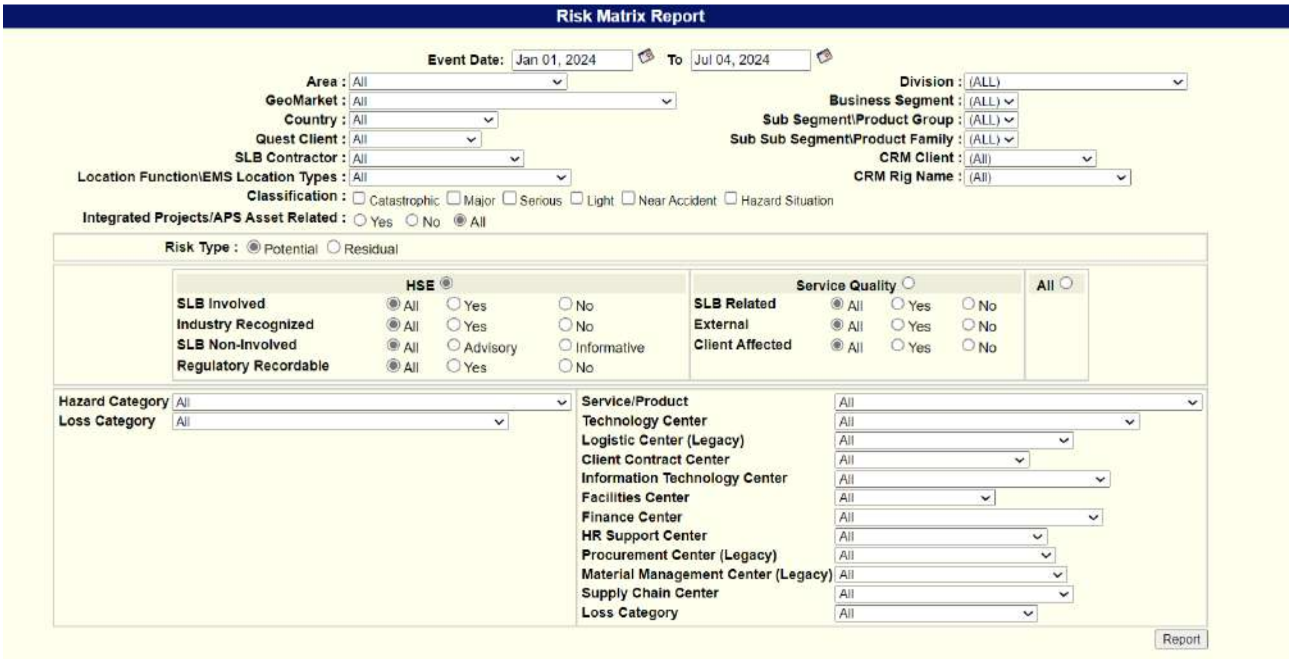
____

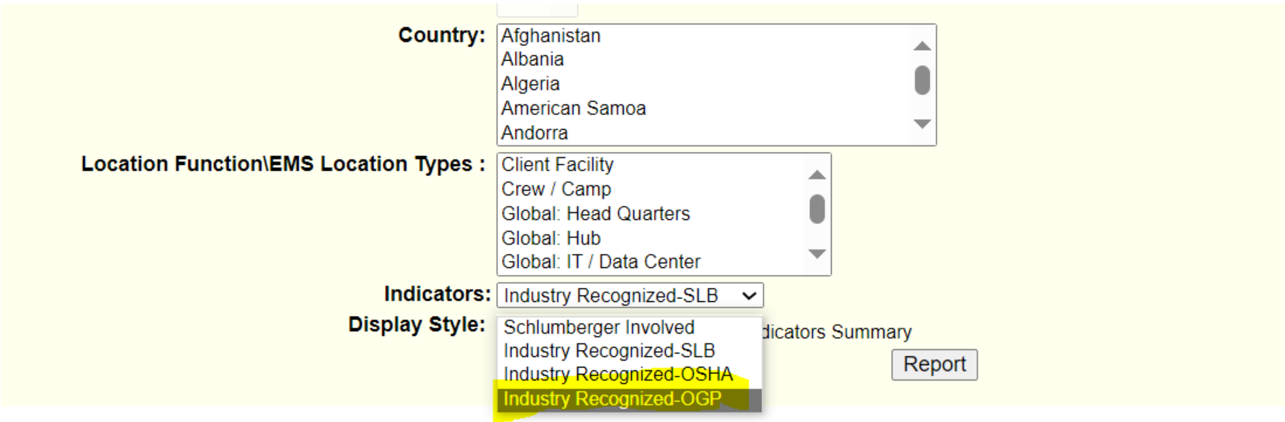
10. What suggestions do you have for improving the class? ________________

____

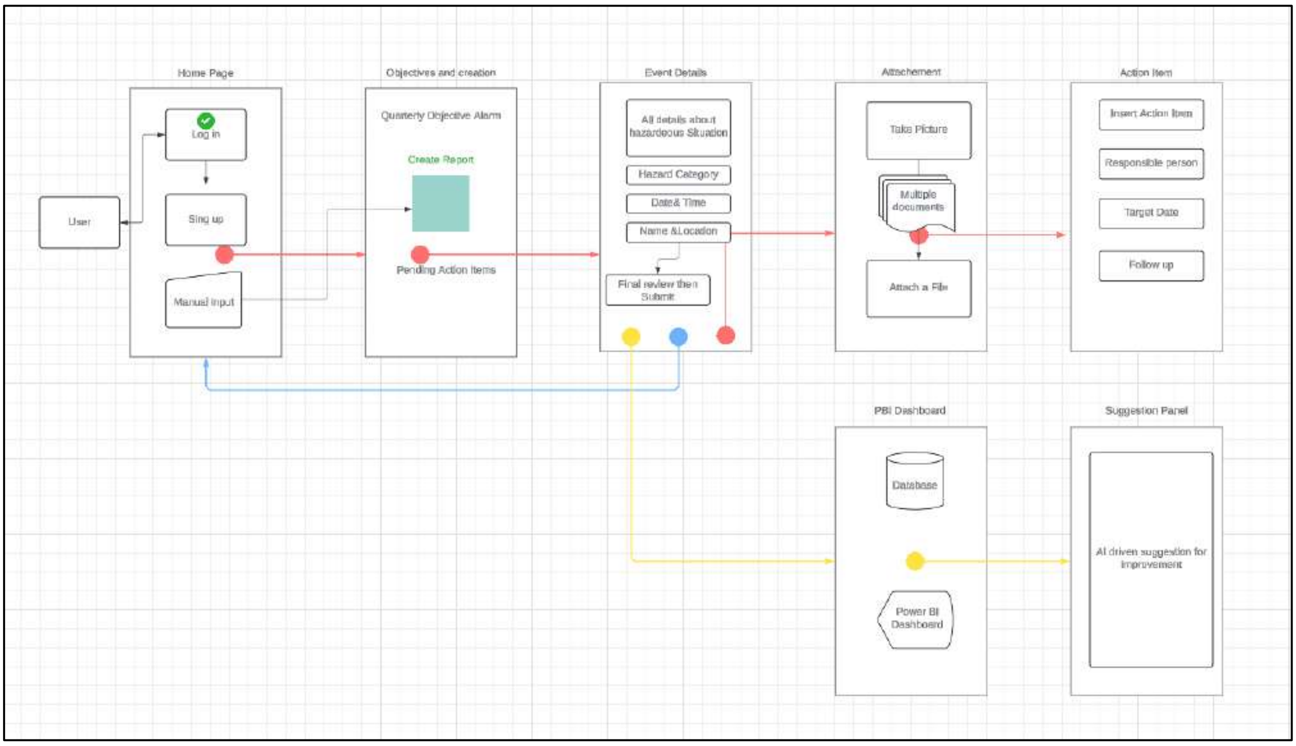
____

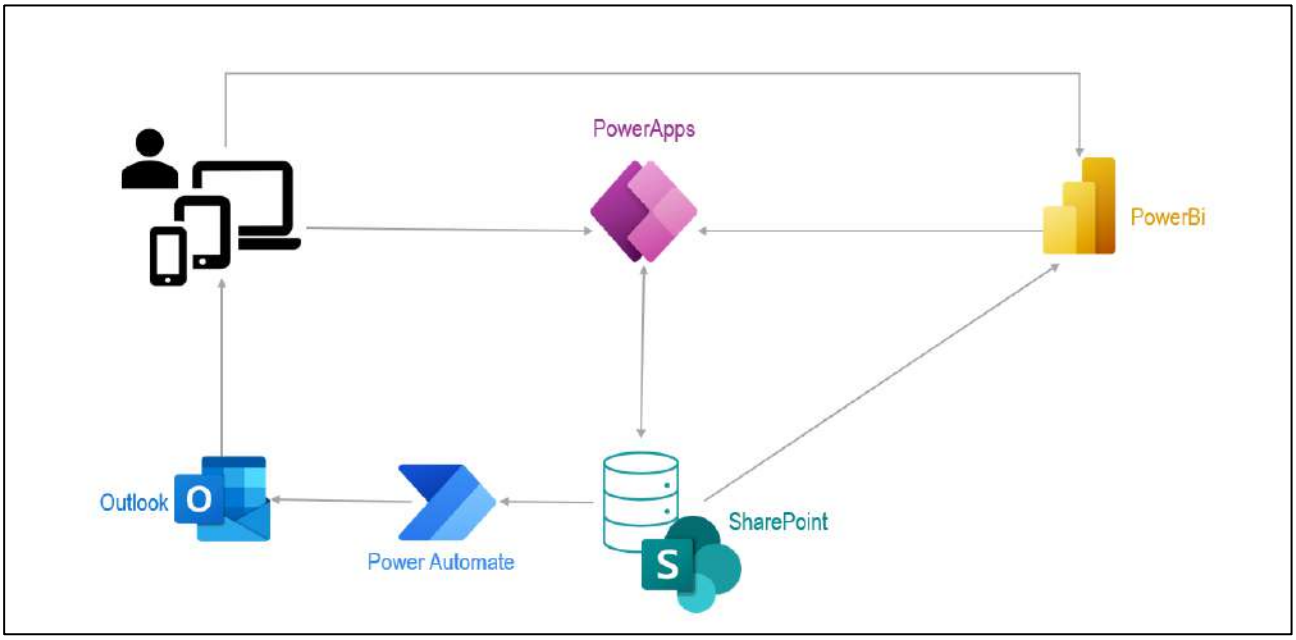
Annex B QUEST Risk Matrix Filters



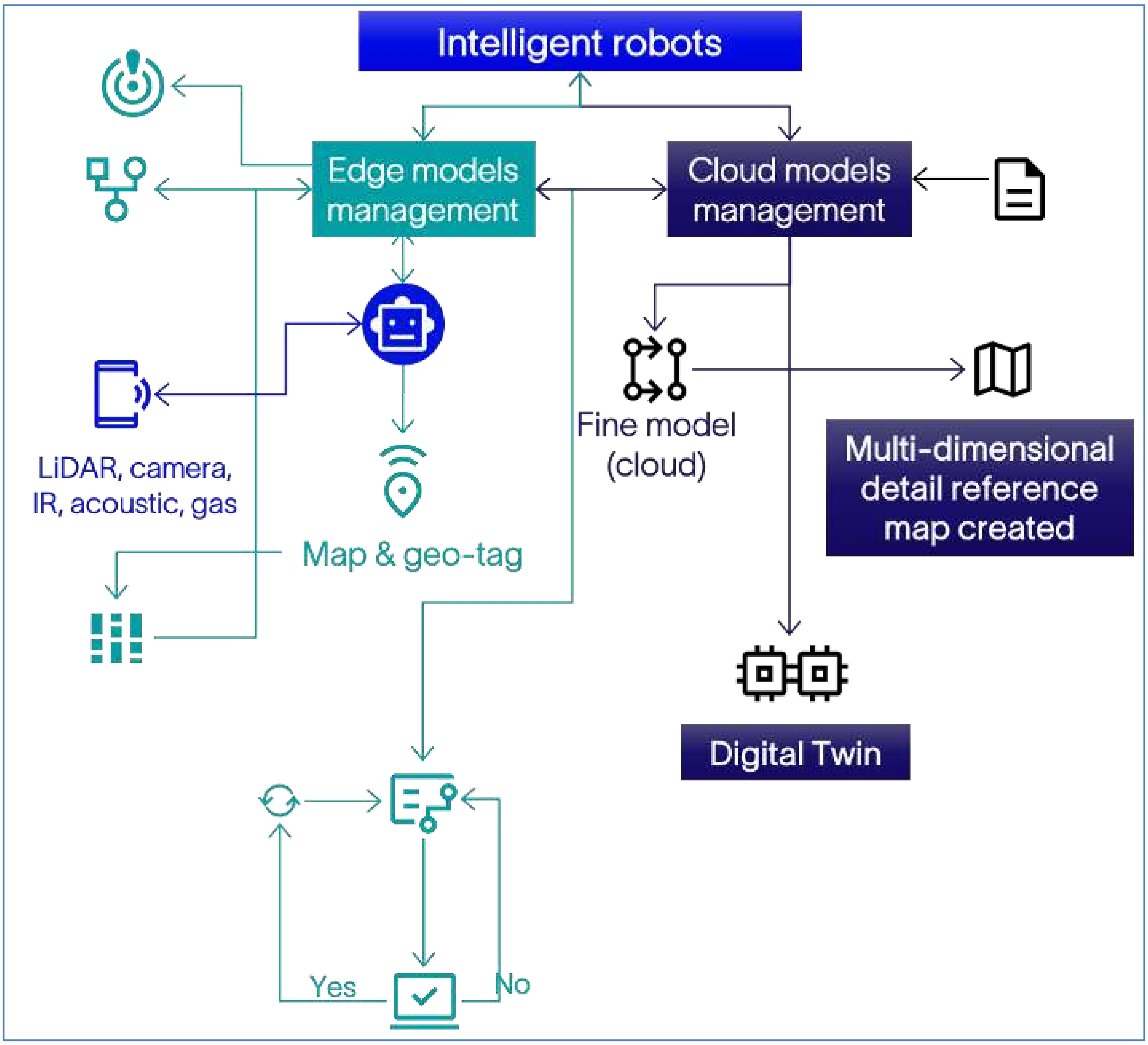


Annex C Predictive Safety App Wireframe





Annex D Autonomous Robot Workflow



BIBLIOGRAPHIES

[1] M. Ghosh et A. Thirugnanam, Introduction to Artificial Intelligence, Springer Science and Business Media Deutschland GmbH, 2021.

[2] R. S. Sutton et A. G. Barto, Reinforcement Learning: An Introduction Second edition., A Bradford Book, 2018, p. 552.

[3] I. Goodfellow, Y. Bengio et A. Courville, Deep Learning, MIT Press, 2016.

[4] M. M. Mijwel, History of Artificial Intelligence, 2015.

[5] I. J. Goodfellow, J. Shlens et C. Szegedy, Explaining and Harnessing Adversarial Examples., 2024.

[6] E. Moch, «The Industrial Revolution of Artificial Intelligence: A New Era of Automation and Innovation,» vol. 8, p. 8, 12 2023.

[7] A. Musa, «Review Paper Revolutionizing Oil and Gas Industries with Artificial Intelligence Technology,» *International Journal of Computer Sciences and Engineering,* vol. 11, pp. 20-30, 2023.

[8] Z. C. Lipton, «The mythos of model interpretability,» vol. 61, pp. 96-100, 10 2016.

[9] V. C. Müller, «Ethics of Artificial Intelligence and Robotics,» vol. 2020, p. 31, 04 2020.

[10] International Energy Agency, «Key world energy statistics,» *IEA Reports ,* p. 1, 2021.

[11] companiesmarketcap, «Largest oil and gas companies by market cap,» *Companies market cap,* p. 1, 2023.

[12] A. Hassan, «Review of the global oil and gas industry: a concise journey from ancient time to modern world,» *Petroleum Technology Development Journal,* pp. 127-128, 2013.

[13] EPA , «Coalbed Methane Outreach Program: Promoting Coal Mine Methane Recovery and Use,» *Coalbed Methane Outreach Program ,* p. 1, 2011.

[14] API, «Definition of Upstream Company and description,» *Wayback Machine,* p. 1, 2011.

[15] IOGP, «IOGP Safety performance indicators - 2022 data,» *IOGP Report,* pp. 10-13, 2022.

[16] R. G. B. a. J. M. Yarus, «Applied Hydrocarbon Thermodynamics: Volume 1: Fundamental Concepts,» *CRC Press,* 2020.

[17] A. K. C. a. S. Maurya, «Artificial Intelligence in the Oil and Gas Industry: A Comprehensive Review,» *Journal of Petroleum Science and Engineering,* 2021.

[18] J. F. G. a. D. R. Bonilla, «AI and Data-Driven Solutions for Reservoir Management: Opportunities and Challenges,» *Society of Petroleum Engineers Journal,* 2022.

[19] I. A. A. a. S. U. R. A. H. M. Hamid, «A Review of AI Applications in Safety Management in the Oil and Gas Industry,» *Safety Science,* 2021.

[20] K. H. D. Tang, «Artificial Intelligence in Occupational Health and Safety Risk Management of Construction, Mining, and Oil and Gas Sectors: Advances and Prospects,» vol. 26, n° %16, pp. 241-253, Journal of Engineering Research and Reports.

[21] 2023 Annual Report, «2023 Annual Report Form (10-k),» *U.S. Securities and Exchange Commission,* 2024.

[22] D. Wethe, « Schlumberger Fourth-Quarter Profit Rises as Drilling Booms,» *Bloomberg News,* 2012.

[23] « About Celsius Energy Geothermal Building Heating Solutions,» *Celsius Energy ,* 2022.

[24] Abbott et Dean., «Applied Predictive Analytics: Principles and Techniques for the Professional Data Analyst,» 14 04 2014.

[25] Bari, C. Anasse, J. Mohamed et Tommy., «Predictive Analytics For Dummies,» p. 360, 2014.

[26] D. Pyle, D. D. Cerra et M. Kaufmann, «Data Preparation for Data Mining,» Morgan Kaufmann Publishers Inc, San Francisco, 1999.

[27] M. Bishop et Christopher, «Pattern Recognition and,» 2006.

[28] Companies Market, «Largest oil and gas companies by market cap,» *Global Ranking* , 2023.

ملـخـص:

في هذه المذكرة نقوم بفحص كيفية تأثير الذكاء الاصطناعي على السلامة الصناعية في قطاع النفط والغاز. نصف أحدث التطورات في تطوير الأدوات القائمة على الذكاء الاصطناعي وتأثيرها على عمليات الصناعة التي تسرع وتقلل من المخاطر، بناءً على تحليل إمكانات تطبيق الذكاء الاصطناعي ومراجعة الاستخدامات الحالية. نبحث في أحدث التقنيات التي نفذتها إحدى أكبر الشركات في خدمات النفط والغاز، وهي شركة SLB. كما نناقش المشكلات المتعلقة بالبيانات والأفراد وأشكال التعاون الجديدة التي تعيق الاستخدام الواسع للذكاء الاصطناعي في قطاع النفط والغاز. ونقدم أيضًا كيفية تأثير الذكاء الاصطناعي على مستقبل الصحة والسلامة والبيئة الصناعية في السنوات القليلة القادمة.

كلمـات مفتاحيـــة: الذكاء الاصطناعي، ، التنبؤ،التعلم الألي، شركات البترول والغاز

Résumé :

Dans cette mémoire nous examinons comment l'intelligence artificielle impacte la sécurité industrielle dans le secteur du pétrole et du gaz. Nous décrivons les développements les plus récents dans le développement d'outils basés sur l'IA et leur impact sur les processus industriels qui accélèrent et réduisent les risques, en nous basant sur une analyse du potentiel d'application de l'IA et une revue des utilisations actuelles. Nous examinons les technologies les plus récentes mises en œuvre par l'une des plus grandes entreprises de services pétroliers et gaziers, SLB. Nous abordons également les problèmes liés aux données, aux personnes et aux nouvelles formes de coopération qui entravent l'adoption généralisée de l'intelligence artificielle dans le secteur du pétrole et du gaz. Nous présentons également comment l'intelligence artificielle pourrait impacter l'avenir de la SSE industrielle dans les prochaines années.

Mots-clés: Intelligence Artificielle, Santé, Sécurité et Environnement, Sécurité Industrielle, Pétrole et Gaz.

Abstract:

In this dissertation we examine how Artificial Intelligence impacts the industrial safety in the oil and gas sector . We describe the most recent developments in AI-based tool development and their impact on industry processes that accelerate and de-risk, based on an analysis of AI application potential and a review of current uses. We look into newest technologies implemented by one of the largest companies in the oil and gas services, SLB. We also go over the issues with data, people, and new kinds of cooperation that hinder the widespread use of artificial intelligence in the oil and gas sector. We also present how artificial intelligence may impact the future of industrial HSE within the next few years.

Key Words : AI, predictive safety analytics, forecast, machine learning, oil and gas industry.