HUB TECH IA

Deliverable report 32

AI and IAGEN Application Use Case

Advanced Drilling Trajectory Optimization Using Artificial Intelligence in Vaca Muerta

I. Introduction

- **The Strategic Significance of Vaca Muerta**

  Vaca Muerta is known worldwide for its vast hydrocarbon reserves. unconventional, occupying second place in gas reserves and fourth place in unconventional oil reserves with 16.2 billion barrels. This Magnitude underscores Vaca Muerta's potential to transform self-sufficiency Argentina's energy sector and strengthen its position in the energy landscape international. The vastness of these reserves attracts significant investment and requires the implementation of highly efficient extraction methodologies to maximize their intrinsic value.

- **The Evolution of Drilling Challenges and the Need for Optimization**

  The Vaca Muerta formation presents a geological and stratigraphic complexity remarkable. This intrinsic complexity makes precise drilling difficult and underlines the need for technologies capable of adapting to the diverse conditions of the subsoil. The heterogeneous nature of the formation requires methods sophisticated to identify and access hydrocarbon-rich areas.

  Specific challenges have been encountered during drilling, such as high pore pressure and a resistant lithology, which generates operational complexities and well abandonment. These obstacles directly impact the efficiency and performance of drilling costs, making real-time adjustment capabilities

and prediction of artificial intelligence are extremely valuable. The high Abandonment rates and operational difficulties highlight the limitations of the traditional methods and the potential of artificial intelligence to mitigate these issues.

Directional drilling has established itself as a key technique for accessing efficiently to the formations in Vaca Muerta. This technique is essential to maximize contact with the reservoir, but its effectiveness depends largely measure of precise trajectory control. The ability to drill horizontally and at angles significantly increases the accessible resource, but requires advanced guidance to achieve optimal results.

II. Real-Time Data Acquisition and Analysis

Sensors installed on the drilling rig collect a variety of data crucial factors, including pressure, resistance encountered during drilling, information on the geological formations crossed and the speed of penetration. This diversity of sensor data provides a comprehensive view of the subsurface environment, allowing for more informed decisions based on the Artificial intelligence. Each data point offers unique insights into the process of drilling and the surrounding geology.

Artificial intelligence models filter, process and analyze this information into real-time to identify patterns and anomalies. This real-time analysis capability real time is essential to make timely adjustments to the drilling path. speed and efficiency of artificial intelligence in processing large data sets are far superior to manual methods.

The effectiveness of artificial intelligence depends largely on the quality of the data. data and overcoming the challenges associated with data sources fragmented and legacy systems. The quality and accessibility of the data that uses artificial intelligence are paramount to its performance. Addressing the data management issues is a fundamental prerequisite for a

successful implementation of artificial intelligence.

Today, there are even greater opportunities for optimization by applying,
Additionally, models based on Generative AI, as will be seen later.
Generative Artificial Intelligence (GENAI) is a branch of artificial intelligence that is
focuses on creating new content, such as models, images, code or text,
from existing data. This technology uses advanced algorithms to analyze
large amounts of information, identify patterns and generate new content and
original that is often indistinguishable from that created by humans.

Dynamic Trajectory Adjustment and Autonomous Geo-steering:

Artificial intelligence recalibrates the drilling path based on variations
unexpected in geological formations detected in real time. This ability
Adaptive allows for drilling optimization even in the face of uncertainty
Geological. Real-time adjustments ensure the well remains within the
target area and avoid possible obstacles.
Autonomous geo-steering technologies, such as SLB's Neuro™ and iCruise®
Halliburton, play a critical role in guiding the drill bit through
from the area of greatest productivity of the deposit without human intervention. The
Autonomous geo-steering represents a significant advance in technology
drilling, improving accuracy and efficiency. These systems use the
artificial intelligence to interpret downhole measurements and make
immediate management decisions.

These systems offer notable benefits, including improved well placement,
a higher rate of penetration (ROP) and a reduction in downlinks.
These benefits translate directly into cost and time savings.
faster drilling. More efficient drilling reduces operating costs and
accelerates project timelines.

III. Application of agents powered by Generative AI in the activity

IV. **Concept of IAGEN agents**

In recent years, generative artificial intelligence (GAI) has revolutionized the way we interact with technology, enabling the development of systems capable of generating content, answering complex questions and assisting with tasks high-demand cognitive skills. From this capacity, a new architecture emerges Technological: IAGen-powered agents. These agents are not simple conversational interfaces, but autonomous systems that can interpret instructions, make decisions, execute tasks and learn from their interactions with the around.

An IAGen agent combines large language models with components additional features such as external tools, memory, planning and autonomous execution. This allows them to operate in complex environments, with the ability to break down objectives in steps, coordinate multiple actions, interact with digital systems (such as databases, APIs or documents) and adapt to context changes in real time. These qualities distinguish them from traditional chatbots, and open a spectrum of more sophisticated and customizable applications.

At the organizational level, these agents are being used to automate processes, generate data analysis, assist in decision making and improve the user experience, both internally and externally. For example, they can assume human resources, legal, financial or logistical tasks, and even those linked to the technical areas of production processes, acting as intelligent assistants that collaborate with human teams. This ability to integrate knowledge and execute tasks autonomously transforms the way organizations can scale your operations without losing quality or control.

In addition, agentic workflows—structures where multiple agents collaborate with each other to solve complex problems—allow responsibilities to be distributed between different agent profiles, each with specific functions. This generates

Hybrid work environments where humans and agents coexist, optimizing times, costs, and results. The ability to connect agents with tools such as Google Drive, CRMs or document management platforms further expands its capabilities.

The development of IAGen-powered agents represents a crucial step towards a new era of intelligent automation.

Among the benefits of authentic workflows driven by business models generative artificial intelligence, the possibility of automating processes is found complete, end-to-end production systems, and even add value from the leveraging the skills of language models based on these technologies.

However, its implementation also poses technical, ethical and legal challenges, from responsible design to human oversight. Therefore, understanding your architecture, its operational logic and its potential impacts is fundamental to its effective and safe adoption in various professional contexts.

2. Agentic Workflow Design Proposal

- Detailed Description of the Agentic Workflow:
  - Data Collection: Various types of sensors are used, including downhole and surface sensors, to capture data with high frequency and in various formats such as time series data and logs of wells. The granularity and variety of the data collected are fundamental to the analysis of artificial intelligence. Data flows High-frequency sensors provide a near real-time view of the manufacturing process. drilling.
  - Initial Processing: Raw data undergoes cleaning steps, filtering and pre-processing to ensure quality before use by artificial intelligence models. Proper data preparation

It is a crucial step to train and implement intelligence models
artificial effectiveness. Eliminating noise and inconsistencies from data
improves the accuracy of artificial intelligence predictions.

- Optimal Trajectory Generation: Artificial intelligence algorithms, such as Recurrent Neural Networks (RNNs) or Transformers, use
the data processed to predict the most efficient drilling route and
productive, considering the geological restrictions and the characteristics of the
deposit. The artificial intelligence model leverages its training with
historical data to identify optimal drilling strategies. The
The objective of the model is to maximize contact with the reservoir and minimize the
drilling risks.
- Adjustment and Simulation: The generated trajectory is simulated in a virtual environment (digital twin) to test its feasibility and possible results before its implementation.
execution in the real world. Simulation allows for risk assessment and
trajectory optimization in a safe and cost-effective manner. The tests
Virtual tests can identify potential problems and allow adjustments before
the actual drilling.
- Execution and Monitoring: The artificial intelligence system guides the team of drilling in real time, making autonomous adjustments based on the
continuous feedback of data. Autonomous control improves the
precision and responsiveness during the drilling process. The
Artificial intelligence acts as a co-pilot in real time, optimizing
constantly monitor drilling parameters.
- Reporting and Learning: Drilling process data is stored,
analyze and use to refine artificial intelligence models for future
drilling operations, creating a continuous learning cycle. This
feedback mechanism allows the intelligence system
artificial improve its performance over time. Each drilling operation
provides valuable data to improve the accuracy and effectiveness of the

artificial intelligence.

V. Concrete Opportunities, Quantifiable Benefits and Strategic Advantages

- **Greater Efficiency and Reduction of Operating Costs:**

  Artificial intelligence can achieve a reduction in drilling time up to 25%. Shorter drilling times translate directly in lower platform costs and faster production time. The Reducing drilling time minimizes overhead costs associated with the construction of the well.

  A reduction of up to 30% in operating expenses can be achieved due to to the optimization of the use of tools and resources. Artificial intelligence can help optimize drilling parameters and selection of tools, leading to significant cost savings. Efficient utilization of resources minimizes waste and reduces overall operating costs.

- **Safety Improvement and Risk Mitigation:**

  Artificial intelligence helps avoid previously unstable geological zones identified through real-time data analysis. The identification and Proactive avoidance of hazardous areas improves the safety of operations drilling. By predicting potential risks, artificial intelligence can help prevent accidents and damage to equipment.

  Autonomous systems minimize human intervention in environments dangerous, which reduces operational risks. Automation reduces the personnel exposure to potentially hazardous tasks. Operations remote and robotic systems can perform high-risk activities.

  Predictive maintenance powered by artificial intelligence can prevent equipment failures and reduce the risk of accidents. Proactive maintenance ensures the reliability of critical equipment and minimizes the likelihood of Security incidents. Predicting and resolving equipment problems before they occur are crucial for safety and operational continuity.

Artificial intelligence can detect anomalies and potential hazards in real time. real, allowing for timely interventions. Early detection of security issues allows for rapid corrective action. Monitoring and Continuous analysis of operational data can identify deviations from the normal conditions.

- **Strategic Competitive Advantage:**

Early adoption of IAGEN can give companies an advantage significant competitiveness in the exploitation of unconventional resources in Vaca Dead. Being at the forefront of technological innovation can lead to market leadership and increased profitability. Companies that adopt Advanced technologies early can achieve greater efficiency and lower costs compared to its competitors.

The potential increase in production, reduction of costs and improvement of the Security can translate into greater profitability and market share [11].

These operational advantages directly impact a company's results and its market position. Greater efficiency and lower costs make a company to be more competitive in the market.

The market for artificial intelligence in the oil and gas sector is in growth, indicating a trend towards adoption by companies pioneers can capitalize on the growing investment in artificial intelligence by part of the industry points to its growing importance and potential for future impact.

Alignment with industry trends and technology adoption promising can position a company for long-term success.

VI. **Comparison with Traditional Methods: A Detailed Analysis**

Comparison of Traditional Methods vs. IAGEN.

Parameter	Traditional Method	IAGEN
Decision making	Based on experience, static data	Based on analysis of real-time data, predictive modeling
Trajectory Settings	Manuals and reagents, based in the operator intervention	Automated and proactive, based on AI algorithms
Drilling Accuracy	Average, prone to human errors and geological uncertainty	High, leveraging data in real time and direction autonomous
Operating Costs	High due to inefficiencies and potential of errors	Reduced due to drilling time optimized, utilization of resources and fewer failures of equipment
Efficiency (ROP)	Lower, limited by manual settings and static planning	Superior, driven by time optimization real and autonomous control
Security	It depends largely of procedures manuals and experience	Improved through analysis predictive, hazard avoidance and

	of the operator	reduction of the human intervention in risky tasks
Environmental Impact	Potentially greater due to inefficiencies and lower precision in the targeting	Potentially minor due to optimized use of resources, less drilling time and better placement of the well
Adaptability to Geological Variations	Limited, the settings are reactive and can be slow	Highly adaptable, the real-time analysis allows settings dynamic

VII. Overcoming Implementation Challenges and Navigating the Landscape Regulatory

- Building a Robust Data Infrastructure and Quality Assurance the Data:

The necessary investments in sensors and acquisition systems must be detailed. data and secure data storage solutions. An infrastructure of Solid data is the foundation for effective artificial intelligence applications. A Reliable and complete data collection is essential for training and operating artificial intelligence models.

The challenges of integrating artificial intelligence with the outdated infrastructure and legacy systems prevalent in the industry of oil and gas. Compatibility issues can pose obstacles

significant for the implementation of artificial intelligence. A careful planning and strategic integration to overcome these challenges. Data quality, including accuracy, completeness and consistency, plays a key role. a fundamental role in the reliability of artificial intelligence models. The "garbage in, garbage out" principle applies to artificial intelligence, which makes data quality paramount. Investing in cleaning and data validation is essential.

Strategies for data management, including governance, should be mentioned. of data, standardization and elimination of data silos. A data management Effective data management ensures that AI models have access to the right data at the right time. Centralized data platforms and clear data governance policies can facilitate the implementation of artificial intelligence.

- Short-term investment in AI agent implementation teams

  Technology and training: Investment in proof of concept and testing is required pilot. The focus here has to be on training the talent to implement, since There is a trend towards cost reduction in systems that allow "no code" and "low code" automation. For the first stage, we also recommends using teams with experience in design and implementation AI agents. Finally, it is key to form an in-house team for the accompaniment and appropriation of an agentic culture that redefines the human-computer interaction.

- Navigating Environmental and Safety Regulations in Argentina:

  An overview of environmental regulations must be provided relevant in Argentina, particularly those specific to Vaca Muerta and unconventional drilling (e.g., Decree 1483). Understanding and complying with local regulations is essential for operating in Vaca Muerta. These Regulations govern aspects such as water use, waste disposal and environmental impact assessments.

How artificial intelligence can help in monitoring should be discussed. environmental, emissions monitoring and regulatory compliance. The Artificial intelligence can automate environmental monitoring and identify potential compliance issues. Real-time data analysis and Predictive modeling can help companies stay within the regulatory limits.

VIII. Conclusion

Artificial intelligence applied to the optimization of drilling trajectories in the Vaca Muerta's challenging environment presents significant transformative potential. Key benefits, including increased efficiency, reduced costs, safety improved and a strategic competitive advantage, are compelling. While there are implementation challenges, appropriate strategies can mitigate these Obstacles. The adoption of artificial intelligence is presented as an imperative strategic for companies seeking success in the energy landscape in evolution. The continued advancement and impact of artificial intelligence on the industry Oil and gas are undeniable, and Vaca Muerta is positioned as a key region. for its application.

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