Journal of Excellence for Economics and Management Research
ISSN 2572-0171
Vol 08, N° 02 : (2024)
P 258 - 278

مجلة الامتياز لبحوث الاقتصاد والإدارة
ISSN 2572-0171
المجلد 08، العدد: 02 (2024)،
ص 258- 278

Transforming Oil and Gas Operations with GIS: Insights from the Sonatrach SOD Project

Rachid Yassine AKKOUCHE [1(*)], Kamel Boussafi [2]

[1]Doctoral Student, at Ecole Supérieure de Commerce, Kolea, Algeria
✉ r_akkouche@esc-alger.dz
ORCID https://orcid.org/0009-0000-1450-2763
[2] Professor at Ecole Supérieure de Commerce, Kolea, Algeria
✉ k_boussafi@esc-alger.dz
ORCID https://orcid.org/0000-0002-2719-7048

Received: 19/9/2024 **Accepted**: 1/12/2024 **Published**: 16/12/2024

Abstract: *This study examines the implementation and impact of Geographic Information Systems (GIS) in the oil and gas industry, focusing on the Smart Oil Data (SOD) project at Sonatrach, Algeria's national Oil and Gas company. As the energy sector undergoes rapid digital transformation, GIS has emerged as a tool for optimizing operations, enhancing decision-making, and addressing environmental concerns. The research employs a case study approach to analyze Sonatrach's experience with SOD, an integrated GIS solution built on ESRI's platform. The study investigates how GIS technologies are applied across the upstream, midstream, and downstream segments, and in Health, Safety, and Environment management. It also explores the challenges of implementing such a system, including data standardization, organizational change management, and integrating innovation and renewable energy initiatives. Findings show that the SOD project significantly improved Sonatrach's operational efficiency, data management, and strategic planning. However, the implementation underscored the need for robust change management strategies and continuous innovation.*

Keywords: Geographic Information Systems (GIS), Oil and Gas Industry, Digital Transformation, National Oil Companies, Smart Oil Data (SOD)
JEL Classification Codes : M15 ; O33

* *Corresponding Author.*

Doi: https://doi.org/10.34118/jeemr.v8i2.4048

Journal of Excellence for Economics and Management Research
ISSN 2572-0171
Vol 08, N° 02 : (2024)
P 258 - 278

مجلة الامتياز لبحوث الاقتصاد والإدارة
ISSN 2572-0171
المجلد 08، العدد: 02 (2024)،
ص 258- 278

تحويل عمليات النفط والغاز باستخدام نظم المعلومات الجغرافية: رؤى من مشروع SOD بسوناطراك

عكوش رشيد ياسين [1] (*)، بوصافي كمال [2]

[1] طالب دكتوراه، المدرسة العليا للتجارة
r_akkouche@esc-alger.dz
https://orcid.org/0009-0000-1450-2763
[2] بروفيسور ، المدرسة العليا للتجارة
k_boussafi@esc-alger.dz
https://orcid.org/0000-0002-2719-7048

تاريخ الاستلام: 2024-09-19 **تاريخ القبول:** 2024-12-01 **تاريخ النشر:** 2024-12-16

ملخص: تبحث هذه الدراسة في تنفيذ وتأثير نظم المعلومات الجغرافية (*GIS*) في صناعة النفط والغاز، مع التركيز على مشروع البيانات الذكية للنفط (*SOD*) في شركة سوناطراك، وهي الشركة الوطنية الجزائرية للمحروقات. في ظل التحول الرقمي السريع الذي يشهده قطاع الطاقة، برزت نظم المعلومات الجغرافية كأداة لتحسين العمليات، وتعزيز اتخاذ القرار، ومعالجة القضايا البيئية. تعتمد الدراسة على منهج دراسة الحالة لتحليل تجربة سوناطراك مع مشروع *SOD*، وهو حل متكامل لنظم المعلومات الجغرافية مبني على منصة *ESRI* . تبحث الدراسة في كيفية تطبيق تقنيات نظم المعلومات الجغرافية عبر قطاعات المنبع، الوسط، والمصب، وكذلك في إدارة الصحة والسلامة والبيئة. كما تستكشف التحديات المتعلقة بتنفيذ هذا النظام، بما في ذلك توحيد البيانات، إدارة التغيير التنظيمي، ودمج الابتكار ومبادرات الطاقة المتجددة. أظهرت النتائج أن مشروع *SOD* حسّن بشكل كبير من كفاءة العمليات وإدارة البيانات والتخطيط الاستراتيجي في سوناطراك. ومع ذلك، أكد التنفيذ على الحاجة إلى استراتيجيات قوية لإدارة التغيير والابتكار المستمر.

الكلمات المفتاحية: نظم المعلومات الجغرافية؛ صناعة النفط والغاز ؛ التحول الرقمي؛ الشركات النفطية الوطنية؛ بيانات النفط الذكية.

تصنيف JEL : M15 ؛ O33

(*) المؤلف المرسل

المعرف الرقمي للمقال (doi): https://doi.org/10.34118/jeemr.v8i2.4048

1. INTRODUCTION

In an era characterized by rapid technological advancement and increasing environmental concerns, the oil and gas industry faces critical challenges across its complex value chain. This chain encompasses upstream ***(exploration and extraction)***, midstream ***(transportation)***, and downstream ***(refining, processing, and distribution)*** operations **(Gülen, 2016)**. The industry confronts multiple challenges, including declining accessible reserves **(Ighosewe, 2021)**, volatile market conditions **(Mensi et al., 2021)**, stricter environmental regulations, and climate change mitigation efforts **(Vormedal, 2021)**. Additionally, the need for digital transformation aligned with Industry 4.0 principles necessitates a fundamental overhaul of operations **(Wanasinghe et al., 2019; Maroufkhani et al., 2022; Haouel & Nemeslaki, 2024)**.

Geographic Information Systems (GIS) have emerged as a crucial component of digital transformation across various sectors, including agriculture **(Kotsur et al., 2019)**, water management **(Bindler et al., 2022)**, and energy **(Avtar et al., 2019; Shorabeh et al., 2022)**. The oil and gas industry, standing at the threshold of a new energy era, is poised to leverage GIS technology to address its challenges and opportunities. Sonatrach's Smart Oil Data (SOD) project exemplifies this trend, offering insights into the transformative potential of GIS in the oil and gas sector.

This study examines the implementation of the SOD project at Sonatrach, Algeria's national oil company. Built on ESRI's GIS platform, SOD represents an innovative approach to harnessing spatial intelligence across the oil and gas value chain. By analyzing Sonatrach's experience, this research aims to contribute to the growing body of knowledge on digital transformation in the energy industry, with a particular focus on the challenges and opportunities faced by national oil companies in North Africa.

The objectives of this study are:

1. To analyze the development and implementation of the SOD system across Sonatrach's operations.
2. To evaluate the impact of this integrated GIS solution on operational efficiency, decision-making processes, and overall organizational performance.
3. To identify key lessons and best practices that can inform similar initiatives in other national oil companies, particularly in the North African region.

This research addresses several key questions:

1. How does an integrated GIS solution impact operations across the upstream, midstream, and downstream segments of the oil and gas industry?
2. What are the main challenges in implementing a comprehensive GIS system within a national oil company?
3. What recommendations can be drawn from Sonatrach's experience to inform similar initiatives in other national oil companies?

Through a detailed analysis of the SOD project, this paper offers insights into the practical applications of GIS in the oil and gas sector. It examines the project's role within Sonatrach's integrated value chain and its position in the company's broader 2030 transformation strategy. The study explores the project's implementation steps, challenges faced, organizational changes required for successful implementation, and the potential for such systems in the industry.

By addressing these objectives and questions, this study contributes to the growing body of knowledge on digital transformation in the oil and gas sector, with a specific focus on the role of integrated GIS solutions in driving operational excellence and strategic decision-making in national oil companies.

2. Literature review

Geographic Information Systems (GIS) have revolutionized the way spatial data is analyzed and visualized across various industries. **Kumar et al. (2023)** define GIS as a software system that uses digital maps and information to analyze and visualize real-world features. The evolution of GIS, as described by **McHaffie et al. (2023)**, has progressed from manual map-making to complex digital systems utilizing satellite data. This development has significantly enhanced our understanding of spatial relationships between people, environments, economies, and cultures.

At its core, GIS operates on two fundamental data types: spatial data, which defines where things are (such as addresses), and attribute data, which provides details about them (like building type or population) **(Kumar et al., 2023 pp 63-75)**. This dual nature of GIS data enables a wide range of applications across multiple sectors, including healthcare **(Akindote et al., 2023)**, disaster management **(Cao et al., 2023)**, planning and managing natural resources **(Deane, 1994; Kumar et al., 2015; Kong et al., 2023)**, and energy **(Rekik & El Alimi, 2023; Zinovieva et al., 2023)**.

In the oil and gas industry, GIS has emerged as a critical tool for decision-making and operational efficiency. **Abdalla (2024, pp 3-12)** highlights its role in enabling effective and collaborative data sharing for emergency preparedness, risk mitigation, and resource allocation optimization. **Escobar et al. (2022)** note its capability for remote identification and response to incidents. **Wade & Artz (2023)** identify three primary advantages of GIS implementation in this industry: Operational efficiency through process optimization and cost reduction; Improved decision-making by leveraging data insights across the value chain; and Enhanced sustainability by minimizing environmental impact and supporting responsible practices.

Table 1. GIS Applications in the Oil & Gas Industry sectors

Area	Impact
Upstream	- Analyzing vast amounts of data for informed exploration and investment decisions. - Designing and optimizing well placement and infrastructure. - Tracking assets and personnel in real-time for safety and compliance. - Identifying suitable locations for carbon capture projects.
Midstream	- Gaining real-time visibility into the entire energy network for efficient operations. - Improving route planning, inspections, and compliance through location intelligence. - Optimizing shipping through predictive modeling.
Downstream	- Managing refinery operations, distribution networks, and retail outlets effectively. - Creating digital twins of assets for better monitoring and maintenance. - Identifying market opportunities by analyzing energy market data. - Optimize fuel delivery routes.
Health, Safety & Environment (HSE)	- Improving preparedness and response to emergencies through risk identification and planning. - Streamlining data collection and analysis for HSE processes, leading to safer operations. - Enhancing situational awareness and communication during emergencies. - Integrate biodiversity conservation into decision-making for a sustainable future. - Track and report carbon emissions for sustainability goals

Source: Adapted from Wade & Artz (2023, pp 98-104)

The impact of GIS spans the entire oil and gas value chain, from upstream to downstream operations, as well as in health, safety, and environmental (HSE) management (See Table 1).

In the upstream sector, GIS is employed to integrate diverse exploration data based on geographical location **(Xu et al., 2012)**. It also facilitates the creation of comprehensive databases containing both static and dynamic information on major oil and gas fields **(Odintsova et al., 2018)**. Furthermore, GIS is instrumental in data integration, analysis, modeling, and interpretation for facility planning, reservoir modeling, and carbon sequestration **(Kumar, 2009)**. Additionally, GIS is used to optimize exploratory drilling site selection **(Turenko et al., 2020)** and enhance production processes, operations, and management within oil and gas companies **(Wang, 2022)**.

In midstream operations, **Abudu & Williams (2015)** and **Gyabeng & Bernard (2020)** illustrate GIS's role in finding optimal routes for oil and gas pipelines and analyzing land use, water contamination, and finding response to spills. **Balogun et al. (2017)** focus on its application in optimizing subsea oil pipeline routes. **Eljabri & Gallagher (2012)** demonstrate its use in preventing risks and assessing environmental impacts through oil spill monitoring and identification. **Narimisa & Narimisa (2015)** explore how GIS aids in detecting surrounding vegetation, pollutants released, and potential consequences of technical problems. **Ibanga (2021)** discusses its role in understanding oil spill patterns and planning effective responses to minimize environmental damage and protect communities.

Downstream applications of GIS are equally significant. **Igbokwe et al. (2022)** show how it's used to analyze factors for identifying potential areas for refineries and petrochemical plants. **Danesh et al. (2021)** focus on its role in assessing toxic and hazardous wastes of industrial units. **Rovira et al. (2021)** explore its use in evaluating environmental impact and public health risks associated with chemical/petrochemical facilities. **Yahya & Safian (2022)** and **Idhoko et al. (2024)** demonstrate its application in analyzing the location and distribution of existing petrol stations and their proximity to features like roads and health facilities. **Meza et al. (2024)** discuss its role in identifying market players, while **Inye & Hamilton (2022)** highlight how GIS-enabled competitor intelligence contributes to organizational resilience in Nigerian oil and gas firms.

Table 2. Esri GIS: Tailored Solutions for Oil & Gas

Category	Role	Fields	Products
Upstream	Real-time understanding, streamlined operations	Exploration, Land Management, Production, Operations, Unconventional Resources, Carbon Capture Technologies	Field Operations, Imagery and Remote Sensing
Midstream	Visualization, Operational Awareness, Responsiveness	Pipeline, Trucking, Shipping	Asset Tracking and Analysis, Field Operations, Gas and Pipeline Data Management
Downstream	Manage refinery operations, improve distribution networks, increase returns, grow retail networks	Refining and Chemicals, Supply and Trading, Retail	Field Operations, 3D GIS, Data Management
HSE	Predictive Analytics, Smart Maps and Dashboards	Health and Safety, Environment and Biodiversity, Net-Zero Carbon Emissions, Corporate Social Responsibility (CSR), Emergency Response	Imagery and Remote Sensing, Real-time Visualization and Analytics, ArcGIS Mission
Renewable	Researching, developing,	Wind, Solar, Hydrogen and	Spatial analysis and data

Energy	and deploying technologies for efficient and cleaner energy	Geothermal	science, ArcGIS Insights, ArcGIS Enterprise
Technology and innovation	Driving cost efficiencies, enabling safer operations, providing new revenue opportunities, changing business models	Digital transformation location, Intelligent operations, Robotics, Research and development	ArcGIS Enterprise, ArcGIS Velocity and ArcGIS Image

Source: Adapted from Esri, (2024)

The comprehensive application of GIS in the oil and gas industry is exemplified by platforms like Esri's Oil & Gas GIS. This system provides powerful data analysis, visualization, and integration tools across upstream, midstream, downstream, HSE, renewable energy, and technology innovation sectors **(See Table 2)**. Recent studies have demonstrated its diverse applications, including gathering seismic data **(Breton et al., 2024)**, managing well information **(Wittenberger, 2021)**, estimating flaring from oilfields **(Zhang et al., 2021)**, assessing environmental risks posed by oil pipelines and installations **(Galalizadeh et al., 2020)**, analyzing pipeline data to avoid geological hazards **(Li et al., 2010; Yan et al., 2021)**, monitoring methane emissions from industrial facilities **(Odunsi, 2024)**, and evaluating oil and gas investment opportunities **(Abdulhameed et al., 2023)**.

These GIS platforms enable real-time monitoring, digital twin creation, and advanced analytics to optimize decision-making and improve operations. They support traditional oil and gas operations while also facilitating the transition to cleaner energy sources like wind, solar, and geothermal. Additionally, they aid in digital transformation efforts, driving cost efficiencies, enhancing safety, and opening new revenue opportunities **(See Table 2)**.

From exploration and production to distribution, retail, and renewable energy development, GIS solutions offer location-based intelligence to help Oil and Gas companies navigate complex challenges, streamline workflows, and drive sustainable growth in a rapidly evolving energy landscape **(Esri, 2024)**. As the industry continues to evolve, particularly with the transition towards cleaner energy sources, the role of GIS is likely to expand further, integrating with emerging technologies to address the complex challenges facing the oil and gas sector in an increasingly digital and environmentally conscious world.

While extensive research has been conducted on the application of GIS in various aspects of the oil and gas industry, a significant gap exists in the literature regarding comprehensive GIS implementation across the entire value chain of national oil companies, particularly in the context of broader digital transformation efforts. Existing studies primarily focus on GIS applications in specific operational areas such as exploration, production, or pipeline management. However, there is a notable lack of research on integrated systems that encompass multiple facets of operations, from upstream to downstream activities.

The present study aims to address this gap by examining Sonatrach's implementation of the Smart Oil Data (SOD) system, a comprehensive GIS solution that spans the company's entire value chain. By focusing on Sonatrach, Algeria's state-owned oil company and a major player in the global energy market, this research provides valuable insights into the process, challenges, and impacts of adopting an integrated GIS within a broader digital transformation strategy framework.

3. Methodology

A qualitative approach was employed for this case study. Document analysis was utilized as a primary research method due to its efficiency, cost-effectiveness, and unobtrusive nature. This method involves a systematic process of examining and interpreting written or visual documents to extract meaning and knowledge **(Bowen, 2009)**. Additionally, interviews were conducted to capture individuals' experiences and perspectives through interactive conversations **(Dursun, 2023)**.

The document analysis included two parts. The first part examined internal documents, such as the organization of the SOD project and the User Manuals of the GIS System Emergency Support Subsystem, which comprises 282 pages. The second part reviewed reports and published documents, including articles from the Sonatrach official website, the Sonatrach News revue, and annual reports from 2017 to 2022. Furthermore, reports from partners like Huawei (the cloud computing partner) and KLD (the integrator of SOD) were analyzed.

Semi-structured interviews, incorporating both pre-planned and spontaneous questions **(Dursun, 2023)**, were conducted between March and June 2024. The duration of these interviews varied between 10 and 20 minutes. The interviewees included the SOD project director, the PMO of the SOD project, a project PMO within the Coordination of Digital Structures overseeing the SOD project, and seven executives who are intended users of the software across four activities within Sonatrach's value chain. These activities encompass upstream (Exploration & Production - E&P), midstream (Pipeline Transportation - TRC), and downstream (Liquefaction and Separation - LQS and Refining and Petrochemicals - RPC). The commercialization activity is not yet included in most digital projects.

For data analysis, a qualitative content analysis was employed. This method is suitable for analyzing diverse data types, such as interviews, observations, and documents. The process involves deconstructing data into smaller units, identifying patterns (categories and themes), and interpreting their meanings **(Lindgren et al., 2020)**. Categories describe the surface level of the data, while themes reveal deeper underlying meanings **(Lindgren et al., 2020)**. The analysis process alternates between breaking down and recombining data to achieve a comprehensive understanding of the research topic **(Lindgren et al., 2020)**.

4. Sonatrach, an Oil & Gas in a broad transformation

Sonatrach, Algeria's national Oil & Gas company, specializes in the research, production, transportation, processing, and marketing of hydrocarbons **(Joradp, 1998)**. Founded in 1963 initially for transporting and marketing oil and gas, Sonatrach gradually expanded its operations to encompass the entire value chain **(Sonatrach, 2022)**. The nationalization of hydrocarbons in 1971 significantly strengthened its position **(Sonatrach, 2022)**. Today, Sonatrach is involved in all aspects of the oil and gas sector, including partnerships and investments in the energy sector, ensuring a reliable long-term supply of hydrocarbons for Algeria while exploring ventures in alternative energy sources. The company oversees 115 subsidiaries and participations, with 42 located abroad **(Sonatrach, 2022)**.

Sonatrach has undergone several restructurings. Now, its core activities encompass the entire hydrocarbon value chain. According to **Sonatrach, (2024)**, this includes:

- **Exploration and Production (E&P):** Encompasses prospecting, searching, exploring, developing, and exploiting oil and gas fields. This activity is conducted independently and through partnerships, adhering to the legal framework governing hydrocarbon activities and other relevant laws.

- **Pipeline Transportation (TRC):** Responsible for the operation, maintenance, and development of Algeria's 22,000 km pipeline network, transporting oil and natural gas from southern production hubs to northern demand centers and processing facilities for domestic supply and export.
- **Liquefaction and Separation (LQS):** Focuses on transforming hydrocarbons through natural gas liquefaction and separating liquefied petroleum gases (LPG) into by-products such as ethane, propane, butane, and gasoline.
- **Refining & Petrochemicals (RPC):** Manages refining and petrochemical production facilities to primarily meet the national market demand for petroleum products.
- **Marketing (COM):** Supplies the national market with petroleum and gas products and optimizes the international commercialization and valuation of hydrocarbons.

Additionally, Sonatrach supports its activities through a complex organization with various directorates handling specific tasks, including Transformation Planning (TRF), Communication Strategies (CMN), Long-Term Vision Development (SPE), Financial Management (FIN), Growth Opportunities (BDM), Human Resources (RHU), Procurement and Logistics (P&L), Resource Management (R&N), Major Project Execution (EPM), Legal Affairs (JUR), Digitalization Implementation (DSI), Safety and Environmental Well-being (HSE), and Research and Development (R&D). This comprehensive structure ensures Sonatrach remains a key player in the global energy sector, maintaining its commitment to innovation and sustainability **(Sonatrach, 2024)**.

Since 2017, Sonatrach is establishing its 2030 Transformation, also known as SH2030, a comprehensive strategic plan to propel the Algerian national oil and gas company into the top 5 of its kind globally by 2030 **(Sonatrach, 2017)**. Recognizing the shifting energy landscape and the challenges posed by depleting reserves, volatile oil prices, rising energy demands, talent renewal and environmental regulations, Sonatrach has embarked on this transformation since 2017. The transformation plan encompasses various initiatives across the entire value chain, from exploration and production to refining, petrochemicals, and marketing **(Sonatrach, 2017)**.

SH2030 tackles these challenges head-on through a multi-pronged approach. The plan prioritizes enhanced expertise and performance across all business segments. This encompasses optimizing operational efficiency and value creation in exploration and production, refining, petrochemicals, and marketing **(Sonatrach, 2017)**. Sustainable development is another cornerstone of the plan. Sonatrach aims to align its activities with Algeria's economic, social, and environmental goals, fostering a more responsible and sustainable future. Ultimately, achieving global competitiveness is a key objective **(Sonatrach, 2017)**. By leveraging its resource base and operational excellence, Sonatrach aspires to become a top contender in the international energy market **(Sonatrach, 2017)**.

Table 3 Illustrates key initiatives within Sonatrach’s transformation areas.

Table 3. SH2030 initiatives

Areas	Initiatives
Human Resources	- Attracting, developing, and retaining top talents - Revamping recruitment, career management, performance evaluation, and competency development processes. - Launching the "SONATRACH Management Academy" for employee training and leadership development.
Core Operations	- Setting more ambitious and measurable performance targets across all business units. - Establishing a central Engineering & Project Management department to oversee major projects. - Optimizing well productivity and implementing advanced technologies (IOR/EOR) to increase production. - Strengthening refining and petrochemical operations, including potential acquisitions and partnerships. - Developing offshore resources in the Mediterranean through international partnerships. - Reorienting gas exports to higher-value markets and expand international trading activities.
Digital	- (Will be discussed later).
Procurement and Logistics	- Establishing a central Procurement & Logistics department to develop strategies and reduce costs.
Energy Transition	- Initiating a transition towards renewable energy, particularly solar power, in preparation for the post-oil era.

Source: Adapted from Sonatrach (2017, pp 31-46)

The plan recognizes the importance of fostering a culture conducive to achieving its goals. A dedicated Transformation Directorate oversees the plan's implementation **(Sonatrach, 2017)**. This directorate is responsible for monitoring progress, identifying and addressing roadblocks, collaborating with project leaders, anticipating and mitigating risks, providing regular updates to leadership, communicating the vision and strategy across the organization, and resolving critical issues that could impede progress **(Sonatrach, 2017)**.

In conclusion, Sonatrach's 2030 Transformation represents a bold and necessary step for the Algerian national oil and gas company to remain competitive and sustainable in the evolving energy landscape. By embracing innovation, operational excellence, and a commitment to sustainability, Sonatrach is poised to secure its position as a leading global energy player in the years to come.

5. SOD within the Framework of Sonatrach’s Digital Transformation

Sonatrach's Digital Transformation is a strategic, enterprise-wide initiative to drive operational excellence and competitive gains by adopting advanced digital technologies **(Huawei, 2019)**. As part of the company's broader transformation roadmap for 2030 **(Sonatrach, 2019)**, the digital transformation program has two key focus areas:

1. **Establishing an ERP (SH One Project)**: Implementing an Enterprise Resource Planning system across all production sites to significantly improve management practices and competitiveness.
2. **Adopting Digital Tools**: Through deploying the Huawei Cloud Stack (HCS) - an enterprise-grade full-stack hybrid cloud solution that integrates existing IT resources, eliminates silos, enables unified resource management, on-demand provisioning

across multiple data centers and rapid service rollout.

According to **Sonatrach, (2019)**, other key digital initiatives include:

- CEOIII Solution for operational improvements
- Private Cloud Smart Oil & Gas Solution
- Geographic Information System (GIS)
- Innovation Center for digital innovation
- Facilities Management & Information Systems (FM & IS)
- Innovative big data service platforms for data-value mining and digital oilfield evolution

By embracing digital technologies, Sonatrach aims to realize transformative benefits such as integrated business oversight, accelerated decision-making, productivity gains, seamless communication and collaboration, reduced operational costs, risk mitigation through data integrity and financial control **(Sonatrach, 2022)**. Ultimately, the digital transformation positions Sonatrach as a catalytic force in the industry, driving performance excellence, agility, and sustainable competitive advantage.

Among digital initiatives, the Smart Oil Data (SOD) project is an initiative within Sonatrach's digital transformation strategy. It aims to establish a next-generation geographic information system (GIS) encompassing the entire value chain, from upstream exploration and production to pipeline transportation and downstream activities.

Through Standardizing and unifying spatial data, the primary objectives of the SOD project are:

- Enhanced risk management, particularly concerning environmental factors.
- Accelerated decision-making processes through improved data accessibility and analysis.
- Augmented security and safety protocols for Sonatrach's facilities.

Since its inception in 2018, the SOD project has undergone several organizational transitions. Initially under the Strategy, Planning and Economy Corporate Direction, it was subsequently transferred to the Central Direction of Digitalization and Information Systems (Appendix 1). Currently, the project is positioned within the Coordination of Digital Structures, under the direct management of a CEO advisor.

Table 4. The SOD organization

Role	Key Responsibilities
Project Director	- Oversees project team and organization - Ensures resources and contract compliance - Validates deliverables and reports to the CEO’s advisor - Facilitates communication and knowledge transfer.
Project Managers	- Plan and execute project work - Monitor service providers and approve technical changes - Ensure deliverables meet specifications - Report regularly to the Project Director.
Project Management Officer	- Support Project Director with daily tasks and processes - Develop project metrics and consolidate data - Assist in communication planning and administrative support.
Executive	- Assist Project Manager in all aspects - Ensure health and safety in project specs - Review deliverables and provide support.

Source: Adapted from Appendix 1

The SOD project employs a multi-tiered governance structure, typical of large-scale initiatives in the Oil & Gas sector. This structure is characterized by clearly defined roles, established communication channels, and strict adherence to project objectives (Table 4).

6. Characteristics and Subsystems Developed in SOD

SOD has emerged as a data management system addressing challenges related to aging infrastructure and the need for informed decision-making in risk mitigation. Initially considered non-essential due to technical limitations, SOD has demonstrated its importance by surpassing the functionalities of a conventional GIS, offering a platform for data integration and collaboration across various business units.

Implemented on Sonatrach's private cloud infrastructure, SOD leverages Esri's ArcGIS Enterprise, a GIS platform, ensuring scalability and facilitating future expansion. The system employs a decentralized user management approach, optimizing data access control by assigning permissions based on user roles. Key users can modify data for in-depth analysis, while super users manage access and configurations. End users can efficiently retrieve and visualize data relevant to their tasks.

SOD fosters a cohesive information system by integrating diverse data sources from across Sonatrach's operations. It connects to ProSource (an SLB software) to access well and seismic data used by the Exploration and Petroleum Engineering & Development (PED) divisions. Additionally, it integrates with Landmark (a Halliburton software) for real-time drilling data uploads. Integration with the Production Division's dashboard is already established, and future plans include incorporating more data from TRC and Downstream activities.

Key features of the SOD project include:

- **GIS Capabilities**: SOD supports essential GIS functions like positioning, spatial querying, feature identification, base map switching, and map and report printing.
- **Flexible Data Models**: The system features extendable data models designed to handle domain-specific technical data, ensuring adaptability for future expansions and compliance with industry standards.
- **Microservices Architecture**: Utilizing microservices technology, SOD facilitates efficient implementation of specific functions and workflows, allowing for streamlined system upgrades and maintenance.
- **Data Visualization**: SOD offers multiple data views, enhancing users' ability to analyze and interpret spatial information from various domains.
- **Integrated Data Management**: The system integrates crucial data, enabling management to swiftly review operational and production statuses, thus supporting informed decision-making and efficient daily operations.
- **Role-Based Access Control**: SOD employs role-based access control to manage user permissions, ensuring secure authorization, protecting sensitive information, and maintaining data integrity.

To enhance Sonatrach's Geographic Information System, SOD has engineered a suite of specialized subsystems to optimize various operational functions within the oil and gas sector. These subsystems are designed to integrate, providing comprehensive support for management. The key subsystems are:

1. **Centralized GIS:** Tailored for senior management, it offers an integrated overview of operational, and strategic planning data. It aggregates information from various domain-specific subsystems, facilitating data consolidation. This integration supports management in both daily operations and strategic decision-making by providing expeditious access to comprehensive operational status and business overviews.
2. **Exploration & Production (E&P) Subsystem:** This subsystem focuses on upstream activities, including exploration, drilling, and reservoir management. It integrates

diverse data sets from wells, seismic surveys, and geological formations. A distinguishing feature is its unique graphical user interface (GUI) that visualizes data through multiple representations such as hierarchical trees, grids, tables, gauges, curves, and charts.

3. **Pipeline Transportation (TRC) Subsystem:** Dedicated to managing the pipeline networks essential for product flow, this subsystem provides tools for monitoring and managing pipelines. Features include dynamic segmentation, pipeline profiling, and statistical analysis. Enhancing operational efficiency, it enables detailed analysis and visualization of pipeline data, including transportation logistics, leak detection, and event management, crucial for maintaining pipeline integrity and minimizing environmental risks.
4. **Liquefaction & Separation (LQS) and Refining & Petrochemical (RPC) Subsystem:** Supporting downstream operations, this subsystem covers liquefaction, refining, petrochemical processes, and associated logistics. It manages data related to refining and petrochemical facilities, pipelines, storage tanks, and transportation networks. Offering tabular and GIS displays of industrial zone entities, it visualizes production data using gauges, line charts, histograms, and grids.
5. **Authorization Subsystem:** Managing system access control to enhance security and data integrity, this component employs a role-based access control mechanism. It ensures that users can only access modules and functions pertinent to their roles, safeguarding sensitive information and ensuring compliance with access policies.
6. **Emergency Subsystem:** This subsystem manages emergency resources and incident responses, providing a comprehensive toolkit for emergency management. It includes statistical analysis, location display, and diffusion simulation capabilities. And is Supporting incident response and post-incident analysis.

Additionally, SOD offers a suite of data visualization tools:

- **Row View:** Presents data in a familiar tabular format for easy sorting and filtering.
- **GIS View (Location):** Offers a geographical representation of Sonatrach's assets and activities.
- **Form View (Hierarchical Exploration):** Enables users to explore data in a hierarchical manner using a parent-child query structure.

These subsystems collectively provide a framework for managing Sonatrach's operations through the integration of specialized tools and comprehensive data representations. This exemplifies how advanced information systems can be leveraged to address the complex challenges of the oil and gas industry, enabling sustainable and efficient operations

7. System implementation and challenges within SOD

Sonatrach's Smart Oil Data (SOD) project is structured in two distinct phases:

The initial phase, implemented in collaboration with a Chinese integrator (Richfit or KLD, a subsidiary of CNPC), focused on establishing a robust foundation for improved operational efficiency and decision-making. This phase prioritized standardized, non-automated data relevant to core business functions, with over 1,000 users trained on the system. The collected data has proven valuable for Exploration & Production (E&P) and Refining & Chemicals (TRC) activities, supporting technical research, pipeline risk assessments (including cutting and slope analysis), and identification of underperforming production sites.

The first phase implied two fundamental strategies:

- **Firstly,** it established a coherent foundation through reference frameworks. This involved geodetic reference standardization, aligning all spatial data with national standards set by the National Institute of Cartography and Remote Sensing, ensuring spatial data consistency across the organization. Additionally, a standardized site naming policy was implemented to eliminate ambiguity and streamline data management.

- **Secondly,** the project focused on unifying information for strategic decision-making. This involved comprehensive asset coverage, creating a unified information system encompassing diverse data types including seismic data, collection pipelines, transportation pipelines, and production facilities. Data integration across divisions, particularly between TRC pipelines and Production Division activities, was pivotal in consolidating disparate data sources into a single, cohesive system.

The second phase of the SOD project aims to expand its capabilities through strategic partnerships. This expansion focuses on two primary objectives: enhanced functionality and data comprehensiveness. Partnerships with the National Institute of Cartography and Remote Sensing (INCT), ESRI, and the Algerian Space Agency (ASAL) are expected to leverage their expertise in areas like environmental monitoring, integrating spatial variables such as discharges and emissions. Collaboration with ENAGEO, a Sonatrach subsidiary, grants access to the "Trail" database, ensuring the preservation of transported equipment data. Future partnerships with public environmental consulting firms are envisioned to integrate data on groundwater, archaeological sites, reserves, and urbanization surrounding Sonatrach's installations.

However, the implementation of SOD at Sonatrach encounters various challenges across technical, organizational, and operational domains. As outlined in the table, these include database standardization, data granularity issues, and limitations in gas dispersion simulation. Organizational challenges involve change management and aligning SOD with broader digital transformation efforts. Operationally, the system faces human resource constraints and inconsistent data entry from various units. These challenges highlight the complexity of implementing a comprehensive data management system in a large oil and gas company, affecting the system's effectiveness and rollout across the organization.

Table 5. The SOD visualization tools

Challenge	Description
Database Standardization	Integrating diverse data sources into a consistent structure; requires systematic approach to design and management.
Data Granularity	Incorporating detailed data from the entire value chain to enhance functionality and enable advanced analysis.
Organizational Change Management	Implementing updates within Sonatrach's structure; addressing resistance and ensuring stakeholder buy-in.
Technological Alignment	Aligning SOD with Sonatrach's broader digital transformation strategy; requires inter-departmental collaboration.
Gas Dispersion Simulation	Generic diffusion model lacks accuracy for specific gas leak scenarios; development paused due to limitations.
Human Resource Constraints	Limited project team size (< 10 people) causing bottlenecks, especially in user onboarding and categorization. The project lacks a dedicated change management team, risking unforeseen challenges in stakeholder communication, resistance management, and overall

	project adoption.
Incomplete Data Entry	Inconsistent data input from operational units is hindering system effectiveness in certain areas. Drilling and production details, along with subsurface models, transported oil and gas, and real-time liquefied and refined oil and gas data remain inadequately integrated within local systems and are not being shared among workers.

Source: Adapted from interviews (Appendix 2)

These challenges underscore the complexity of implementing a comprehensive data management system in a large oil and gas company like Sonatrach. As the project progresses, addressing these issues will be crucial for maximizing the system's effectiveness and ensuring its successful rollout across the organization. The strategic partnerships formed in the second phase are expected to play a key role in overcoming these challenges and further enhancing SOD's capabilities.

8. Discussion

The SOD project at Sonatrach represents a significant digital transformation initiative in the oil and gas sector. This case study, employing a qualitative approach through document analysis and semi-structured interviews, offers valuable insights into the implementation and impact of a comprehensive geographic information system within a large national oil company.

The project's organizational structure aligns well with Mintzberg's organizational configuration theory, incorporating elements of strategic apex, middle management, technostructure, and operating core **(Mintzberg, 1980)**. The matrix overlay facilitates interaction between project-specific roles and Sonatrach's functional departments, consistent with Galbraith's concept of lateral coordination mechanisms **(Galbraith, 2014)**. This structure appears designed to address the project's complexity while maintaining adaptability, reflecting principles of contingency theory. Moreover, the emphasis on knowledge transfer, training programs, and continuous communication suggests an alignment with Senge's concept of a learning organization **(Senge, 1996)**, contributing to long-term organizational capacity building.

A primary objective of the SOD project is data standardization, crucial for ensuring consistency, accuracy, and reliability across the organization. The implementation of a unified information system encompassing diverse data types from various divisions represents a significant step towards integrated business oversight and improved decision-making capabilities. The project's focus on standardizing geodetic references and implementing a uniform site naming policy addresses critical issues in data management and inter-organizational collaboration, likely yielding benefits in terms of error reduction, efficient data retrieval, and improved cross-functional communication.

Technologically, the SOD project incorporates advanced features such as microservices architecture, flexible data models, and role-based access control. The suite of specialized subsystems (Centralized GIS, E&P, TRC, LQS & RPC, Authorization, and Emergency) demonstrates a comprehensive approach to addressing various operational needs. Multiple data visualization tools (Row View, GIS View, Form View) cater to diverse user preferences and analytical requirements, enhancing the system's usability and effectiveness.

The analysis shows several potential impacts of the SOD project, including enhanced inter-organizational collaboration, improved data integrity, better regulatory compliance, and more efficient asset lifecycle management. The integration of geospatial information with enterprise data is expected to transform Sonatrach's operational capabilities, potentially leading to more informed decision-making, improved risk management, and increased operational efficiency.

However, the study also highlights an absence of mentioning renewable energy and technology innovation sectors, as outlined in the literature review. Additionally, the implementation of the SOD project encountered several challenges, including database standardization, data granularity, organizational change management, and human resource constraints. These obstacles underscore the complexities inherent in large-scale digital transformations within the oil and gas industry.

While the findings provide valuable insights, it's important to note their limitations. The relatively short duration of interviews and potential reliance on internal documents may limit the depth and breadth of perspectives captured. The study also focuses primarily on qualitative aspects, with less emphasis on quantitative measures of the project's impact. Additionally, the absence of perspectives from the commercialization activity or renewables (not currently part of the SOD Project) represents a gap in understanding SOD's impact across Sonatrach's entire value chain.

To address these limitations, future research could benefit from a longitudinal approach, tracking the long-term impacts of the SOD project on Sonatrach's performance. Incorporation of quantitative metrics on system performance, user adoption rates, and operational improvements would provide a more comprehensive evaluation of the project's success. Comparative studies with similar projects in other oil and gas companies could offer valuable context and identify best practices in the industry.

In conclusion, despite its limitations, this case study offers a detailed examination of a significant digital transformation initiative in the oil and gas sector. The SOD project demonstrates how the integration of geospatial information systems with enterprise data can transform organizational capabilities, potentially enhancing decision-making, operational efficiency, and risk management. As such, it provides valuable insights for both practitioners and researchers in the fields of information systems and energy management, while also highlighting areas for further investigation to fully understand the impact and effectiveness of such large-scale digital transformation projects in the complex and dynamic environment of the oil and gas industry.

9. Conclusion

Geographic Information Systems (GIS) have emerged as a critical tool for digital transformation in the oil and gas industry, spanning the entire value chain from upstream to downstream operations, including Health, Safety, and Environment (HSE) management. Modern GIS platforms, such as ESRI's solution for the oil and gas sector, offer comprehensive data analysis, visualization, and integration tools that extend beyond traditional operations to include renewable energy and technological innovation.

The SOD project at Sonatrach, built on ESRI's GIS platform, aligns with these industry trends, demonstrating the potential of integrated GIS solutions to improve operations, enhance decision-making, and support sustainable practices. By leveraging spatial intelligence across its operations, SOD enables Sonatrach to address complex challenges in the evolving energy landscape.

However, the implementation of such a comprehensive system presents significant challenges, particularly in data standardization, organizational change management, and human resource allocation, as well as integrating features related to renewables and innovation. This study contributes to the literature on digital transformation in the oil and gas sector by providing insights into the adoption of an integrated GIS within a national oil company. The findings from Sonatrach's experience with SOD offer valuable lessons for similar initiatives in other national oil companies, especially in the North African region.

Future research directions should include longitudinal studies to assess the long-term impacts of integrated GIS solutions on organizational performance and decision-making processes. Comparative studies across different national oil companies could also yield insights into best practices for implementing comprehensive GIS solutions in diverse organizational contexts.

Suggestions:

To ensure success, the implementation should incorporate:

- Prioritizing user adoption and change management through effective communication, tailored training, and continuous feedback mechanisms.
- Focusing on robust data management and integration, emphasizing data quality, standardization, and seamless integration with existing enterprise systems.
- Fostering collaboration and knowledge sharing through partnerships with industry peers, academic institutions, and technology providers to drive continuous innovation.

These strategies can help organizations navigate the complexities of digital transformation and maximize the benefits of integrated GIS solutions in the oil and gas industry.

10. Bibliography List

Books:

Abdalla, R. (2024). Perspective Chapter: GIS and Remote Sensing in Assessing Interdependencies within Oil and Gas Infrastructure. IntechOpen.

Galbraith, J. R. (2014). Designing organizations: Strategy, structure, and process at the business unit and enterprise levels. John Wiley & Sons.

Kumar, M., Singh, R.B., Singh, A., Pravesh, R., Majid, S.I., Tiwari, A. (2023). Data Input in GIS. In: Geographic Information Systems in Urban Planning and Management. Advances in Geographical and Environmental Sciences. Springer, Singapore.

Wade, G., & Artz, M. (2023). Managing our world: GIS for natural resources. Esri Press.

Journal article:

Abdulhameed, A., Abdulhameed, M., & Abdullahi Yakubu, A. (2023). GIS analysis and economic evaluations of oil and gas field development project. Quest Journals: Journal of Research in Environmental and Earth Sciences, 9(2), 117-128.

Abudu, Dan and Williams, Meredith (2015) GIS-based optimal route selection for oil and gas pipelines in Uganda. Advances in Computer Science: An International Journal, 4 (4):16.

Akindote, O. J., Adegbite, A. O., Dawodu, S. O., Omotosho, A., Anyanwu, A., & Maduka, C. P. (2023). Comparative review of big data analytics and GIS in healthcare decision-making. World Journal of Advanced Research and Reviews, 20(3), 1293-1302.

Avtar, R., Sahu, N., Aggarwal, A. K., Chakraborty, S., Kharrazi, A., Yunus, A. P., ... & Kurniawan, T. A. (2019). Exploring renewable energy resources using remote sensing and GIS—A review. Resources, 8(3), 149.

Balogun, A. L., Matori, A. N., Hamid-Mosaku, A. I., Umar Lawal, D., & Ahmed Chandio, I. (2017). Fuzzy MCDM-based GIS model for subsea oil pipeline route optimization: An integrated approach. Marine Georesources & Geotechnology, 35(7), 961-969.

Bowen, G. A. (2009). Document analysis as a qualitative research method. Qualitative research journal, 9(2), 27-40.

Breton, C., Shensky, M., & Savvaidis, A. (2024). Induced seismicity data prep: Automate data processing and data set production in Texas and New Mexico using Python and ArcGIS Pro tools. Interpretation, 12(2), SC1-SC7.

Cao, Y., Xu, C., Aziz, N. M., & Kamaruzzaman, S. N. (2023). BIM–GIS integrated utilization in urban disaster management: the contributions, challenges, and future directions. Remote Sensing, 15(5), 1331.

Danesh, G., Monavari, S. M., Omrani, G. A., Karbasi, A., & Farsad, F. (2021). Detection of suitable areas for waste disposal of petrochemical industries using integrated methods based on geographic information system. Arabian Journal of Geosciences, 14, 1-12.

Deane, G. C. (1994, June). The role of GIS in the management of natural resources. In Aslib proceedings (Vol. 46, No. 6, pp. 157-161). MCB UP Ltd.

Dursun, B. (2023). A qualitative research technique: Interview. Disiplinlerarası Eğitim Araştırmaları Dergisi, 7(14), 100-113.

Eljabri, A., & Gallagher, C. (2012). Developing integrated remote sensing and GIS procedures for oil spills monitoring at Libyan coast. WIT Transactions on Ecology and the Environment, 44 (4): 17-20.

Galalizadeh, S., Karimi, H., Malekmohammadi, B., Sadeghi, A., & Shirzadi, S. (2020). Environmental risk assessment and mapping of oil installations to Chamshir Dam water basin using GIS and HAZOP method. International Journal of Risk Assessment and Management, 23(3-4), 207-222.

Gülen, G. (2016). Importance of Midstream in Oil and Gas Resource Development. Current Sustainable/Renewable Energy Reports, 3, 23-27.

Gyabeng, B. A., & Bernard, A. (2020). Selection of optimum petroleum pipeline routes using A multi-criteria decision analysis and GIS least-cost path approach. International Journal of Scientific and Research Publications (IJSRP), 10(06), 572-579.

Haouel, C., & Nemeslaki, A. (2024). Digital transformation in oil and gas industry: opportunities and challenges. Periodica Polytechnica Social and Management Sciences, 32(1), 1-16.

Ibanga, O. A. (2021). GIS-Based Oil Spill Incidents and Hazard Mapping in Gokana Local Government Area, Rivers State, Nigeria. International Journal of Social Sciences, 14(1).

Idhoko, K., Kelechi, O. C., Emengini, E. J., & Obiahu, L. (2024). GIS BASED SPATIAL DISTRIBUTION ANALYSIS OF PETROL FILLING STATIONS IN AWKA, ANAMBRA STATE. International Journal of Research Publications and Reviews, 5(2), 1964-1978.

Igbokwe, J. I., Iwuanyanwu, P. E., & Oliha, A. O. (2023). Determining suitable sites for large-scale petrochemical industry in South Eastern Nigeria using GIS-based multicriteria analysis. Journal of Engineering Research and Reports, 25(11), 64-72.

Ighosewe, E. F., Akan, D. C., & Agbogun, O. E. (2021). Crude oil price dwindling and the Nigerian economy: A resource-dependence approach. Modern Economy, 12(7), 1160-1184.

Inye, A. U., & Hamilton, D. I. (2022). Competitor intelligence and resilience of firms in the oil and gas downstream sector of South-South, Nigeria. International Journal of Business & Entrepreneurship Research, 13(3), 92-105.

Kong, W., Wang, T., Liu, L., Luo, P., Cui, J., Wang, L., ... & Su, F. (2023). A novel design and application of spatial data management platform for natural resources. Journal of Cleaner Production, 411, 137183.

Kotsur, E. V., Veselova, M. N., Dubrovskiy, A. V., Moskvin, V. N., & Yusova, Y. S. (2019, December). GIS as a tool for creating a global geographic information platform for digital transformation of agriculture. In Journal of Physics: Conference Series (Vol. 1399, No. 3, p. 033009). IOP Publishing.

Kumar, N., Yamaç, S. S., & Velmurugan, A. (2015). Applications of remote sensing and GIS in natural resource management. Journal of the Andaman Science Association, 20(1), 1-6.

Lindgren, B. M., Lundman, B., & Graneheim, U. H. (2020). Abstraction and interpretation during the qualitative content analysis process. International journal of nursing studies, 108, 103632.

Maroufkhani, P., Desouza, K. C., Perrons, R. K., & Iranmanesh, M. (2022). Digital transformation in the resource and energy sectors: A systematic review. Resources Policy, 76, 102622.

Mensi, W., Rehman, M. U., & Vo, X. V. (2021). Dynamic frequency relationships and volatility spillovers in natural gas, crude oil, gas oil, gasoline, and heating oil markets: Implications for portfolio management. Resources Policy, 73, 102172.

Meza, A., Ari, I., Al Sada, M., & Koç, M. (2023). Relevance and potential of the Arctic Sea Routes on the LNG trade. Energy Strategy Reviews, 50, 101174.

Mintzberg, H. (1980). Structure in 5's: A Synthesis of the Research on Organization Design. Management science, 26(3), 322-341.

Narimisa, M. R., & Narimisa, M. R. (2015). Modeling by AHP-GIS-based prioritization of Environmental Impact Assessment of oil refineries in Iran: A case study from the Current and Compare of Tehran and Isfahan oil refineries. International Journal, Special December, 1356-1395.

Odintsova, A., Gvishiani, A., Nakicenovic, N., Rybkina, A., Busch, S., & Nikolova, J. (2018). The world"s largest oil and gas hydrocarbon deposits: rosa database and GIS project development. Russian Journal of Earth Sciences, 18(3), 1-14.

Odunsi, L. (2024). A satellite constellation dedicated to frequently monitor methane emissions from oil and gas facilities around the world. Australian Energy Producers Journal, 64(2), S181-S185.

Rekik, S., & El Alimi, S. (2023). Optimal wind-solar site selection using a GIS-AHP based approach: A case of Tunisia. Energy Conversion and Management: X, 18, 100355.

Rovira, J., Nadal, M., Schuhmacher, M., & Domingo, J. L. (2021). Environmental impact and human health risks of air pollutants near a large chemical/petrochemical complex: Case study in Tarragona, Spain. Science of the Total Environment, 787, 147550.

Senge, P. M. (1996). Leading learning organizations. Training & development, 50(12), 36-37.

Shorabeh, S. N., Firozjaei, H. K., Firozjaei, M. K., Jelokhani-Niaraki, M., Homaee, M., & Nematollahi, O. (2022). The site selection of wind energy power plant using GIS-multi-criteria evaluation from economic perspectives. Renewable and Sustainable Energy Reviews, 168, 112778.

Vormedal, I., Gulbrandsen, L. H., & Skjærseth, J. B. (2020). Big oil and climate regulation: Business as usual or a changing business?. Global Environmental Politics, 20(4), 143-166.

Wang, K. (2022). [Retracted] Application of Cloud Computing and GIS Based on Internet of Things in Oil and Gas Storage and Transportation Production Management and Safety Monitoring and Early Warning System. Mobile Information Systems, 2022(1), 1875479.

Wittenberger, G., Cambal, J., Skvarekova, E., Senova, A., & Kanuchova, I. (2021). Understanding Slovakian gas well performance and capability through ArcGIS system mapping. Processes, 9(10), 1850.

Yahya, M. S. S., & Safian, E. E. M. (2022). Gis Based Spatial Distribution Map of Petrol Stations Using Geostatistical Analysis in Selangor Malaysia. International Research Journal of Modernization in Engineering Technology and Science, 4(12), 375-383.

Zhang, Z., Sherwin, E. D., & Brandt, A. R. (2021). Estimating global oilfield-specific flaring with uncertainty using a detailed geographic database of oil and gas fields. Environmental Research Letters, 16(12), 124039.

Zinovieva, I. S., Iatsyshyn, A. V., Artemchuk, V. O., Stanytsina, V. V., Sheludchenko, L. S., Popov, O. O., ... & Iatsyshyn, A. V. (2023, October). The use of GIS in renewable energy specialist's learning. In Journal of Physics: Conference Series (Vol. 2611, No. 1, p. 012016). IOP Publishing.

Seminar article

Escobar, M. T., Slaney, L., Titus, M., Rubling, T., Silva, J., Crespo, J., ... & Cascone, L. (2022, June). Centralized Gis Digital Platform for High Efficiency Maintenance, Risk Control and Mitigation of Operated Assets. In 83rd EAGE Annual Conference & Exhibition (Vol. 2022, No. 1, pp. 1-5). European Association of Geoscientists & Engineers.

Kumar, P. (2009, December). Data Integration, Analysis and Visualization for Knowledge Management in Oil and Gas Upstream Industry-An Emphasis on Using Advanced GIS Technologies. In International Petroleum Technology Conference (pp. IPTC-13317). IPTC.

Li, Z., Li, P., Wu, M., & Wang, W. (2010, June). Application of ArcGIS pipeline data model and GIS in digital oil and gas pipeline. In 2010 18th International Conference on Geoinformatics (pp. 1-5). IEEE.

Turenko, S. K., Prozorova, G. V., & Spielman, A. V. (2020, October). Smart GIS Subsystem to Plan the Exploratory Oil and Gas Well Locations. In 2020 International Multi-Conference on Industrial Engineering and Modern Technologies (FarEastCon) (pp. 1-6). IEEE.

Xu, X. H., Peng, G., Liu, X. F., & Shao, Y. L. (2012, August). Oil and gas exploration information integration management plan based on GIS technology. In 2012 Fourth International Conference on Computational and Information Sciences (pp. 526-529). IEEE.

Internet websites:

Bindler, E., & Johnstone, S. (2022). The foundational role of GIS in digital water transformation. Water Environment Federation. Retrieved July 17, 2024, Retrieved from https://www.accesswater.org?id=-10080261 (Accessed on 01.07.2024).

Esri. (2024). Petroleum - Supporting the entire energy value chain with GIS. Retrieved from https://www.esri.com/en-us/industries/petroleum/overview (Accessed on 01.07.2024).

Huawei. (2019, February 27). Sonatrach transforms its oilfields in Algeria Sonatrach transforms its oilfields in Algeria. ICT Insights (25). Retrieved from https://e.huawei.com/th/ict-insights/global/ict_insights/201902271023/Success-Story/201904170833 (Accessed on 30.06.2024).

Joradp. (1998). Décret présidentiel n°2000-271 modifiant et complétant le décret présidentiel n°98-48 [Presidential Decree No. 2000-271 amending and supplementing Presidential Decree No. 98-48]. Journal Officiel de la République Algérienne du Dimanche 24 Septembre 2000. Retrieved from https://www.joradp.dz/FTP/jo-francais/2000/F2000057.PDF (Accessed on 26.06.2024).

Sonatrach. (2017). Annual Report. Retrieved from https://sonatrach.com/wp-content/uploads/2019/03/Rapport-Annuel_2017.pdf (Accessed on 10.06.2024).

Sonatrach. (2019, March 7). SH2030 - Transformation Plan. Retrieved from https://www.us-algeria.org/attachments/article/280/SH2030.pdf (Accessed on 16.06.2024).

Sonatrach. (2022). Annual Report. Retrieved from https://sonatrach.com/wp-content/uploads/2023/11/RA_2022_EN_Web.pdf (Accessed on 11.12.2023).

Sonatrach. (2024). Une novelle ère s'offre à Sonatrach ; L'efficacité et la performance au service de la nouvelle organisation [A new era unfolds for Sonatrach ; Efficiency and Performance in the Service of the New Organization] (Translated by the author). Retrieved from https://sonatrach.com/organisation (Accessed on 04.01.2024).

11. Appendices

Appendix 1: The SOD organization

N° 233 /DG

Classement : 1.03.1
Référence : A-1211
Page : 2 de 3

Missions Essentielles :

1. **Le Directeur Projet Smart Oil Data** est chargé de :
   - Encadrer l'équipe projet et organiser l'ensemble des travaux ;
   - Veiller à la mise en place des moyens nécessaires pour la réussite du projet ;
   - Faciliter les conditions d'exécution des travaux entre les prestataires et les structures concernées de SONATRACH ;
   - S'assurer de la réalisation des travaux et livrables conformément aux termes de référence et aux spécifications techniques contractuelles ;
   - S'assurer de la bonne exécution des contrats, notamment en termes de respect des délais et du budget ;
   - Valider les livrables du projet et les Présenter au Directeur Exécutif SPE ;
   - S'assurer du transfert de connaissances vers les équipes de SONATRACH et de l'exécution des programmes de formation ;
   - Assurer la communication continue sur le projet ;
   - Assurer un reporting régulier et permanent au Directeur Exécutif.

2. **Les Chefs de projets** sont chargés de :
   - Planifier les travaux et s'assurer de leur exécution ;
   - Suivre et participer aux travaux exécutés par les prestataires ;
   - Examiner et approuver les modifications techniques proposées par les prestataires ;
   - S'assurer de la conformité des livrables avec les termes de références et les spécifications techniques contractuelles ;
   - Assurer le transfert de la documentation technique en vue d'être conservée et exploitée par les structures concernées de SONATRACH ;
   - Contribuer à la communication sur le Projet ;
   - Assurer un reporting régulier au Directeur de Projet.

3. **Le Project Management Office (PMO)** est chargé de :
   - Assister le Directeur de projet dans la mise en oeuvre opérationnelle des processus du projet ;
   - Consolider les données et élaborer les indicateurs de suivi du Projet ;
   - Assister les chefs de projets dans le pilotage des projets ;
   - Elaborer et mettre en application le plan de communication ;

Manuel Général d'Organisation

سوناطراك
sonatrach

DECISION N° 233 /DG

OBJET : CREATION DE LA DRECTION PROJET SMART OIL DATA

Classement : 1.03.1
Référence : A-1211
Page : 1 de 2

Le Président Directeur Général,

Vu le décret présidentiel du 22 mars 2017, portant nomination de Monsieur Abdelmoumen OULD KADDOUR, en qualité de Président Directeur Général de SONATRACH ;

Vu le décret présidentiel n°98-48 du 11 février 1998, modifié et complété par le décret présidentiel n°2000-271 du 23 septembre 2000, portant statuts de SONATRACH ;

Vu la décision A-001 (R30) du 28 août 2017, portant schéma d'organisation de la macrostructure de SONATRACH ;

Vu la décision A-504 (R10) du 14 juillet 2018, portant organisation de la Direction Corporate Stratégie, Planification et Economie.

DECIDE

ARTICLE 1 : Il est créé, au sein de SONATRACH, une structure d'organisation dénommée Direction Projet Smart Oil Data « SOD », rattachée à la Direction Corporate SPE.

ARTICLE 2 : La Direction Projet Smart Oil Data, placée sous l'autorité d'un Directeur de Projet a pour objet de tracer la feuille de route, de préparer les termes de références et d'entreprendre les travaux nécessaires pour la mise en place d'un Système d'Information Géographique unique, intégrant des fonctionnalités opérationnelles d'exécution des processus métier et d'aide à la décision.

ARTICLE 3 : La Direction Projet Smart Oil Data est assistée dans ses missions par les prestataires sélectionnés à cet effet.

ARTICLE 4 : La Direction Projet Smart Oil Data est organisée autour de :
- Un Projet Data Management ;
- Un Projet Information Technology (IT) ;
- Un projet Environmental Data ;
- Un Project Management Office (PMO) ;
- Trois Cadres ;
- Un Secrétariat.

Chacun des trois projets est placé sous la responsabilité d'un Chef de Projet.

ARTICLE 5 : La présente décision est complétée par les annexes suivantes :
- Annexe I : Missions essentielles ;
- Annexe II : Equipe de Projet SOD.

Manuel Général d'Organisation

	N°[illegible]/DG	Classement : 1.03.1 Référence : A-1211 Page : 3 de 3

- Assister le Directeur de projet dans les volets planning, administration et finances.

4. **Les Cadres** sont chargés de :
   - Assister le Directeur de Projet dans l'ensemble des aspects du projet ;
   - S'assurer de la prise en charge des volets Sécurité et Environnement dans les termes de référence et les spécifications techniques ;
   - Examiner les livrables du Projet et assurer le suivi des travaux sous l'autorité du directeur de projet ;
   - Apporter toute assistance nécessaire au Directeur et aux Chefs de Projets.

Fait à Alger, le
Le Président Directeur Général,

A. OULD KADDOUR

Interview Guide for Smart Oil Data (SOD) at Sonatrach

This guide is designed to facilitate semi-structured interviews with various profiles within Sonatrach regarding the Smart Oil Data (SOD) system. The interviews aim to gather insights into the use, benefits, impacts, and challenges of SOD from different perspectives within the organization.

The guide is structured to cover key areas: a presentation of the participant's structure, the benefits of SOD, its impacts, and the challenges faced in its implementation and use. The questions are tailored for different roles, ensuring that the information gathered is comprehensive and relevant.

General Structure of the Interview

Introduction

- Starting by welcoming and thanking the participant for their time.
- Briefly explain the purpose of the interview, emphasizing the focus on understanding their experiences and insights regarding SOD.
- Assuring the participant of the confidentiality of their responses and explain how the data will be used.
- Obtaining consent to record the interview to ensure accuracy in capturing their responses.

Presentation of the Participant's Structure

- Asking the participant to describe their role and responsibilities within Sonatrach. This helps contextualize their perspective.
- Requesting an overview of their department or division, including its main functions and how it interacts with other parts of the organization.

Benefits of SOD

- Exploring how SOD is integrated into their daily operations. This includes asking about specific tasks or processes where SOD is used.
- Discussing the main benefits they perceive from using SOD, such as improvements in efficiency, accuracy, or decision-making.
- Inquiring about the specific tools and features of SOD they find most useful and why.

Impacts of SOD

- Investigating the tangible impacts of SOD on their activities. This can include operational improvements, cost savings, or enhanced data management.

Challenges with SOD

- Identifying any challenges they have encountered in implementing or using SOD. This can cover technical issues, data integration problems, or user adoption barriers.
- Discuss any difficulties related to inter-departmental collaboration or data consistency.
- Exploring their suggestions for overcoming these challenges and improving the system.

Closing:

- Offering the interviewee an opportunity to add any additional thoughts or insights
- Thank them for their participation and valuable input.

Profiles of interviewees

The interviews conducted cover a diverse range of executives and specialists from various activities and divisions within Sonatrach. The interviewees include IT executives from the Pipeline Transportation Activity (TRC) and Refining and Petrochemical Activity (RPC), each with extensive experience in their respective fields. A geophysicist with 30 years of experience from the Exploration Division of the Exploration & Production (E&P) Activity provides insights from the upstream sector.

The Smart Oil Data (SOD) project is represented by both a Project PMO and the Project Director, offering comprehensive perspectives on the implementation and management of this strategic initiative. The Coordination of Digitalization Structures is represented by a PMO with 22 years of experience, providing a broader view of Sonatrach's digital transformation efforts. The Petroleum Engineering and Development (PED) Division's perspective is provided by an IT development executive with 25 years of experience. The Liquefaction and Separation (LQS) Activity is represented by an executive with 10 years of experience, while the Production Division of the E&P Activity is represented by an IT executive with 10 years of experience.

These profiles collectively represent a cross-section of Sonatrach's operations, from upstream exploration and production to downstream activities like refining and liquefaction. Their roles span technical, operational, and strategic aspects of the company, providing a comprehensive view of SOD's implementation and impact across Sonatrach's value chain.