

RÉPUBLIQUE ALGÉRIENNE DÉMOCRATIQUE ET POPULAIRE
MINISTÈRE DE L'ENSEIGNEMENT SUPÉRIEUR ET DE LA
RECHERCHE SCIENTIFIQUE
ÉCOLE NATIONALE POLYTECHNIQUE



Département Génie Industriel

*End-of-study project dissertation for obtaining the State Engineer's degree in
Industrial Engineering
Option: Industrial Management*

Developing a planning panel to forecast truck fleet size
based on activity forecast

Presented by

Oussama RAHMANI
Salah Eddine ADJABI

Defended on: **June 25th, 2025**

In front of the jury composed of:

Dr. Imene BARECHE	MCB (ENP)	President
Dr. Iskander ZOUAGHI	MCA (ENP)	Promoter
Dr. Samia BELDJOUDI	MCA (ENP)	Examiner
Mr. Ramtane BENKERROU	LDL (SLB)	Invited

ENP 2025

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Département Génie Industriel

*Mémoire de Projet de fin d'Etudes pour l'obtention du Diplôme d'Ingénieur
d'Etat en Génie Industriel*
Option: Management Industriel

Développement d'un panel de planification pour
prévoir la taille de la flotte de camions sur la base des
prévisions d'activité

Présenté par
Oussama RAHMANI
Salah Eddine ADJABI

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Devant le jury composé de:

Dr. Imene BARECHE	MCB (ENP)	Présidente
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Dr. Samia BELDJOUDI	MCA (ENP)	Examinatrice
Mr. Ramtane BENKERROU	LDL (SLB)	Invité

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ملخص

تتناول هذه الأطروحة أوجه القصور اللوجستية للفرع المحلي لشركة Algérie SLB من خلال تطوير حل متكامل مكون من أداة تخطيط ونموذج تحسين ونموذج متابعة الأداء. تعمل لوحة التخطيط، التي تم تصميمها باستخدام برنامج VBA، Excel على تحسين الرؤية حول تخطيط العمل وتخصيص الشاحنات ومتطلبات المواد. يتم استخدام نموذج التحسين الخطي المختلط الصريح لتقدير الحد الأدنى لحجم الأسطول اللازم لتلبية الطلب السابق مع احترام القيود التشغيلية. تُرجع لوحة المعلومات عبر استخدام أدوات BI Power لمؤشرات الأداء الرئيسية من أجل تقييم الكفاءة ودعم اتخاذ القرار.

تُظهر النتائج أن الأدوات المستندة إلى البيانات تُحسن بشكل كبير من دقة التخطيط واستخدام الشاحنات ووضوح الرؤية. ومع ذلك، لا تزال هناك قيود في تكامل البيانات ومنطق توحيد الشاحنات وتوسيع نطاقها، مما يمهّد الطريق لإجراء أبحاث مستقبلية.

كلمات مفتاحية: خدمات النفط والغاز، تحسين سلسلة التوريد، النمذجة الرياضية، أدوات دعم اتخاذ القرار.

Résumé

Ce mémoire traite des inefficacités logistiques de la branche domestique de SLB Algérie à travers le développement d'une solution intégrée composée d'un outil de planification, d'un modèle d'optimisation et d'un tableau de bord de performance. Le panneau de planification, conçu sous Excel VBA, améliore la visibilité sur la planification des travaux, l'allocation des camions et les besoins en matériel. Un modèle d'optimisation linéaire en nombres entiers mixtes est utilisé pour estimer rétroactivement la taille minimale de flotte nécessaire pour répondre à la demande passée tout en respectant les contraintes opérationnelles. Un tableau de bord Power BI permet de visualiser les indicateurs de performance clés afin d'évaluer l'efficacité et d'appuyer la prise de décision. Les résultats montrent que les outils basés sur les données améliorent significativement la précision de la planification, l'utilisation des camions et la visibilité. Néanmoins, des limites subsistent en matière d'intégration des données, de consolidation des expéditions et de passage à l'échelle, ouvrant ainsi la voie à des recherches futures.

Mots clés : Services pétroliers et gaziers, Optimisation de la chaîne d'approvisionnement, Modélisation mathématique, Outils d'aide à la décision, planification de la chaîne logistique, ordonnancement dynamique.

Abstract

This thesis addresses inefficiencies in SLB Algeria's domestic logistics by developing an integrated solution composed of a planning tool, an optimization model, and a performance dashboard. The planning panel, built in Excel VBA, improves visibility over job schedules, truck allocation, and material requirements. A mixed-integer linear programming model is implemented to retrospectively determine the minimum truck fleet needed to fulfill past demand while respecting operational constraints. A Power BI dashboard visualizes key performance indicators to assess efficiency and support decision-making. Findings show that data-driven tools significantly improve planning accuracy, fleet utilization, and visibility. However, challenges remain regarding data integration, shipment consolidation logic, and tool scalability, indicating directions for future research.

Keywords : Oil and Gas Services, Supply Chain Optimization, Mathematical Modeling, Decision Support Tools, supply chain planning, planning adherence, Dynamic Scheduling.

DEDICATION

God, all praise is due to You as is befitting to the majesty of Your face and the greatness of Your authority. God, I ask You for well-being in my religion, my worldly life, my family, and my wealth. God, make me among those who are grateful for Your blessings, who remember Your grace, and who remain steadfast in obeying You. God, grant me enjoyment of my hearing, my sight, and my strength for as long as I live, and make them my inheritors.

In the name of God, the Most Gracious, the Most Merciful.

God, all praise is due to You as is befitting to the majesty of Your face and the greatness of Your authority. God, I ask You for well-being in my religion, my worldly life, my family, and my wealth. God, make me among those who are grateful for Your blessings, who remember Your grace, and who remain steadfast in obeying You. God, grant me enjoyment of my hearing, my sight, and my strength for as long as I live, and make them my inheritors.

To the Sun of my solar system, the unwavering light that guided me through every orbit, my mother. Every achievement I claim, every milestone I cross, every horizon I chase is rooted in your love, sacrifice, and strength. Thank you for believing in your strong son, he carries your dreams in his heart and promises that his journey will always be one that makes you proud.

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To Aymen, Raihane, Rayane, Mouna, Yasmine, Fares, Haitem, Mehdi Khammoum, Zadek mouloudia, Sofiane and Sofiane, Sara, Amira, Yazid,

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To anyone I may have hurt—intentionally or by accident—know that it was never from malice, but perhaps from misjudgment or a clouded mind.

For that, I offer my sincerest apologies and my wish for peace.

This is not just a thesis. It is the story of a journey, one written with your presence, your kindness, and your unwavering belief in me. Thank you.

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Ouss

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LIST OF ACRONYMS

AI: Artificial Intelligence

API: American Petroleum Institute (referring to API gravity)

b/d: Barrels per Day

BI: Business Intelligence

BL: Business Line

CCS: Carbon Capture and Storage

CCUS: Carbon Capture, Utilization, and Storage

CPLEX: IBM ILOG CPLEX Optimization Studio

D&I: Digital & Integration Division

D&M: Drilling & Measurements

DL: Domestic Logistics

DST: Drill Surface Testing

ESG: Environmental, Social, and Governance

ETA: Estimated Time of Arrival

ETD: Estimated Time of Departure

FDP: Field Data Platform

FSA: Formation Sampling and Analysis

GBS: Global Business Services

GDP: Gross Domestic Product

GHG: Greenhouse Gas

HSE: Health, Safety, and Environmental

ICV: In-Country Value

INE SC: Shanghai International Energy Exchange Crude Oil Futures

IoT: Internet of Things

KPI: Key Performance Indicator

LNG: Liquefied Natural Gas

MILP: Mixed-Integer Linear Programming

MINLP: Mixed-Integer Nonlinear Programming

MWD: Measurement While Drilling

OFS: Oilfield Services

OPEC: Organization of the Petroleum Exporting Countries

OTIF: On-Time-In-Full

OTM: Oracle Transportation Management

P/E: Price-to-Earnings

PS: Production Systems Division

PSD: Product Service Delivery

RP: Reservoir Performance Division

RPS: Reservoir and Production Services

S&OP: Sales and Operations Planning

SCM: Supply Chain Management

SDGs: Sustainable Development Goals

SEM: Socio-Economic Management

SH: Shipment Handling

SLB: Schlumberger

TCE: Transaction Cost Economics

TMS: Transportation Management System

TR: Transport Request

TTM: Trailing Twelve-Month

UAE: United Arab Emirates

UML: Unified Modeling Language

VBA: Visual Basic for Applications

VRP: Vehicle Routing Problem

VUCA: Volatility, Uncertainty, Complexity, and Ambiguity

WC: Well Construction Division

WCF: Well Construction Fluids

WCM: Well Construction & Measurements

WIS: Well Intervention Services

WL/WLES: Wireline Logging Services

XES: SPDR S&P Oilfield Services ETF

ETL: Extract, Transform, Load

In an era marked by volatile energy markets, heightened environmental scrutiny, and accelerating technological transformation, the oil and gas industry finds itself navigating a complex and evolving landscape. As hydrocarbon exploration and production grow increasingly data-driven and cost-sensitive, operational efficiency emerges not merely as a competitive advantage, but as a strategic imperative. Within this context, logistics, particularly domestic logistics, plays a pivotal role in enabling agile, resilient, and optimized operations, especially for global oilfield services providers such as SLB.

This thesis is situated at the intersection of logistics performance, cost optimization, and digital enablement within the oilfield services sector, with a specific focus on the Algerian market. **Chapter 1** presents a comprehensive overview of the global oil and gas landscape, the strategic evolution of the oilfield services industry, and SLB's positioning as a technological and operational leader. It further delves into Algeria's market characteristics, investment frameworks, and logistical infrastructure, before narrowing the lens to the domestic logistics function within SLB. A detailed analysis of the company's internal systems, ranging from sales to execution, uncovers fragmented data flows, visibility gaps, and coordination inefficiencies that have historically impeded the performance of the Domestic Logistics (DL) department. These findings form the foundation of the problem space explored in this research.

Chapter 2 builds the theoretical underpinnings necessary to address these challenges. Through an extensive literature review, the thesis explores the evolution of supply chain management and transportation theory, with a dedicated emphasis on their application in the oil and gas sector. Key concepts such as transaction cost economics, fleet visibility, scheduling adherence, and sustainability are examined in light of both academic discourse and practical implementation. A cross-case analysis of industry-specific logistics optimization initiatives, particularly in crude oil and LNG transport, offers critical insights into how advanced modeling techniques are reshaping decision-making under operational constraints.

Chapter 3 presents the proposed solution architecture. It details the development of a decision-support platform that integrates a planning panel, a mathematical optimization model, and a performance dashboard. Built using Excel VBA, CPLEX optimization, and Power BI, the platform aims to enhance visibility, streamline fleet allocation, and enable data-informed performance tracking across the Domestic Logistics department. The model operates retrospectively to analyze historical shipment patterns and generate optimal fleet sizing recommendations. The planning panel facilitates proactive job allocation and materials planning, while the BI dashboard consolidates KPIs that evaluate

cost-efficiency, resource utilization, and service reliability.

By triangulating analytical rigor, operational realism, and technological pragmatism, this thesis contributes a multi-faceted solution to an entrenched logistical problem. While the approach demonstrates tangible benefits, it also reveals limitations related to data integration, scenario complexity, and organizational adoption, opening pathways for future research into predictive logistics, consolidation mechanisms, and enterprise-wide deployment.

CHAPTER 1

COMPANY OVERVIEW AND CURRENT ENVIRONMENT

Schlumberger Limited (SLB), a multinational leader in oilfield services and technology, operates within a complex matrix of global scalability and localized execution. Founded in **1926**, the company has evolved into a cornerstone of hydrocarbon exploration and production, delivering advanced solutions across drilling, reservoir management, and digital integration. SLB's organizational structure—a hierarchical framework of GeoUnits, Divisions, and Business Lines—enables it to standardize operations while adapting to regional market dynamics, from Algeria's Sahara basins to Norway's offshore fields. Central to its strategy is a dual emphasis on digital innovation (e.g., AI-driven platforms like DELFI) and sustainability, as reflected in its *Net-Zero 2050* roadmap and **30%** reduction in Scope 1–2 emissions since **2020** [43].

This chapter provides a systematic dissection of SLB's operational ecosystem, beginning with its Business Lines—technical service domains such as Well Construction and Artificial Lift—and its Supply Chain, which integrates R&D-driven technology deployment with circular logistics practices. A critical focus is placed on Domestic Logistics (DL), where localized challenges, including fleet optimization and decarbonized transport, intersect with global standards. Through previous projects analysis, this chapter evaluates SLB's adherence to process efficiency and identifies gaps in its Algerian DL operations, particularly in truck fleet sizing. The Problem Definition crystallizes these findings, proposing that dynamic fleet-sizing models could mitigate inefficiencies caused by demand volatility and geopolitical constraints, offering a scalable solution for SLB's global energy transition objectives.

1.1 Oil and Gas Sector Context

The **oil and gas sector** operates within a highly dynamic global marketplace, where the pricing mechanisms of crude oil are fundamentally shaped by the interplay of **supply**, **demand**, and **quality differentiation**. On the supply side, production is driven by extraction companies that bring crude oil to the market. Conversely, demand is principally generated by **refiners**, who transform this unrefined input into usable petroleum products. The interaction between these two forces creates the **market equilibrium price**, a central determinant in the global oil economy.

Within this structure, three main categories of **spot markets** define how oil is transacted and priced. The first is the **physical spot market**, often referred to simply as the "spot market." This market enables **immediate or near-immediate physical**

delivery of crude oil, factoring in logistical considerations. It serves as a core platform for **price discovery** and **physical settlement**. Key participants include national oil companies such as *Sonatrach*, and international corporations like *Total*, *BP*, *Gazprom*, *Chevron*, and *Saudi Aramco*.

The **forward physical market** represents a more deferred structure. In this market, oil is traded for **future delivery**—usually scheduled between **three and six months** ahead—at prices fixed at the time of agreement. It allows **producers to hedge** against price volatility and provides **contractual certainty** for both producers and buyers.

Distinct from the previous two is the **futures market**, which functions as a **financial derivatives platform**. It facilitates the exchange of standardized contracts for oil, with settlement via **financial instruments rather than physical delivery**. This market is key for **risk management**, **liquidity**, and setting **benchmark prices**.

Analyzing these markets requires understanding the **diversity of crude oil**. It varies in **density**, **sulfur content**, and **geographic origin**, and is classified into **benchmarks and grades**. These physical distinctions are essential to market behavior, pricing, and **global trade flows**.

Global oil reserves are highly concentrated. As of **2020**, the **Middle East** held **48.3%** of proven reserves (about **0.84 trillion barrels**), followed by **Central and South America** with **18.7%**, and **North America** with **14.0%**. **Venezuela** led globally with **303.8 billion barrels**, ahead of Saudi Arabia and Canada. Notably, **95.7%** of Canada's reserves are **unconventional oil sands**, reshaping extraction and refining strategies.

Regarding **production**, global output reached **93.85 million barrels/day (b/d)** in **2022**. Leading producers—the **United States**, **Saudi Arabia**, **Russia**, **Canada**, **Iraq**, **China**, and the **UAE**—accounted for **63.1%** of total production (Figure 1.1). (Figure 1.1).

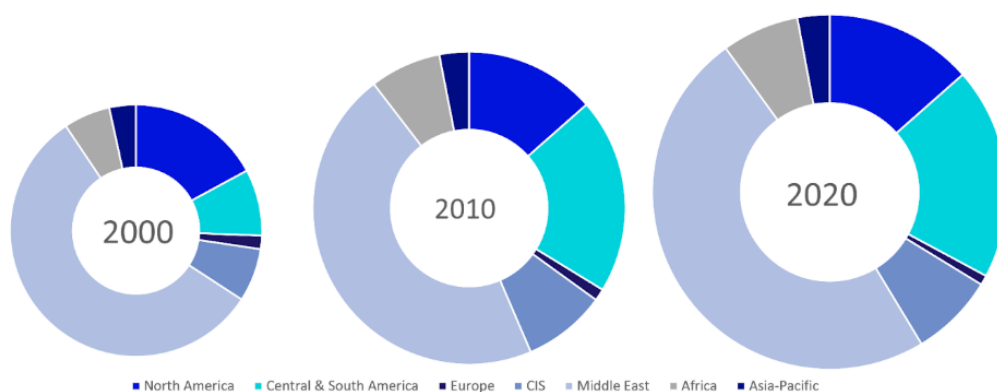


Figure 1.1: Proven oil reserves in 2000, 2010 and 2020 by region (bn bbl)

Patterns of consumption reveal a complementary dynamic on the **demand side**. In **2022**, global oil consumption reached **97.31 million b/d**, with the **United States** (**19.14 million b/d**), **China** (**14.30 million b/d**), and **India** emerging as the largest consumers. This surge in demand followed the **post-COVID economic rebound**, although China's strict lockdown policies during that period caused its consumption to decline by **4.0%** compared to the previous year.

Industrial applications accounted for **half of the global oil demand**, underscoring

oil's indispensable role in **heavy manufacturing, chemicals, and energy generation**. **Transportation** followed as the second most significant sector, comprising approximately **25%** of demand—reflecting the continued reliance on oil-based fuels in **road, air, and marine mobility** (Figure 1.2).

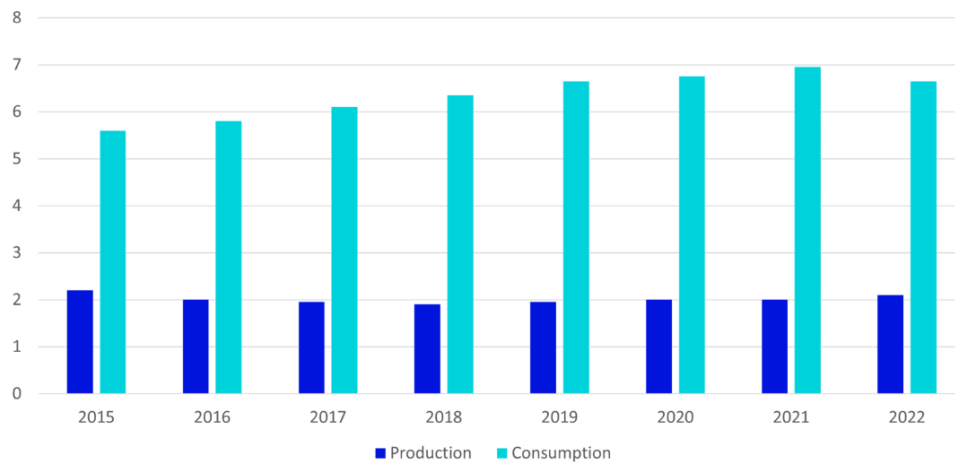


Figure 1.2: China's crude oil production and consumption (100 million metric tons)

Understanding oil price behavior also necessitates a deep appreciation of **crude oil quality differentials**, as these attributes significantly influence market valuation. Crude oil is primarily classified by two dimensions: **density** (measured in **API gravity**) and **sulfur content**. **Light crude oils**, with an API gravity above **34.9**, are favored due to their higher yield of refined products like gasoline and diesel. For instance, **Murban crude** from the UAE commands a **¥5 per barrel premium**. In contrast, **heavy crude oils** ($\text{API} \leq 29.2$) require more intensive processing and thus trade at discounts—for example, **Iraq's Basrah Medium** typically sells at **¥10 per barrel below** benchmark prices.

Sulfur content further stratifies crude into **sweet** and **sour** grades. **Sweet crudes**, with sulfur levels below **0.8%**, are less corrosive and more environmentally compliant, making them cheaper to refine. As a result, they command higher market prices; for example, **Brazil's Tupi crude**, a sweet variety, often trades at a **¥10 premium**. Conversely, **sour crudes** such as **Basrah Light**, with sulfur content near **3.5%**, face discounts due to their higher desulfurization costs and environmental burdens.

These benchmarks have been standardized across trading platforms, including the **Shanghai crude futures market (INE SC)**, which accepts delivery of streams such as **Dubai, Oman, Upper Zakum** (medium-sour crudes at no premium/discount), **Shengli** (a heavy Chinese crude at a **¥5 discount**), and **Murban** (light, low-sulfur crude at a **¥5 premium**).

Crude oil prices are ultimately shaped by a confluence of **geopolitical, macroeconomic, and physical market factors** (Figure 1.3). Events such as the **Russia–Ukraine conflict**, combined with **OPEC+ supply cuts**, injected volatility into energy markets throughout **2023**. On the macroeconomic side, **interest rate hikes** by central banks in major economies lowered demand projections and curtailed speculative trading.

Regional price disparities also emerged: while the **INE SC** settled at **¥542.7 per barrel** in **2023** (down **4.49%** year-over-year), **Brent crude** fell more sharply to **\$85.96 per barrel**, marking a **10.33%** contraction. These variations reflect not only

broad market sentiment but also technical factors like **sulfur content**, **API gravity**, and **logistical costs** linked to transportation to refineries and end markets.

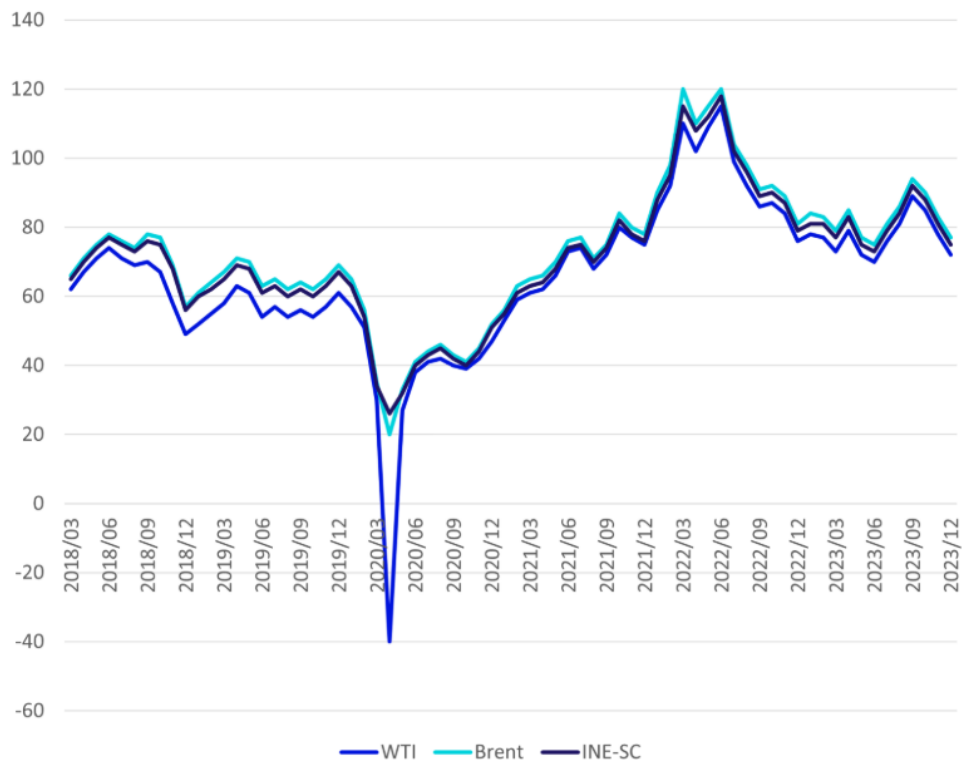


Figure 1.3: International crude oil price trend (USD/barrel))

1.1.1 Recent Developments in Global Oil Markets

Recent developments in global oil markets have underscored the ongoing volatility and complexity of **supply–demand interactions**. In early **2025**, global oil demand exhibited moderate growth, expanding by approximately **1 million barrels per day (bpd)**. However, this rising consumption was quickly counterbalanced by production increases, most notably from **OPEC+ member states**. The coordinated decision by these producers to elevate output introduced an **oversupply condition**, leading to a sharp rise in global commercial oil inventories. By **March 2025**, stockpiles had exceeded **7.7 billion barrels**, with forecasts suggesting continued accumulation through the **2025–2026** horizon [35]. This divergence between demand growth and aggressive supply expansion has begun to weigh on **price stabilization efforts** and heightens the risk of **market disequilibrium**.

The strategic posture adopted by the **OPEC+ coalition**—led by **Saudi Arabia** and **Russia**—reflects an assertive attempt to safeguard **market share** amidst growing competition from **non-conventional producers**, particularly **U.S. shale operators**. On **May 3, 2025**, OPEC+ formally announced an **increase in production quotas**, a move intended to solidify their pricing influence and reaffirm control over global supply fundamentals. While this approach may reinforce short-term dominance, it introduces significant pressure on **high-cost producers**. Analysts have expressed concern that prolonged periods of **low prices**, induced by supply-driven strategies, could undermine the economic viability of U.S. shale extraction, potentially prompting a **structural shift** in the global production hierarchy [35].

In addition to supply–demand dynamics, **geopolitical factors** remain a potent source of market instability. In **May 2025**, tensions escalated in the **Middle East** over the potential for **Israeli military engagement** targeting **Iranian nuclear infrastructure**. This situation triggered a **crude oil risk premium exceeding 1%**, demonstrating the market’s acute sensitivity to geopolitical developments [35]. Such episodes of geopolitical uncertainty reinforce the **intrinsic volatility** of oil markets and complicate **forecasting efforts** for both producers and policy-makers. These developments collectively reflect a market environment where pricing outcomes are shaped as much by **policy and geopolitics** as by the underlying fundamentals of production and consumption.

1.1.2 Competitive Landscape of Oilfield Services and SLB’s Strategic Position

The global **oilfield services (OFS)** sector has undergone a significant transformation in the aftermath of a prolonged downturn. Following cumulative losses exceeding **\$155 billion** between 2015 and 2021, the industry recorded a dramatic recovery, with aggregate net income reaching approximately **\$50 billion** between 2022 and 2024. This resurgence has been underpinned by a triad of structural shifts: **disciplined capital allocation**, **accelerated digitalization**, and **strategic investments in decarbonization technologies**. Leading OFS providers have progressively evolved toward "**energy technology**" archetypes, integrating **AI**, **carbon capture and storage (CCS)**, and **geothermal development** into their core service offerings.

Within this ecosystem, the competitive architecture of the OFS sector can be classified into three archetypes. First, **integrated majors** such as **SLB**, **Halliburton**, and **Baker Hughes** command global scale, diversified portfolios, and advanced R&D capabilities that allow them to provide end-to-end service solutions (Table 1.1). Second, **diversified**

players like **TechnipFMC** and **Weatherford** occupy specialist niches—most notably in subsea engineering and completion systems. Lastly, **focused specialists** such as **NOV Inc.** leverage deep technical expertise in specific domains, including **drilling equipment** and **rig automation systems**. Each category plays a distinct role in an increasingly **modular** and **technology-intensive** market structure.

SLB (formerly Schlumberger) continues to assert itself as the **global leader** in oilfield services, with operational presence across **120 countries** and a workforce exceeding **98,000 employees**. The company maintains leading market shares in key technical services, notably **wireline logging**, **production testing**, and **logging-while-drilling**. Approximately **20% of SLB's revenues** are now attributable to **emerging technologies**, signaling a deliberate pivot toward **innovation-led growth**.

A core pillar of SLB's competitive strategy is the **integration of technology and digitalization** into its service delivery. Through proprietary **AI-enabled platforms** such as *Lumi*, used extensively in **subsurface reservoir modeling**, and the growth of its **Digital & Integration** business segment (which reported a **10% year-over-year increase in 2024**), SLB reinforces its position at the frontier of **data-driven service delivery**. Moreover, the company is investing heavily in **energy transition technologies**, including **carbon capture**, **direct lithium extraction**, and **green hydrogen production**, aligning its capabilities with the broader **decarbonization agenda** of global energy markets.

From an organizational standpoint, SLB's transition to a **functionally aligned operating model**—centered around **centralized expertise** and **trans-geographic coordination**—has addressed long-standing inefficiencies related to **regional silos**. This structural reform has also enhanced **knowledge sharing** and **talent retention**, critical factors in an industry where **workforce attrition** and **generational skill gaps** pose systemic risks.

Table 1.1: Key Competitive Strengths of SLB vs. Peers

Dimension	SLB	Baker Hughes	Halliburton
Market Cap	\$48.7B	\$39.2B	\$19.8B
Global Reach	120 countries	120+ countries	70+ countries
Tech Focus	AI, decarbonization, digital integration	Supercritical CO ₂ turboexpanders	Pressure pumping, drilling
R&D Investment	High (e.g., \$728M in 2007)	Moderate	Moderate

1.1.3 Financial Overview and Strategic Outlook of SLB

Financially, **SLB demonstrates robust fundamentals**. The firm reports a trailing twelve-month (TTM) **net income of \$4.19 billion**, with a **profit margin of 11.62%** and a **price-to-earnings (P/E) ratio of 12.23**. **Shareholder returns** remain competitive, supported by a **\$1.14 per share dividend (3.16% yield)** and an authorized **\$4 billion share buyback program**. However, **stock performance reflects some volatility**. While SLB has **outperformed the SPDR S&P Oilfield Services ETF (XES) by nearly 10% year-to-date**, it trails behind peers such as **Baker Hughes**, which recorded a **37.6% gain over the past 52 weeks**. Notably, **SLB trades below both its 50- and 200-day moving averages**, despite favorable Q1 2025 earnings,

suggesting cautious investor sentiment amid **macroeconomic and sector-specific uncertainties**.

SLB and its peers operate within a **structurally cyclical industry** that remains vulnerable to **exogenous shocks**, including **commodity price volatility** and **geopolitical disruptions**. For instance, **negative gas pricing events in the Permian Basin** have underscored the fragility of regional infrastructure and the sensitivity of operations to mid-stream bottlenecks. Internally, the company faces **execution risk**—especially in **post-merger integration contexts** such as the recent acquisition of **ChampionX**—and **capital structure constraints**, with a **debt-to-equity ratio of 68.14%** limiting financial agility. **Human capital** also emerges as a strategic vulnerability, as the company contends with an **aging workforce** and an estimated **22% attrition rate in field roles**, reflecting **limited career progression pathways**.

Looking ahead, SLB is **positioning itself to capitalize on multiple growth vectors**. **Operational optimization in North America**, particularly through new pipeline capacity in the Permian Basin (e.g., **Matterhorn Express**), offers near-term uplift. Concurrently, the company is expanding its **low-carbon portfolio**, with scalable initiatives in **CCS** and **geothermal development** that aim to hedge against long-term fossil fuel demand contraction.

However, SLB’s **dominance is not unchallenged**. **Agile technology startups** are increasingly competing in **digital drilling analytics**, and **Baker Hughes’ advances in turboexpander-based carbon capture technology** signal intensifying competition in decarbonization solutions. Despite these threats, **SLB’s extensive global footprint**, sustained **investment in R&D**, and vertically integrated “**energy technology**” model equip it with **resilient competitive moats**.

In summary, SLB’s **evolution from a traditional OFS provider into a digitally enabled energy technology firm** is both **proactive and strategically coherent**. While macroeconomic volatility and structural challenges persist, the firm’s ability to **operationalize digital innovation**, enhance **cross-functional expertise**, and scale **sustainable solutions** reinforces its **strategic relevance** in an industry undergoing rapid transformation.

1.2 Overview of SLB

Schlumberger (SLB) operates a dual supply chain framework that integrates technology innovation with operational excellence, enabling the company to remain at the forefront of the global energy services sector. The first of these, the **Technology Innovation Supply Chain**, is designed to accelerate the development and industrial deployment of advanced technologies. This includes **artificial intelligence (AI)-driven digital platforms**, **modular carbon capture systems** (such as **CCUS**), and other decarbonization-oriented solutions. **Strategic partnerships**, such as the collaboration with **Aker Carbon Capture**, have played a critical role in scaling innovative systems like the “**Just Catch**” plants, which are now integrated into industrial workflows to support emissions reduction goals.

The second branch, the **Oil and Gas Services Supply Chain**, delivers core operational services across **drilling**, **reservoir management**, and **production optimization**. This chain focuses on the application of technologies generated by the innovation arm, including **smart meters**, **hydraulic fracturing systems**, and **emission con-**

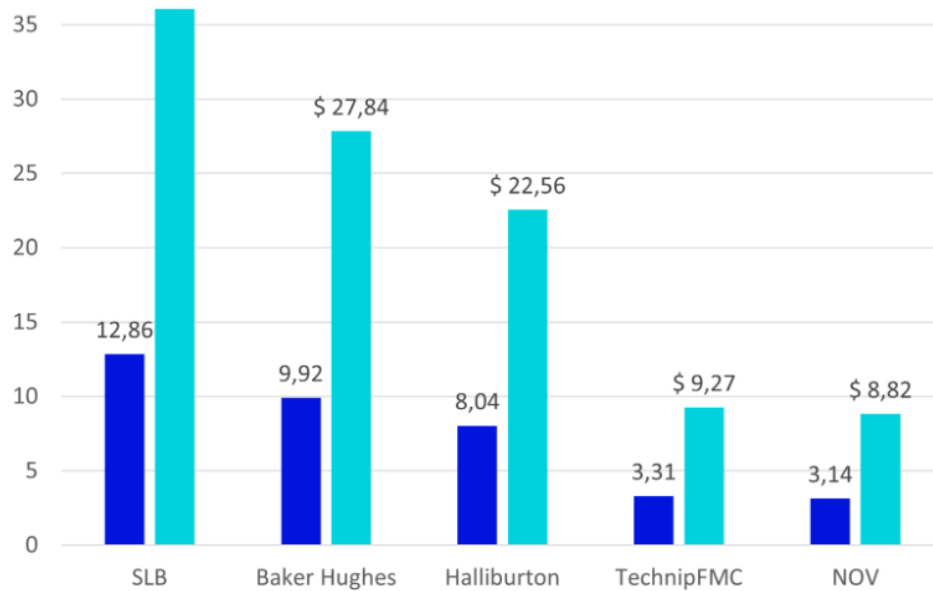


Figure 1.4: Oil and gas services companies

trol mechanisms. By aligning technological deployment with on-the-ground operational needs, SLB ensures a seamless transfer of innovation into practice, enhancing **efficiency**, **safety**, and **sustainability** in hydrocarbon operations worldwide.

SLB's **global strategic positioning** underscores its expansive operational reach and commitment to **sustainable development**. With operations spanning over **120 countries** and more than **900 facilities**, SLB leverages **localized expertise** to deliver scalable energy solutions while aligning with international frameworks such as the **Paris Agreement** and the **United Nations Sustainable Development Goals (SDGs)**. The company has set ambitious climate targets, including achieving **net-zero Scope 1 and 2 emissions by 2050**. As of 2024, SLB has already reduced **Scope 1–2 emissions by 30%**, while **Scope 3 emissions intensity fell by 18%** through proactive supplier engagement and circular economy principles.

Digital transformation remains a central pillar of SLB's growth strategy. In **Q1 2025**, **digital solution revenues increased by 17%** year-on-year, primarily driven by **AI-based platforms** and **cloud-native data analytics**. On the governance side, SLB upholds rigorous standards through initiatives such as **conflict-free mineral sourcing** and comprehensive **human rights due diligence** across its supply network of over **750 suppliers**. Furthermore, its global **STEM education programs**—such as those in **Libya**—have reached hundreds of students, advancing **inclusive and equitable access to technology-related education**.

In **Algeria**, SLB has maintained a robust presence since the country's independence, positioning itself as a **strategic partner in national energy development**. The establishment of the **Ouargla Hub of Excellence** has fostered **localized innovation** in energy and environmental technologies, contributing to **job creation** and **entrepreneurship** in southern Algeria. SLB also supports **gender equity** through initiatives like "**Women in Engineering**" and other **community-centered sustainability programs**, promoting the participation of women in **technical and leadership roles**. In 2024, SLB announced plans to scale up its Algerian operations by deploying **cutting-edge drilling and decarbonization technologies**, reinforcing its commitment to **in-country value (ICV)** and deepening its collaboration with national stakeholders to

meet Algeria's **energy and climate objectives**.

1.2.1 SLB Divisions

Schlumberger (SLB) structures its global operations across more than 120 countries through a robust organizational framework composed of four principal operational divisions (Figure ??). Each division is supported by specialized business lines that deliver targeted services and technologies, enabling SLB to address the full lifecycle of oilfield development and management. This divisional approach promotes integration, specialization, and adaptability across geographies and project types.

- **The Digital & Integration (D&I) division:** This division focuses on the collection, analysis and interpretation of seismic and geological data. Its objective is to optimise performance by reducing cycles and risks, accelerating returns, and productivity, while minimising costs and carbon emissions. At the same time, it is dedicated to integrating data, digital technologies and processes to effectively improve the company's assets.
- **The Production Systems (PS) division:** This division focuses on completion systems, artificial lift, wellheads and surface fracturing services. It also specialises in the development of advanced technologies and provides expertise to optimise the production and recovery of resources from underground reservoirs to the surface, through pipelines and refineries.
- **Well Construction Division (WC):** This division offers a wide range of products and services designed to maximise drilling efficiency and improve reservoir contact, while reducing risks and promoting dynamic operations. It offers drilling rig operators and manufacturers integrated solutions for the design and construction of drilling rigs.

In Algeria, the division's main business lines: Well Construction Fluids (WCF) and Well Construction & Measurements (WCM) work in close coordination to ensure efficient, safe, and high-integrity well construction. The WCM business line supports real-time well placement and trajectory control, with Drilling & Measurements (D&M) delivering essential services such as Directional Drilling and Measurement While Drilling (MWD). Meanwhile, WCF focuses on engineered fluids designed to stabilize formations, manage pressure, and maintain wellbore integrity. A core component of WCF is cementing, which involves the design and placement of cement slurries to anchor casing, seal formations, and ensure long-term isolation of subsurface zones. Together with drilling and completion fluids, cementing services form an integrated approach to constructing safe, efficient, and high-integrity wells.

- **Reservoir Performance (RP) Division:** This division focuses on the in-depth evaluation of reservoir performance, including studies of productivity, fluid properties, composition, capacity, as well as state variables such as temperature, flow rate and pressure. By integrating innovative technologies and services, it ensures the ongoing optimization of reservoir performance, enabling customers to better understand and maximize the value of their sub-surface assets.

The Reservoir Performance division in Algeria comprises four key business lines that collectively aim to optimize hydrocarbon recovery and sustain long-term well productivity.

Reservoir Performance Stimulation (Fracturing) focuses on enhancing formation permeability through hydraulic fracturing, a technique in which high-pressure fluids are injected to create fractures that increase flow capacity and improve reservoir contact. Well Intervention Services (WIS), primarily through coiled tubing operations, enable maintenance, remediation, and stimulation activities without the need for conventional rigs, effectively addressing issues such as formation damage and production decline. Well Testing Services deliver critical insights into reservoir behavior and well performance by applying techniques such as Drill Stem Testing (DST), Formation Sampling and Analysis (FSA), and surface or production testing to assess pressure, permeability, and fluid composition. Wireline Logging Services (WL/WLES) support reservoir evaluation and well diagnostics through electric cable-conveyed tools that acquire high-resolution measurements of porosity, resistivity, saturation, and other key formation parameters, using advanced technologies such as RST, PSP, USIT, and PMIT.

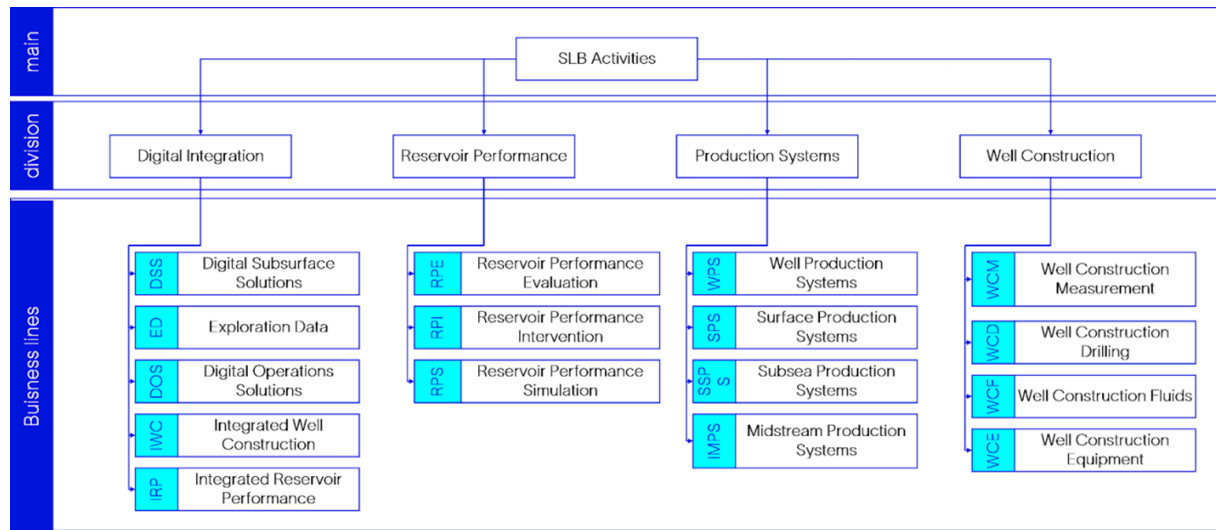


Figure 1.5: SLB Operational Structure

SLB's core divisions are supported by comprehensive **Support Functions** that ensure operational cohesion and compliance with environmental, social, and governance (ESG) standards. The **Logistics & Supply Chain** team implements decarbonized procurement strategies, blockchain-enabled traceability, and circular economy practices to reduce waste and emissions. The **Procurement & HSE** functions adhere to SLB's Responsible Supply Chain framework, with commitments to conflict-free sourcing and Scope 3 emissions tracking. The **IT & Digital** infrastructure, centered around platforms such as *DELFI*, enables real-time connectivity between offshore and onshore teams. Finally, global support in **HR**, **Legal**, and **Finance** is consolidated under the **Global Business Services (GBS)** model, with operational hubs in **Colombia**, **Romania**, and **Malaysia** ensuring standardized service delivery across regions.

SLB's Supply Chain for Oil & Gas Services

Schlumberger (SLB) organizes its global operations through a hierarchical geographical framework designed to balance global oversight with local responsiveness. At the highest level, operations are segmented into five global **Basins**, which act as strategic operational clusters. These are further divided into **GeoUnits**, which manage regional business activities across one or more countries.

For example, the **North Africa GeoUnit** oversees operations in Algeria and neighboring nations. Each GeoUnit reports to the **Executive Vice President of Geogra-**

phies, a role currently held by *Steve Gassen*, who ensures alignment between regional sales efforts, commercial execution, and corporate strategic objectives. This multilayered geographic structure allows SLB to adapt to regional market dynamics while leveraging its global capabilities.

In response to increasing competitive pressure within the oilfield services market, SLB has adopted an organizational strategy focused on reducing operational costs without compromising service quality or delivery timelines. Central to this approach is a highly structured and integrated supply chain, which is divided into four interrelated departments:

- **Planning:** Oversees the Sales and Operations Planning (S&OP) process. It plays a critical role in forecasting demand, aligning operational capacity with commercial objectives, and developing long-term strategies that support both global and regional business goals.
- **Purchasing and Supply:** Manages the procurement cycle through supplier segmentation, contract administration, and the development of sustainable supplier relationships. This function supports SLB's broader **Environmental, Social, and Governance (ESG)** commitments by ensuring that procurement decisions are both economically viable and socially responsible.
- **Global Distribution:** Supervises international trade and the movement of goods. Its responsibilities include managing import-export operations, centralized inventory control, and the efficient coordination of material flows across SLB's global supply chain network to ensure that equipment and materials are available where and when needed to meet project timelines.
- **Domestic Logistics:** Responsible for transporting tools, equipment, and resources between SLB's operational bases and customer work sites. This function is especially critical in remote or logistically challenging environments, where transportation costs and timing directly impact service quality and operational efficiency.

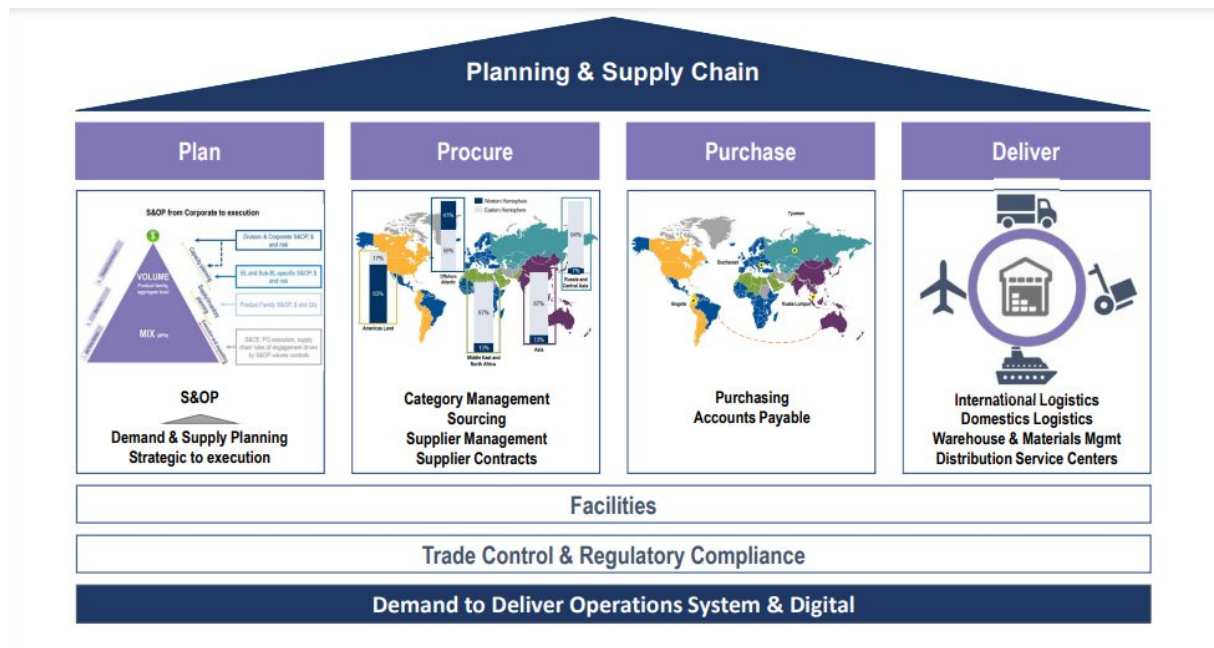


Figure 1.6: SLB Planning and Supply Chain Process

Together, these departments form an integrated supply chain framework that enables SLB to deliver value across diverse operating environments while maintaining its reputation for technical excellence and operational reliability. The supply chain process at SLB follows a distinct sequence. It commences with a service request that is immediately subjected to a two-part validation: an internal feasibility check and a thorough regulatory compliance review. Upon successful validation, the team formulates a strategic procurement plan to acquire all necessary equipment and products for the project. The final stage is delivery, where the transportation and handling methods are customized based on the specific nature of the work. This overview sets the stage for a more detailed examination of SLB's domestic logistics function and its operating procedures.

SLB Domestic Logistics

The **Domestic Logistics** function at SLB encompasses the management of all heavy vehicle road transport activities within the country. This includes the relocation of assets between SLB bases, as well as the transportation of equipment and resources to external sites operated by clients. In addition to managing heavy vehicle operations.

The organizational structure of Domestic Logistics is founded upon three fundamental pillars that collectively enhance operational control, coordination, and compliance. **First, centralization and co-location of teams** ensures streamlined communication, real-time coordination, and improved process oversight. This setup supports more efficient cross-functional collaboration and facilitates end-to-end planning integration among various team members. **Second, a regional and geographical distribution of planning roles** ensures that coordination is tailored to specific areas or inter-regional operations. This enables clearer upstream and downstream workload visibility, enhancing synchronization across business lines. **Third, segregation of duties across shipping and transport-related roles** ensures strict compliance with internal controls while fostering specialization. By designating experts for specific responsibilities, SLB maximizes efficiency and ensures accountability across the logistics workflow.

Despite the operational complexity, SLB's Domestic Logistics does **not maintain ownership** of its transport fleet. Instead, the strategy focuses on **leasing and optimizing** the use of a diverse range of truck types to meet dynamic operational needs, as shown in Table 1.2. This **asset-light approach** allows the organization to maintain flexibility, reduce capital expenditure, and better align capacity with real-time demand.

To support this strategy, SLB deploys **multiple transport models** adaptable to varying logistical requirements, with particular emphasis on **shipment consolidation** and **route optimization**. These models are implemented through structured contracts with third-party carriers and are categorized into two main leasing strategies:

- **Call-Out Trucks:** Contracted on-demand for individual journeys. There are no fixed payment obligations outside of executed trips, providing maximum flexibility and responsiveness to fluctuating field requirements. This model is ideal for high-variability transportation environments.
- **Monthly Rental Trucks:** Involves fixed-period leasing—typically one month or more—at a predetermined rate. Operational costs such as fuel and tolls are paid per journey. This model guarantees exclusive vehicle availability for SLB during the lease period and may involve arrangements nearing partial ownership.

The rental fleet is further segmented into:

- **Dedicated Trucks:** Assigned to specific segments or business lines over extended periods. These ensure uninterrupted service for high-priority or high-volume operations.
- **Non-Dedicated Trucks:** Flexibly allocated across multiple segments based on real-time demand. This enables **resource pooling** and improves **fleet utilization**.

The following table presents the main truck types utilized in SLB's Domestic Logistics operations, highlighting their structural characteristics and specific functions.

Table 1.2: Truck Types Used in SLB Domestic Logistics

Truck Type	Description & Use
Lowboy Truck	A semi-trailer with a very low deck, specifically designed for transporting oversized or tall equipment (up to 3.66 meters high).
Trailer	A trailer designed to carry goods, which connects to and is partially supported by the towing vehicle via a "fifth wheel" platform.
Watertank Truck	A vehicle equipped with a large tank for transporting water to be used for various operational purposes on-site.
Fuel Tanker Truck	A vehicle equipped with a specialized, reinforced tank for safely transporting flammable liquids like fuel, xylene, and other chemicals.
SOLO Truck (Tractor Unit)	A tractor without a trailer attached. Its purpose is to tow semi-trailers, thereby forming an articulated vehicle (tractor-trailer).

Domestic Logistics Workflow

- **Capture the Need:** The transportation lifecycle at SLB begins with the submission of a Transport Request (TR), which can be initiated through the FLM platform. This digital interface collects essential shipment information required by the Domestic Logistics team to arrange vehicle movement. Once submitted, the request is captured by the Online TR system and automatically interfaced with the Transportation Management System (OTM), ensuring streamlined data integration and eliminating manual entry errors.
- **Accept the Transport Request:** The Domestic Planning Specialist assumes responsibility for validating and processing the TR. Assigned by region, the planner reviews the completeness and accuracy of the submitted information. Based on this assessment, the request may be either accepted or rejected. Once a decision is made, the requester is notified automatically. Accepted requests move forward to the shipment planning phase, where logistical arrangements are initiated.
- **Plan Shipment:** This step considers multiple variables including dates, cargo constraints, and geographical routing to assess opportunities for consolidation. The Domestic Planning Specialist determines whether the new transport order can be integrated into an existing shipment, or whether a standalone shipment must be created. Truck availability is checked, and transportation costs are selected from a list of pre-negotiated rates loaded into the system. If no applicable rate exists or if the projected cost exceeds thresholds defined at the GeoMarket level, a competitive bidding process is initiated in TESS, SLB's tendering platform. In some cases, additional information may be required from the requester to finalize the decision-making process.
- **Issue Work Order:** This includes entering specific equipment details, driver information (when applicable), and key scheduling metrics such as the Estimated Time of Departure (ETD) and Estimated Time of Arrival (ETA). These temporal benchmarks serve as a reference for both SLB coordinators and suppliers. Once the details are confirmed, the Work Order is finalized and notifications containing all arrangement information are sent to the involved stakeholders—including suppliers, requesters, and any third parties linked to the original TR. Depending on the country's approval matrix, the Work Order may undergo additional validation before becoming operational.
- **Coordinate Execution:** For both rental and call-out trucks, the Coordinator ensures on-time execution of the shipment, including cargo loading and unloading. Delivery ticket signatures with time stamps for truck arrival, loading, and unloading are captured by drivers. During execution, the **Gate Events** to confirm the date and time of each shipment stage are entered into the system to measure overall process cycle time and allow the process to move to the Billing step.

There are three ways to capture Gate Events (listed in order of preference):

1. Supplier enters Gate Events during execution directly in OTM via the Vendor Portal.
2. Supplier submits a Shipment Report (every 2 hours, at least 4 times a day) to the Coordinator, who can mass upload the Gate Events in OTM.
3. Coordinator contacts the driver/supplier during execution and manually updates the Gate Events in OTM.

In the future, a **Global Traceability Solution** will be introduced as a fourth and most preferred option. This will allow SLB to automate all data capturing and enable real-time visibility of shipments.

– **Validate Cost:** Upon completion of all Gate Events, the process advances to the cost validation phase. Suppliers access the OTM Vendor Portal to input final charges and upload supporting documentation. A Billing Specialist then verifies the submitted cost data. The invoice must pass through an approval process before being cleared for payment.

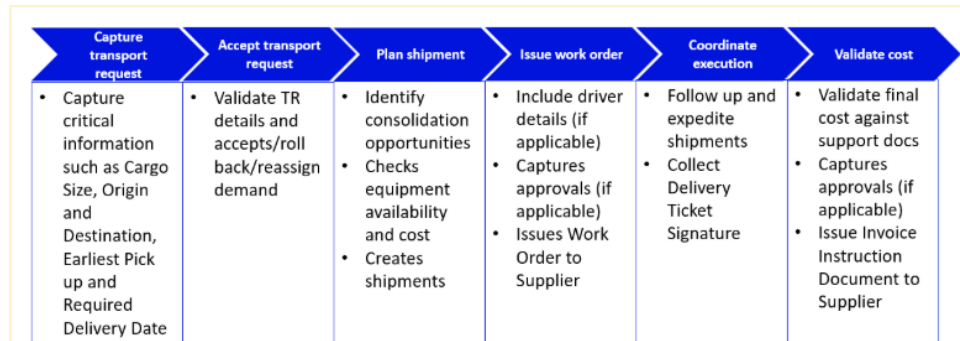


Figure 1.7: Domestic Logistics Steps

This systematic workflow, from request submission to final billing, reflects SLB’s structured approach to managing domestic logistics in a highly dynamic and compliance-driven operational environment.

The Strategic Nexus of Logistics and Cost Optimization

Logistics constitutes the operational spine of modern supply chains, orchestrating the movement of materials, information, and services from point of origin to final consumption. Its role transcends mere transportation or warehousing; it directly influences customer responsiveness, product availability, operational continuity, and ultimately, competitive differentiation. In industries characterized by complexity and volatility, such as oil and gas, logistics becomes not only a facilitator of service delivery but also a determinant of strategic resilience. The sector’s magnitude is reflected in its economic footprint, with logistics expenditures accounting for nearly **12% of global GDP**. This underscores its centrality to **value creation** across multiple industries.

The relevance of logistics is particularly acute in asset-intensive and geographically dispersed sectors like oilfield services, where delivery reliability, equipment availability, and lead-time adherence are prerequisites for upstream productivity. Logistics operations in such environments face multidimensional challenges, including remote terrain, hazardous conditions, and fluctuating demand profiles. Consequently, logistical efficiency becomes synonymous with business continuity. The COVID-19 pandemic, geopolitical disturbances, and supply-side shocks further revealed the critical need for resilient infrastructures, with firms exhibiting higher visibility and coordination capabilities proving more adept at mitigating **disruption** and maintaining **continuity**.

Parallel to its operational role, logistics also represents a significant lever for financial performance. Transportation, inventory holding, and warehousing often comprise a substantial share—ranging from **5% to 50%**—of total product cost. In this context, optimizing logistics is not merely a tactical exercise in savings but a strategic imperative to enhance margin structure, support pricing flexibility, and fund innovation. **Cost**

optimization within logistics must strike a balance: maintaining service quality and reactivity, while minimizing **inefficiency**.

Importantly, effective logistics cost optimization does not operate in isolation but aligns with broader corporate performance metrics. Integrating cost-reduction strategies with key performance indicators (KPIs) related to customer service, risk exposure, and sustainability yields a more holistic approach to value generation. Collaborative models, including shared fleet use or pooled transportation assets, are increasingly explored as mechanisms to achieve economies of scale and improve **asset utilization** and overall **efficiency**.

In sum, the confluence of logistical precision and cost discipline forms a foundational element of strategic supply chain management. For oilfield service providers operating in Algeria and similar markets, enhancing fleet visibility and consolidating transportation needs across business lines offer concrete pathways to achieve **cost competitiveness** and **service excellence**. As such, this thesis posits that addressing the domestic logistics fleet, through improved planning, optimization models, and decision-support tools, is not only a matter of operational fine-tuning but a central component of long-term organizational resilience and strategic agility.

State of the Evolution of DL Issues Through Years

In the ever-demanding landscape of oilfield operations, where precision, efficiency, and responsiveness dictate competitiveness, SLB North Africa has long understood that logistics isn't a support function, it's a **strategic backbone**. Yet, over the years, the domestic logistics (DL) system, especially in the harsh and expansive terrain of southern Algeria, revealed persistent **bottlenecks**: inefficiencies in transport planning, visibility gaps, and limited digital integration. To address these challenges, a sequence of student-led innovation projects unfolded, each one building upon the previous, collectively shaping a cohesive roadmap for SLB's logistics transformation (Figure 1.8).

In the aftermath of the COVID crisis and economic slowdowns, the need to control costs and anticipate logistics needs became imperative. The duo tackled **diesel supply logistics**, a high-volume and high-cost upstream process. Their work introduced a forecasting culture (via ARMA models), an optimization engine (in MATLAB), and a Power BI dashboard, marking SLB's first step toward **predictive logistics**. It was a foundational effort: demonstrating that planned logistics outperforms reactive Call Out strategies, and that visibility begins with data structuring[7].

Riding the momentum, this project widened the scope to the entire transport fleet and downstream logistics. For the first time, SLB's SH activities (Shipment Handling) were forecasted by zone, and truck types (Rental vs. Call Out) were dynamically allocated. A **Python-based decision tool** handled the complexity of zone-specific operations, supported by a Power BI dashboard. Here, the shift was clear: SLB was moving from **cost-cutting** to fleet performance management, from prediction to prescriptive logistics[39].

By 2023, the logistical vision evolved from planning to **real-time control**. Gaps remained in traceability, multi-stakeholder coordination, and performance monitoring. Yasmine & Melissa tackled these by designing an **end-to-end visibility** platform, linking truck status to delivery documentation, and visualizing daily KPIs. For the first time, Product Lines and DL teams shared access to live metrics, creating cross-functional transparency. They even explored machine learning and IoT-based future upgrades, aligning SLB with digital supply chain trends[6].

At this point, SLB had visibility on the fleet. But what about the processes on the ground? Raihane & Hani focused on the most critical pain point: the inefficiency of loading/unloading cycles, and the **space congestion** at operational bases. By redesigning layouts and deploying a mobile app with a portal, they captured **dwelt times**, mapped movement flows, and ensured traceable corrective actions. Their work bridged physical operations with digital interfaces, anchoring logistics in real-world behaviors and constraints[42].

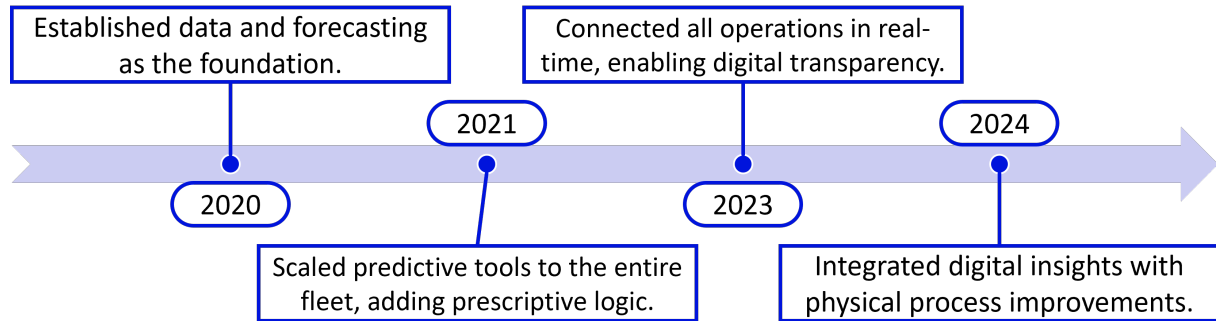


Figure 1.8: Previous research work done by the department's students

Diagnostic Framework and Problem Structuring

The analytical framework underpinning this research is structured around a three-stage methodology: **Observation**, **Analysis**, and **Consolidation & Validation**. This sequence was selected to navigate the inherent complexity of SLB's domestic logistics environment, marked by fragmented data systems, operational discontinuities, and fluctuating transportation demands. The aim was to convert scattered operational anomalies into structured, validated problem statements that could inform targeted solutions.

The observation phase began with a comprehensive **data audit** across SLB's transportation systems, including FDP (Sales input layer), OTM (planning tool), and E-Journey (execution tracking). This diagnostic revealed recurrent anomalies such as mismatched job visibility across platforms, inconsistent data flows between planning and execution layers, and pronounced demand variability across customer segments. These patterns suggested not isolated incidents but structural inefficiencies embedded within the logistics ecosystem.

In the analysis phase, several diagnostic tools were employed to interpret the findings. **Demand variance analysis** was conducted across rigs and timeframes to assess the degree of unpredictability and highlight dispatching inconsistencies. The **VUCA framework** served as a conceptual structure to categorize observed issues: for example, reactive dispatching was mapped to volatility, and fragmented feedback loops to ambiguity. These tools collectively enabled the formulation of coherent, operationally grounded problem statements.

The final phase of consolidation and validation focused on triangulating insights with stakeholders. **Semi-Directive interviews** with planners, fleet coordinators, and field operators clarified behavioral drivers such as reliance on call-out contracts, often the result of insufficient forecasting rather than scheduling discretion. The **5 Whys technique** was then applied to trace such symptoms back to systemic causes, including the absence of predictive tools and centralized visibility. Finally, **cross-functional workshops** were conducted to align stakeholders around the validated findings and co-develop

a unified diagnostic baseline. This iterative and evidence-based approach ensured both analytical depth and practical relevance.

This section presents the diagnostic strategy used to assess systemic inefficiencies, anchored in the **Funnel-Based Problem-Solving Framework** (Figure 1.9). The methodology progresses from exploratory analysis to targeted root cause validation.

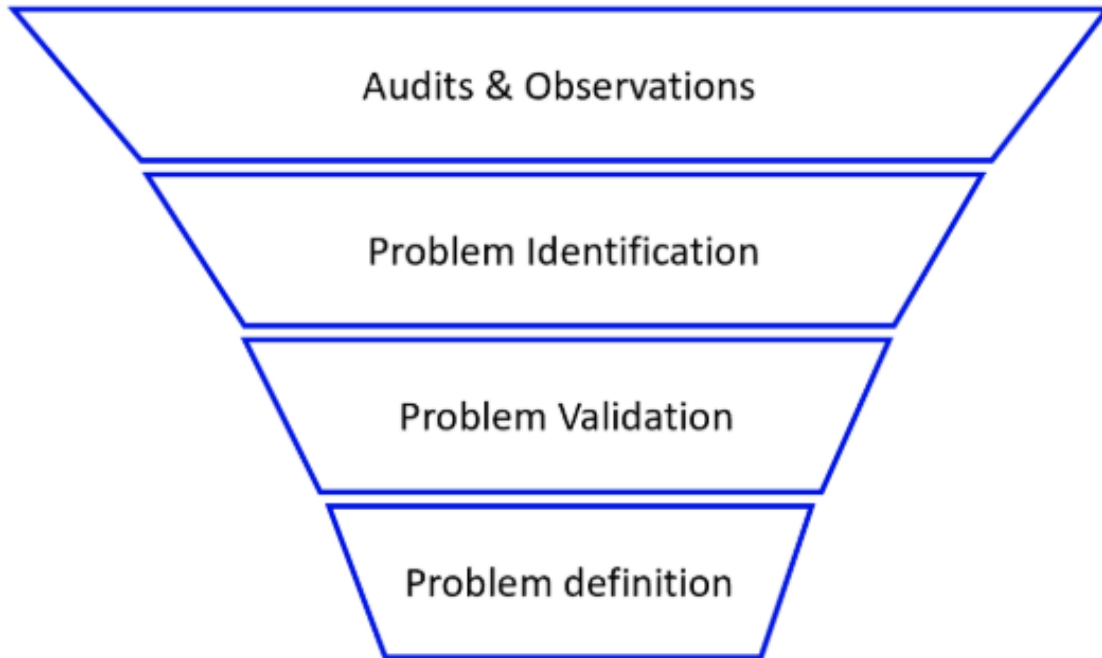


Figure 1.9: Problem definition road map

1.2.2 Stage 1: Audit & Observation

Information Flow

In complex industrial service operations like those managed by SLB, the reliability and efficiency of the logistics system are closely tied to the coherence between **strategic planning**, operational execution, and commercial alignment. Diagnosing inefficiencies in such systems requires a clear understanding of how information flows across various organizational levels and functions. To support the development of a robust methodology for truck fleet sizing, a multilayer information audit was conducted. This diagnostic approach focused on tracing data propagation and decision-making from the point of client demand through to execution, via three interdependent digital platforms: the Field Data Platform (FDP), Oracle Transportation Management (OTM), and E-Journey.

The first layer, **Sales (FDP – Field Data Platform)**, serves as the initial entry point for client service requests. FDP acts as the strategic interface between SLB’s product lines and its clients, capturing commercially validated job demands. Each confirmed job in FDP reflects an approved service request raised by a business segment—such as Wireline, Drilling, or Testing—and validated by the Product Service Delivery (PSD) manager. While FDP provides reliable **demand signals**, it lacks granularity on logistics parameters such as truck types, required volumes, or scheduling details. Consequently, FDP cannot be used in isolation for predictive logistics planning or fleet forecasting, necessitating integration with downstream systems.

The second layer, **Planning (OTM – Oracle Transportation Management)**, is the core logistics planning tool at SLB. In OTM, the abstract job entries from FDP are operationalized into detailed shipment plans. This includes specifying vehicle types, allocating resources, and setting dispatch schedules. OTM is designed to bridge the **strategic–operational** gap by translating projected service needs into actionable transportation plans. Ideally, each FDP entry should correspond to a shipment in OTM, ensuring traceability and planning consistency. However, analysis revealed that a significant proportion of FDP jobs fail to appear in OTM, pointing to structural misalignments in the planning workflow. This disconnect suggests issues in data transfer protocols or inconsistencies in planner engagement, which compromise the fidelity of fleet requirement forecasts.

The third layer, **Execution (E-Journey)**, captures real-world logistics activities as they unfold. Unlike OTM’s predictive function, E-Journey provides **retrospective visibility**, logging actual vehicle usage, trip durations, routes, and delivery confirmations. It serves as the definitive source of execution data, offering insights into discrepancies between planned and actual operations. E-Journey is particularly valuable for identifying unplanned trips—often initiated in response to emergency requirements or failures in upstream planning. It thus plays a critical role in validating the operational accuracy of OTM and revealing latent inefficiencies across the logistics pipeline.

Together, these three layers—**Sales, Planning, and Execution**—form the digital backbone of SLB’s logistics management framework. A comprehensive understanding of their interplay is essential for optimizing fleet deployment, improving visibility, and aligning logistical performance with commercial and operational objectives.

Information Flow Audit Scope and Method

The audit was designed to rigorously evaluate the consistency and robustness of information flows across SLB’s primary logistics management systems: the Field Data Platform (FDP), Oracle Transportation Management (OTM), and E-Journey. A systematic **cross-platform verification** methodology was employed to detect points of failure or misalignment in both job registration and shipment execution processes. The objective was to assess whether operational demand, as initially captured in FDP, was appropriately reflected in planning and execution layers, thus ensuring coherence between commercial commitments and logistical fulfillment.

The audit unfolded along two principal dimensions. The first focused on **job-level integration**, analyzing whether all confirmed jobs recorded in FDP had been successfully migrated into OTM for transportation planning. This verification step was critical for validating the completeness and fidelity of the planning pipeline, as misalignment at this stage would inevitably compromise dispatch accuracy and resource allocation. The second dimension concentrated on **shipment-level consistency**, whereby the audit compared truck movements scheduled in OTM with the actual trips logged in E-Journey. This phase aimed to detect field-initiated operations that bypassed centralized planning, thereby exposing informal workarounds or breakdowns in protocol adherence.

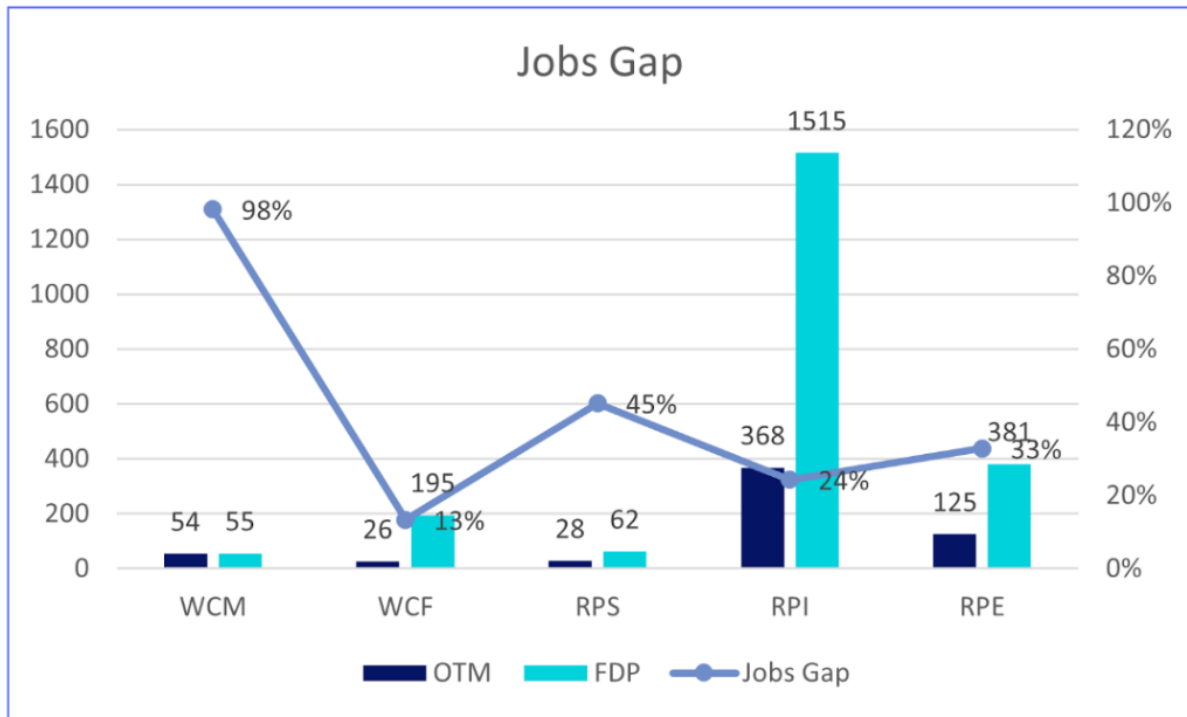


Figure 1.10: Tactical Job Gap Assessment

Most notably, the **job-level audit** exposed systematic failures in data migration from FDP to OTM (Figure 1.10). In the case of the Well Construction Measurement (WCM) business line, virtually all confirmed jobs recorded in FDP failed to appear in OTM, indicating a total breakdown in the planning interface. Similarly, the Reservoir and Production Services (RPS) segment exhibited a job transfer failure rate nearing 50%, underscoring a severe disconnect between **job initiation** and logistical planning. Even in business lines where integration rates were relatively higher, the presence of non-transferred jobs suggests the absence of a uniformly applied standard operating procedure for job synchronization.

The **shipment-level analysis** revealed even more pronounced discrepancies between planned and actual logistics execution (Figure 1.11), underscoring a significant misalignment within SLB's transportation planning framework. While the job-level audit focused on the migration of operational demand from the Field Data Platform (FDP) to Oracle Transportation Management (OTM), this second layer of assessment compared **scheduled dispatches** in OTM with actual truck movements recorded in the E-Journey execution system. The findings were particularly striking in asset categories characterized by high operational intensity. In the Reservoir and Production Services (RPS) segment, actual execution volumes exceeded planned shipments by an astonishing 221%, implying that more than twice the number of truck movements were initiated than had been formally planned. This massive divergence suggests a widespread reliance on informal or **reactive dispatching** practices, whereby shipments are initiated directly in the field without corresponding entries in the planning system.

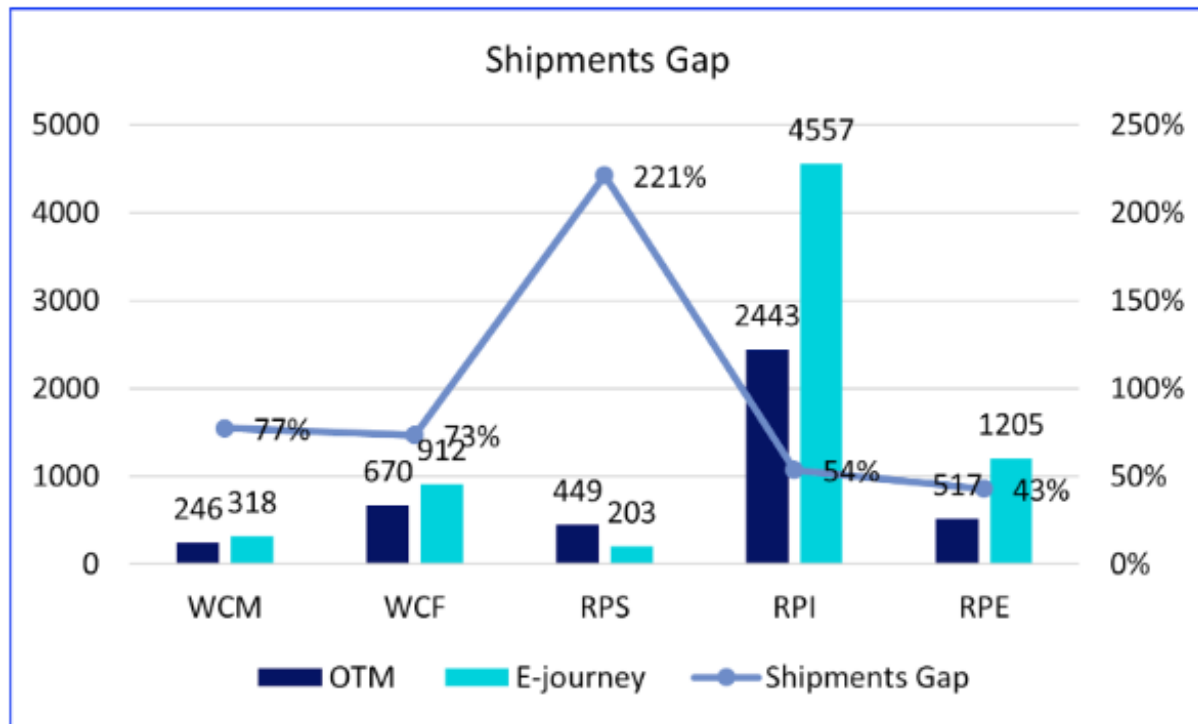


Figure 1.11: Operational Shipment Gap Assessment

These findings carry serious **strategic implications**. Without a synchronized planning-execution-feedback loop, SLB's ability to accurately forecast transportation needs, optimize truck fleet sizing, and evaluate key logistics KPIs is fundamentally compromised. Decision-making becomes reactive rather than strategic, cost management is weakened, and the organization's overall operational agility is constrained—a particularly risky position in a volatile sector where **responsiveness and efficiency** are paramount. Addressing these shortcomings requires structural improvements in data integration, governance enforcement, and system interoperability.

1.2.3 Stage 2: Problem Identification

In order to identify the apparent causes behind the dysfunctions observed in SLB's domestic logistics, we adopted a dual diagnostic approach combining the **VUCA framework** and **stakeholder analysis**. This integrated method allowed us to investigate both the systemic dimensions of volatility, uncertainty, complexity, and ambiguity, as well as the practical realities encountered by operational actors. By aligning strategic frameworks with field-level insights, we ensured a comprehensive and grounded problem identification process.

VUCA Analysis

In order to move beyond surface-level observations and systematically uncover the drivers of inefficiencies within SLB's domestic logistics operations, a structured analytical approach was adopted. This stage combines two complementary diagnostic tools: the **VUCA framework**—which examines **Volatility**, **Uncertainty**, **Complexity**, and **Ambiguity**—and stakeholder analysis, which captures first-hand operational insights from key actors within the logistics value chain. The VUCA framework serves as a multidimensional lens for dissecting the structural, informational, and behavioral constraints shaping

SLB's logistics performance (Figure 1.12).

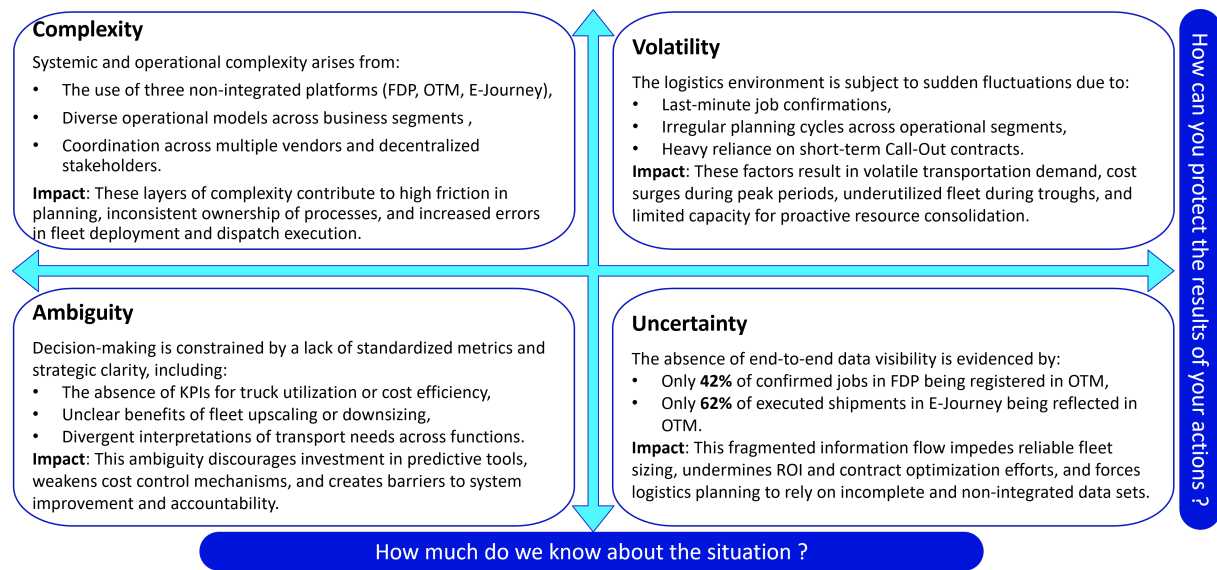


Figure 1.12: VUCA framework “Volatility, Uncertainty, Complexity, and Ambiguity”

Volatility within SLB's logistics operations is primarily driven by **reactive planning** practices and irregular job confirmations. These fluctuations in demand and job validation timelines undermine fleet scheduling reliability, making it difficult to allocate transportation resources efficiently. This irregularity forces planners into short-term decisions, leading to cost surges and resource misalignments.

Uncertainty stems from a lack of **data visibility** across key systems. Only 42% of jobs confirmed in FDP and 62% of shipments executed were found in OTM. This major loss of information between strategic and operational layers limits accurate fleet sizing and timely decision-making. Without a full view of activities, planners cannot forecast demand or capacity reliably.

Complexity is intensified by fragmented **digital systems** and inconsistent planning methods. FDP, OTM, and E-Journey each operate in silos, and lack of integration disrupts operational flow. The absence of standardized models and dispersed ownership of logistics functions leads to coordination issues and overlapping responsibilities.

Ambiguity emerges from the absence of clearly defined **KPIs** and governance mechanisms. Interviews revealed vague procedural

The application of the VUCA framework not only clarified the nature of the systemic challenges but also informed the prioritization of root cause validation and the targeted design of solutions in subsequent analysis phases. This structured interpretation serves as a foundation for transitioning from diagnostic insights to the implementation of robust, data-integrated logistics strategies.

Stakeholder Interviews Insights

As part of our diagnostic study, we conducted semi-directive interviews with a diverse set of stakeholders across SLB's logistics and operations ecosystem—including segment engineers, PSD managers, and domestic logistics planners. These interviews provided

first-hand insights into **field practices** and planning systems, as well as coordination challenges.

To structure and deepen our analysis, we applied a methodological framework inspired by the **socio-economic approach**. This involved systematically identifying key themes and sub-themes based on recurring patterns observed in our field data. We validated these themes across segments, extracted critical “**mirror effects**” (convergence of issues), and uncovered underlying dysfunctions that hinder system performance.

The final outcome of this process is the **Matrix of Convergence**, which consolidates our findings into a structured table. It captures the core **logistical and organizational** challenges across SLB segments and reveals the main potential root causes limiting the effectiveness of transport planning, system integration, and operational alignment.

Table 1.3: Matrix of Convergence – Stakeholder Insight Summary

Themes	Sub-Themes	Convergence	Dysfunctions
Data Integration and Digital System Gaps	- FDP, OTM, and E-Journey are not synchronized - Missing or inconsistent job data	- Jobs recorded in FDP don't appear in OTM (e.g., Well Construction – Measurements) - Shipments in Well Testing, RPS, and WIS are not logged in a central system	Fragmentation – Reflects lack of coordination between departments and segments
Forecasting, Planning, and Visibility Failures	- No transport demand forecasting - Siloed operations by segment - Poor visibility	- Sudden demand in Well Testing, Cementing, and RPS leads to last-minute responses - No resource sharing across Wireline and WIS	Unpredictability – Captures uncertain demand, reactive operations, and inability to forecast
Execution Inefficiency and Workflow Friction	- Trucks reused without proper tracking - No traceability in the system - Last-minute rerouting	- Trucks are reused across jobs in RPS, Cementing, and WIS - Unplanned changes happen often in Wireline and Well Testing	Inefficiency – Represents poor truck usage, daily jobs misalignment, and overprocessing
System Governance and Organizational Gaps	- No standard procedures enforced - Unclear roles and responsibilities - Fragmented planning	- The control tower doesn't manage the full job cycle in RPS, WIS, and Well Testing - Process owners are not defined in Measurements and Wireline	Dominance – Refers to the client's upper hand in a monopsony market
Strategic Misalignment Between Planning and Execution	- Tools not integrated - Job confirmation doesn't match system readiness	- Jobs are confirmed without logistics support in Well Testing, RPS, and Cementing - Field teams often skip OTM in WIS and Wireline	Constraint – Highlights workforce shortages, strict HSE standards, and lengthy driver selection

This analysis is presented in greater detail in Appendix 3.3, with Table 5 offering

a visual synthesis of the main diagnostic themes, stakeholder convergence points, and corresponding dysfunctions.

1.2.4 Stage 3: Problem Validation

5 Whys Analysis

To support the root cause identification process within this research, we employed the **5 Whys** analysis until the foundational issue is revealed (Table ??). In the context of SLB's domestic logistics system, where surface-level symptoms such as fleet under-utilization, reactive dispatching, or inconsistent planning often mask deeper operational misalignments, the 5 Whys approach allowed us to move beyond correlation toward causal narratives. Here's a breakdown of the results of using this tool.

Table 1.4: Root Cause Exploration Using the 5 Whys Technique

Step	Question	Answer	Linked Dysfunction
Why 1	Why do segments not input their real transport activity data?	Because they reuse a single truck (TR) for multiple unplanned trips to meet urgent demands.	Inefficiency – Untracked reuse, misaligned daily job planning
Why 2	Why do segments reuse trucks instead of scheduling efficiently?	Because there is no visibility on planned trips across departments, so they make reactive decisions.	Unpredictability – Siloed operations and last-minute actions
Why 3	Why is there no visibility on planned trips?	Because there is no centralized tool to track or forecast transportation needs in real time.	Fragmentation – Disconnected systems (FDP, OTM, E-Journey)
Why 4	Why hasn't a centralized planning tool been implemented?	Because the organization lacks performance tools to assess fleet sizing or justify investment.	Constraint – Absence of fleet KPIs, planning tools
Why 5	Why is there no tool to evaluate fleet performance?	Because of workforce shortages, long driver selection processes, and a reactive approach to wellsite issues.	Constraint & Dominance – Labor shortage, strict HSE, monopoly dynamics

1.2.5 Stage 4: Problem Definition

The root cause of the challenges observed in SLB’s domestic logistics operations is **a lack of visibility into planned transportation activities**, which stems from fragmented and poorly integrated data systems. Across key platforms—namely FDP, OTM, and E-Journey—data flows are disjointed, and the absence of automated synchronization mechanisms significantly impairs the consistency of operational records. This lack of systemic coherence leads to an unreliable representation of logistical demand and execution, preventing logistics teams from building a robust, forward-looking fleet management strategy.

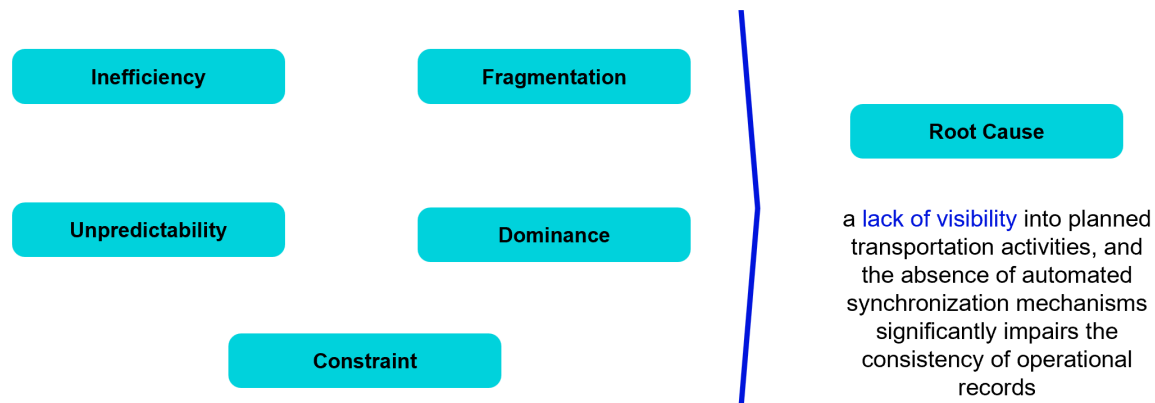


Figure 1.13: Root Cause Analysis

Furthermore, the **absence of analytical tools capable of evaluating fleet adequacy and utilization** exacerbates this visibility issue. Without the ability to model or simulate different resource allocation scenarios, SLB’s Domestic Logistics department is unable to assess the return on investment of resizing initiatives or to measure performance against cost and service-level expectations. As a result, fleet sizing decisions remain largely reactive and operational execution lacks data-driven precision.

These operational inefficiencies are symptomatic of a broader **strategic misalignment**. SLB, despite its legacy of excellence in innovation and sustainability, faces increasing difficulty adapting to rapidly evolving industry trends, particularly those related to digital transformation, decarbonization imperatives, and intensifying regulatory constraints. The company’s heavy dependence on legacy systems and conventional planning models limits its responsiveness to market volatility and demand fluctuations. Moreover, SLB’s continued reliance on traditional reservoir simulation tools restricts its ability to exploit emerging technologies that could improve upstream operational efficiency and optimize capital deployment in field development.

Collectively, these issues hinder SLB’s ability to sustain competitive advantage in a global energy sector that is increasingly complex, digitized, and emissions-conscious. The company’s operational rigidity in logistics reflects broader organizational challenges in aligning strategy with market expectations, thereby constraining its potential for long-term growth and resilience.

These observations lead us to the central research question of this work:

How can SLB improve planning adherence of its domestic fleet sizing and scheduling through enhanced visibility across field operations?

This chapter lays the theoretical and empirical groundwork for addressing transportation logistics within the oil and gas services industry—a sector marked by operational complexity, geographical dispersion, and acute exposure to market volatility. In a global landscape increasingly shaped by supply shocks, cost pressures, and regulatory shifts, supply chain management (SCM) has transitioned from a support function to a strategic lever for resilience, cost optimization, and competitive differentiation.

The chapter opens by framing SCM through its functional, strategic, systemic, and relational dimensions, offering a comprehensive conceptual foundation for understanding coordination and performance across the value chain. This general framework is then adapted to the specific context of the oil and gas industry, where transportation logistics operate under unique constraints: long supply lines, high variability in demand, significant capital intensity, and the critical need for service reliability in hazardous and remote environments.

Transportation, in this context, is not a secondary function—it is a core operational pillar. Its effectiveness directly impacts service levels, cost structures, and the ability to respond to uncertainty. However, endemic issues such as fragmented planning architectures, schedule non-adherence, and limited visibility into fleet movements continue to undermine performance. These challenges are compounded by a lack of integration between planning and execution layers, resulting in inefficiencies, inflated costs, and missed opportunities for resource optimization.

To interpret and formalize these coordination failures, the chapter introduces the lens of Transaction Cost Economics (TCE), highlighting how uncertainty, asset specificity, and bounded rationality drive logistical frictions and increase the cost of coordination. This perspective enables a deeper understanding of why traditional planning systems fall short in high-variability environments.

2.1 Foundations of Supply Chain Management

2.1.1 Supply Chain definition

In today's increasingly volatile and complex global economy, uncertainty has emerged as a dominant force reshaping industrial dynamics and organizational strategies. From geopolitical disruptions and resource scarcity to technological shifts and pandemics, firms

are compelled to navigate an environment marked by heightened variability in demand, supply, and operational continuity [10]. In this context, it becomes imperative not only to identify but to systematically manage the evolving web of partners, competitors, and intermediaries that influence enterprise performance. The concept of the **supply chain**—and more critically, its management—provides a framework for structuring this complex environment and enabling coordinated, resilient value creation across firms.

Supply chain and supply chain management (SCM) are conceptualized differently depending on the analytical lens adopted. As Zouaghi and Laghouag (2021) assert, the supply chain can be viewed through five distinct but complementary perspectives: **functional and process-oriented**, **strategic**, **systemic**, **structural and network-oriented**, and **relational**. Each lens emphasizes a different dimension of the supply chain's complexity—ranging from internal process optimization to interorganizational collaboration and network governance. Understanding SCM through this pluralistic framework allows for a more nuanced and adaptive management approach, particularly under conditions of uncertainty where linear models of supply no longer suffice. We'll now present the five different perspectives according to Zouaghi and Laghouag (2021).

Functional and Process-Oriented Perspective

From a functional standpoint, the supply chain is primarily conceived as a sequence of operational activities—procurement, production, distribution—executed across firm boundaries to deliver value to the final customer. This perspective emphasizes intra- and interorganizational process efficiency, cost control, and lead time reduction. It aligns closely with early definitions of supply chain management as the coordination of flows—materials, information, and finance—across upstream and downstream partners[51].

Strategic Perspective

The strategic view considers the supply chain as a lever for competitive advantage. Here, supply chain decisions are tightly linked to corporate strategy, with a focus on adaptability, responsiveness, and long-term value creation. Strategic supply chain management involves aligning supply network capabilities with market requirements, ensuring that sourcing, manufacturing, and logistics decisions support overarching business goals [51]. This perspective also integrates risk mitigation and sustainability as strategic imperatives.

Systemic Perspective

The systemic perspective frames the supply chain as a complex system of interdependent actors governed by dynamic interactions and feedback loops. Rather than linear transactional relationships, it emphasizes system-wide coordination, emergent behaviours, and holistic performance. This view draws on systems theory to understand how disruptions propagate and how local decisions affect global outcomes, particularly in volatile environments[51].

Structural and Network-Oriented Perspective

This perspective highlights the architecture of the supply chain, focusing on the configuration and interconnectivity of actors within the network. It investigates how nodes (suppliers, manufacturers, distributors) and links (flows of goods and information) are organized to ensure resilience and efficiency. Key concerns include network design, centralization versus decentralization, and the role of intermediaries. Zouaghi and Laghouag argue that this perspective is vital for managing globalized, multi-tiered supply chains.

Relational Perspective

The relational approach positions the supply chain as a nexus of relationships shaped by trust, power, and cooperation. It emphasizes the behavioural and contractual dynamics between firms, moving beyond transactional efficiency to examine how governance structures, collaboration, and social capital influence supply chain outcomes. As noted by Zouaghi and Laghouag, this perspective is particularly relevant in contexts requiring resource sharing, joint problem-solving, or long-term partnerships.

Drawing from multiple theoretical lenses, the supply chain can be comprehensively defined as a dynamic, multi-tiered network of organizations engaged in the coordinated execution of activities that transform raw materials into finished products and deliver them to end-users. It encompasses a strategic alignment of functional operations—procurement, production, distribution—within and across firms, while simultaneously managing relational interdependencies shaped by trust, governance, and collaboration. Structurally, the supply chain operates as an interconnected system wherein each node influences the performance of the whole, subject to environmental volatility and systemic complexity. At its operational core, the supply chain is characterized by the integration of four fundamental flows: the **physical flow** of goods and materials, the **information flow** that facilitates visibility and synchronization, the **financial flow** that governs transactional value and liquidity, and the **knowledge flow**, which encompasses the exchange of experience-based insights, tacit know-how, and innovation-critical capabilities. As Nonaka and Toyama highlight, knowledge creation and dissemination are central to organizational learning and adaptive capacity, making knowledge flow an indispensable pillar of supply chain competitiveness. The interdependence of these flows transforms the supply chain into a dynamic ecosystem capable of navigating uncertainty, fostering resilience, and delivering sustainable value.

2.1.2 Supply Chain in the Oil and Gas Industry

Industry-Specific Supply Chain Characteristics

The oil and gas industry operates within a uniquely complex supply chain environment characterized by capital intensity, process segmentation, and operational volatility. Its supply chain spans three main domains—upstream (exploration and production), mid-stream (transportation and storage), and downstream (refining and distribution)—each presenting distinct logistical and coordination challenges. Operations are typically asset-heavy, with high equipment specificity and long lifecycle investments (e.g., rigs, pipelines), making flexibility and responsiveness difficult to achieve [8]. Furthermore, the industry frequently operates in geographically dispersed and logistically constrained regions—such as deserts, offshore platforms, or politically unstable zones—where infrastructure limitations heighten lead times and operational uncertainty [13]. The hazardous nature of hydrocarbons also imposes stringent safety and environmental compliance requirements, complicating transportation planning and inventory management. These structural and environmental complexities make the oil and gas supply chain particularly sensitive to disruptions, requiring highly coordinated logistics systems tailored to both technical and contextual demands.

Uncertainty and Risk as Central Themes

Uncertainty and risk are intrinsic features of supply chain management in the oil and gas industry due to its exposure to geopolitical volatility, fluctuating commodity prices, regulatory shifts, and operational hazards. The sector is particularly vulnerable to demand and supply imbalances caused by global market dynamics and macroeconomic instability. As highlighted by Araz et al. (2020)[1], disruptions such as price wars, embargoes, or pandemics can induce significant ripple effects across the upstream and

downstream supply chains, resulting in idle capacities, contract renegotiations, and inventory misalignments. In parallel, operational risks stemming from hazardous materials, complex interdependencies, and remote site operations necessitate robust safety and contingency planning. These factors increase the importance of developing resilient supply chain structures and predictive risk management tools tailored to the oil and gas context. Furthermore, risk propagation is exacerbated by limited visibility across nodes and contractual fragmentation, underscoring the need for integrated systems capable of real-time monitoring and coordinated decision-making. Hence, uncertainty in this industry is not only pervasive but systemic, requiring advanced modeling, scenario planning, and adaptive logistics frameworks.

Digitalization and Smart Supply Chain Trends

Digitalization has emerged as a pivotal transformation driver in oil and gas supply chains, enabling enhanced operational visibility, predictive capabilities, and real-time decision-making. The integration of Internet of Things (IoT) devices, advanced analytics, and cloud-based platforms allows companies to monitor asset performance, track fleet movement, and dynamically respond to disruptions. As emphasized by Barreto et al. (2017)[4], the transition toward smart supply chains enhances coordination across geographically dispersed operations and facilitates data-driven optimization. In particular, digital twins, blockchain, and machine learning algorithms are increasingly employed to model logistical flows, automate procurement, and improve demand forecasting[18]. For upstream and midstream logistics, these technologies help reduce downtime, prevent equipment failure, and optimize routing under volatile field conditions. Moreover, the deployment of integrated ERP and fleet management systems contributes to higher scheduling adherence and supplier alignment, reducing transaction costs and response delays[12]. However, the industry still faces challenges in digital maturity, data standardization, and cybersecurity, especially in developing regions and among subcontractors. Overall, digitalization is not merely a technological shift but a structural enabler of agility, resilience, and sustainability in oil and gas logistics.

Sustainability Pressures and Resilient Supply Chains

Sustainability and resilience have become interdependent imperatives in the oil and gas supply chain, driven by mounting regulatory, environmental, and societal pressures. The industry faces increasing scrutiny to reduce its carbon footprint, optimize resource usage, and ensure business continuity amid climate disruptions and geopolitical volatility. As pointed out by Govindan et al. (2014)[13], sustainable supply chain practices in oil and gas necessitate the integration of environmental, social, and economic objectives into core logistics operations. This includes minimizing greenhouse gas (GHG) emissions through route optimization, modal shifts, and the adoption of alternative fuels. These dimensions align with the conceptual model (Figure 2.1) illustrating how synergistic lean (e.g., waste elimination through JIT), resilient (e.g., flexible sourcing, risk management), and green practices (e.g., cleaner production, ISO 14001) collectively advance supply chain sustainability.

At the same time, resilience strategies—such as supply base diversification, predictive maintenance, and scenario planning—enhance adaptability to disruptions, particularly in remote or politically unstable regions [21]. Moreover, supply chain transparency, enabled through traceability systems and sustainability reporting, is essential to meeting stakeholder expectations and global climate targets. Research by Paul et al. (2017)[30] highlights that firms capable of balancing lean operational efficiency with robust contingency planning are better positioned to withstand shocks while adhering to sustainability mandates. The challenge lies in synchronizing long-term environmental goals with short-term

operational performance, particularly in capital-intensive, risk-sensitive supply networks such as oil and gas.

Thematic Trends in Academic Research

Over the past decade, academic research on oil and gas supply chains has coalesced around a set of recurring thematic concerns that reflect both industry evolution and global socio-economic pressures. A prominent focus has been placed on optimization models for logistics network design and transportation planning under uncertainty, as seen in the works of Al-Haidous et al. (2022)[15], who emphasize the role of multi-objective formulations to balance cost, resilience, and sustainability. Digital transformation has emerged as a second dominant theme, with increasing attention to technologies such as IoT, blockchain, and digital twins that improve visibility and traceability in geographically dispersed operations. A third pillar of research involves supply chain risk management, particularly in the context of geopolitical instability, environmental regulations, and global pandemics. Scholars such as Fahimnia et al. (2015)[11] have advanced the discourse by developing risk assessment frameworks tailored to high-stakes, asset-heavy sectors like oil and gas. Lastly, the integration of sustainability metrics—including carbon emissions, energy intensity, and waste minimization—into supply chain evaluation models reflects an increased academic and industrial alignment with ESG (Environmental, Social, and Governance) imperatives. These themes collectively underscore a research agenda that is both technically rigorous and contextually grounded in the sector’s operational realities.

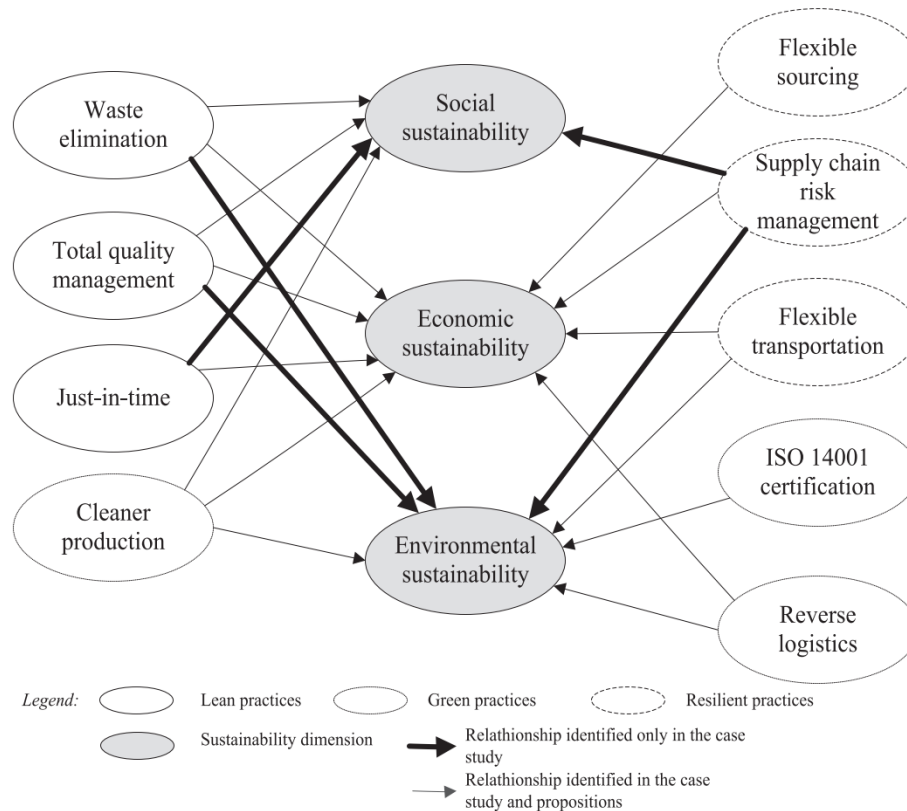


Figure 2.1: Model for the impact of lean, resilient and green SCM practices on SC sustainability.

2.1.3 Role of Transportation in Supply Chain Performance

Transportation as a Strategic Enabler of Supply Chain Efficiency:

Transportation serves not merely as a logistical function, but as a strategic enabler that underpins the structural integrity and operational efficiency of the entire supply chain. It acts as the physical integrator across procurement, production, distribution, and customer delivery nodes—creating temporal and spatial alignment that allows firms to synchronize material flows, information exchange, and service commitments (Tseng, Yue, & Taylor, 2005)[44]. This strategic role positions the transportation system (Figure 2.2) at the nexus of diverse forces including policy mandates, economic fluctuations, demographic trends, environmental constraints, and technological disruption. A well-orchestrated transportation network contributes directly to the realization of lean supply chain principles by minimizing excess inventory, reducing transit time variability, and enhancing process reliability. Simultaneously, it supports agility by enabling rapid reconfiguration of routes and capacities in response to demand volatility or supply disruptions (Christopher & Holweg, 2011)[9]. According to Fahimnia (2015)[11], Strategic investments in multimodal logistics, cross-docking systems, and hub-and-spoke distribution architectures further underscore transportation's role in optimizing flow, reducing lead times, and managing supply chain complexity (Rushton, Croucher, & Baker, 2017)[38]. Consequently, transportation is not a downstream afterthought but a strategic lever through which firms operationalize competitive priorities such as cost, responsiveness, and flexibility—particularly in complex, asset-intensive industries such as oil and gas.

Impact on Service Level and Customer Satisfaction:

Transportation plays a central role in shaping customer satisfaction by directly influencing service-level metrics such as delivery lead time, reliability, and flexibility. Efficient transportation systems enable firms to meet promised delivery dates, reduce variability, and respond to last-minute changes, which are critical performance indicators in modern supply chains. On-Time-In-Full (OTIF) delivery has emerged as a key metric for evaluating customer-facing performance, where any deviation—be it in timing, quantity, or quality—can have cascading impacts on customer trust and retention[16]. In customer-centric supply chains, transportation functions are no longer viewed as cost centers but as value-generating processes that ensure alignment between market demand and supply network responsiveness (Waller & Fawcett, 2013)[46]. This shift is particularly salient in service-based industries such as oil and gas, where timely transportation of equipment and materials directly affects project timelines and operational continuity.

Transportation Costs and Trade-Off Decisions:

Transportation represents a significant component of total logistics cost—often accounting for 30% to 60% of the overall supply chain expenditure depending on the industry—making it a focal point for optimization efforts [36]. As conceptualized in (Figure 2.2) **[The Geography of Transport Systems Framework]**, these costs exist within a complex system shaped by macroeconomic forces (economic growth, global trade), policy interventions (regulation, taxation, pricing), and societal shifts (demography, urbanization). Strategic transportation management requires careful balancing of trade-offs among cost, speed, service quality, and inventory levels. Reducing transportation costs by consolidating shipments can increase inventory holding costs or compromise customer service if not properly managed. This cost-service trade-off necessitates the use of total cost models and cost-to-serve frameworks that integrate transportation decisions with upstream and downstream activities [22]. Moreover, the selection of transportation modes—e.g., road vs. rail, or dedicated vs. shared fleets—has implications not only for cost-efficiency but also for flexibility and risk exposure. In capital-intensive and geographically dispersed

industries like oil and gas, such trade-offs must be evaluated in real-time to avoid suboptimization of isolated functions at the expense of end-to-end supply chain performance.

2.1.4 Risk, Innovation, and Sustainability in Transportation

Role of Transportation in Risk Mitigation and Supply Chain Resilience:

In an increasingly volatile and uncertain global environment, transportation functions are instrumental in enhancing supply chain resilience. The ability to reroute shipments, switch carriers, or adapt transportation schedules in response to disruptions—whether caused by natural disasters, pandemics, or geopolitical tensions—is a critical resilience capability[32]. Flexibility in transport mode selection, buffer capacity, and real-time visibility technologies have been cited as key enablers for absorbing shocks and ensuring business continuity[40]. In the oil and gas sector, where operations span remote, politically sensitive, or infrastructure-challenged regions, transportation systems are not merely supportive—they are risk management instruments in their own right. The proactive configuration of transportation networks to include redundant routes, multiple suppliers, and responsive carriers significantly mitigates the bullwhip effect and enhances the ability of the entire system to recover from disturbances [19].

Technological Innovations and Visibility Enablers:

The digital transformation of transportation is reshaping the performance frontier of supply chains through the adoption of smart logistics systems. Technological advancements such as GPS tracking, transportation management systems (TMS), Internet of Things (IoT), and blockchain have redefined the real-time visibility, traceability, and control over transportation flows. These advancements represent key facets of the 'Technology' dimension within the broader transport system framework (Figure 2.2), which also interacts critically with policy, energy availability, and societal demands. These systems enable dynamic routing, predictive maintenance, and automated scheduling, thereby reducing delays, optimizing fuel consumption, and enhancing vehicle utilization [24]. Moreover, the integration of transportation data into broader supply chain analytics platforms supports proactive decision-making and continuous performance improvement (Mekonnen, De Blas, & Atos, 2021)[27]. In complex environments like oil and gas logistics, where operations are dispersed and highly time-sensitive, the role of digital infrastructure becomes even more pivotal. Enhanced situational awareness and data-driven coordination foster a responsive, adaptive, and resilient transportation system—fundamental to competitive advantage in volatile markets.

Sustainability and Environmental Performance:

Transportation decisions are increasingly scrutinized through the lens of environmental sustainability, as firms face growing pressure to align their operations with global emissions targets and sustainability frameworks. The interconnected drivers of sustainable transportation—highlighted in (Figure 2.2) [**The Geography of Transport Systems Framework**—include energy constraints, climate imperatives, technological innovation (alternative fuels, engine tech), and evolving regulatory landscapes (policy, taxation). Freight transportation, particularly via road and air, contributes significantly to greenhouse gas (GHG) emissions, making it a critical leverage point for decarbonizing supply chains (McKinnon, 2010)[26]. Sustainable transportation strategies—such as modal shifts to rail or inland waterways, route optimization, and the adoption of alternative fuel vehicles—can reduce the environmental footprint while maintaining service levels [5]. Regulatory mechanisms such as carbon pricing, emission caps, and green procurement further incentivize firms to reassess their transportation configurations. In energy-intensive industries like oil and gas, where scope 3 emissions dominate, integrating sustainability

into transportation design is no longer optional—it is a strategic imperative that impacts brand equity, compliance risk, and long-term viability . Thus, sustainable transportation is both a moral and operational component of modern supply chain performance.

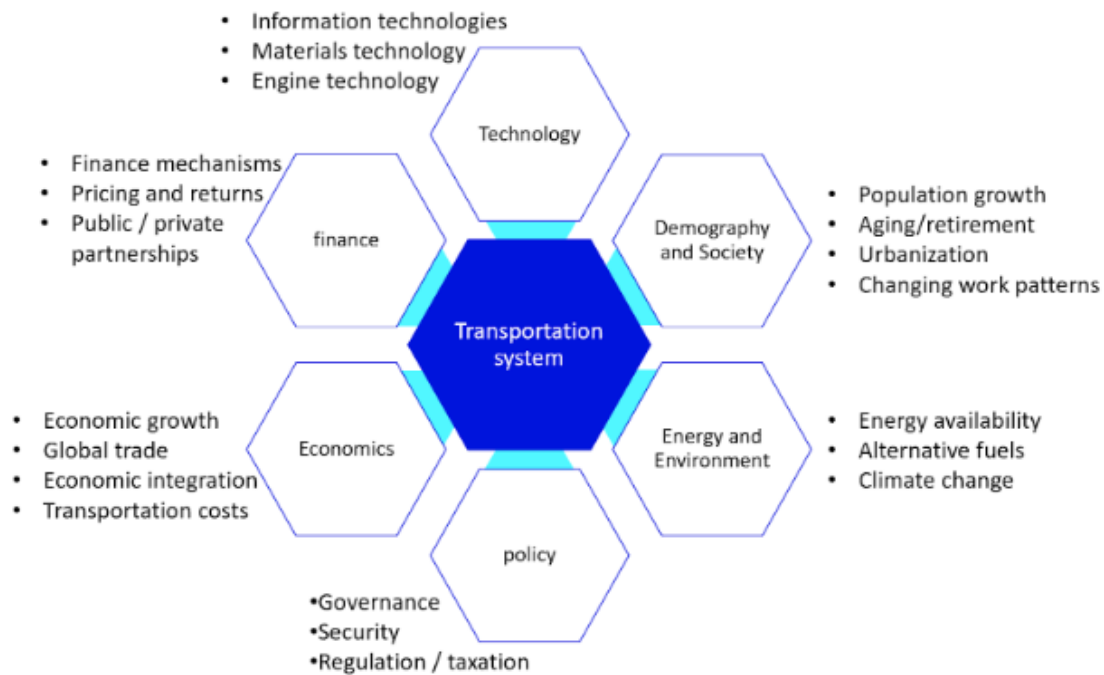


Figure 2.2: From The Geography of Transport Systems book

2.1.5 Transportation and Logistics Challenges in the Oil and Gas Services Industry

Fleet management optimization has emerged as a critical research domain within the broader field of logistics and supply chain management, particularly in industries characterized by high asset intensity and operational complexity, such as oil and gas. Historically, fleet management was dominated by heuristic approaches centered on static routing and cost minimization. However, with the rise of computational logistics and the integration of information systems, the domain experienced a shift towards dynamic and data-driven optimization models. In the early 2000s, operations research techniques such as mixed-integer linear programming (MILP), vehicle routing problem (VRP) variants, and simulation-based decision support systems became prevalent in addressing fleet deployment and scheduling challenges. More recently, the field has embraced multi-objective optimization paradigms, reflecting the growing pressure to balance economic efficiency with environmental sustainability and resilience against external disruptions [13]. This evolution is especially pertinent in energy logistics, where volatile demand, remote geographies, and environmental constraints necessitate adaptive and robust fleet planning strategies. The case studies examined in this section—focused respectively on crude oil and LNG transportation—demonstrate the progression of methodological sophistication in fleet optimization, incorporating sustainability metrics, scenario-based planning, and resilience modelling in the face of climate and geopolitical uncertainty.

Purpose of Case Study Integration

The inclusion of case studies within this review serves a dual purpose: to ground the conceptual discussion of fleet visibility and coordination in the oil and gas industry with empirical evidence, and to illustrate the practical implications of advanced fleet optimization methodologies in comparable industrial contexts. Given the complex, capital-intensive nature of logistics operations in oilfield service environments, the challenges of optimizing transportation resources—particularly under conditions of uncertain demand and fragmented information—demand more than theoretical exploration. By analyzing documented case studies that have employed rigorous optimization models to address similar constraints, this section offers tangible insights into how multi-objective planning, sustainability metrics, and resilience frameworks have been operationalized in real-world scenarios. These empirical illustrations are particularly relevant to the research objective of enhancing truck fleet visibility and exploring cross-segment resource sharing, as they expose tested strategies, performance trade-offs, and contextual factors that influence implementation outcomes. In doing so, they provide both methodological guidance and comparative benchmarks for assessing the applicability of co-sharing logistics frameworks in the Algerian oilfield services context.

Scope of Case Study Selection

The case studies selected for this review are deliberately focused on the oil and gas industry, reflecting the critical role of logistics and transportation optimization in this capital- and asset-intensive sector. The decision to restrict the temporal scope to the last ten years (2015–2024) stems from a bibliometric assessment indicating that approximately 75.52% of relevant publications in fleet management and sustainability within oil and gas logistics have emerged within this period (Figure 2.3), with 62.17% published since 2018 and 38.16% since 2021. This trend underscores a growing scholarly and industrial interest in resilient and sustainable logistics operations, particularly in response to emerging environmental constraints and evolving supply chain challenges. Consequently, this temporal focus ensures that the selected studies reflect both contemporary technological capabilities and current industry practices. Furthermore, the inclusion criteria emphasized case studies that integrate both fleet management strategies and sustainability dimensions, as these are directly aligned with the research objective of improving fleet visibility and evaluating opportunities for shared transportation resources. No exclusions were applied based on methodological rigor, allowing for the inclusion of both quantitative optimization models and broader qualitative or hybrid approaches to capture a holistic view of real-world implementation dynamics. This inclusive lens ensures that the reviewed cases offer both depth and breadth in their relevance to operational and strategic decision-making in oilfield logistics. We will be presenting 2 case studies: (1) The case by Atmayudha and Syauqi (2021)[2], and (2) The study by Al-Haidous and Govindan (2022)[15].

The forthcoming analysis explores two emblematic case studies that underscore critical dimensions in the optimization of fleet management systems within the oil and gas logistics domain. These cases are examined through a comparative lens to extract insights across four key analytical themes: (1) the methodological strategies employed to address multi-objective optimization in transportation planning, particularly under environmental and operational constraints; (2) the role of digitalization and data-driven modeling in enhancing fleet efficiency and sustainability outcomes; (3) the institutional and contextual challenges faced during the implementation of optimization frameworks, especially in highly regulated or environmentally sensitive environments; and (4) the observable outcomes in terms of cost efficiency, environmental performance, and resilience of logistics networks. While the case by Atmayudha and Syauqi (2021)[2] focuses on green logistics in crude oil transport using a multi-objective optimization approach, the

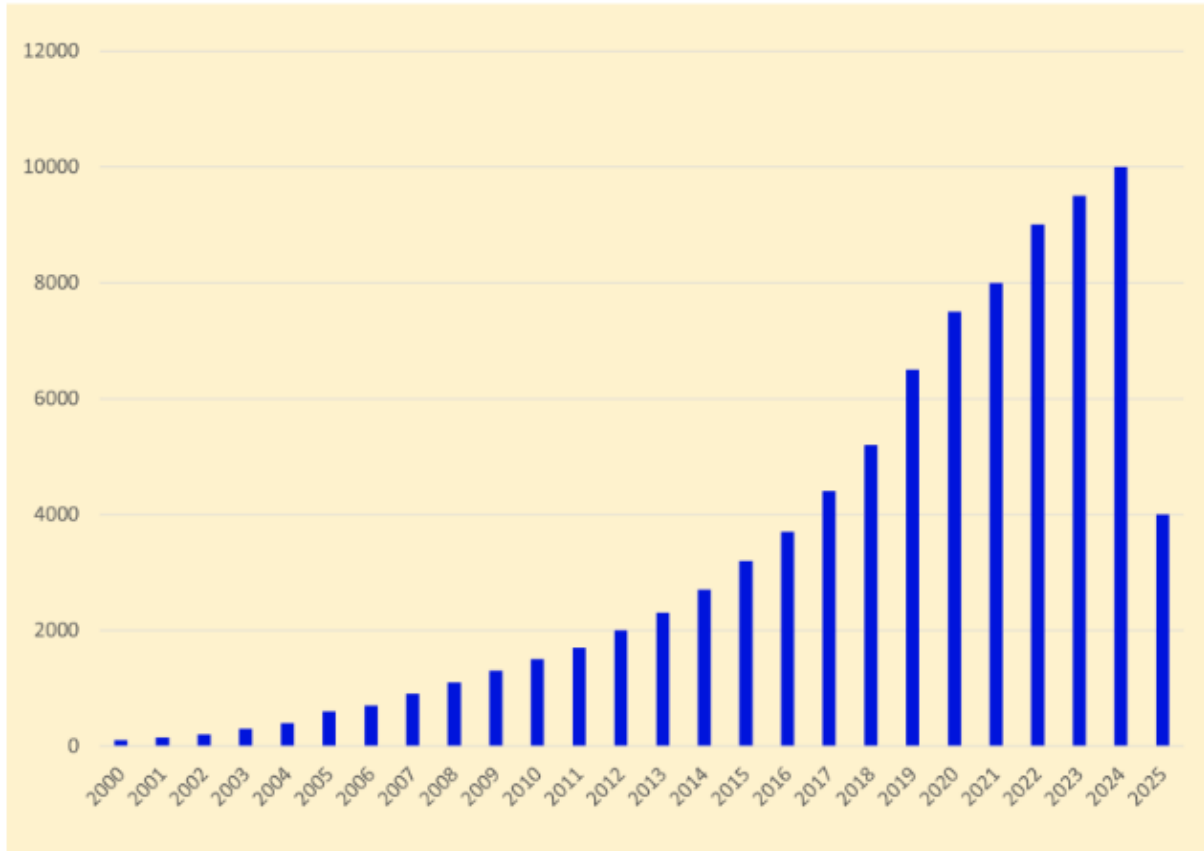


Figure 2.3: Publication number on the fleet management - From Lens.com

study by Al-Haidous and Govindan (2022)[15] provides a robust examination of resilience-enhancing strategies in the LNG supply chain through sustainability-oriented modeling under environmental constraints. Together, these cases offer complementary insights into the evolving role of advanced modeling techniques in transforming logistics performance and decision-making in the oil and gas sector. Their juxtaposition allows for a nuanced exploration of how optimization tools are being practically deployed to reconcile economic efficiency with ecological responsibility in fleet-centric operations.

Cross-Case Synthesis and Discussion The comparative analysis of the two case studies—Atmayudha and Syauqi’s (2021)[2] green logistics optimization in crude oil transportation, and Al-Haidous and Govindan’s (2022)[15] sustainability-enhancing approach to LNG supply chains in Qatar—reveals a number of salient themes that converge despite contextual differences. Both studies employ multi-objective optimization frameworks to address the dual imperatives of operational efficiency and environmental responsibility, suggesting a growing consensus around the viability of mathematical modeling and simulation-based techniques as strategic tools in fleet and logistics planning. Furthermore, both cases highlight the centrality of data integration and scenario-based analysis in managing transportation complexity, particularly in resource-constrained, regulation-intensive oil and gas environments.

A key insight that cuts across both studies is the pivotal role of contextual adaptability in determining the success of optimization strategies. While Atmayudha and Syauqi (2021)[2] emphasize route-based optimization under carbon emission constraints, Al-Haidous and Govindan (2014)[14] foreground resilience modeling in the face of geopolitical and ecological volatility. This divergence underscores that optimization models must be carefully tailored to the distinct logistical ecosystems they are deployed in—a

finding that aligns with existing literature emphasizing the bounded rationality of universal models in complex supply networks[14]. However, the studies also converge in validating that optimization frameworks, when grounded in real-time data and aligned with sustainability objectives, can yield tangible improvements in cost structures, fleet utilization, and environmental performance.

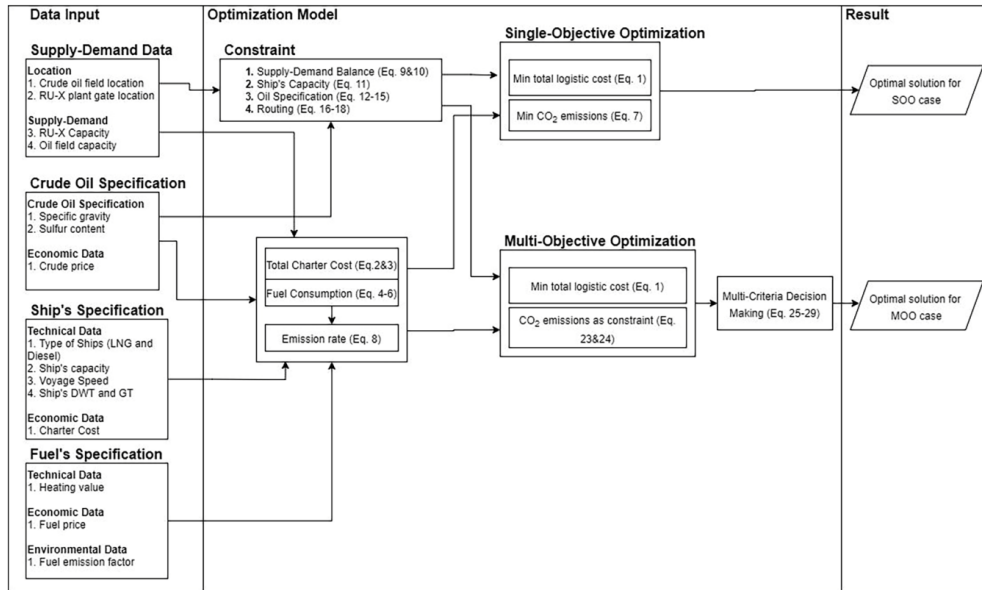


Figure 2.4: Optimization model - Green logistics of crude oil transportation

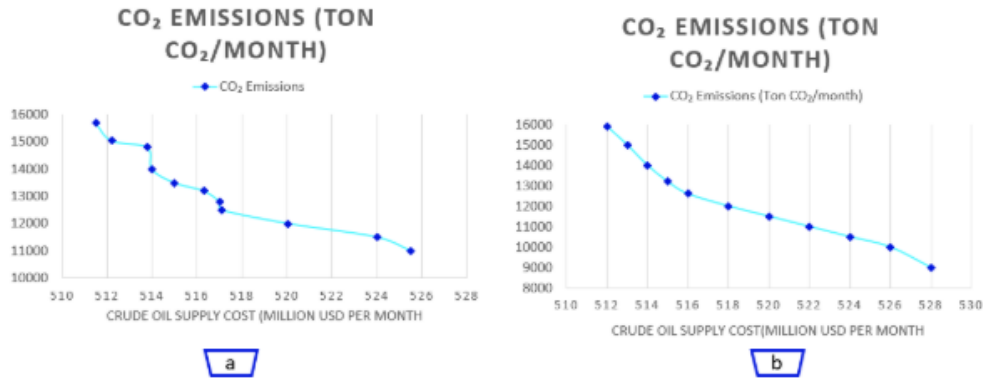


Figure 2.5: Pareto-optimal front curves for (a) scenario 3A; (b) scenario 3B

From a theoretical standpoint, the findings substantiate the increasing relevance of hybridized approaches that integrate concepts from operations research, environmental economics, and systems engineering. Notably, the studies reinforce the argument that logistics performance in oil and gas services cannot be fully understood through cost-efficiency metrics alone; environmental impact and resilience must be jointly optimized to ensure long-term viability. This multidimensional perspective refines traditional transport planning theories that often isolate cost minimization as the primary objective.

However, both studies also exhibit notable limitations. Most prominently, they omit the social and workforce-related dimensions of sustainability, thereby neglecting the human factors that influence fleet operations and logistical coordination. This gap is particularly salient given the increasing call for human-centric logistics models that integrate

labor efficiency, operator well-being, and social equity into optimization designs . Moreover, the geographical specificity of the cases—Indonesia for crude oil[2] and Qatar for LNG [15]—may constrain the transferability of findings to other oil-producing contexts, particularly those with different regulatory, infrastructural, or geopolitical constraints. Additionally, while both studies rely on robust optimization methodologies, they differ in data granularity, modeling scope, and implementation readiness, which introduces variability in result interpretation. Future research could benefit from cross-regional comparative studies using harmonized methodologies to validate these findings in broader settings.

In relation to the present research question—how visibility and optimization in domestic logistics fleets can foster resource sharing and operational synergy within oilfield service companies—these case studies offer preliminary support. They illustrate how advanced analytics, when integrated with context-sensitive fleet management strategies, can serve as enablers for shared asset utilization and systemic coordination. However, they also point to the need for further empirical investigation into the behavioral and organizational dynamics that underpin such sharing models, a dimension not fully captured in optimization-based studies.

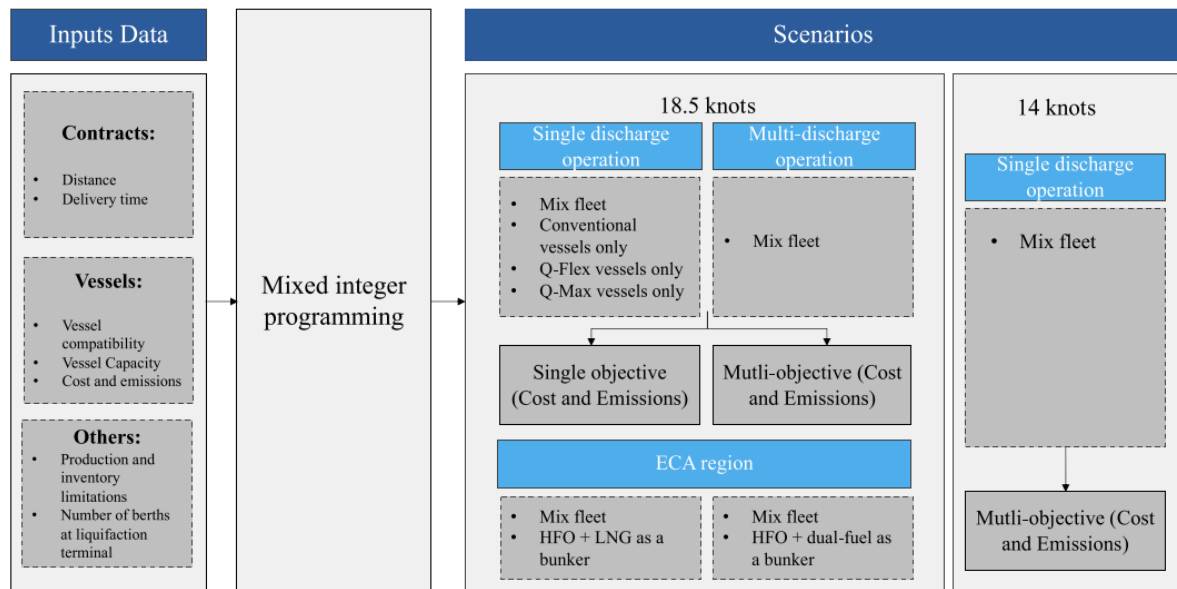


Figure 2.6: A summary of the applied methodology - From Qatar case study

Conclusion & Implications

The comparative analysis of the two case studies—Atmayudha[2] on green logistics for crude oil transportation and Al-Haidous[15] on LNG supply chain resilience—has yielded several critical insights into the evolving landscape of fleet management and sustainable logistics in the oil and gas sector. Foremost among these is the recognition that modern fleet optimization must transcend traditional cost-centric approaches and incorporate multi-objective frameworks that align environmental sustainability, resilience, and operational efficiency. Both studies highlight the growing relevance of advanced optimization techniques—such as Pareto-based multi-objective modeling and scenario-based simulations—in enabling decision-makers to navigate complex trade-offs in volatile operating environments. Furthermore, the evidence underscores the importance of context-sensitive planning, where fleet configurations and routing strategies are dynamically adapted to infrastructural, geopolitical, and environmental constraints.

This case-based inquiry substantiates the central thesis of this research: that enhanced visibility and intelligent resource-sharing within logistics systems can serve as levers for operational excellence in oilfield service operations. The findings resonate with the broader literature's emphasis on the shift toward greener and more adaptive supply chain configurations, especially under conditions of market volatility and regulatory tightening. The nuanced understanding of fleet responsiveness, emission minimization, and infrastructural constraints presented across both cases provides a compelling rationale for extending traditional planning paradigms to incorporate real-time visibility, shared logistics assets, and sustainability-driven key performance indicators (KPIs).

As this thesis transitions into a broader literature review and empirical exploration, the case studies provide a conceptual and methodological foundation for analyzing domestic fleet visibility gaps and co-utilization inefficiencies among business lines in the oil and gas service industry. For theory, the results invite further integration between transaction cost economics, resource-based views of supply chain assets, and sustainability performance models. For practice, they suggest that oilfield service firms can gain not only cost efficiencies but also strategic resilience by embedding data-driven and environmentally responsible fleet management frameworks. Finally, for future research, the comparative findings raise fertile questions around the generalizability of optimization models across geographies, the scalability of collaborative logistics, and the long-term value realization from sustainability-aligned transportation systems.

2.2 Fleet Management, Coordination Costs, and Operational Execution

2.2.1 Fleet Management and Visibility in Transportation Systems

Evolution of Fleet Management Systems and Their Functional Scope:

Fleet management systems (FMS) have evolved from manual oversight tools into integrated digital platforms that support complex operational functions in various logistics environments. The initial reliance on basic logbooks and static scheduling has been replaced by sophisticated technologies such as Global Positioning System (GPS), telematics, and cloud computing [34]. These systems now facilitate real-time monitoring of vehicle diagnostics, driver behavior, routing decisions, and maintenance schedules. As described by Moradi Afrapoli and Askari-Nasab (2019)[29], the shift toward data-driven optimization has allowed organizations to implement predictive analytics, dynamic fleet allocation, and lifecycle cost management. Consequently, FMS has transformed from operational support tools into strategic levers to improve service levels, reduce downtime, and improve cost efficiency.

Real-Time Visibility and Its Impact on Operational Efficiency:

Real-time visibility has become a cornerstone of efficient fleet operations, enabling proactive decision-making in fast-changing logistics environments. IoT-enabled sensors and advanced telematics now transmit continuous data on vehicle location, load status, and environmental conditions[3]. This visibility supports dynamic scheduling, facilitates preemptive maintenance actions, and strengthens customer communication, ultimately contributing to improved delivery reliability and reduced total cost of ownership. Wycislak (2023)[49] emphasizes that real-time data not only improves service responsiveness but also fosters adaptive coordination in uncertain and volatile transportation contexts. These capabilities are particularly relevant in sectors such as oil and gas, where responsiveness and operational continuity are critical.

Challenges in Implementing Fleet Visibility in Fragmented Systems:

Despite technological progress, the implementation of integrated fleet visibility remains challenging, especially in organizational environments characterized by siloed operations and fragmented information systems. As Raptis et al. (2019)[33] highlight, legacy infrastructure and lack of interoperability standards often hinder seamless data integration across departments and platforms. This fragmentation can delay decision-making, obscure key performance indicators, and inflate transaction costs. Moreover, the successful adoption of FMS requires not only technological investment but also organizational readiness for digital transformation, including staff training, change management strategies, and alignment of operational goals[49]. Thus, achieving fleet-wide visibility is as much a socio-technical challenge as it is a technological one.

2.2.2 Transaction Cost Economics and Resource Sharing in transportation

Transaction Cost Drivers in Oil and Gas Transportation Logistics:

The oil and gas services industry exhibits a uniquely complex logistics landscape that amplifies transaction costs through several interrelated dimensions. Key among these is

asset specificity, particularly the need for specialized transportation assets such as ADR-certified trucks and high-capacity trailers, which are not easily transferable across tasks or segments [48]. This specificity increases the cost of misallocation and the risk of asset underutilization. Moreover, the *geographical dispersion* of operations—especially in remote and harsh environments like the Algerian Sahara—introduces logistical uncertainty, elevating coordination and monitoring costs [25]. The highly variable nature of demand, driven by drilling schedules and field readiness, further complicates fleet allocation, necessitating either costly overcapacity or flexible rental agreements. Additionally, the sector is subject to stringent *Health, Safety, and Environmental (HSE)* regulations, which demand rigorous compliance and oversight, thereby increasing contractual and enforcement costs [20]. The combination of unpredictable job scheduling, safety-critical requirements, and remote operational contexts makes transportation coordination in oilfield services a high transaction cost activity, requiring nuanced governance and planning structures to mitigate inefficiencies.

Governance Structures and Vertical Integration in Oilfield Logistics:

The governance of transportation assets in oilfield service operations is increasingly shaped by the need to balance transaction costs with flexibility and operational control. In contexts where *asset specificity* and *uncertainty* are high—such as oilfield transportation—firms often lean toward *vertical integration* or hybrid governance mechanisms to mitigate opportunistic behavior and ensure service reliability [47]. For example, when transporting hazardous materials across remote drilling sites, the cost of contract enforcement, quality assurance, and compliance can render market-based solutions inefficient. As conceptualized in **Figure 2.3** (Williamson’s Governance Theory Framework), such contexts necessitate a shift toward private ordering—where hierarchical control (vertical integration) or relational contracts (hybrid models) align incentives and reduce opportunism [47]. In such scenarios, owning transportation assets or establishing long-term partnerships provides better alignment of incentives and reduces the risk of coordination failures [41]. This is particularly relevant in oilfield logistics, where disruptions can lead to significant financial losses and reputational damage. Empirical studies in the energy sector have shown that firms adopt mixed governance models—such as strategic alliances and long-term leasing arrangements—to achieve cost-effective flexibility while safeguarding against asset misappropriation and contractual disputes. In oil and gas services, such as those observed in SLB’s domestic logistics, this hybridization allows firms to adapt to demand volatility while managing critical safety and performance constraints, ultimately optimizing both transaction cost efficiency and operational reliability.

Cost-Benefit Evaluation of Resource Pooling under Uncertainty:

In the oil and gas services sector, particularly in remote and volatile operating environments such as the Algerian Sahara, *resource pooling* strategies—such as shared trucking fleets between business lines—must be rigorously evaluated through a *transaction cost lens* to assess their net value. Resource sharing introduces the potential for economies of scale and higher asset utilization; however, it also entails significant *coordination costs*, especially when demand is stochastic and capacity planning lacks predictive accuracy. According to Crocker and Masten (1996)[47], firms must weigh the exact cost of designing adaptable contracts and information systems against the ex post costs of renegotiation, opportunism, and service failure. In oilfield logistics, pooling decisions are further complicated by *temporal specificity*, where transport resources must be available at precise windows to avoid operational downtime. As demonstrated by Ménard (2004)[28], hybrid arrangements—such as platform-based sharing with centralized scheduling—can offer a viable compromise, reducing redundant capacity without compromising responsiveness.

Moreover, recent studies emphasize the importance of visibility tools and joint performance metrics in mitigating the risks inherent in shared resource governance [50]. For oilfield service providers like SLB, such cost-benefit evaluations are central to determining whether collaborative models will yield operational efficiencies or merely shift the burden of uncertainty.

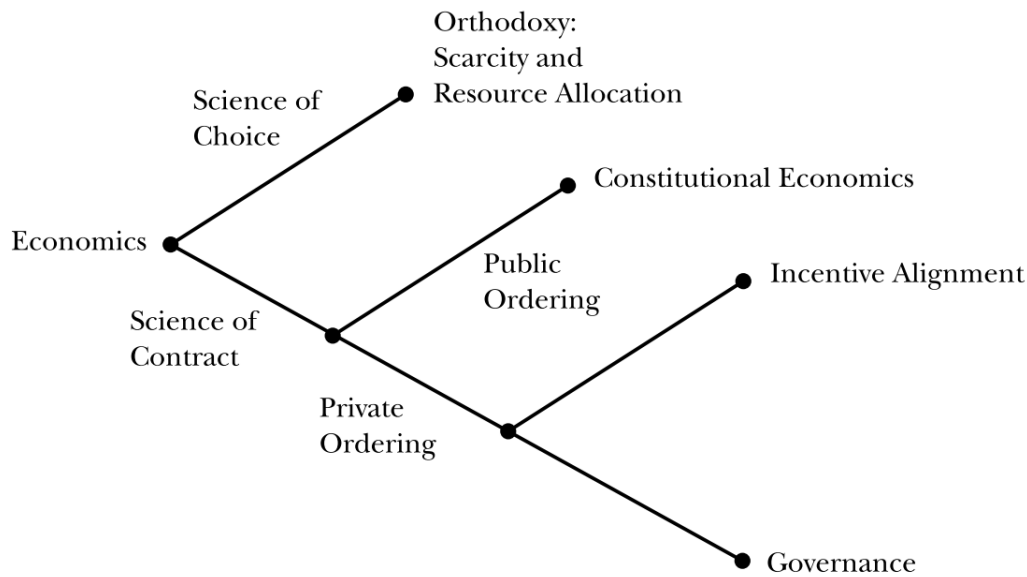


Figure 2.7: Williamson's governance theory diagram

2.2.3 Adherence to Planning and Scheduling: Challenges and Solutions

Structural Complexity and the Fragmentation of Planning Layers:

In the oil and gas services sector, transportation planning is often executed through siloed layers—sales forecasts, operational scheduling, and field execution—each managed by separate systems and organizational units. This structural fragmentation undermines the cohesion necessary for effective transportation planning and schedule adherence. Decentralized decision-making in large-scale industrial operations frequently leads to inconsistencies between planned and executed activities. In oilfield logistics, this misalignment is exacerbated by the use of disjointed digital platforms such as FDP (Field Data Platform), OTM (Operations Transportation Management), and field-level journey logs. These systems typically lack integration, resulting in information discontinuities that obscure transportation demand signals and hinder proactive fleet coordination. Consequently, despite having well-defined scheduling frameworks, organizations struggle with late dispatches, underutilized fleets, and reactive decision-making—outcomes that degrade both cost-efficiency and service reliability.

Volatility of Operational Demand and Its Impact on Schedule Robustness:

Another fundamental challenge in transportation planning adherence stems from the inherent volatility in operational demand within oilfield service operations. Service jobs in remote locations are frequently rescheduled, resized, or cancelled altogether due to factors like last-minute changes in drilling conditions, client-side approvals, or equipment readiness. This volatility imposes a high degree of uncertainty, rendering static transportation schedules quickly obsolete. As shown in the work of Van der Vorst and Beulens

(2002)[45], planning systems in volatile environments must accommodate flexibility to remain viable. However, in many oil and gas service contexts, transportation schedules are generated based on rigid forecasts without embedded flexibility mechanisms, such as real-time buffers or conditional routing options. The absence of adaptive planning frameworks leads to frequent plan deviations, emergency dispatches, and poor utilization of truck resources [31]. In essence, unless transportation schedules are designed to absorb variability, adherence remains aspirational rather than operational.

Behavioral and Organizational Constraints to Schedule Compliance:

Beyond technological and systemic fragmentation, behavioral and organizational dynamics often play a critical role in limiting adherence to transportation planning. In oil and gas service operations, where multiple actors—including field supervisors, logistics planners, and subcontracted drivers—must align their actions, informal decision-making and tactical deviations are common. As observed by Holweg et al. (2005)[17], discrepancies between planned operations and actual execution often arise from human factors such as mistrust in centralized planning, overreliance on local knowledge, or resistance to system-driven decisions. These behaviors are frequently reinforced by performance metrics that reward short-term responsiveness over long-term schedule discipline. In practice, such misalignments are compounded in decentralized geographies like the Algerian Sahara, where logistical constraints, environmental unpredictability, and weak feedback loops allow deviations from plan to persist undetected. This human-centric disconnect undermines not only operational efficiency but also the effectiveness of digital fleet management systems that depend on consistent data inputs [37].

Data Feedback Loops and Their Role in Continuous Planning Optimization:

An essential enabler of schedule adherence is the establishment of robust data feedback loops that inform continuous planning improvements. Effective logistics operations require not only forward-looking plans but also backward-looking data to evaluate performance, diagnose variances, and recalibrate forecasts. In oilfield transportation, this loop is often broken: job completions are recorded manually or sporadically, and critical performance indicators—such as actual versus scheduled truck dispatches, utilization rates, and delivery lead times—are rarely fed back into planning systems. As highlighted by Lee et al. (2000)[23], without feedback-driven recalibration, supply chain systems fail to learn from execution and remain vulnerable to repeated disruptions. Furthermore, visibility tools that support these loops—such as transport control towers or integrated fleet dashboards—remain underutilized in oil and gas service logistics, despite evidence showing their value in fostering synchronization and reducing total cost-to-serve. Thus, schedule adherence should not be viewed as a static compliance metric but as a dynamic, data-informed process that evolves through institutional learning.

2.2.4 Optimization Methods in Supply Chain Management

Building on the insights derived from the comparative analysis of case studies in oil and gas logistics, it becomes evident that addressing the sector’s transportation inefficiencies and sustainability trade-offs requires more than descriptive evaluations. The complex interplay between fluctuating demand, geographic dispersion of assets, and environmental constraints necessitates rigorous decision-support mechanisms. In this context, optimization modeling emerges as a powerful analytical tool, capable of transforming empirical observations into prescriptive strategies. The following section delves into the spectrum of optimization approaches—ranging from classical mathematical programming to advanced metaheuristics and simulation-based frameworks—highlighting their applicability, structure, and relevance to upstream fleet planning challenges in oilfield service operations.

Mathematical optimization stands as a foundational pillar in contemporary logistics research, providing systematic frameworks to derive the most efficient solutions under defined constraints. Mixed Integer Linear Programming (MILP), in particular, has emerged as a salient technique for modeling logistical decisions that involve both continuous and discrete variables, such as truck allocation, facility location, and shipment routing. XuLi et al. (2024) illustrate the utility of MILP in comprehensive supply chain network design, where integer variables represent binary decisions—such as whether to open facilities or dispatch trucks—while linear constraints enforce resource capacities and demand fulfillment. The theoretical underpinnings of MILP rely on branch-and-bound and branch-and-cut algorithms, which systematically explore candidate solutions and use linear relaxations to prune the search space, efficiently navigating the exponential complexity introduced by integer variables.

Empirical evidence further underscores the potency of MILP in logistical contexts. Vicente et al. (2024) applied a MILP model to a multi-echelon inventory system, demonstrating its efficacy in optimizing (s,S) policies across multiple facilities, effectively balancing ordering, holding, and transportation costs. Additionally, MILP has been successfully utilized in bioresource logistics: Nunes et al. (2024) developed a MILP-based optimization for vineyard pruning biomass collection, realizing a remarkable 30% reduction in transportation cost while accommodating scattered collection points—showcasing how MILP models can internalize routing, capacity constraints, and temporal considerations in a unified framework.

From a methodological standpoint, MILP models benefit from the advances in solver technologies. Bixby (2024) reports that solvers like CPLEX and Gurobi have achieved up to fourfold performance improvements over the past three decades, attributed to refined algorithms and parallel computing capabilities. Comparative studies affirm that CPLEX outperforms Gurobi for very large-scale MILP problems—though both remain benchmark tools for linear and integer programming applications. Furthermore, open-source platforms such as COIN-OR’s CBC and CLP offer accessible alternatives while maintaining robustness in solving large linear formulations.

However, not all logistical phenomena can be captured through linear relationships. Nonlinearities in cost structures, economies of scale, and travel-time functions often necessitate Mixed Integer Nonlinear Programming (MINLP). While MINLP can more accurately model real-world complexities, it also increases computational difficulty significantly. A common workaround is piecewise linearization, whereby nonlinear functions are approximated with linear segments to reframe the problem into a MILP, enabling the use of efficient solvers while still approximating nonlinear relationships.

Beyond exact methods, heuristic and metaheuristic algorithms—including genetic algorithms, particle swarm optimization, and ant colony optimization—provide approximate but computationally tractable solutions for large, non-convex problems. These approaches are often implemented in software environments like MATLAB, HeuristicsLab, and OptaPlanner, enabling problem-tailored strategies when traditional solver-based methods are impractical due to complexity or scale.

Simulation-based optimization represents another hybrid approach, integrating performance modeling through simulation with optimization routines. Tools like AnyLogic and Simio allow practitioners to evaluate scenario-based outcomes under varied operational settings and uncertainties, feeding insights back into optimization loops. This method, while less rigorous than MILP, offers greater realism when systems are too complex to

model strictly analytically.

In recent years, artificial intelligence and machine learning have emerged as supplementary yet powerful tools in logistics optimization. Frameworks such as TensorFlow and PyTorch facilitate the development of predictive or prescriptive models that can inform or augment traditional optimization engines, although the integration of ML into MILP-based pipelines remains an evolving frontier.

Finally, a broad spectrum of commercial and academic software tools supports these methodologies. Aside from CPLEX and Gurobi, notable packages include FICO Xpress—pioneering parallel MIP solving since the 1990s—and open-source options like COIN-OR, which provide effective platforms for prototyping and deployment. For discrete-event and agent-based modeling frameworks, AnyLogic, Arena, Simul8, FlexSim, and MATLAB/Simulink are widely adopted in industrial logistics for both analysis and optimization.

Conclusion This state-of-the-art review has rigorously dissected the evolving discipline of supply chain management, culminating in a critical exploration of transportation and logistics inefficiencies specific to the oil and gas services sector. It began by re-establishing the supply chain not as a linear flow of goods, but as a dynamic, interdependent system shaped by strategic alignment, relational coordination, and systemic integration. This comprehensive framing was then contextualized within the oil and gas industry—an operating environment defined by its extreme volatility, asset-intensive operations, and spatial complexity.

Within this context, transportation emerged as both a strategic enabler and a persistent bottleneck. It is a primary determinant of service quality, cost control, and operational responsiveness. Yet, evidence consistently points to chronic inefficiencies rooted in fragmented planning structures, weak schedule adherence, and the absence of end-to-end visibility. These issues are not merely operational—they reflect deeper structural flaws that inhibit cross-functional coordination and strategic agility.

By applying the lens of Transaction Cost Economics, this review has clarified why these inefficiencies persist. High asset specificity, environmental uncertainty, and the lack of standardized governance significantly elevate coordination costs and reinforce siloed behavior. As a result, transportation systems in the oilfield services context remain reactive, under-optimized, and incapable of adapting to fluctuating demand with efficiency.

In response, the chapter has mapped a robust prescriptive framework centered on mathematical optimization. The exploration of Mixed Integer Linear Programming (MILP) and related methods establishes a methodological pathway capable of transforming reactive logistics operations into proactive, data-driven systems. These techniques offer the precision and scalability required to improve planning accuracy, enable resource co-sharing, and enhance fleet visibility across business lines.

This review thus serves not only as a comprehensive diagnostic of the logistical challenges in the sector but also as a strategic launchpad for solution development. It anchors the rationale for designing an optimization model that aligns transportation planning with operational realities—advancing toward a logistics ecosystem that is more integrated, cost-efficient, and resilient in the face of uncertainty.

This final chapter addresses the resolution of the initially identified problem through the implementation of a digitized transportation planning solution. The proposed approach utilizes an interactive Gantt chart interface to streamline planning processes and improve operational visibility.

The solution is specifically designed to enhance domestic logistics planning by identifying job-specific requirements, execution timelines, committed timeframes, and logistics response times. It incorporates key operational parameters such as job location, transit time, truck type, shipment volume, and opportunities for cross-segment consolidation and backhaul optimization. By integrating these elements, the tool enables accurate alignment between available transport capacity and job execution requirements.

This chapter outlines all phases of implementation—from initial design and feature development to system testing and performance evaluation. It presents the core functionalities, the validation methodology, and the results observed during deployment. Ultimately, the solution equips planners with a comprehensive and integrated platform to optimize execution planning and effectively manage domestic logistics resources across the supply chain.

3.1 Solution Architecture

To address the company's challenges, we are taking a functional analysis approach aimed at precisely defining requirements and designing a digital platform to digitize the transportation planning process. The solution is based on the development of an interactive Gantt chart interface that allows for the identification of job requirements, execution timelines, committed timeframes, and logistics response times. It incorporates key operational parameters such as job location, transit time, truck type, shipment volume, and opportunities for cross-segment consolidation and backhaul optimization. A planning panel was also developed using Excel VBA to support planners in visualizing transport activities and aligning resources efficiently. Additionally, a Vehicle Routing Problem (VRP) model was implemented to determine the optimal truck fleet size. An interactive Power BI dashboard complements the system, enabling effective monitoring of domestic logistics operations, reducing excess rental costs, and strengthening cross-segment transport synergies. This integrated solution aims to improve the accuracy, responsiveness, and overall performance of transportation planning processes.

3.1.1 Data collection

To design our planning database, we collected information from various sources: legacy files used by planners, semi-structured interviews with business line employees, and data extracted from information systems such as FDP, OTM, and eJourney — with a particular focus on FDP. These sources provided valuable insights into operational data, job requirements, fleet management, execution tracking, and job timeframes, forming the foundation of our database. In addition to leveraging historical data, the database will be continuously updated through an agile planning approach that reflects real-time changes in operational needs.

3.2 Development and Implementation Strategy

We adopted an iterative and agile development approach to ensure adaptability, continuous improvement, and alignment with end-user needs throughout the project lifecycle. By following an incremental delivery model, features were developed, tested, and integrated in successive sprints, allowing us to validate functionality progressively and adjust priorities based on feedback.

3.2.1 Needs assessment

The diagnostic conducted during the initial evaluation and presented in the first chapter provided an in-depth assessment of the current state of the transportation planning process. This analysis clearly revealed the need for digitization to address inefficiencies, limited visibility, and recurring operational bottlenecks. In response, a digital solution was developed to enable the identification of job requirements, execution timelines, committed timeframes, and logistics response times. The system integrates key operational parameters such as job location, transit time, truck type, shipment volume, and opportunities for cross-segment consolidation and backhaul optimization. Additionally, a planning panel was developed using Excel VBA to support planners in visualizing transport activities and effectively aligning logistics resources with operational demands.

A. Identifying the need

In this phase, our goal is to identify the needs of the solution by answering the following questions:

- What is the purpose of the solution?
- Who is affected by the solution?
- What elements does the solution act on?

To illustrate the answers to these questions, we will use the “Horned Animals” diagram, which will show the various interactions between the answers to these questions. product use diagram simplifies the identification of needs by schematizing the interac-

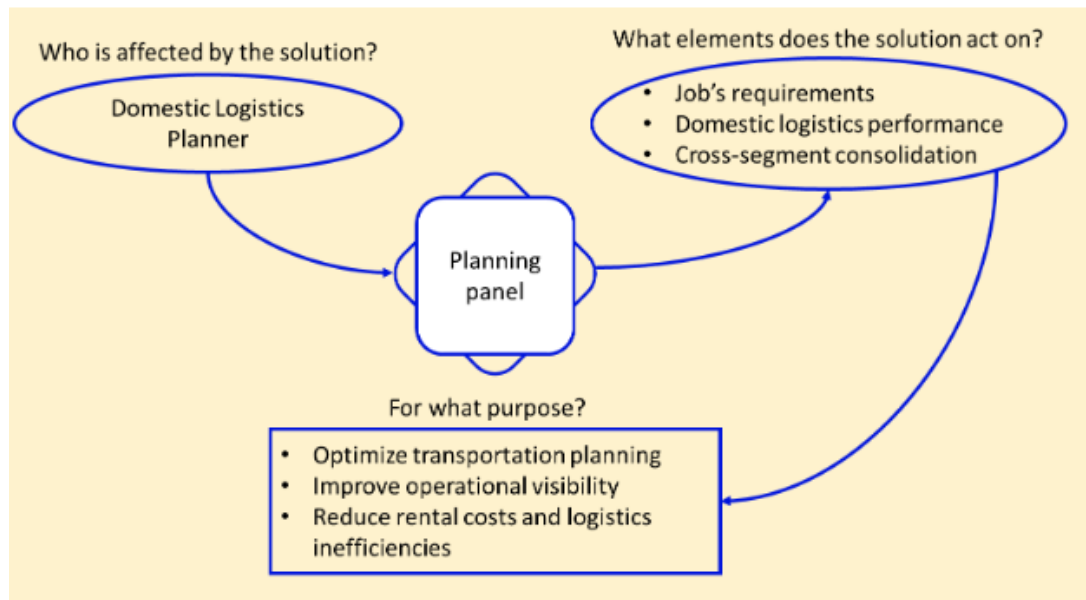


Figure 3.1: product use diagram

tions between the different components of the project and providing clear answers to essential questions.

B. Validating the need

We are now validating the identified needs using the answers to the following key questions

Why does this need to exist?

- Poor alignment between job requirements and available transport capacity
- Increased use of short-term truck rentals
- Missed opportunities for route consolidation and backhaul utilization
- Limited ability to anticipate bottlenecks or optimize execution timelines

What could cause the need to change?

- Increased operational complexity, such as a growing number of job sites, transport modes, or regulatory constraints
- Digital transformation initiatives, prompting the integration of more advanced technologies like AI-based routing or IoT tracking
- Organizational changes, such as centralization of logistics functions or shifts in sourcing/production locations
- External disruptions, including fuel price volatility, labor shortages, or geopolitical risks that impact transport dynamics

What could cause the need to disappear?

- **Full outsourcing of logistics operations** to third-party providers, where planning is handled externally
- **Transition to a fixed fleet model** with stable routes and minimal variability, reducing the need for dynamic planning tools

- **Adoption of an enterprise-wide TMS (Transportation Management System)** that already includes advanced scheduling, optimization, and tracking features
- **Significant drop in operational volume**, making advanced planning tools unnecessary or cost-inefficient

C. Project planning

To ensure the success of our iterative approach, close collaboration with the master planning team is essential in order to clearly identify and prioritize essential requirements. Next, we establish clear objectives for each phase of the project, precisely identifying the features that need to be developed. Development will take place in short cycles called “sprints,” where each iteration focuses on the implementation of specific functionalities (Figure 3.2). This methodology allows us to effectively plan the progress of the project while remaining flexible to adjust priorities and requirements along the way.

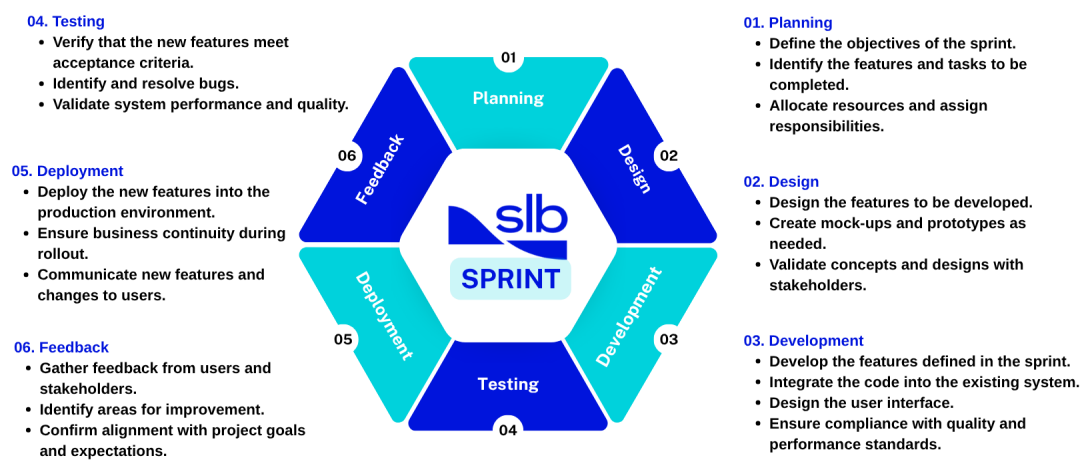


Figure 3.2: The key processes of each iteration according to the agile approach, illustrating the planning, development, testing, and review phases in collaboration with the user.

D. Solution Design

After reviewing the requirements and understanding the context of the project, we move on to the solution design stage using UML (Unified Modeling Language) (Figure 3.3). This language allows us to create models to visualize and specify the proposed solution.

This approach aims to present the platform in a clear and simple way, facilitating communication with decision-makers and users. The component diagram provides a schematic representation of the functional behavior of the actors in relation to the system, illustrating the interactions in a conceptual diagram.

E. Solution Development

We chose a sprint-based approach to structure our development. During each sprint, we held regular meetings with the planner to discuss progress, gather feedback, and validate the features developed. This collaboration allows us to quickly adjust our approach and respond to changing needs throughout the development process.

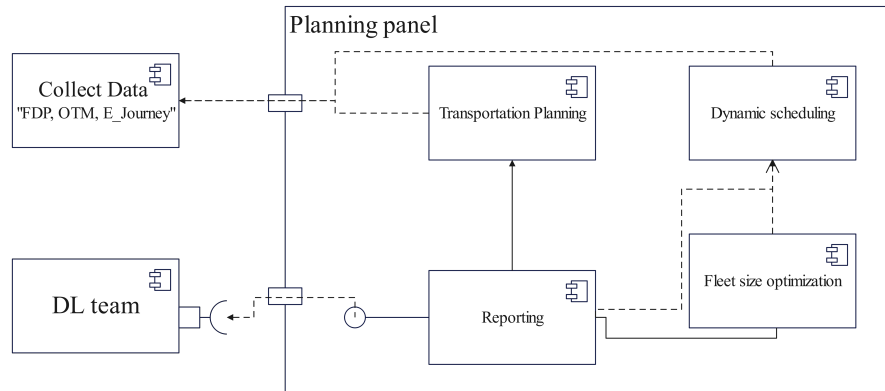


Figure 3.3: The component diagram

Table 3.1: Platform Development Phases

Sprint	Objectives
Sprint 1	Design and initial setup of the digital platform, focusing on establishing core architecture and integrating foundational components. Includes data collection, stakeholder interviews, and enhancing the data model with segment-specific constraints.
Sprint 2	Implementation of standardized execution timelines, data refresh cycles, and automated planning. A Gantt chart is developed for real-time job and resource visualization.
Sprint 3	Development of dynamic scheduling algorithms, optimization of job sequencing, and automation of transport and tracking reports. Advanced analytics are supported.
Sprint 4	Full component testing and feedback integration. KPIs related to planning, utilization, and performance are defined and tracked.
Sprint 5	Implementation of adaptive planning mechanisms, final refinements, and preparation for large-scale deployment.

By following this iterative structure, we can ensure that each feature is carefully developed, tested, and validated before integrating new features. This also allows us to gather regular feedback from the planner, ensuring that the final solution will meet the company's operational and strategic needs. We will then detail the VBA macro development modules that automate key transportation planning processes, as documented in Appendix 3.3.

Modules Used :

Modules facilitate program factorization, improve readability, and simplify maintenance. In addition, module procedures and functions can be reused in other programs.

The deployed modules are presented in detail in the appendix. We have organized the modules according to the macros used in each feature.

Browsing modules

- OpenPlan
- OpenWCF, OpenWCM, OpenWL, OpenWTS, OpenWIS, OpenRPS
- OpenMasterDataTrucks
- OpenDashboarding
- OpenOverview

These macros allow navigation to the main functionalities within the workbook. The code is designed to display only the selected sheet and hide the others, ensuring clear and concise navigation throughout the document.

Module *DynamicScheduling*:

- AssignTrucksRPS, AssignTrucksWTS, AssignTrucksWCM
- AssignTrucksWCF, AssignTrucksWL, AssignTrucksWIS

These macros manage the assignment of available trucks for each operational segment. Each macro ensures truck allocation aligns with segment-specific parameters such as scheduling constraints, resource needs, and delivery timing. This structure supports a dynamic and responsive planning process while improving overall logistics efficiency.

Module *Planning*:

- PlanWCF, PlanWCM, PlanWL, PlanWTS, PlanWIS, PlanRPS

These macros are responsible for executing planning-related actions for each operational segment. They may involve initializing planning parameters, preparing data for visualization, or triggering pre-calculated planning logic. The purpose is to support structured, segment-level planning while maintaining clarity and consistency across the platform.

Module *Data*:

- RefreshDataFDP
- RefreshDataOTM

This module manages access to all key data sheets and updates. The refresh macros ensure that the latest data is loaded for each segment or system, keeping the planning and operational environment accurate and synchronized. The additions of RefreshDataFDP and RefreshDataOTM specifically ensure that data from the FDP and OTM sources is always up to date.

F. Solution Report

The application developed to implement the proposed solution is based on Excel VBA, using mainly worksheets and macros to provide a user-friendly interface and interactive features.

In this section, we will present the various features of our planning panel application.

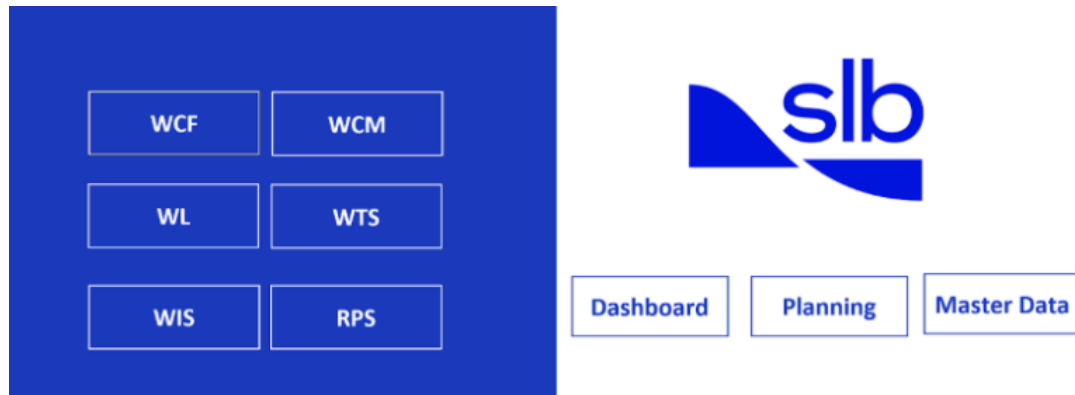


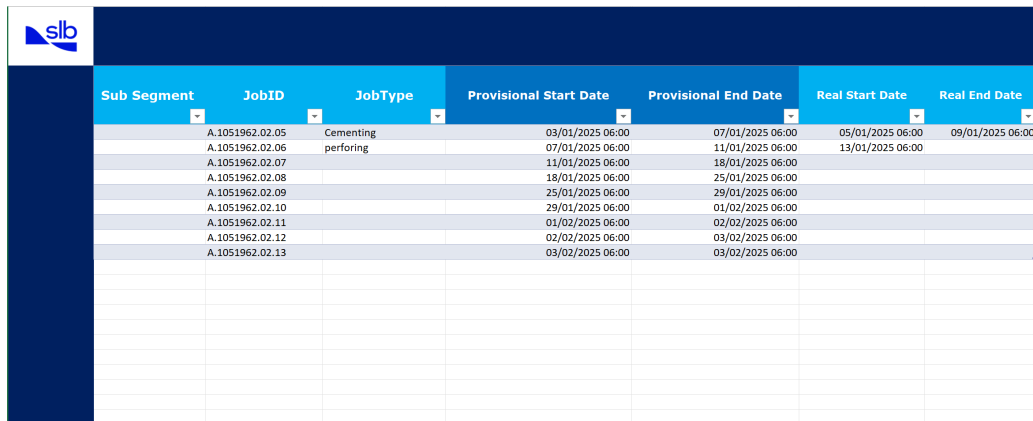
Figure 3.4: The application's home page

3.3.1 Data Management Tools

Data Entry In this feature, the planner is required to input essential data to generate the planning panel. When the corresponding button is pressed, an interface is displayed, allowing the planner to select the data to be entered—such as the estimated job start dates, job durations, and the results of the dynamic scheduling algorithm. At the same time, basic data such as planned start and end dates, the number of confirmed jobs, and their types is automatically and frequently refreshed from FDP and OTM, ensuring the planning panel remains aligned with the latest operational information.

Dynamic Scheduling Dynamic scheduling within the platform relies on two essential data components: the forecasted number of trucks available and the assignment of each truck to specific jobs. This assignment process is governed by a set of prioritization rules that account for both inter-segment hierarchy and job criticality, ensuring that the most urgent and strategically significant operations are addressed first. The algorithmic framework supporting this logic is designed to optimize resource allocation while minimizing idle time and operational bottlenecks.

The detailed structure and functioning of the scheduling algorithms are presented in the annex. The results, illustrated in the figure below, demonstrate the system's ability to generate feasible, priority-respecting schedules that enhance fleet utilization and improve overall planning efficiency.



Sub Segment	JobID	JobType	Provisional Start Date	Provisional End Date	Real Start Date	Real End Date
	A.1051962.02.05	Cementing	03/01/2025 06:00	07/01/2025 06:00	05/01/2025 06:00	09/01/2025 06:00
	A.1051962.02.06	performing	07/01/2025 06:00	11/01/2025 06:00	13/01/2025 06:00	
	A.1051962.02.07		11/01/2025 06:00	18/01/2025 06:00		
	A.1051962.02.08		18/01/2025 06:00	25/01/2025 06:00		
	A.1051962.02.09		25/01/2025 06:00	29/01/2025 06:00		
	A.1051962.02.10		29/01/2025 06:00	01/02/2025 06:00		
	A.1051962.02.11		01/02/2025 06:00	02/02/2025 06:00		
	A.1051962.02.12		02/02/2025 06:00	03/02/2025 06:00		
	A.1051962.02.13		03/02/2025 06:00	03/02/2025 06:00		

Figure 3.5: Output of the dynamic scheduling algorithm

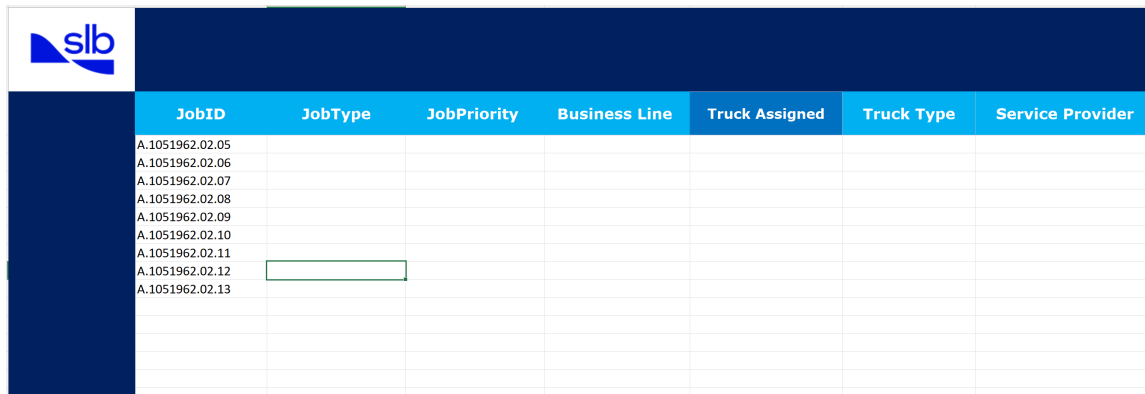
After each frequent refresh, the updated data is automatically distributed across the structure shown in the figure below. This figure presents the essential basic data—such as planned start and end dates, confirmed job types, and volumes—used to feed the interactive Gantt chart. This visual component enables clear and real-time tracking of job scheduling and resource allocation.



Figure 3.6: Automatic distribution of refreshed data for planning

The data entered and automatically retrieved through this interface serves as the foundation for the scheduling process. Once the planning panel is populated with accurate and up-to-date job information—such as confirmed job types, start and end dates, and durations—it becomes possible to trigger the dynamic scheduling engine. This engine leverages the curated dataset to assign available fleet resources efficiently, ensuring that operational priorities and constraints are fully respected in the planning logic.

Planning At the heart of the application’s functionalities, the *Planning* sheet in Excel acts as the central hub where all key planning data converges. It serves as the final step in the planning workflow, consolidating both manually entered and frequently refreshed data—such as job types, start and end dates, durations, and truck assignments—into a unified visual interface.



The image shows a screenshot of an Excel spreadsheet titled 'Planning Sheet Overview'. It features a dark blue header bar with the 'slb' logo on the left. Below the header, there is a table with columns: JobID, JobType, JobPriority, Business Line, Truck Assigned, Truck Type, and Service Provider. The JobID column contains a list of identifiers starting with 'A.1051962.02.05' and ending with 'A.1051962.02.13'. The JobType column has a single cell with a green border. The other columns are empty.

JobID	JobType	JobPriority	Business Line	Truck Assigned	Truck Type	Service Provider
A.1051962.02.05						
A.1051962.02.06						
A.1051962.02.07						
A.1051962.02.08						
A.1051962.02.09						
A.1051962.02.10						
A.1051962.02.11						
A.1051962.02.12						
A.1051962.02.13						

Figure 3.7: Planning Sheet Overview

For each job and each truck, the sheet displays both planned and realized transportation times, along with dedicated rows for planned jobs, realized jobs, and truck capacity indicators. The *Planned Truck Capacity* row reflects forecasted resource allocation, while the *Realized Truck Capacity* row captures actual usage and adherence to the plan.

These data points are extracted and structured using a visual indexing formula: $(\text{month} - 1) \times 30 + \text{day} + 2$, enabling precise and intuitive representation within the interactive Gantt chart.

By bringing together the outputs of data entry, dynamic scheduling, and performance tracking, this sheet functions as the application’s control tower—ensuring end-to-end visibility and coherence between planning logic and operational execution.

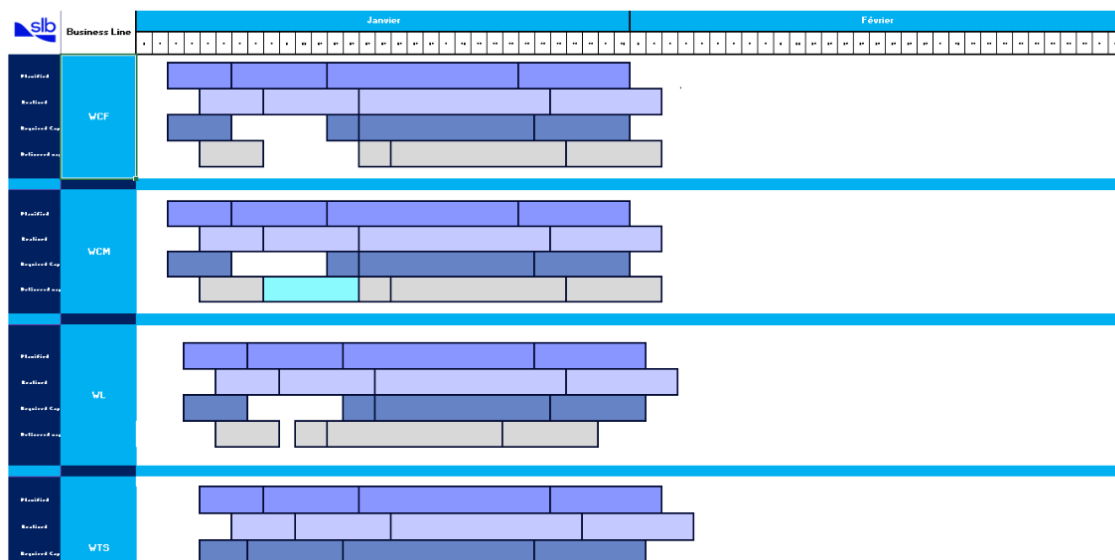


Figure 3.8: Planning overview - Gantt chart

3.2.2 Optimization Model

To support evidence-based fleet planning within SLB’s domestic logistics operations, we developed a mathematical optimization model aimed at identifying the minimum number

of trucks required to execute all shipping activities recorded over the past month. This retrospective model does not incorporate uncertainty, as it is based on realized (historical) demand, and seeks to derive a theoretically optimal truck configuration to cover those needs at the lowest possible cost.

Model structure

The model is structured as a **binary mixed-integer linear program (MILP)** and defined over a 30-day planning horizon. The core elements of the model are organized into four principal components: **sets**, **parameters**, **decision variables**, and **constraints**.

- **Sets** define the entities involved: the rigs (destinations), the shipments to be transported, truck types, available trucks, and the days of the planning period.
- **Parameters** include shipment start times, truck occupation durations, rig-specific demand matrices for each truck type and day, cost and emission profiles per truck type, and maximum fleet size constraints.
- **Decision Variables** Let:
 - $X[i][j][k] \in \{0, 1\}$: Binary variable equal to 1 if truck i of type j is assigned to shipment k ; 0 otherwise.
 - $Z[i][j] \in \{0, 1\}$: Binary variable equal to 1 if truck i of type j is used (i.e., assigned to at least one shipment); 0 otherwise.
 - $Y[i][j][t] \in \{0, 1\}$: Binary variable equal to 1 if truck i of type j is occupied (i.e., active) on day t ; 0 otherwise.
- **Objective Function** Minimize the total cost of used trucks:

$$\text{Minimize} \quad \sum_{i \in \text{Trucks}} \sum_{j \in \text{TruckTypes}} Z[i][j] \cdot C[j] \quad (3.1)$$

Where $C[j]$ is the cost of using one truck of type j .

- **Constraints**

C0: Link Occupation to Assignments

Ensure that a truck is considered active ($Y[i][j][t] = 1$) if it is assigned to any shipment active on day t :

$$Y[i][j][t] \geq \sum_{k \in \text{Shipments}} \sum_{t \in [\text{StartDay}[k], \text{StartDay}[k] + L[k] - 1]} X[i][j][k] \quad \forall i, j, t \quad (3.2)$$

C1: Link Assignment to Usage

A truck cannot be assigned to a shipment unless it is activated:

$$X[i][j][k] \leq Z[i][j] \quad \forall i, j, k \quad (3.3)$$

C2: Time Occupation Constraint

Prevent a truck from being assigned to more than one shipment at the same time:

$$\sum_{k \in \text{Shipments}} \sum_{t \in [\text{StartDay}[k], \text{StartDay}[k] + L[k] - 1]} X[i][j][k] \leq 1 \quad \forall i, j, t \quad (3.4)$$

C3: Demand Satisfaction

Ensure that the total number of active trucks of each type satisfies rig-specific demand on each day:

$$\sum_{i \in \text{Trucks}} Y[i][j][t] \geq D[r][j][t] \quad \forall r, j, t \quad (3.5)$$

C4: Fleet Capacity Constraint

Ensure that the total number of trucks used per type does not exceed the maximum fleet size available:

$$\sum_{i \in \text{Trucks}} Z[i][j] \leq \text{MaxFleet}[j] \quad \forall j \quad (3.6)$$

C5: Shipment Assignment

Each shipment must be assigned to exactly one truck of its required type:

$$\sum_{i \in \text{Trucks}, j \in \text{TruckTypes} \mid \text{TruckTypeOf}[k]=j} X[i][j][k] = 1 \quad \forall k \in \text{Shipments} \quad (3.7)$$

$$\begin{aligned}
(C) = \left\{ \begin{array}{l}
\textbf{Decision variables :} \\
\\
X_{ijk} \in \{0, 1\}, \quad \forall i, j, k \quad (\text{Truck } i \text{ of type } j \text{ allocated to the shipment } k) \\
Y_{ijt} \in \{0, 1\}, \quad \forall i, j, t \quad (\text{Truck } i \text{ of type } j \text{ is active in the day } t) \\
Z_{ij} \in \{0, 1\}, \quad \forall i, j \quad (\text{Truck } i \text{ of type } j \text{ is used}) \\
\\
\textbf{Objectif function :} \\
\\
Z_{\min} = \sum_{i \in \text{Trucks}} \sum_{j \in \text{TruckTypes}} Z_{ij} \cdot C_j \\
\\
\textbf{S.C. (Constraints) :} \\
\\
\text{C0 :} \quad Y_{ijt} \geq \sum_{\substack{k \in \text{Shipments} \\ t \in [\text{StartDay}_k, \text{StartDay}_k + L_k - 1]}} X_{ijk}, \quad \forall i, j, t \\
\\
\text{C1 :} \quad X_{ijk} \leq Z_{ij}, \quad \forall i, j, k \\
\\
\text{C2 :} \quad \sum_{\substack{k \in \text{Shipments} \\ t \in [\text{StartDay}_k, \text{StartDay}_k + L_k - 1]}} X_{ijk} \leq 1, \quad \forall i, j, t \\
\\
\text{C3 :} \quad \sum_{i \in \text{Trucks}} Y_{ijt} \geq D_{rjt}, \quad \forall r, j, t \\
\\
\text{C4 :} \quad \sum_{i \in \text{Trucks}} Z_{ij} \leq \text{MaxFleet}_j, \quad \forall j \\
\\
\text{C5 :} \quad \sum_{\substack{i \in \text{Trucks}, j \in \text{TruckTypes} \\ \text{TruckTypeOf}_k = j}} X_{ijk} = 1, \quad \forall k \in \text{Shipments}
\end{array} \right.
\end{aligned}$$

Figure 3.9: Optimization Model summary

Model Verification and Validation Tool: IBM ILOG CPLEX Optimization Studio

IBM ILOG CPLEX Optimization Studio is a comprehensive suite of tools designed specifically for mathematical and constraint programming. It offers an integrated environment for modeling, solving, and validating complex optimization problems, particularly in the domains of linear programming (LP), mixed-integer programming (MIP), and constraint programming (CP).

Development Environment and Modeling Language

Depending on the operating system, users can access one of two integrated development environments (IDEs): the **CPLEX Studio IDE** for Windows or **opldev** for Linux. These environments provide a user-friendly interface for constructing and solving

optimization models.

Central to this toolset is the **Optimization Programming Language (OPL)**, a domain-specific language developed to closely mirror the structure and logic of mathematical formulations. OPL facilitates the modeling of linear and quadratic programs using a syntax that is intuitive for optimization practitioners. This language allows users to separate the problem model from the input data, enabling easy testing and reuse of models with various data sets—an essential feature for comparative analysis and scenario testing.

Solvers and Capabilities

The platform integrates two main solvers:

- **IBM ILOG CPLEX Solver:** This solver is specialized in mathematical programming. It efficiently handles linear and quadratic problems, including pure linear, mixed-integer, and integer formulations. It is widely recognized for its robustness and computational performance in solving large-scale optimization problems.
- **IBM ILOG CP Optimizer:** Designed for constraint programming, this solver addresses problems characterized by logical, scheduling, or sequencing constraints, often found in planning and scheduling applications.

Together, these solvers allow users to tackle a broad range of industrial problems by switching seamlessly between different solving paradigms depending on the structure of the problem.

Modeling and Test Implementation in CPLEX

In the context of our study, the CPLEX Optimization Studio was used to implement and test the optimization model developed for the transportation fleet sizing problem (Figure 3.10). The first test (Figure 3.11) was conducted using dummy data to validate the correctness of the model structure and its alignment with the mathematical formulation.

The following figures illustrate both the implemented OPL model and the corresponding solution output. These initial tests confirm the functionality of the model and serve as the foundation for further simulations under real-world data conditions.



Figure 3.10: Model in CPLEX

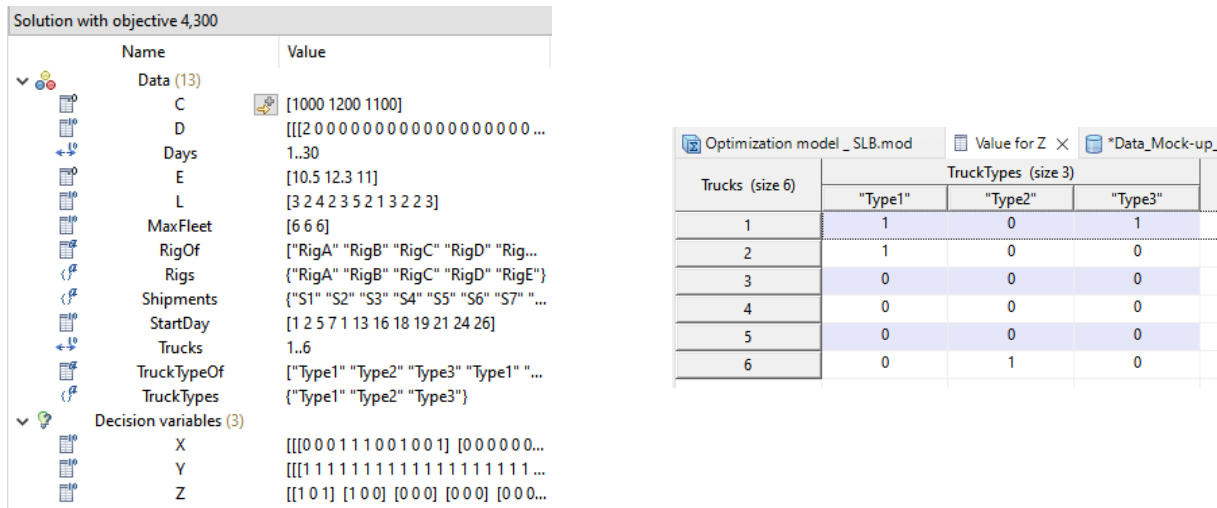


Figure 3.11: Model test results

This modeling and testing phase ensures the technical soundness of the proposed solution and sets the stage for performance evaluation and calibration against empirical scenario.

The overall architecture of the BI solution is illustrated in the figure below.

3.2.3 Visualizing Domestic Logistics Performance

The Business Intelligence (BI) solution developed for Domestic Logistics at SLB integrates key architectural principles of modern BI systems. It is designed to transform fragmented operational data into a centralized, strategic decision-support system. The architecture aligns with best practices outlined in BI literature, combining structured data modeling, ETL processes, and performance visualization through Power BI.

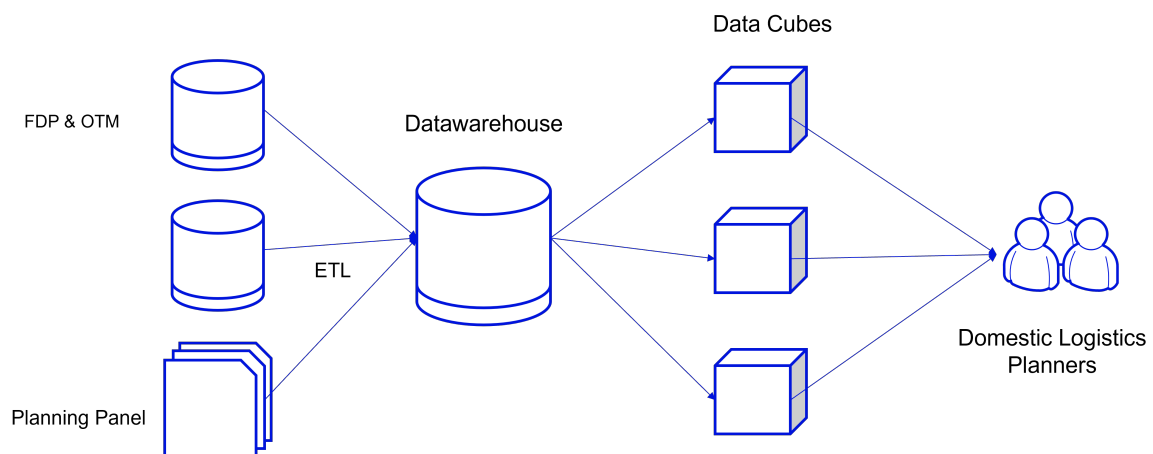


Figure 3.12: BI Solution Architecture.

Data Sources and ETL Integration

In the absence of a conventional data warehouse dedicated to Domestic Logistics, the **Planning Panel functions as the logical core** of the Business Intelligence (BI) system.

It consolidates all logistics-related data in a structured, maintainable, and operationally aligned format. Far beyond a planning tool, the Planning Panel integrates business line specific datasets across:

- Well Construction Fluids (WCF)
- Reservoir Performance and Stimulation (RPS)
- Wireline Logging (WL)
- Well Intervention Services (WIS)
- Well Construction and Measurement (WCM)
- Well Testing Services (WTS)

In addition to segment level data, the panel incorporates master data sources, including truck specifications and availability, and is continuously updated through frequent refreshes from external systems such as **Oracle Transportation Management (OTM)** and **Field Delivery Platform (FDP)**.

The reporting system developed in this project constitutes the visualization and reporting layer of the Planning Panel solution itself. It is designed to leverage the panel's structured datasets to produce **real-time dashboards and performance indicators**, forming a decision-support environment tightly aligned with field operations.

To ensure data consistency and reduce manual workload, a **dedicated ETL (Extract, Transform, Load) pipeline** was developed to automatically ingest, process, and integrate logistics data into the data warehouse. This pipeline forms the technical backbone of the Business Intelligence system, allowing for continuous data synchronization across diverse sources.

- **Extract:** The pipeline retrieves data from multiple operational and planning systems, including Oracle Transportation Management (OTM), Field Delivery Platform (FDP), segment specific tracking tools, and internal Planning Panel spreadsheets. These data sources reflect the distributed and heterogeneous nature of SLB's logistics operations. Key extracted elements include job execution records, truck assignments, schedule parameters, and resource availability metrics.
- **Transform:** The extracted data is then automatically cleaned, validated, and standardized. Transformations include date and time harmonization, categorical decoding (e.g., job types, service providers), resolution of missing values, and the reconciliation of inconsistent codifications, notably for identifiers such as Truck IDs and Job IDs, which vary across FDP and OTM systems. Job types are also grouped into higher level job families to support aggregated reporting and cross-functional analysis.
- **Load:** Once transformed, the data is loaded directly into the data warehouse, populating both fact and dimension tables. These structured datasets feed into the Power BI reporting layer, supporting the generation of real-time dashboards, KPI visualizations, and performance diagnostics.

Following **Kimball’s data warehousing best practices**, this automated ETL process ensures semantic consistency, historical traceability, and analytical reliability, all within a flexible and operationally aligned BI framework. It also enhances scalability and timeliness, enabling SLB’s Domestic Logistics teams to base decisions on continuously refreshed, high-quality data.

Data Warehouse

The Planning Panel solution is underpinned by a **star schema data model**, tailored to support real-time logistics monitoring and advanced business intelligence. This structure ensures efficient querying, performance scalability, and full compatibility with OLAP-style operations such as slicing, dicing, roll-up, and drill-down, essential for strategic diagnosis and operational insight generation. The model consists of centralized fact tables and a constellation of linked dimension tables, each representing a distinct analytical axis relevant to SLB’s Domestic Logistics function.

The structure of the Planning Panel’s data warehouse, based on a star schema model, is illustrated in the figure below

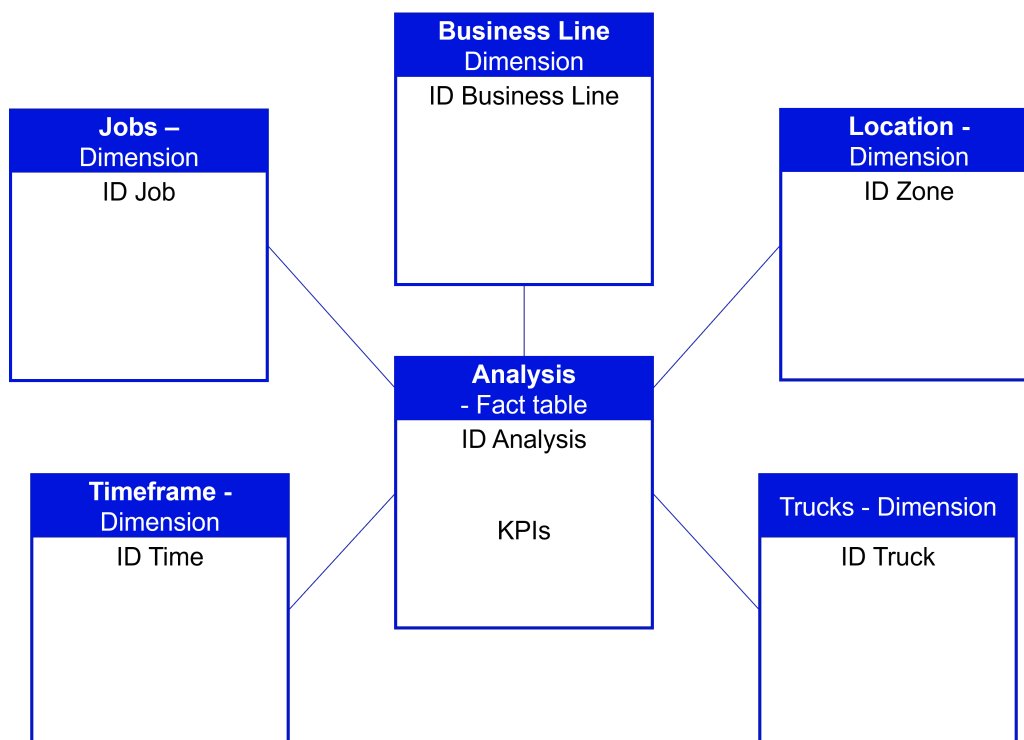


Figure 3.13: Solution Datawarehouse.

Fact Tables The fact tables consolidate all core **quantitative performance metrics** derived from SLB’s logistics operations. These include measures such as:

- **Execution Reliability KPIs**

- On-Time Delivery Rate

- On-Time Job Start
- **Fleet Management KPIs**
 - Truck Availability Gap
 - Truck Utilization Rate
- **Schedule Adherence KPI**
 - Schedule Adherence Index

These indicators form the **analytical backbone** of the Planning Panel and are directly mapped to the Key Performance Indicators (KPIs) detailed in the subsequent section. This structural alignment ensures that each metric captured is not only measurable but also strategically actionable within SLB’s logistics decision-making framework.

Dimension Tables Each dimension table captures a different axis of analysis, providing context and segmentation logic to the fact tables. The main dimensions include:

- **Timeframe:** Defines the temporal granularity of analysis, ranging from daily operations to quarterly reviews, supporting time-series forecasting and historical trend evaluation.
- **Truck ID:** Uniquely identifies vehicles used in logistics operations. Given the multiplicity of external service providers (e.g., Baouchi, SARL Telli), trucks are often referenced using inconsistent codification schemes. To ensure referential integrity and unified tracking, a harmonized Truck ID dimension was implemented, mapping provider codes to SLB’s internal asset registry. This enables cross-provider fleet performance tracking, vehicle-level utilization analysis, and lifecycle monitoring.
- **Job ID:** Functions as the primary key linking execution records across systems. Logistics jobs originate from both OTM (Oracle Transportation Management) and FDP (Field Delivery Platform), two distinct systems operated by different software vendors (Oracle and SAP, respectively). These platforms use divergent job ID formats. A standardized Job ID dimension was constructed to resolve these discrepancies and enable unified analysis across the planning pipeline.
- **Job Type and Job Family:** Each job is classified by its technical nature (e.g., mobilization, pumping, hauling). To simplify analytical aggregation, these types are grouped into broader Job Families, providing a higher-level segmentation layer suitable for executive reporting and performance clustering.
- **Business Line:** Reflects SLB’s current divisional taxonomy and field-level operations. While SLB operates officially through strategic divisions (e.g., Well Construction, Reservoir Performance), legacy systems and field teams often refer to functional segments such as Cementing, Coiled Tubing, Wireline, or Fracturing. A unified Business Line dimension reconciles this nomenclature, mapping historical and functional labels to the official divisional structure. Within the Planning Panel, the following sub-divisions are used consistently:
 - WCF: Well Construction Fluids
 - WCM: Well Construction & Measurements

- RPS: Reservoir Performance Stimulation
 - WIS: Well Intervention Services
 - WTS: Well Testing Services
 - WL: Wireline Logging
- **Geographic Location and Zoning:** To account for spatial variability in performance, all work locations are grouped into strategic zones. Zoning enables intra-regional analysis, route optimization (e.g., backhauls), and supports fleet pooling scenarios where trucks are shared across zones and business lines.

Data Cubes & Dashboarding

A **data cube** is a multidimensional data structure used in Online Analytical Processing (OLAP) systems to enable in-depth, flexible analysis across several analytical dimensions. Each cell within the cube represents an aggregated measure (e.g., truck utilization, job execution time, cost) at the intersection of specific dimension values such as Job Type, Business Line, and Timeframe.

In the context of SLB’s Domestic Logistics Business Intelligence solution, the data cube is constructed from the fact and dimension tables designed in a star schema within the Planning Panel data warehouse. This model provides a semantically consistent and scalable analytical framework, enabling users to interact with logistics data through operations such as:

- **Slicing**
Viewing a single layer of the cube, such as job performance for a specific business line or region
- **Dicing**
Extracting a sub-cube to analyze jobs of a certain type over a selected time frame and location
- **Drill-down**
Exploring finer-grained details, for example from monthly KPIs to daily job execution logs
- **Roll-up**
Aggregating detailed data into higher-level summaries, such as weekly truck utilization trends
- **Pivoting**
Rotating dimensions to view performance from different analytical perspectives (e.g., by Job Family instead of Business Line)

This approach transforms the Planning Panel from a static planning tool into a dynamic analytical engine, empowering logistics managers and planners to generate actionable insights, benchmark performance across segments, and detect inefficiencies or anomalies in real time.

Execution Reliability KPIs Within the Domestic Logistics Business Intelligence (BI) framework, On-Time Delivery Rate and On-Time Job Start represent two foundational Key Performance Indicators (KPIs) designed to evaluate the operational reliability and responsiveness of field logistics. These metrics are particularly critical in Wireline Intervention (WI), where precise coordination between scheduling and execution directly affects service continuity and resource utilization.

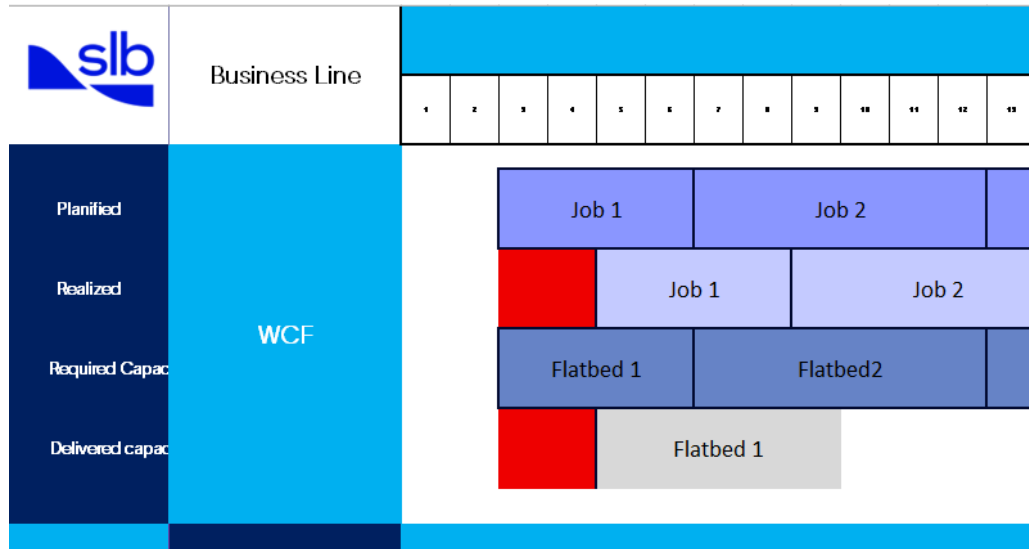


Figure 3.14: Comparative Gantt chart showing On-Time Delivery Rate and On-Time Job Start across operational segments.

Table 3.2: Execution Reliability KPIs

KPI	Definition	Strategic Purpose	Operational Insight
On-Time Delivery Rate	Percentage of logistics jobs completed within their allocated delivery windows	Measures service reliability and the ability to meet internal/external delivery commitments	High rates signal robust planning and execution; low rates reveal delivery inefficiencies
On-Time Job Start	Percentage of jobs that commence at or before their scheduled start time	Assesses planning adherence and operational readiness	Delays indicate potential issues with truck availability, resource staging, or coordination

Both KPIs are illustrated through comparative Gantt-style charts, which juxtapose planned versus actual execution timelines across operational segments. These visual representations serve as diagnostic tools that highlight scheduling discrepancies—such as late job starts or delayed deliveries—by segment and resource. The Gantt layout enables planners and operations managers to visually assess alignment between planning and execution, facilitating immediate recognition of deviations and enabling root-cause analysis. This comparative approach not only supports the evaluation of historical adherence to schedules but also enhances the capacity for continuous planning optimization and operational agility within SLB’s domestic logistics workflows. In parallel, both KPIs are

also numerically represented in the Power BI dashboard, where they support real-time tracking and executive-level reporting.

Fleet Management KPIs Within SLB's Domestic Logistics BI framework, Truck Availability Gap and Truck Utilization Rate are key indicators used to evaluate the efficiency and adaptability of fleet management practices. These KPIs help logistics managers ensure that trucks are not only available when needed but also optimally deployed across business lines.

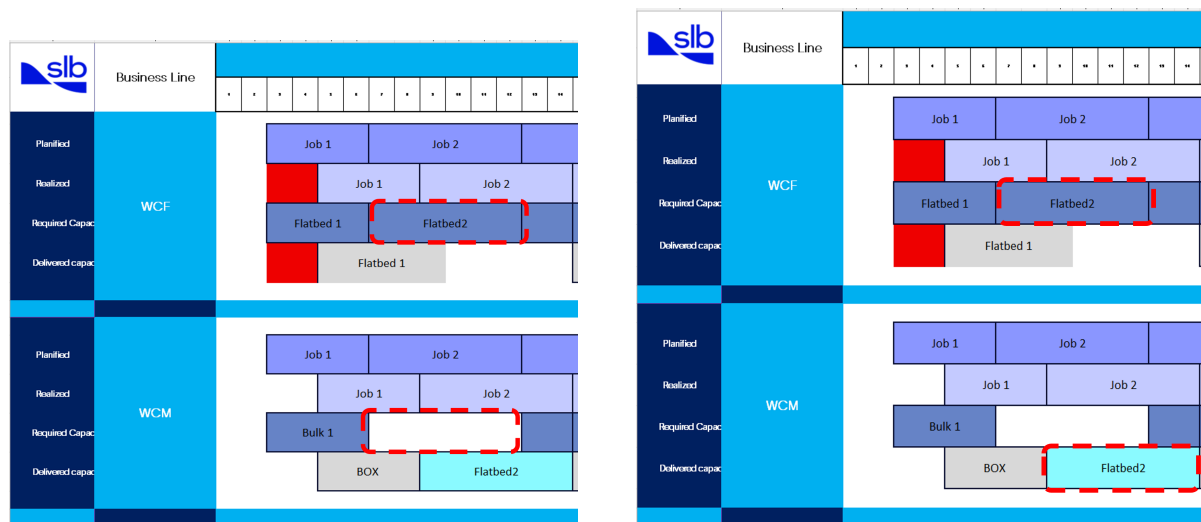
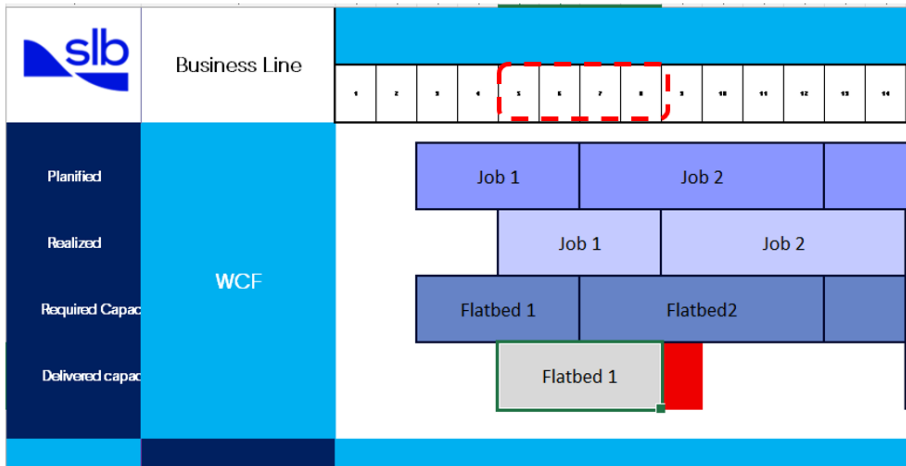


Figure 3.15: (Left) Job cancellation and reassignment of Flatbed 2; (Right) Truck activity timeline showing utilization trends.

Truck Availability Gap quantifies the number of planned jobs that could not be executed due to unavailable transport resources. This KPI highlights planning-resource mismatches and supports operational diagnostics when job cancellations or delays occur. In the figure, a job cancellation triggered the detection of Flatbed 2 as available, enabling its immediate reassignment to another job in a different segment. This real-time response showcases the system's agility and flexibility in adapting to disruptions, made possible through frequent data refreshes and real-time visibility.

Truck Utilization Rate, in parallel, measures the percentage of time trucks are actively used versus idle. It reflects overall fleet productivity and directly impacts cost efficiency. High utilization rates indicate optimal dispatching and low idle time, whereas lower values may reveal scheduling inefficiencies or surplus capacity. The swift reassignment of Flatbed 2 in the example illustrates how dynamic resource reallocation supports higher utilization, reinforcing SLB's responsive and data-driven logistics planning approach.

These KPIs are essential for tracking logistics productivity and capacity performance across business lines. While their operational patterns are visualized through comparative Gantt charts, their real-time numeric values are also integrated into the Power BI dashboard, enabling trend monitoring, segment-level comparisons, and informed operational decision-making.



While deviations are visualized through comparative Gantt-style timelines, the Schedule Adherence Index is also reported numerically in the Power BI dashboard, enabling

logistics managers to track trends over time, benchmark performance across segments, and investigate root causes of delay.

Table 3.4: Schedule Adherence KPI

KPI	Definition	Strategic Purpose	Operational Insight
Schedule Adherence Index	Ratio of actual job duration to planned job duration	Monitor execution efficiency and detect deviations from scheduled timelines	Deviations highlight execution overruns, field delays, or planning misestimations

The implementation of the Planning Panel and its underlying Business Intelligence (BI) architecture marks a transformative advancement in SLB's Domestic Logistics operations. By integrating fragmented data sources into a unified analytical environment, the solution enables near real time performance monitoring, centralized decision making, and predictive planning capabilities. Notably, the solution is projected to enhance operational visibility by up to **80%**, significantly improving the department's ability to detect inefficiencies, allocate resources effectively, and respond proactively to logistical challenges. This increase in visibility translates directly into better service reliability, improved fleet utilization, and stronger alignment between field execution and planning layers, making the Planning Panel not only a planning tool but a strategic enabler of logistics excellence.

3.3 Limitation and further research section

One of the foremost limitations encountered in this project lies in the fragmented nature of data across SLB's internal systems. The planning panel aggregates information from disparate platforms such as FDP (Forecast Demand Planning), OTM (Operational Transport Management), and E-Journey (Execution and Tracking), each of which maintains its own logic, structure, and update frequency. This heterogeneity imposes a significant barrier to real-time automation, rendering the current tool semi-manual and dependent on data cleaning and reconciliation routines. To integrate this planning tool seamlessly into SLB's operational fabric, future research should explore the use of application programming interfaces (APIs) or data lakes that enable automated, real-time ingestion of structured and validated datasets. Another significant limitation is the static nature of the optimization engine. The current model operates exclusively on historical data (i.e., the previous month's demand), thereby excluding forecasting or predictive analytics. This reactive orientation limits its utility in proactive fleet sizing or what-if scenario planning. Future iterations should consider integrating machine learning forecasting models or scenario-based simulation engines to evaluate alternative logistics strategies under anticipated demand conditions, risk events, or price volatility.

While Excel VBA provides accessibility and flexibility, it suffers from inherent limitations in computational efficiency, multi-user collaboration, and data scalability. As data volumes grow and the complexity of scenarios increases, the planning panel may face performance degradation or crash risks. Future research and development should evaluate cloud-based platforms (e.g., Azure, Google Sheets with Apps Script) or custom-built web applications with more robust backends to ensure long-term viability and cross-functional usage.

Finally, any planning or optimization solution must contend with organizational behavior and human factors. Field coordinators and dispatchers may resist model outputs that deviate from habitual practices or lack visibility into how the model works. To address this, future work should focus on explainability, training, and change management frameworks, ensuring that tools are not only technically sound but also socially accepted and institutionally embedded.

GENERAL CONCLUSION

As the oil and gas services industry undergoes profound structural shifts, driven by energy transition imperatives, digital innovation, and geopolitical volatility, logistics emerges as a critical enabler of operational resilience and financial performance. This thesis set out to explore and address one of the most persistent challenges within this domain: optimizing domestic transportation operations in a highly variable and fragmented logistical ecosystem, using SLB Algeria as a case study.

Through a structured analytical framework, the research began by identifying systemic inefficiencies in SLB's Domestic Logistics processes, particularly those related to visibility gaps, scheduling misalignments, and resource underutilization. These inefficiencies were not isolated anomalies, but rather manifestations of deeper coordination and integration challenges across digital systems and organizational silos. The problem was explored through a combination of data audits, stakeholder interviews, segmentation analyses, and root cause techniques, allowing for a robust and validated problem formulation.

Anchored in the theoretical foundations of supply chain management, fleet visibility, and transaction cost economics, the state-of-the-art chapter examined both foundational concepts and advanced modeling techniques. Special attention was paid to the specificities of oil and gas logistics, including the importance of contextual adaptability, risk exposure, and sustainability integration. Comparative case studies demonstrated that optimization in this domain requires more than just algorithmic sophistication, it demands domain-specific insight, real-time data infrastructure, and cross-functional alignment.

The proposed solution responded to these insights with a modular and practical decision-support tool composed of three interlinked components: a planning panel developed in Excel VBA to visualize job flows and ma-

terial needs; an optimization model leveraging mathematical programming to simulate optimal truck fleet configurations; and a Power BI dashboard synthesizing performance indicators to support managerial oversight. Together, these tools create a digital ecosystem capable of bridging the planning–execution divide, enhancing decision accuracy, and paving the way for resource co-sharing across operational segments.

Yet, the thesis also acknowledged its limitations. Constraints in data availability, platform integration, and real-time adaptability present ongoing challenges to full deployment. Moreover, while the optimization model provides tangible gains in hindsight analysis, future iterations must incorporate uncertainty, real-time scheduling, and zone-based consolidation strategies to further improve its operational utility.

In conclusion, this thesis delivers not only a solution tailored to SLB’s domestic logistics needs, but also a framework for how logistics in the oilfield services sector can be reimagined through data-driven methodologies. It offers a foundation for future research in predictive logistics, shared fleet strategies, and human-centric supply chain optimization, areas that will be increasingly vital as the industry confronts its next wave of transformation.

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Appendix 1 – Socio-Economic Diagnostic Framework

Stakeholder Interview-Based Diagnosis Using SEM Approach

As part of our diagnostic study, we conducted semi-directive interviews with a diverse set of stakeholders across SLB’s logistics and operations ecosystem — including segment engineers, PSD managers, and domestic logistics planners. These interviews provided first-hand insights into field practices, planning systems, and coordination challenges.

Grounded in the **Socio-Economic Management (SEM)** methodology, our goal was not merely to observe surface-level symptoms but to trace systemic dysfunctions that generate both visible inefficiencies and hidden costs.

What follows is a structured diagnostic built around SEM’s **qualimetric model**, combining subjective input, operational data, and cross-segment convergence to surface root causes and systemic inconsistencies. Each step of this framework advances toward a central objective: transforming organizational fragmentation into integrated, human-centered performance.

Diagnostic Themes and Sub-Themes

To translate scattered observations into actionable categories, the diagnostic begins by organizing field data into overarching **themes** and **sub-themes**. In SEM, this is a foundational act of sense-making — a way to connect economic loss with its social underpinnings and operational realities. These themes offer a high-level map of dysfunctions shaping fleet inefficiencies at SLB, as well as areas where coordination, planning, and system coherence are breaking down.

This diagnostic logic also aligns with the SEM principle of “**socio-economic rationality**” — recognizing that technical systems, digital platforms, and human decision-making cannot be decoupled.

Table 1: Diagnostic Themes and Sub-Themes (Based on SEM Framework)

Theme	Sub-Themes
Data Integration and Digital System Gaps	– FDP, OTM, and E-Journey are not synchronized – Missing or inconsistent job data
Forecasting, Planning, and Visibility Failures	– No transport demand forecasting – Siloed operations by segment – Poor visibility
Execution Inefficiency and Workflow Friction	– Trucks reused without proper tracking – No traceability in the system – Last-minute rerouting
System Governance and Organizational Gaps	– No standard procedures enforced – Unclear roles and responsibilities – Fragmented planning
Strategic Misalignment Between Planning and Execution	– Tools not integrated – Job confirmation doesn’t match system readiness

Witness Phrases – Ground-Level Operational Quotes

Following SEM’s **qualimetric approach**, we next gathered expressions directly from front-line actors. These statements function as “*early-warning indicators*” — not captured in traditional performance dashboards, but essential for uncovering soft signals of dysfunction. This step enables organizations to listen to their system from the inside out.

By echoing the language of **users, planners, and operators**, we shift the analysis from abstraction to grounded truth — anchoring strategic intervention in lived operational experience.

Table 2: Witness Phrases from Operational Stakeholders

Business Line	Sub-Line	Quote	Theme	Sub-Theme
RPI	Wireline Slick-line	“Cased Haul peaks require 19–25 trucks – paralyzes other operations”	Fleet Utilization	Allocation Efficiency
RPS	WS Production Services	“18–20 FRAC trucks/job → we exceed pump safety limits”	Operational Resilience	Risk Mitigation
RPE	WL Evaluation Services	“Only 4 logging units for 7 Open Hauls”	Cost & Planning Efficiency	Resource Optimization
WCF	WS Well Integrity	“Reuse expired cement additives to avoid downtime”	Operational Resilience	HSE Protocol Adherence
D&M	Drilling & Measurement	“3-day buffer between phases wastes \$3,750/day”	Cost & Planning Efficiency	Idle Time Management

Mirror Effect – Cross-Segment Symptom Convergence

The diagnostic then transitions to what SEM theory defines as the “**mirror effect**”: validating dysfunctions by comparing patterns across segments. When similar breakdowns emerge in distinct functions (e.g., Wireline, Testing, Cementing), the signal is no longer local — it becomes systemic. This convergence transforms qualitative insight into organizational evidence, calling for structural and procedural rethinking.

This technique also reinforces SEM’s core principle of “**interactive cognition**” — asserting that triangulating diverse viewpoints enables deeper identification of root dysfunctions.

Table 3: Mirror Effect – Cross-Segment Convergence of Field Observations

Sub-Theme	Field Observations	Validated Dysfunction
Allocation Efficiency	RPI: “Cased Haul peaks require 19–25 trucks” RPE: “Only 4 logging units for 7 jobs” RPS: “FRAC jobs need 18–20 trucks” WCF: “Overlapping dispatches” D&M: “Sections compete for trucks”	Fleet Saturation – Peak jobs block multi-segment concurrency
Idle Time Management	RPI: “Permit delays idle trucks 2–3 days” RPE: “Nuclear tools wait in yard” RPS: “Tanks unused between stages” WCF: “Delayed site access for additives” D&M: “Truck idle during 3-day buffer”	Asset Downtime – Losses from underutilized trucks & equipment
Job Planning Misalignment	RPI: “FDP job confirmed, OTM not checked” RPE: “Demand spikes unaccounted” RPS: “No truck validation before FDP entry” WCF: “Field dispatch unsynced” D&M: “Truck gaps ignored at planning”	Disconnected Planning – Job execution misaligned from logistics readiness
Equipment Mismatch	RPI: “Wrong axle truck to loose terrain” RPE: “4×2 used for heavy tanks” RPS: “Wrong trailers in rough zones” WCF: “Tanks exceed rig specs” D&M: “Wrong truck to section”	Deployment Mismatch – Wrong trucks for terrain or job conditions
System Traceability Gaps	RPI: “OTM skipped in field” RPE: “FDP doesn’t update truck logs” RPS: “Reuse not captured” WCF: “Manual additive tracking” D&M: “No truck status linked to progress”	Visibility Loss – Dispatch and execution disconnected from system records
HSE Workaround Behavior	RPI: “Rig used instead of crane” RPE: “Radiation tool unescorted” RPS: “Pump limits overridden” WCF: “Expired chemicals reused” D&M: “Buffer skipped at night”	Protocol Bypass – Safety practices compromised due to time pressure
Permit-Induced Variability	RPI: “72h permit delays” RPE: “Permit windows misaligned” RPS: “Multiple permits per region” WCF: “Environmental clearance delays” D&M: “Permits delay transitions”	Administrative Friction – Permit complexity causes operational lag
Segmental Isolation	RPI: “No shared trucks with Cementing” RPE: “Testing fleet is standalone” RPS: “No coordination across BLs” WCF: “Dedicated trucks idle” D&M: “No cross-phase truck reuse”	Operational Silos – Segments operate in parallel with no fleet synergy

Non-Dits – Unspoken Dysfunctions from Expert Roles

Beyond the visible and verbal lies a powerful layer: the **“non-dits”** — what is known but unspoken. In line with SEM’s focus on **human potential as the only active value-creation lever**, we explored the tacit knowledge of experienced professionals: logistics planners, HSE managers, engineers, and controllers. These insights reveal the cultural and procedural blind spots that prevent improvement — often due to fear of disruption, institutional inertia, or KPI distortions.

Table 4: Unspoken Dysfunctions by Role (Non-Dits)

Expert Role	Observed Dysfunction	Underlying Cause
Domestic Logistics Planner	Fleet saturation and dispatch overlap during Cased Hauls	No load forecasting logic; system fragmentation
	No traceability of truck reuse across segments	FDP–OTM system disconnect; no centralized assignment view
	Night/weekend dispatch updates delayed or missed	Limited control tower visibility outside core hours
HSE Manager	Field teams bypass safety checks in urgency scenarios	High-pressure dispatch culture; HSE seen as secondary
Production Service Delivery	Jobs confirmed without truck availability check	No logistical gate in FDP workflow
Operations Engineer	Wrong truck specs lead to deployment delays or resends	No spec-matching algorithm in job planning
Maintenance Coordinator	Truck under repair disguised as “buffer” time	Lack of fleet health visibility; downtime masking
Cost Controller	Cross-job truck reallocations not costed properly	No activity-based costing in dispatching
Segment Planner (Wireline)	Open Hauls delayed due to automatic prioritization of Cased Hauls	No segment-weighted scheduling logic

Capturing the **“non-dits”** is an essential act in socio-economic diagnostics. It connects **organizational learning** with **change-readiness**, and highlights the mismatch between declared policies and actual behaviors.

Matrix of Convergence – Stakeholder Insight Summary

Finally, we consolidate the findings into a **systemic convergence matrix**, where **themes**, **sub-themes**, and **cross-segment symptoms** are

matched with their **root dysfunctions**. This table is designed not only to document operational and organizational gaps, but also to **trigger the reallocation of human and technical energy** toward value creation.

It represents a true **socio-economic balance sheet in action** — surfacing where costs are hidden, and where performance gains can be unlocked through **coordination, training, and system redesign**.

Table 5: Matrix of Convergence – Stakeholder Insight Summary

Themes	Sub-Themes	Convergence	Dysfunctions
Data Integration and Digital System Gaps	- FDP, OTM, and E-Journey are not synchronized - Missing or inconsistent job data	- Jobs recorded in FDP don't appear in OTM (e.g., Well Construction – Measurements) - Shipments in Well Testing, RPS, and WIS are not logged in a central system	Fragmentation – Reflects lack of coordination between departments and segments
Forecasting, Planning, and Visibility Failures	- No transport demand forecasting - Siloed operations by segment - Poor visibility	- Sudden demand in Well Testing, Cementing, and RPS leads to last-minute responses - No resource sharing across Wireline and WIS	Unpredictability – Captures uncertain demand, reactive operations, and inability to forecast
Execution Inefficiency and Workflow Friction	- Trucks reused without proper tracking - No traceability in the system - Last-minute rerouting	- Trucks are reused across jobs in RPS, Cementing, and WIS - Unplanned changes happen often in Wireline and Well Testing	Inefficiency – Represents poor truck usage, daily jobs misalignment, and overprocessing
System Governance and Organizational Gaps	- No standard procedures enforced - Unclear roles and responsibilities - Fragmented planning	- The control tower doesn't manage the full job cycle in RPS, WIS, and Well Testing - Process owners are not defined in Measurements and Wireline	Dominance – Refers to the client's upper hand in a monopsony market
Strategic Misalignment Between Planning and Execution	- Tools not integrated - Job confirmation doesn't match system readiness	- Jobs are confirmed without logistics support in Well Testing, RPS, and Cementing - Field teams often skip OTM in WIS and Wireline	Constraint – Highlights workforce shortages, strict HSE standards, and lengthy driver selection

Appendix 2 – Planning Panel Macros (VBA Code)

This appendix contains all the source code used in the truck mobilization system. The VBA code is grouped by module, following the order defined in the main report: Browsing, Data, Dynamic Scheduling, and Planning.

2.1 Module: Browsing

```
Sub OpenPlanning()
    Dim ws As Worksheet
    Set ws = ThisWorkbook.Sheets("Plan")
    ws.Activate
End Sub
```

```
Sub OpenWCF()
    Dim ws As Worksheet
    Set ws = ThisWorkbook.Sheets("WCF")
    ws.Activate
End Sub
```

```
Sub OpenMasterDataTrucks()
    Dim ws As Worksheet
    Set ws = ThisWorkbook.Sheets("Master Data")
    ws.Activate
End Sub
```

```
Sub OpenDashboarding()
    Dim ws As Worksheet
    Set ws = ThisWorkbook.Sheets("Dashboarding")
    ws.Activate
End Sub
```

2.2 Module: Data

```
Sub RefreshDataFDP()
    Dim sourceSheet As Worksheet, wcfSheet As Worksheet
    Dim numberOfJobs As Integer, lastRow As Long, i As Integer

    Set sourceSheet = ThisWorkbook.Worksheets("Master Data")
    Set wcfSheet = ThisWorkbook.Worksheets("WCF")
    numberOfJobs = sourceSheet.Range("E3").Value
```

```

wcfSheet.Range("E3:F300").ClearContents

For i = 1 To numberOfJobs
    lastRow = wcfSheet.Cells(wcfSheet.Rows.Count, _
                             "E").End(xlUp).Row
    wcfSheet.Cells(lastRow + 1, "E").Value = _
        "WCF_Job_" & i
    wcfSheet.Cells(lastRow + 1, "F").Value = _
        "Well Construction Fluids"
Next i

MsgBox "WCF job list updated successfully with " & _
        numberOfJobs & " entries from FDP.", vbInformation
End Sub

```

2.3 Module: Dynamic Scheduling

```

Sub AssignTrucksRPS()
    Dim wb As Workbook
    Dim wsJobs As Worksheet, _
        wsTrucks As Worksheet, _
        wsSched As Worksheet
    Dim lastJob As Long, _
        lastTruck As Long
    Dim i As Long, j As Long, _
        modeResp As Integer
    Dim jobList As Collection, _
        jobItem As Variant
    Dim truckUsage As Object, _
        truckInfo As Object
    Dim eligibleTrucks As Collection, _
        truckID As String
    Dim assignedTrucks As String
    Dim k As Long, s As Long

    Set wb = ThisWorkbook
    Set wsJobs = wb.Worksheets("RPS")
    Set wsTrucks = wb.Worksheets( _
        "Master Data")
    Set wsSched = wb.Worksheets( _
        "Dynamic Scheduling")

```

```

lastJob = wsJobs.Cells( _
    wsJobs.Rows.Count, _
    "B").End(xlUp).Row
lastTruck = wsTrucks.Cells( _
    wsTrucks.Rows.Count, _
    "A").End(xlUp).Row

modeResp = InputBox( _
    "Responsiveness Level? " & _
    "(0 = none, 1 = light, 2 = strict)", _
    "Responsiveness", 1)

Set truckUsage = _
    CreateObject("Scripting.Dictionary")
Set truckInfo = _
    CreateObject("Scripting.Dictionary")

For i = 2 To lastTruck
    truckID = wsTrucks.Cells(i, "A").Value
    truckInfo(truckID) = Array( _
        wsTrucks.Cells(i, "C").Value, _
        wsTrucks.Cells(i, "D").Value, _
        wsTrucks.Cells(i, "E").Value, _
        wsTrucks.Cells(i, "F").Value)
    truckUsage(truckID) = _
        wsTrucks.Cells(i, "F").Value
Next i

Set jobList = New Collection
For i = 3 To lastJob
    jobList.Add Array( _
        i, _
        wsJobs.Cells(i, "H").Value, _
        wsJobs.Cells(i, "I").Value, _
        wsJobs.Cells(i, "G").Value, _
        wsJobs.Cells(i, "E").Value, _
        wsJobs.Cells(i, "J").Value)
Next i
SortCollection jobList, 2, 3, 4

wsSched.Range("F3:F" & lastJob) _

```

```
.ClearContents
```

```

For Each jobItem In jobList
    Dim idx As Long, BL As String, _
        prio As Long, jType As String
    Dim trucksNeeded As Long, _
        volReq As Double
    idx = jobItem(0)
    BL = jobItem(1)
    prio = jobItem(2)
    jType = jobItem(3)
    trucksNeeded = jobItem(4)
    volReq = jobItem(5)
    assignedTrucks = ""
    Set eligibleTrucks = New Collection

    For Each truckID In truckUsage.Keys
        Dim info As Variant
        info = truckInfo(truckID)
        If info(0) = jType And _
            info(1) >= volReq Then
            If modeResp = 0 Or _
                (modeResp = 1 And _
                    info(2) <= Date + _
                        TimeSerial(2, 0, 0)) Or _
                (modeResp = 2 And _
                    info(2) <= Now) Then
                eligibleTrucks.Add truckID
            End If
        End If
    Next

    For s = 1 To trucksNeeded
        If eligibleTrucks.Count = 0 Then Exit For
        Dim bestTruck As String, _
            bestLoad As Double
        bestLoad = 9E+99
        For Each truckID In eligibleTrucks
            If truckUsage(truckID) < bestLoad Then
                bestLoad = truckUsage(truckID)
                bestTruck = truckID
            End If
        Next
    Next

```

```

        End If
    Next
    assignedTrucks = assignedTrucks & _
        bestTruck & ", "
    truckUsage(bestTruck) = _
        truckUsage(bestTruck) + 1

    For k = 1 To eligibleTrucks.Count
        If eligibleTrucks(k) = bestTruck Then
            eligibleTrucks.Remove k
            Exit For
        End If
    Next
Next

If assignedTrucks <> "" Then
    wsSched.Cells(idx, "F").Value = _
        Left(assignedTrucks, _
            Len(assignedTrucks) - 2)
Else
    wsSched.Cells(idx, "F").Value = _
        "No available trucks"
End If
Next jobItem

For i = 2 To lastTruck
    truckID = wsTrucks.Cells(i, "A").Value
    wsTrucks.Cells(i, "F").Value = _
        truckUsage(truckID)
Next

MsgBox "Advanced truck scheduling completed.", _
    vbInformation
End Sub

Sub SortCollection( _
    ByRef coll As Collection, _
    ParamArray keys() As Variant)

    Dim i As Long, j As Long
    For i = 1 To coll.Count - 1

```

```
        For j = i + 1 To coll.Count
            If CompareJob( _
                coll(j), _
                coll(i), _
                keys) < 0 Then
                coll.Add coll(i), , j
                coll.Remove i
            End If
        Next
    Next
End Sub
```

```
Function CompareJob( _
    a As Variant, _
    b As Variant, _
    keys As Variant) As Long

    Dim k As Variant, pa, pb
    For Each k In keys
        pa = a(k)
        pb = b(k)
        If pa <> pb Then
            If IsNumeric(pa) Then
                CompareJob = Sgn(pa - pb)
                Exit Function
            End If
            CompareJob = IIf(pa < pb, -1, 1)
            Exit Function
        End If
    Next
    CompareJob = 0
End Function
```

2.4 Module: Planning

```
Sub wcfplanified()
    ThisWorkbook.Sheets("plan").Activate
    Dim StartPlanified As Variant, EndPlanified As Variant
    Dim JobType As String, JobID As String
    Dim StartReal As Variant, EndReal As Variant
    Dim NJ As Long, i As Long
```

```

Range("C4").Select
ActiveCell.FormulaR1C1 = ""
Range("C4:ZZ4").Select
Selection.Clear

With Sheets("WCF")
    NJ = .Range("I" & .Rows.Count).End(xlUp).Row
    MsgBox NJ - 2
End With

For i = 3 To NJ
    StartPlanified = Sheets("WCF").Cells(i, 8).Value
    EndPlanified = Sheets("WCF").Cells(i, 9).Value - 1
    JobType = Sheets("WCF").Cells(i, 4).Value
    JobID = Sheets("WCF").Cells(i, 3).Value
    StartReal = Sheets("WCF").Cells(i, 18).Value
    EndReal = Sheets("WCF").Cells(i, 19).Value - 1

    ' Planified section
    Range(Cells(4, StartPlanified), _
        Cells(4, EndPlanified)).Select
    Selection.Merge
    With Selection
        .HorizontalAlignment = xlCenter
        .VerticalAlignment = xlBottom
        .Interior.Color = RGB(0, 176, 240)
        ActiveCell.FormulaR1C1 = JobType + vbCrLf + _
            " Job" + CStr(JobID)
    End With

    ' Border formatting
    With Selection.Borders
        .LineStyle = xlContinuous
        .ThemeColor = 2
        .Weight = xlMedium
    End With

    ' Realized section
    Range(Cells(5, StartReal), _
        Cells(5, EndReal)).Select

```

```
Selection.Merge
With Selection.Interior
    .Color = RGB(92, 141, 214)
End With

' Border formatting
With Selection.Borders
    .LineStyle = xlContinuous
    .ThemeColor = 2
    .Weight = xlMedium
End With
Next i
End Sub
```