AGING MIDSTREAM SUPPLY CHAIN IN THE OIL AND GAS INDUSTRY: ISSUES AND AI-BASED SOLUTIONS

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Introduction

"The U.S. Department of Energy (DOE) recognizes that sustained investment to build a secure, resilient supply chain will be critical in achieving these goals and capturing the economic opportunity inherent in the energy sector transition."

"*Oil and gas have a long history of insecure supply chains due to geographic resource constraints that have only been reduced in the United States in the last decade due to technological advancements—partly from R&D funded by the DOE.*" (U.S. Department of Energy, 2022)

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Supply chain management has a key role to play in the oil and gas industry as it ensures efficiency and capacity utilization or else the U.S. economy can face a fuel supply crisis due to insufficient thruput capacity, e.g., the crude oil shortage of 2022. The supply chain's role was highlighted during the 2022 crisis with low inventories and soaring prices of fuels (Vasquez, 2023). The U.S. oil and gas production is at an all-time high leading to an increase in the demand for midstream supply chain infrastructure including storage and transportation (Reddy, 2023). The U.S. oil production has increased post-COVID-19, with a peak production of 13.2 million barrels a day in 2022, and is expected to grow through 2024 (Krauss, 2023). The U.S. oil and gas midstream market is predicted to grow steadily between 2022 to 2027 warranting investment in midstream supply chain infrastructure to keep up with the demand (Mordor Intelligence, 2023).

With the projected future growth, the upgraded supply chain is critical for operational success, requiring midstream companies to reassess their supply chain and align with overall company goals and growth (Putnam, 2023). To ensure smooth movement of oil and gas from refineries to customers there is a pressing need to reduce key bottlenecks that slow down production and lead to logistical challenges (Valle, 2023; McIntire, 2022). The increase in demand has led to an increase in production levels requiring a focus on human and technology collaboration to increase operational efficiency. The EY (2024) showed that real-time data and new technology help make smarter decisions throughout the value and supply chain, hence integrating artificial intelligence (AI) into operations and decision-making may boost business value (Jelinek and Kirsch, 2024).

Supply Chain Management in the Oil and Gas Midstream

In the oil and gas industry, midstream refers to the connection between the upstream—exploration, drilling, etc., (Patidar, 2014; Ishanu, Kalita, 2020)—and the downstream—refining, marketing, systems, and processes (Khan et al., 2016). Midstream companies collect oil and gas from producers at the wellhead or

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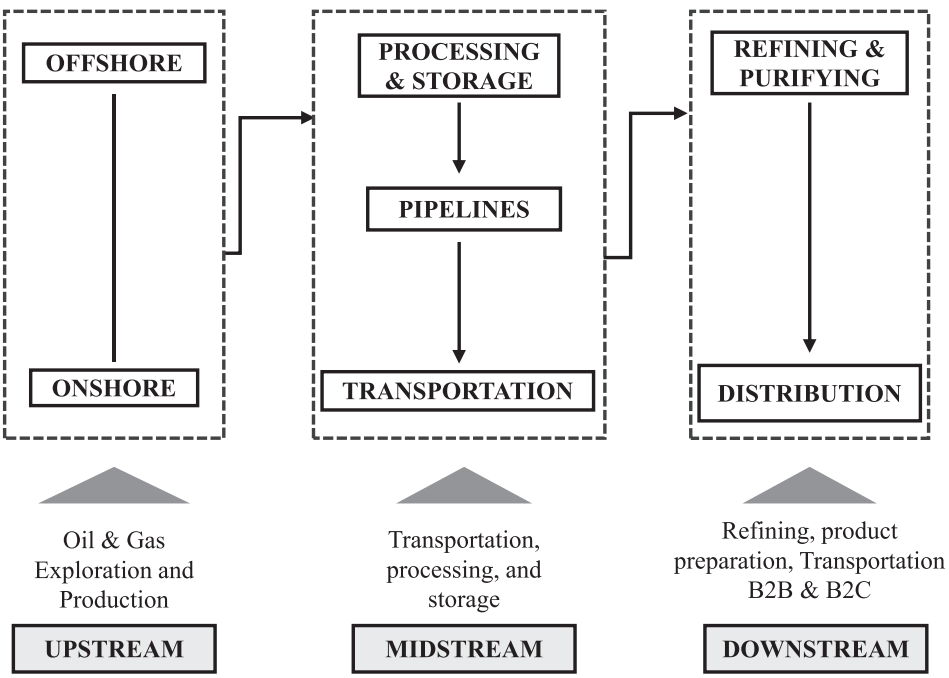
production facility, and separate produced hydrocarbons into different components before delivering those components to end-use markets. Supply chain management (SCM) can help in planning, coordinating activities, and exploring improvements across the chain of activities. The SCM infrastructure in the midstream sector is used to transport, process, and store energy products such as pipelines, the most used as the safest and most efficient way of transport, pumping stations, tank trucks, rail tank cars, and transcontinental tankers (Mette, 2021; Casey, 2023). In the oil and gas industry, SCM faces several challenges within the supply chain partners (Hussain et al., 2006). As of 2020, the U.S. pipeline network had about 3 million miles of mainline and other pipelines (Mordor Intelligence, 2023), transporting about 70% of all crude, natural gas, and related products downstream (Millerman, 2020). Figure 1 provides an overview of the oil and gas industry process flow.

Aging Infrastructure Issue in the Midstream Oil and Gas Industry

Prior research has shown that aging and deteriorating midstream infrastructure assets are posing challenges for industry stakeholders. According to a study

Figure 1
OIL & GAS INDUSTRY PROCESS FLOW



Source: Authors' compilation

conducted by Lamar University in 2023, the aging pipeline system is one of the top ten issues in the midstream industry in the United States, with over 55% of pipeline systems aged over 40 years, exceeding their design's useful life of 25 years (O'Sullivan, 2023). Most of the pipelines that were built before the 1960s, some even before the 1940s, are still in use today. Specifically, 32% of gas distribution lines, 54% of gas transmission lines, and 43% of pipelines that carry hazardous liquids (including crude oil and refined petroleum products) were installed before 1970 (Batbuyan, 2021). It leads to leaks, ruptures, and spills. Over the past decade, there have been over 3,000 pipeline spills in the United States (Millerman, 2020).

Midstream Supply Chain Issues

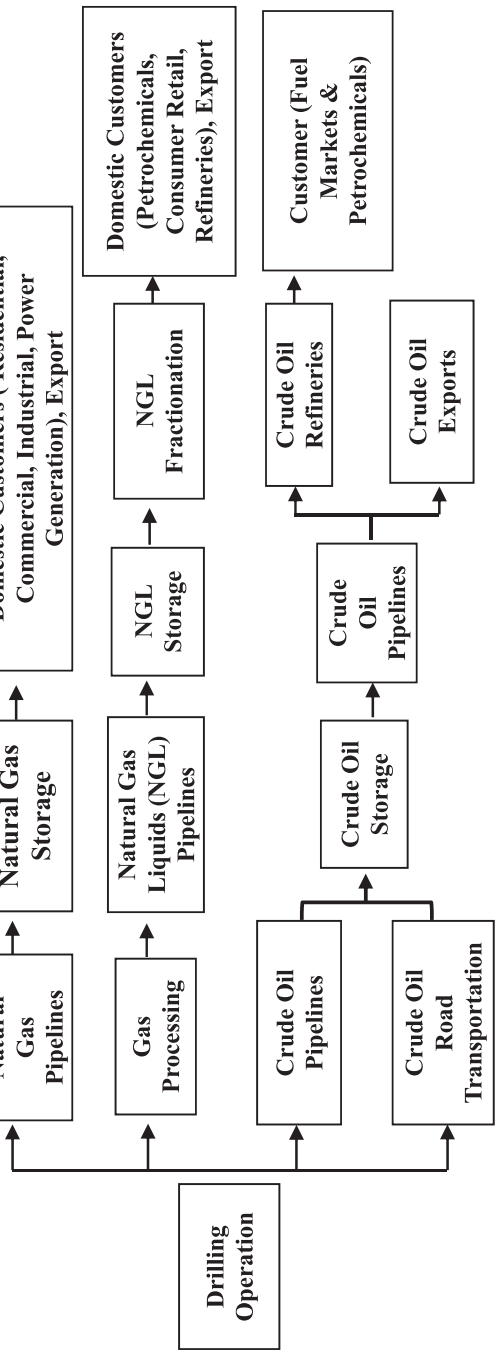
The midstream supply chain contains three components: transportation, storage, and processing (FasterCapital, 2024) making speed and quality crucial for smooth operations. It also needs to follow strict safety rules and government regulations. Any delays or failures can lead to costly problems, fines, and environmental and market harm (Read, 2021). With the growth in 2023 and beyond, the upgraded supply chain has become critical for operational success, requiring midstream companies to reassess their supply chain and align it with the overall company goals (Putnam, 2023), to ensure the smooth movement of oil and gas from refineries to customers (McIntire, 2022), reducing key bottlenecks and logistical challenges (Valle, 2023). Oil and gas companies are dealing with challenges like geopolitical and economic difficulties leading to supply chain complications and uncertainties (Elson et al., 2023). SCM in the midstream requires expertise in infrastructure maintenance, implementing risk mitigation strategies for potential disruptions such as leaks or weather events, and adapting transportation routes to meet market demands (GEP, 2024). Figure 2 illustrates the various components comprising the midstream value chain.

In this study, we have attempted to identify the impact of aging infrastructure on midstream supply chain management and the application of AI to reduce the impact of aging infrastructure in midstream supply chains. In the following sections, we highlight four salient issues in the midstream supply chain in the oil and gas industry—safety, regulatory compliance, operating costs, and supply chain optimization—and their potential AI-based solutions.

Safety

Supply Chain Safety Issues: Aging infrastructure in the midstream industry raises safety risks concerns, and the risks associated with safety in supply chain management include the potential for disruptions and accidents. Such incidents can halt or delay the movement of goods, impacting production schedules and

Figure 2
OIL & GAS INDUSTRY – MIDSTREAM VALUE CHAIN



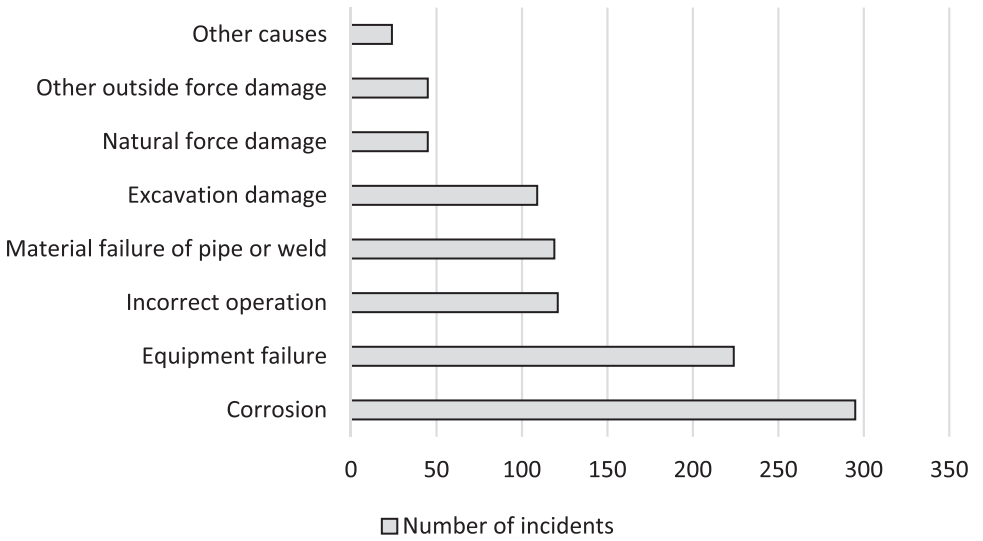
Source: Authors' compilation.

customer satisfaction. Additionally, current infrastructure is at high risk of failure and can cause accidents during transportation and storage within the supply chain which can lead to damage, loss of inventory, injuries, and even fatalities, impacting local communities (Advanced Consulting and Training, 2023). According to the Health and Safety Executive (HSE)-UK, the three most dangerous issues relating to aging infrastructure are erosion, corrosion, and fatigue, some of which are highlighted in Figure 3.

According to data from Statista (2023), corrosion and equipment failure are common causes of incidents reported at oil and biofuel pipelines in the United States. Between 2010 and 2020, there were 295 and 224 accidents caused by corrosion and equipment failure, respectively, that negatively impacted people and the environment. With over half of the nation's pipelines being at least 50 years old, this has led to incidents such as pipeline explosions and accidents in Allentown, Pennsylvania in 2011, resulting in 5 deaths and damage to 50 buildings due to a cast iron pipeline installed in 1928 (Groeger, 2012).

According to the Pipeline and Hazardous Materials Safety Administration's (PHMSA) Pipeline Incidents, there was no significant reduction in the number of pipeline accidents from 2016 to 2023 (see Figure 4). Thus, PHMSA released a proposed rule called "Gas Pipeline Leak Detection and Repair" requiring more frequent checks for leaks, new rules for LNG facilities, fixing leaks promptly,

Figure 3
MOST COMMON CAUSES OF CRUDE OIL, PETROLEUM, AND BIOFUEL PIPELINE INCIDENTS IN THE UNITED STATES BETWEEN 2010 AND 2020



Source: Statista, 2023.

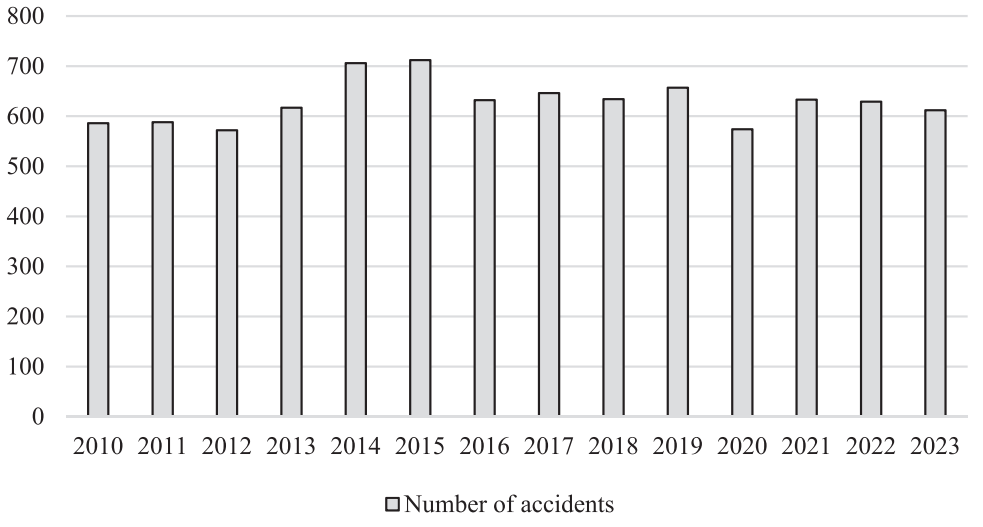
reducing harmful gas releases, and improving pipeline design and maintenance (Kurdock et al., 2023). This may have been prompted as roughly half of all major maintenance costs in mature oil fields are caused by aging infrastructure (The Economist, 2013).

Additionally, explosions and fires devastated multiple towns in the Merrimack Valley, north of Boston, in 2018. This incident occurred while NiSource Inc.'s Columbia Gas of Massachusetts unit was in the process of replacing old gas pipes. (Malik, 2018).

Inadequate technology adoption and dated data management and communication systems can threaten security and hinder efficient data exchange and real-time visibility in the supply chain (Hussain et al., 2006). One such example of a data and security breach in the midstream sector of the petroleum industry is the Colonial Pipeline in the United States. In May 2021, it was a victim of a ransomware attack, bringing the pipeline to a standstill and resulting in jet fuel shortages, panic buying, and a spike in prices at gas stations (Kerner, 2022). This showcased the importance of data security in the supply chain of different kinds.

AI-Based Applications and Solutions for Improved Safety: To improve safety, oil and gas companies deploy corrosion engineers alongside AI-driven tools to monitor equipment conditions. It will help companies manage and signal issues like oil leaks, toxicity levels, and system failure, and improve asset integrity

Figure 4
PIPELINE AND HAZARDOUS MATERIALS SAFETY ADMINISTRATION (PHMSA) PIPELINE INCIDENTS FROM 2010-2023



Source: PHMSA, 2024.

management (Scylla, 2023). Some AI applications will help improve safety due to aging infrastructure.

Pipeline Monitoring and Leak Detection: AI utilizes remote sensing technologies like satellite imagery, LiDAR, and drones to accurately detect and locate leaks along oil and gas pipelines (Kadam, 2023). Besides, the combination of data analytics and AI algorithms has revolutionized gas leak detection. Through analyzing extensive sensor data, AI-powered systems can identify patterns, anomalies, and potential leaks with remarkable precision. Additionally, these intelligent systems learn from past data, adjust to new conditions, and enhance leak detection capabilities over time (New Cosmos U.S.A, 2023). Currently, there are some AI tools for leak detection and pipeline monitoring such as Emerson Automation notes that Real-Time Transient Model (RTTM), Schneider Electric EcoStruxure Pipeline Advisor, Pure Technologies PureHM, KROHNE Pipeline Leak Detection System, among others (Electricsolenoidvalves.com, 2023). Moreover, oil and gas companies also use drones with cameras and AI to inspect pipelines and facilities efficiently and safely. Drones can cover long distances and reach high or risky areas without risking human safety. If there is an emergency such as a leak, AI sends instant alerts to help the emergency team respond quickly (Scylla, 2023).

Analyze Images of Equipment to Detect Damage: The images of assets are captured and analyzed by AI algorithms to detect anomalies like cracks or corrosion. Additionally, AI compares current images with historical patterns, continually improves accuracy over time and reduces major damage (Toyo, 2023).

Predictive Maintenance: Continuous monitoring by AI algorithms detects equipment anomalies early, preventing safety hazards. This proactive approach allows for scheduled maintenance, reducing accident risks and promoting a safer workplace (Srivastava, 2024).

Regulatory Compliance

Supply Chain and Regulatory Compliance Issues: The U.S. oil and gas sector is highly regulated with many federal agencies involved like the Federal Energy Regulatory Commission, U.S. Department of the Interior's Bureau of Land Management, U.S. Department of Transportation's Pipeline and Hazardous Materials Safety Administration, and the Environmental Protection Agency (OP US EPA, 2018). The research showed that the midstream supply chain is subjected to various environmental, safety, and transportation regulations which vary across different jurisdictions (FasterCapital, 2024).

Regulations concerning aging infrastructure significantly affect the midstream supply chain and as they change, it can greatly impact the operations requiring businesses to shift their supply chain strategies, moving from simply adjusting safety procedures and tightening compliance requirements to ensuring they fully comply with the new laws and standards (FasterCapital, 2024).

Concerns about the global environment and safety have prompted stricter regulation for the midstream industry, leading to delays and cost escalation (JML Design Inc., 2023). For example, the Pipeline and Hazardous Materials Safety Administration (PHMSA) was instituted to expand inspection requirements, enhance reporting and record-keeping guidelines, and reconfirm maximum allowable operating pressure for segments of pipes. PHMSA is still working on amending the regulations relating to the aging infrastructure in the oil and gas industry (PHMSA, 2022).

AI-Based Applications and Solutions for Regulatory Compliance: AI can help midstream firms to ensure regulatory compliance by aiding in risk assessment and management. AI algorithms analyze past data on incidents, environmental breaches, and operational disruption, to predict where problems might happen and help prevent them. This ensures operation compliance with emission limits, reporting requirements, and following the environmental rules. AI is equipped to go through all the rules and company records to find areas in which the company needs attention to meet regulatory requirements and with monitoring and reporting of emissions and help companies avoid penalties and maintain their social license to operate (Watson et al., 2023).

AI can help companies stay updated with compliance requirements by analyzing and extracting relevant information from scattered documents across various regulator sites. AI can also notify companies of any new rules or updates, reducing the risk of non-compliance and potential fines. (Anand, 2023; Tripathi, 2023). AI can automate the extraction, validation, and processing of large amounts of data. This will help in compliance reporting, ensuring accuracy, enhancing efficiency, and creating compliance reports with reduced manual effort and errors. Some automated regulation compliance tools available in the market are EHS Insight, Enablon Compliance Management, and Intelex Compliance Management. (Electricsolenoidvalves.com, 2023). AI analytics can also predict compliance trends by analyzing historical data and identifying potential areas of concern (Ghosh, 2023).

Operating Costs

Supply Chain Issues and Operating Costs: The aging midstream infrastructure poses challenges for the oil and gas industry including amplification of the operating costs, which encompass maintenance, repair, and inspection (DiChristopher, 2020; FasterCapital, 2023). There are two types of maintenance: corrective (fix after the failure) and preventative (inspecting before failure). While corrective maintenance of old equipment cannot guarantee the original performance of equipment, resulting in increased operating costs (Li et al., 2006), preventative maintenance aims to slow down aging and reduce the chance of failure. Since midstream companies need to remain compliant with industry standards, they incur significant

costs towards this aim (Antero Midstream, 2024). Midstream companies showed increased operating expenses on maintenance and repair costs. Some examples that highlight the issue are as follows:

- Western Midstream Partner showed an increase of $14.8 million for maintenance and repair expenses (Western Midstream Partners, 2023).
- Enterprise Products Partners LP-midstream company (2023) showed the significant expenditure requirement for maintenance, repair, and delay. Their other operating expense in 2023 increased by $241 million year-to-year primarily due to high maintenance, rental, and employee compensation costs (Enterprise Products Partners, 2023).

In recent years the maintenance and inspection costs have significantly increased due to the increase in labor and material costs (Elson et al., 2023). This prompts the need for cost control in midstream supply chain management, with the increased necessity for flexibility, responsiveness, and integration within the supply chain. Cost optimization in operations plays a pivotal role, offering organizations the opportunity to reinvest in vital areas, swiftly reallocate capital, and facilitate expedited decision-making processes, e.g., when in an economic downturn, it is essential for midstream companies to identify and execute cost reduction strategies to improve operational and financial efficiencies (Samaniego, 2021). Prior research suggests that midstream companies need to focus on investing in automation and technology to optimize operations, improve safety and control, reduce risk, and manage infrastructure (SitePro, 2018; Grand et al., 2024). It also indicates that rather than solely focusing on cost reduction, investing in preventive maintenance to enhance operational efficiency through technological advancements can yield substantial benefits (Horstman et al., 2021).

AI-Based Applications and Solutions for Operating Costs: Predictive maintenance, powered by AI, is transforming the oil and gas sector by helping companies manage their assets, ensuring reliability, and risk reduction. Traditionally, maintenance in the industry has been corrective or done at fixed intervals, which resulted in unnecessary maintenance or unexpected breakdowns. However, with AI-based solutions, the industry can now analyze vast amounts of sensor data, historical maintenance records, and real-time operation data to predict equipment failures before they occur. This is predictive maintenance powered by machine learning algorithms that analyze data to detect patterns and information to teams about potential malfunctions. By identifying early warning signs, the maintenance staff can proactively schedule maintenance activities, replacing components before they fail and avoiding costly shutdowns leading to losses (Srivastava, 2023).

A report showed that, with predictive maintenance, equipment failure rates drop, reducing the chance of major disasters leading to a decrease in maintenance costs, increase in equipment's lifetime, and productivity (Novity, 2023). This is substantiated by the U.S. Department of Energy, which says "Solutions for

equipment maintenance helps oil and gas companies increase production output by 25%, achieve a 30% reduction in maintenance costs, and a 45% reduction in equipment downtime."

Supply Chain Optimization

Supply Chain Optimization Issues: Supply chain optimization refers to the "best configuration" of the various elements of the supply chain to achieve operational efficiencies that yield consistent performance by optimizing logistic cycle times and costs (Wassick, 2009; Lukinskiy et al., 2014). The aging infrastructure in pipeline systems can lead to suboptimal performance due to failure leading to disruptions by reducing its reliability, increasing costs, negatively impacting sales, missed deadlines, unexpected shutdowns, and reduced customer satisfaction (Ebrahimi and Bagheri, 2022). It could also damage the company's reputation and affect investor behavior negatively (Kanike, 2023; PFSD1g1tal, 2023). Prior research has found that the oil and gas industry faces an average of 27 days of unplanned downtime each year, costing around $38 million. In some cases, the losses can be as high as $88 million (Oosterhof, 2021).

The lack of real-time information across the supply chain involving multiple stakeholders reduces operational efficiencies and limits visibility. Moreover, the utilization of different systems, platforms, and processes to generate, manage, and share data and information by various partners along the supply leads to the fragmentation of supply chain components.

AI-Based Applications and Solutions for Supply Chain Optimization: There are several possible applications for supply chain optimization that AI potentially can facilitate and are now presented.

Optimizing Production and Schedule: AI-based applications including cloud-based platforms can help operators predict failures of critical equipment such as submersible pumps. Such applications may use AI algorithms to analyze process data for aberrations, allowing operators to optimize supply chain operations while identifying potential issues early, ultimately improving project efficiency and reducing downtime (Wolfe, 2021).

Logistic Network Optimization: In the midstream supply chain, AI plays an important role by aiding companies in various aspects such as predicting market prices for crude oil and finished products, optimizing planning and scheduling, selecting optimal routes, refining operations, forecasting demand, estimating prices, improving customer relationships, maintaining inventories, managing shipping operations, hedging risks, and reducing overall costs. By leveraging data and analytics, companies can enhance overall efficiency in logistics and capacity optimization by ensuring smooth oil and gas transportation (IBM Supply Chain, 2023) by enabling smarter decision-making and enhancing efficiency (Wolfe, 2021). AI uses

machine learning algorithms and analyzes large datasets, recognizes patterns, and identifies complex relationships to predict market trends and demand patterns (Hussain et al., 2024) and helps predict changes in customer demand more accurately than traditional methods.

Inventory Management: AI can help in inventory and transportation management by optimizing resource allocation across the supply chain leading to precision and effectiveness (Hussain et al., 2024). Midstream companies can use computer vision technology including installing cameras to monitor tanks and pipelines, or drones to assess and utilize the warehouse capacity, thereby helping optimize inventory management (Tsidulko, 2024).

Digital Twin: In the context of supply chain management, a digital twin is a virtual model of integrated digital solutions designed to provide a real-time representation of physical assets, including an object, system, or process. Digital twins can help enable us to transform business processes, project engineering design, construction execution planning, materials handling, and facility operations and maintenance (Aramco, 2024). It is crafted using data and saved in cloud storage and it can encompass every aspect, ranging from large structures to minute components. Since users can conveniently access it online, observe assets, look up information, execute workflows, and engage in remote collaboration (Bo et al., 2020), the players in the oil and gas industry are leveraging digital technology to improve efficiency and value creation (Wanasinghe et al., 2020). Digital twins offer opportunities for better performance, especially for aging infrastructure, which is more focused on maintenance and improved asset integrity. It includes using advanced analytics and visualization tools, machine learning, big data analytics, and virtual reality with data collection and analysis, thereby improving supply chain efficiencies. A survey by Accenture showed digital twin technology can reduce unplanned downtime by 20% (Woynarowich, 2023).

Conclusion

Aging infrastructure in the midstream supply chain management of the oil and gas industry is an issue that has attracted research and policy changes. With the advent of emerging technologies, the speed of adoption of AI-based solutions seems to be the direction the industry needs to take going forward. Our research attempts to identify some key issues in the midstream supply chain management of the oil and gas industry—safety, regulatory compliance, cost management, and supply chain optimization—along with identifying AI-based solutions to mitigate the negative impact of aging issues. Our research uncovers the use of cross functionality-based approaches, involving technology and management, to identify the problems and solutions.

REFERENCES

Advanced Consulting and Training. "The Importance of Supply Chain Safety: Risks and Opportunities." *Advanced Consulting and Training*, 8 Dec. 2023, https://advancedct.com/the-importance-of-supply-chain-safety-risks-and-opportunities/.

"Advancing Oil and Gas Operations through AI and Automation." *Electric Solenoid Valves*, 12 July 2023, https://www.electricsolenoidvalves.com/blog/advancing-oil-and-gas-operations-through-ai-and-automation/.

"Aging Infrastructure: The Cost of Progress: Replacing Aging Infrastructure." *FasterCapital*, 5 Apr. 2024, https://fastercapital.com/content/Aging-infrastructure–The-Cost-of-Progress–Replacing-Aging-Infrastructure.html.

Anand, Vikram. "How AI Can Support Risk Management in Oil and Gas Downstream Operations." *LinkedIn*, 17 May 2023, https://www.linkedin.com/pulse/how-ai-can-support-risk-management-oil-gas-downstream-vikram-anand/.

ANTERO MIDSTREAM CORPORATION- FORM 10-K. UNITED STATES SECURITIES AND EXCHANGE COMMISSION, 2024, https://www.anteromidstream.com/investors/sec-filings/all-sec-filings/content/0001558370-24-001161/0001558370-24-001161.pdf.

Batbuyan, Ulziitushig. "ESG Risks of Aging Pipelines for U.S. Energy Infrastructure Investors." *Sustainalytics*, 11 Aug. 2021, https://www.sustainalytics.com/esg-research/resource/investors-esg-blog/esg-risks-aging-pipelines-us.

Bo, Li, Gai Jiannan, and Xue Xiangdong. "The Digital Twin of Oil and Gas Pipeline System." *IFAC-PapersOnLine*, vol. 53, no. 5, May 2020, pp. 710. DOI: 10.1016/j.ifacol.2021.04.162.

Casey, Sydney. "What Is It – Midstream Sector of the Oil and Gas Industry." *Mansfield Energy*, 12 July 2023, https://mansfield.energy/2023/07/12/what-is-it-midstream-sector-of-the-oil-and-gas-industry/.

DiChristopher, Tom. "With Miles of Aging Pipe, Midstream and Utility Giants Face New Compliance Costs." *S&P Global Market Intelligence*, 6 Feb. 2020, https://www.spglobal.com/marketintelligence/en/news-insights/latest-news-headlines/with-miles-of-aging-pipe-midstream-and-utility-giants-face-new-compliance-costs-56942555.

"Digital Technologies." *Aramco*, 2024, https://www.aramco.com/en/what-we-do/energy-innovation/digitalization/digital-technologies?utm_source=google%20discovery&utm_medium=native advertising&utm_campaign=GO_US_EN_Discovery&utm_term=OTHER&utm_content=TECHNOLOGY&wbraid=ClQKCQjwupGyBhCTARJDAFInPiRwAH4IsYqsc7EdR5iD9oxmjnewV1YBVKYL_YVYF7NPQA48lhPRlGcgPdkG7k6RiYRl3N-RQrvQ95gqEMB2RRoCvck.

Ebrahimi, Seyed Babak, and Ehsan Bagheri. "Optimizing Profit and Reliability Using a Bi-Objective Mathematical Model for Oil and Gas Supply Chain under Disruption Risks." *Computers & Industrial Engineering*, vol. 163, Jan. 2022, p. 107849. DOI: 10.1016/j.cie.2021.107849.

The Economist. "The Impact of Ageing Infrastructure in Process Manufacturing Industries." *The Economist*, pp. 1–34.

Elso, Nigel, Sayan Ganguly, Stephen Hall, Christoph Kloos, and Johann Raunig. "Securing Supply-Chain Resilience in Oil and Gas." *McKinsey & Company*, 2023, https://www.mckinsey.com/industries/oil-and-gas/our-insights/how-oil-and-gas-companies-can-secure-supply-chain-resilience.

ENTERPRISE PRODUCTS PARTNERS L.P - FORM 10-K. UNITED STATES SECURITIES AND EXCHANGE COMMISSION, 2023, https://ir.enterpriseproducts.com/static-files/666c475a-d4d3-4bbc-aad1-fecc7c6c84ae.

"Gas Leak Detection in Aging Infrastructure: Challenges and Innovative Solutions." *New Cosmos U.S.A*, 1 Sept. 2023, https://denovadetect.com/blogs/posts/gas-leak-detection-aging-infrastructure.

Ghosh, Dibakar. "AI in Compliance and Regulatory Reporting in Banks." *LinkedIn*, 10 Dec. 2023, https://www.linkedin.com/pulse/ai-compliance-regulatory-reporting-banks-dibakar-ghosh-9hync/.

Grand, V. Michael, et al. "Industry Credit Outlook 2024 Midstream Energy." 2024, https://www.spglobal.com/_assets/documents/ratings/research/101591879.pdf.

Groeger, Lena V. "Pipelines Explained: How Safe Are America's 2.5 Million Miles of Pipelines?" *ProPublica*, 15 Nov. 2012, https://www.propublica.org/article/pipelines-explained-how-safe-are-americas-2.5-million-miles-of-pipelines.

Horstman, Ashley-Rachelle, Pedro Caruso, and Japun Ahluwalia. "Bringing Agility to Midstream: A Critical Success Factor." Paper presented at the 23rd World Petroleum Congress, Houston, Texas, Dec. 2021.

"How AI Improves Physical Security in the Oil & Gas Industry." *Scylla*, 2023, https://www.scylla.ai/how-ai-improves-physical-security-in-the-oil-and-gas-industry/.

Hussain, R. A. E. D., Tiravat Assavapokee, and Basheer Khumawala. "Supply Chain Management in the Petroleum Industry: Challenges and Opportunities." *International Journal of Global Logistics & Supply Chain Management*, vol. 1, Nov. 2006, pp. 90–97.

IBM Supply Chain. "Supply Chain Visibility in the Energy and Utilities Industry." *IBM Blog*, 30 June 2023, https://www.ibm.com/blog/supply-chain-visibility-in-the-energy-and-utilities-industry/.

Jelinek, Patrick, and David Kirsch. "2024 Oil and Gas Industry Outlook." *EY*, 11 Jan. 2024, https://www.ey.com/en_us/insights/oil-gas/2024-oil-and-gas-industry-outlook.

JML Design Inc. "Navigating the Pipeline: Challenges in the Midstream Sector of the Oil and Gas Industry." *LinkedIn*, 30 Oct. 2023, https://www.linkedin.com/pulse/navigating-pipeline-challenges-midstream-sector-oil-gas-ab7tc/.

Kadam, Diptesh Singh. "Geo-AI for Safer, Real-Time Monitoring of Oil & Gas Pipelines." *Cyient*, 27 Feb. 2023, https://www.cyient.com/blog/geo-ai-for-safer-real-time-monitoring-of-oil-gas-pipelines.

Kalita, Ishanu. "The Oil and Gas Industry of Assam: The Upstream, Downstream, and Midstream Industry." *PalArch's Journal of Archaeology of Egypt / Egyptology*, vol. 17, no. 6, 2020, pp. 13252–67, https://archives.palarch.nl/index.php/jae/article/view/3504.

Kanike, Uday Kumar. "Factors Disrupting Supply Chain Management in Manufacturing Industries." *Journal of Supply Chain Management Science*, vol. 4, no. 1-2, June 2023, pp. 1–24. DOI: 10.18757/jscms.2023.6986.

Kerner, Sean. "Colonial Pipeline Hack Explained: Everything You Need to Know." *TechTarget*, 26 Apr. 2022, https://www.techtarget.com/whatis/feature/Colonial-Pipeline-hack-explained-Everything-you-need-to-know.

Khan, Wazir Zada, Mohammed Y. Aalsalem, Wajeb Gharibi, and Quratulain Arshad. "Oil and Gas Monitoring Using Wireless Sensor Networks: Requirements, Issues, and Challenges." *IEEE Xplore*, 1 Oct. 2016. DOI: 10.1109/ICRAMET.2016.7849577.

Krauss, Clifford. "Surging U.S. Oil Production Brings Down Prices and Raises Climate Fears." *The New York Times*, 1 Dec. 2023, https://www.nytimes.com/2023/12/01/business/energy-environment/us-oil-production-record-climate.html.

Kurdock, Brianne, Jim Curry, Gary Steinbauer, and Lee Banse. "PHMSA Releases Proposed Rulemaking on Gas Pipeline Leak Detection and Repair." *Babst Calland - Attorneys at Law*, 17 May 2023, https://www.babstcalland.com/news-article/phmsa-releases-proposed-rulemaking-on-gas-pipeline-leak-detection-and-repair/.

Li, Wenyuan, E. Vaahedi, and P. Choudhury. "Power System Equipment Aging." *IEEE Power and Energy Magazine*, vol. 4, no. 3, 2006, pp. 52–58. DOI: 10.1109/mpae.2006.1632454.

Lukinskiy, Valery, Vladislav Lukinskiy, and Rostislav Churilov. "Problems of the Supply Chain Reliability Evaluation." *Transport and Telecommunication Journal*, vol. 15, no. 2, Apr. 2014, pp. 120–29. DOI: 10.2478/ttj-2014-0011.

Malik, Naureen S. "Aging Infrastructure Poses Risks for Communities Relying on Natural Gas." *Insurance Journal*, 15 Oct. 2018, https://www.insurancejournal.com/news/national/2018/10/15/504457.htm.

McIntire, Carroll. "Utilizing the Power of Data and Advanced Analytics in Oil and Gas Supply Chains." *SupplyChainBrain*, 28 Feb. 2022, https://www.supplychainbrain.com/blogs/1-think-tank/post/34586-utilizing-the-power-of-data-and-advanced-analytics-in-oil-and-gas-supply-chains.

Mette, Boris. "Upstream, Midstream and Downstream." *STAUFF*, 11 June 2011, https://www.stauffusa.com/en/blog/knowledge/upstream-midstream-and-downstream.

"Midstream Logistics: Streamlining Logistics in the Midstream Sector." *FasterCapital*, Apr. 2024, https://fastercapital.com/content/Midstream-logistics–Streamlining-Logistics-in-the-Midstream-Sector.html#Introduction-to-Midstream-Logistics.

Millerman, Elena. "Developments in Midstream Oil and Gas Finance in the United States." *White & Case LLP*, 10 Apr. 2020, https://www.whitecase.com/insight-our-thinking/developments-midstream-oil-and-gas-finance-united-states.

Novity. "Predictive Maintenance for Midstream Oil & Gas." 2023.

Oosterhof, Marvin. "Unplanned Downtime." *Hint Global*, 18 Nov. 2021, https://www.hint-global.com/blog/cost-of-unplanned-downtime/.

OP US EPA. "Oil and Gas Sector Information." *EPA*, 1 Feb. 2018, https://www.epa.gov/smartsectors/oil-and-gas-sector-information.

O'Sullivan, Louie. "Recognizing Value of Data as Pipeline Integrity Assets." *Pipeline & Gas Journal*, Jan. 2023, https://pgjonline.com/magazine/2023/january-2023-vol-250-no-1/features/recognizing-value-of-data-as-pipeline-integrity-assets.

Patidar, Atul Kumar, Utkkarsh Agarwal, Utkarsh Das, and Tanupriya Choudhury. "Understanding the Oil and Gas Sector and Its Processes." *CRC Press EBooks*, Informa, Sept. 2023, pp. 1–20. DOI: 10.1201/9781003357872-1.

PFSD1g1ta. "Navigating the Perils of Aging Infrastructure." *EHD Insurance*, 7 Dec. 2023, https://ehdinsurance.com/navigating-the-perils-of-aging-infrastructure/.

PHMSA. "Safety of Gas Transmission Pipelines Rule Fact Sheet: MAOP Reconfirmation, Expansion of Assessment Requirements, and Other Related Amendments, RIN 1 Objectives." *PHMSA*, 2022, https://www.phmsa.dot.gov/technical-resources/pipeline/rin-1/safety-gas-transmission-pipelines-rule-fact-sheet-maop-reconfirmation-expansion-of-assessment-requirements-and-other-related-amendments-RIN1-objectives.

"Pipeline Incident 20 Year Trends." *PHMSA*, 2024, https://www.phmsa.dot.gov/data-and-statistics/pipeline/pipeline-incident-20-year-trends.

Putnam, Cody, and Al Paul. "Oil and Gas Must Prioritize Supply Chain Excellence." *EY*, 14 July 2023, https://www.ey.com/en_us/oil-gas-digital-skills-survey/oil-and-gas-must-prioritize-supply-chain-excellence.

Reddy, Rohan. "Energy & MLP Insights: Record-High U.S. Oil and Gas Output Requires Midstream Infrastructure." *Global X ETFs*, 20 Oct. 2023, https://www.globalxetfs.com/energy-mlp-insights-record-high-u-s-oil-and-gas-output-requires-midstream-infrastructure.

Samaniego, Mauricio. "Midstream/MLPs: 2020 Cost Discipline Has Benefits into 2021." *ETF Database*, 26 Apr. 2021, https://etfdb.com/index-insights/midstream-mlps-2020-cost-discipline-has-benefits/.

SitePro. "Midstream Automation: What Is the Future of Fluid Management?" *SitePro*, 3 Aug. 2018, https://blog.sitepro.com/resources/blog/midstream-automation-what-is-the-future-of-oilfield-transportation/.

Srivastava, Sudeep. "Nine Best Use Cases of AI in the Oil and Gas Industry." *Appinventiv*, 17 Aug. 2023.

"Supply Chain Management in Oil and Gas Industry." *GEP Blog*, Mar. 2024, https://www.gep.com/blog/strategy/supply-chain-management-in-oil-and-gas-industry.

Toyo, Mario. "The Impact of AI on Asset Integrity Management." *Inspenet*, 31 Dec. 2023, https://inspenet.com/en/articulo/ai-in-asset-integrity-management/.

Tripathi, Panka. "Document AI for Efficient Compliance and Risk Management." *Docsumo*, 14 Nov. 2023, https://www.docsumo.com/blog/automate-compliance-with-document-ai#:~:text=to%20compliance%20management.-.

Tsidulko, Joseph. "Benefits of AI in the Supply Chain." *Oracle*, 11 Jan. 2024, https://www.oracle.com/scm/ai-supply-chain/.

U.S. Department of Energy. "America's Strategy to Secure the Supply Chain for a Robust Clean Energy Transition." *U.S. Department of Energy*, 24 Feb. 2022, https://www.energy.gov/policy/articles/americas-strategy-secure-supply-chain-robust-clean-energy-transition-fact-sheet.

"US Oil and Gas Midstream Market - Outlook, Overview & Forecast Trend." *Mordor Intelligence*, 2023, https://www.mordorintelligence.com/industry-reports/united-states-oil-and-gas-midstream-market.

"U.S. Oil Pipeline Incident Causes 2020." *Statista*, 15 Dec. 2023, https://www.statista.com/statistics/1271803/most-common-us-oil-pipeline-incident-causes/.

Valle, Elm. "The Crucial Impact of Supply Chain on the Oil and Gas Industry: Insights and Projections." *LinkedIn*, 1 June 2023, https://www.linkedin.com/pulse/crucial-impact-supply-chain-oil-gas-industry-insights-elm-valle/.

Vasquez, David. "The Importance of U.S. Refining Capacity." *America First Policy Institute*, 20 Nov. 2023, https://americafirstpolicy.com/issues/the-importance-of-u.s-refining-capacity#:~:text=Without%20adequate%20refining%20capacity%2C%20the.

Wanasinghe, Thumeera R., et al. "Digital Twin for the Oil and Gas Industry: Overview, Research Trends, Opportunities, and Challenges." *IEEE Access*, vol. 8, 2020, pp. 75–97. DOI: 10.1109/access.2020.2998723.

Wassick, John M. "Enterprise-Wide Optimization in an Integrated Chemical Complex." *Computers & Chemical Engineering*, vol. 33, no. 12, Dec. 2009, pp. 1950–63. DOI: 10.1016/j.compchemeng.2009.06.002.

Watson, Kim, Sandip Bhattacharya, and Brian Bench. "AI Implementation Fuels Decarbonization for Midstream Energy Industry." *Wipro*, 2023.

WESTERN MIDSTREAM PARTNERS, LP WESTERN MIDSTREAM OPERATING, LP. UNITED STATES SECURITIES AND EXCHANGE COMMISSION, 2023, https://www.sec.gov/Archives/edgar/data/1423902/000142390223000023/wes-20221231.htm.

Wolfe, Todd. "13 Remarkable Applications of AI in the Oil & Gas Industry." *Birlasoft*, 31 Aug. 2021, https://www.birlasoft.com/articles/13-remarkable-applications-ai-oil-gas-industry.

Woynarowich, Mark. "Digital Twins for Oil and Gas Pipelines: The Next Evolution in Asset Management and Optimization." *LinkedIn*, 11 May 2023, https://www.linkedin.com/pulse/digital-twins-oil-gas-pipelines-next-evolution-asset-mark-woynarowich/.