

MINISTRY OF HIGHER EDUCATION AND SCIENTIFIC RESEARCH

NATIONAL HIGHER SCHOOL OF MANAGEMENT

ENSM.KOLÉA.U.C



**Thesis Submitted in Partial Fulfilment of the Requirements
for Master's Degree in « Project Management and
Entrepreneurship »**

**Lean Six Sigma Based Optimization of
Transportation Processes at Schneider Electric's
Logistics Centre**

Developed by:

MOUSSAOUI Meriem
SELLAF Abdelkader Ishak

Supervised by:

Dr. BEDAIDA Imad Eddine
Dr. NEDIL Lamia

2024/2025

Acknowledgments

First and foremost, all praise and gratitude are due to Allah, the Most Gracious, the Most Merciful. Without His divine guidance and blessings, none of this would have been possible.

We extend our deepest thanks to all those who have supported us throughout this journey.

To our tutors and professors, whose wisdom and dedication have shaped our understanding, we are sincerely grateful. We are especially thankful to Dr Bedaida Imad Eddine and Dr Nedil Lamia, whose guidance and encouragement as our academic supervisors were invaluable throughout the development of this work.

A special word of thanks is also extended to Ms Nawal, with heartfelt appreciation. We are equally indebted to Mr Aziz Belkacem, our supervisor at Schneider Electric, whose generosity, patience, and unwavering readiness to assist enriched our experience beyond words. His guidance was a steady compass throughout this project.

Our heartfelt appreciation also goes to our families, our parents, who stood by us with unconditional love and strength, and our friends, old and new. To those companions who walked beside us over the past two years, who laughed with us, worked late with us, and made this school feel like a second home, we thank you deeply. These memories shall forever remain etched in our hearts.

This work is not merely the result of our own efforts but a reflection of the care, wisdom, and kindness of many. To all who have contributed, directly or silently, we are eternally grateful.

*M. Meriem
and
S. Abdelkader Isbak*

Abstract

This thesis explores how Lean Six Sigma can be used to improve transport and communication processes with logistics providers at Schneider Electric.

The study focuses on the delivery phase, where the absence of a clear system for choosing transport providers has led to inefficiencies, such as using more expensive options or mismatched trucks. Our objective was both academic and practical: to understand the root causes of these issues and propose solutions that could benefit the company in real, measurable ways. We applied the Lean Six Sigma DMAIC method to guide our approach, combining data analysis with process improvement tools. To build our study, we analysed 264 delivery lines from the past three months using invoice data, and we conducted four formal interviews, in addition to many informal discussions and brainstorming sessions with team members.

The results highlighted key gaps in both communication and decision-making. In response, we proposed several improvements, including clearer selection criteria and better coordination practices.

This work shows how Lean Six Sigma can help streamline logistics operations and support more effective communication with external partners.

Keywords: Lean Six-Sigma, Process improvement, complex problem-solving methods, DMAIC, Logistics transportation.

Résumé

Ce mémoire explore comment la méthode Lean Six Sigma peut être utilisée pour améliorer les processus de transport et de communication avec les prestataires logistiques chez Schneider Electric.

L'étude se concentre sur la phase de livraison, où l'absence d'un système clair de sélection des transporteurs a entraîné des inefficacités, telles que le recours à des options plus coûteuses ou à des camions mal adaptés. Notre objectif était à la fois académique et pratique : comprendre les causes profondes de ces problèmes et proposer des solutions bénéfiques pour l'entreprise de manière concrète et mesurable. Nous avons appliqué la méthode DMAIC de Lean Six Sigma pour guider notre démarche, en combinant l'analyse de données avec des outils d'amélioration des processus. Pour construire notre étude, nous avons analysé 264 lignes de livraison des trois derniers mois à partir des données de facturation et mené quatre entretiens formels, ainsi que de nombreuses discussions informelles et sessions de brainstorming avec les membres de l'équipe.

Les résultats ont mis en évidence des lacunes importantes dans la communication et la prise de décision. En réponse, nous avons proposé plusieurs améliorations, notamment des critères de sélection plus clairs et de meilleures pratiques de coordination.

Ce travail montre comment Lean Six Sigma peut contribuer à rationaliser les opérations logistiques et à favoriser une communication plus efficace avec les partenaires externes.

Mots-clés : Lean Six-Sigma, amélioration des processus, méthodes de résolution de problèmes complexes, DMAIC, transport logistique

الملخص

تتناول هذه الأطروحة كيفية استخدام منهجية Lean Six Sigma لتحسين عمليات النقل والتواصل مع مزوّد

الخدمات اللوجستية في شركة Schneider Electric.

تركّز الدراسة على مرحلة التسليم، حيث أذى غياب آلية واضحة لاختيار مزوّد خدمات النقل إلى حدوث اختلالات، مثل استخدام خيارات أكثر تكلفة أو شاحنات غير ملائمة. كان هدفنا أكاديميًا وعمليًا في آنٍ واحد: فهم الأسباب الجذرية لهذه المشكلات واقتراح حلول عملية يمكن أن تعود بالنفع الحقيقي والمقاس على الشركة. اعتمدنا على منهجية DMAIC الخاصة بـ Lean Six Sigma لتوجيه عملنا، من خلال الجمع بين تحليل البيانات واستخدام أدوات تحسين العمليات. قمنا بتحليل 264 عملية تسليم خلال الأشهر الثلاثة الماضية باستخدام بيانات الفواتير، وأجرينا أربعة مقابلات رسمية، إلى جانب العديد من النقاشات غير الرسمية وجلسات العصف الذهني مع أعضاء الفريق.

أظهرت النتائج وجود فجوات واضحة في كل من التواصل واتخاذ القرار. وبناءً عليه، اقترحنا عددًا من التحسينات، منها وضع معايير أكثر وضوحًا للاختيار وتحسين ممارسات التنسيق.

تُبيّن هذه الدراسة كيف يمكن لـ Lean Six Sigma أن تُسهم في تبسيط العمليات اللوجستية وتعزيز فعالية التواصل مع الشركاء الخارجيين.

الكلمات المفتاحية: اللين ستة سيغما (Lean Six-Sigma)، تحسين العمليات، أساليب حل المشكلات المعقدة، DMAIC، النقل اللوجستي.

Summary

Acknowledgments	I
Abstract.....	II
Résumé.....	III
الملخص.....	IV
Summary.....	V
List of Tables	VII
List of Symbols and Abbreviated Terms	XI
General Introduction	1
Chapter 01: Context and Research Problem.....	1
1 Context Of The Study	2
2 Research Question	3
3 Objectives of the Study	4
4 Reasons for Choosing the Topic.....	4
5 Epistemology of the Study	5
6 .Relevance of the Study	6
7 Context and Description of the Study Site	7
Chapter 02: Theoretical Framework	15
Section 01: Literature Review.....	15
1 Lean Six Sigma and process improvement:	15
2 Lean Six Sigma and supply chain enhancement :	17
3 Critical analysis :	20
Section 02: Key Theoretical Concepts Underpinning the Project.....	25
1 Process Improvement.....	25
2 Methods for Solving Complex Problems.....	26
3 Lean Six Sigma	27
4 Six Sigma project: DMAIC methodology.....	35
5 Transport Management as a Strategic Function in the Supply Chain.....	46
6 Logistics Service Provider (LSP) Management: Coordinating Outsourced Logistics for Competitive Advantage.....	47

Chapter 03:	49
1 Qualitative approach	49
2 Quantitative approach	52
Chapter 04:	55
Presentation and Analysis of Results	55
1 Pre-Six Sigma Phase: Problem Selection	55
2 DEFINE	64
3. MEASURE	73
4 ANALYSE	84
5 IMPROVE	90
6 CONTROL	96
7 Results' discussions	99
General Conclusion	104
Appendices	99
Table of contents	115

List of Tables

Table 01: Summery for the critical analysis.....	22
Table 02 : Sigma scores.....	32
Table 03: comparative summary of DMAIC and DMADV approaches.....	34
Table 04 : complementarity between Lean and Six Sigma	35
Table 05: CTQ.....	37
Table 06: The interviewees list.....	50
Table 07 : Needs' analysis	57
Table 08: Risk Prioritization Matrix: Application of the Eisenhower, Stephen Covey, and Paul J. Meyer Methods	59
Table 09: Risk Prioritization Matrix: Risk Assessment Matrix	60
Table 10: Prioritisation Matrix as per ISO 13053:2011 for CTQ post VOC	63
Table 11: SIPOC diagram for the delivery process in SEA	65
Table 12: CTQs of the studied process.....	68
Table 13: Problem Definition Based on the 5W1H Method	69
Table 14: Types of Data Collected.....	74
Table 15: Key Visual Elements and Extracted Metrics.....	75
Table 16 : Two-Way ANOVA Results with Interaction	76
Table 17: Variance Components Analysis	77
Table 18 : Gage Evaluation	77
Table 19: Effect of the Warehouse Operator (Magasinier).....	78
Table 20 : Effect of the Carrier (Transporter)	78
Table 21: Current State of the Process	82

Table 22: Capability and Performance Indices.....	82
Table 23 : Sigma Level.....	83
Table 24: Correlation Between Sub-Process and Global Cycle Time	87
Table 25 : Process Steps Breakdown.....	87
Table 26: Capability Indices (Short-term and Long-term).....	88
Table 27: 5 WHYS.....	89
Table 28: Key Functionalities of the proposed app.....	92
Table 29: Action plan for improving transport planning and provider coordination	93
Table 30 : FMEA risk analysis for the improvement plan	95
Table 31: the control's monitoring plan (schedules).....	96
Table 32: assigning responsibilities for the control phase.....	97

List of Figures

Figure 1: Schneider Electric’s history.	8
Figure 2: Schneider electric's global presence.....	8
Figure 3:Schneider electric’s global presence	11
Figure 4: DC and factory structure	12
Figure 5: Principles of Lean management.....	28
Figure 6: Types of waste	29
Figure 7: Types of waste	31
Figure 8: Derivation of the sigma scores.....	32
Figure 9 : an example of a process map	37
Figure 10 : Black box	38
Figure 11: SIPOC Diagram	38
Figure 12: Logigramme.....	39
Figure 13:an example of a control chart.....	42
Figure 14: A generic representation of the Ishikawa diagram aka Fishbone diagram	44
Figure 15: Example of a Value Stream Mapping	44
Figure 16: PDCA (Plan Do Check Act) Cycles refers	46
Figure 17 : the internal organisational mapping that's concerned with the studied process	56
Figure 18: Logigram flowchart for the studied process	67
Figure 19: Visualisation of the service providers' performance	75
Figure 20: Price in function of transporter ID	80
Figure 21: Process capability	81
Figure 22: Process Capability for Cost_per_tonne_km.....	83

Figure 23: VSM for the transport process	85
Figure 24: Value stream mapping for provider selection	86
Figure 25: Value stream mapping for transport planning.....	86
Figure 26: fishbone diagram (ishikawa).....	88

List of Symbols and Abbreviated Terms

Symbols

c	Number of defects (nonconformities)
μ	Location of the process; population mean value
$nCTQC$	Number of critical to quality characteristics
$nunits$	Number of units surveyed
p	Proportion of nonconforming items
σ	Population standard deviation
u	Number of defects (nonconformities) per item
X	Value
\bar{X} (X -bar)	Sample arithmetic mean value
$YDPMO$	Calculated number of defects per million opportunities
z	Standardized normal distribution deviate
$Zvalue$	Sigma score or value

Abbreviations

5S	Sort, Set, Shine, Standardise, Sustain (used in visual factory/workplace)
5-Why	Method for finding the potential root cause of a problem
ANOVA	Analysis of Variance
CTQ	Critical to Quality
CTQC	Critical to Quality Characteristic
DMAIC	Define, Measure, Analyse, Improve, Control
DPMO	Defects per Million Opportunities
KPI	Key Performance Indicator

KPIV	Key Process Input Variable
KPOV	Key Process Output Variable
MSA	Measurement System Analysis
NPR	Number of Problem Reports
OTD	On-Time Delivery
ppm	Parts per Million
RACI	Responsible, Accountable, Consulted, Informed
RR	Return Rate
SIPOC	Supplier, Inputs, Process, Outputs, Customer (Flowchart)
SOP	Standard Operating Procedure
SPC	Statistical Process Control

| General Introduction

Quality management has come a long way over the years. What started as a simple concern for consistency and standards has grown into a complex, structured field that now includes powerful methods like Lean Six Sigma. At the same time, logistics, especially in large companies, has had to keep up with the pressures of globalisation, technology, and increasing customer demands. Both fields are evolving quickly, and the connection between them is becoming more and more important.

This thesis focuses on one of the real challenges companies face today: how to improve the way they handle transport and communicate with their logistics providers. Our work took place at Schneider Electric, where we are doing our internship. It gave us the chance to look closely at how things work on the ground, not just in theory. We noticed issues that affect delivery efficiency and communication, and we wanted to find ways to make the process smoother, clearer, and more cost effective.

We used the Lean Six Sigma approach to guide our research, a method known for combining data analysis with process improvement. The goal isn't just to solve problems but also to understand the root causes and suggest long-term solutions that make sense for the company.

The thesis follows a well-structured build to explain and expand the idea in both academic and practical aspects; it contains four defined chapters. The first chapter introduces the context of our study, the reasons behind our research, and a presentation of the company, followed by the second chapter, which presents the literature review, where we explore what other researchers have said about logistics, communication, and Lean Six Sigma, and also we explain the conceptual framework we used to organise our thinking. The third chapter explains our methodology: how we collected data, what tools we used, and how we analysed the situation, and finally, the fourth chapter which presents the results of our work, including our observations, analysis, and the improvements we proposed.

By the end of this study, we hope to contribute both academically and practically, offering insights that can help improve operations at Schneider Electric's logistics centre and that might also be useful for others dealing with similar challenges.

Chapter 01: Context and Research Problem

This chapter introduces the context, motivations, and research orientation of the present study. It begins by presenting the background and significance of the research topic, then formulates the core problem statement, outlines the research objectives, and positions the study epistemologically. Finally, it provides a brief overview of Schneider Electric and its logistics centre, which serves as the case study for the applied research. This chapter sets the stage for the theoretical and methodological developments presented in the subsequent sections.

1 Context Of The Study

In recent years, companies have faced increasing pressure to improve service quality, reduce operational delays, and ensure better delivery performance. These challenges are especially critical in logistics operations, where even small inefficiencies can impact customer satisfaction, cost control, and overall supply chain reliability.

To address such challenges, many organisations have adopted Lean Six Sigma (LSS), a combined approach that focuses on reducing waste (Lean) while minimising process variability (Six Sigma). LSS, mainly, is now recognised as a powerful framework for continuous improvement in both manufacturing and service environments, including logistics (Hoerl & Snee, 2020). In fact, its structured methodology (DMAIC: Define, Measure, Analyse, Improve, Control) is increasingly applied to core logistics processes such as order handling, warehousing, and transport coordination (Gutierrez-Gutierrez et al., 2016).

However, and despite its global success, research shows that Lean Six Sigma is still underutilised in logistics services, particularly in the delivery phase, which often involves multiple actors, tight time constraints, and external partners like transportation providers (Gutierrez-Gutierrez et al., 2016); (Pardamean Gultom & Wibisono, 2019). This phase is especially vulnerable to disruptions, such as delays due to miscommunication, late vehicle arrivals, or unstructured provider selection, which can ultimately affect service quality and client trust.

Several authors argue that applying LSS tools in logistics environments can lead to major gains: reduced lead times, fewer errors in communication, and improved performance tracking (Pardamean Gultom & Wibisono, 2019). Tools like SIPOC, process mapping, and root cause analysis help organisations better understand the internal and external factors influencing logistics outcomes.

This study focuses specifically on improving the delivery coordination process, with a particular emphasis on how transport providers are selected and how communication flows throughout the shipment operation. By applying the LSS methodology, starting with the Define phase and moving into the Measure and Analyse phases, this research aims to identify the main problems, assess their impact, and propose sustainable process improvements that could be applied in similar logistics contexts.

Ultimately, this study contributes to filling a knowledge gap by exploring how Lean Six Sigma can be practically implemented in the selected process, providing both a real-world case and theoretical insights into its potential in service-based operations.

2 Research Question

Many studies from around the world have explored the application of Lean Six Sigma in various service industries, including healthcare, telecommunications, and finance. These studies often focus on process optimisation, quality improvement, and waste reduction. However, there remains a noticeable gap in the literature when it comes to the logistics delivery process, especially in service-orientated environments where there are third-party providers involved.

While Lean Six Sigma has been widely applied in manufacturing, its application to logistics coordination and transport provider selection is still relatively underdeveloped, particularly in contexts where service reliability, communication, and delivery timing are critical (Pardamean Gultom & Wibisono, 2019) In these environments, small inefficiencies can have a major impact on operational flow, customer satisfaction, and specially internal cost structures.

And so given this gap, the aim of our study is to explore how Lean Six Sigma can be applied to improve the delivery process, with a specific focus on the communication and coordination with transportation providers.

Based on this context, the guiding research question is:

“How can Lean Six Sigma be used to optimise the delivery coordination process, particularly in the selection and communication with transportation providers?”

This problem's question aims to uncover not only the root causes of current inefficiencies but also will lead us to propose a structured framework for improvement using Lean Six Sigma tools.

3 Objectives of the Study

The main objective of our research project is to improve the efficiency and reliability of the delivery coordination process through the application of Lean Six Sigma tools. The study focuses specifically on the phase where internal logistics teams select and communicate with transportation providers, which is considered an area that often lacks standardisation and leads to operational issues such as delivery delays or last-minute cancellations.

To achieve this, our project will follow a structured approach aligned with the DMAIC methodology to deliver both theoretical insights and practical improvements that can enhance the performance of delivery operations in complex logistics environments, addressing the following specific objectives:

- ❖ Bridge the research gap by focusing on the underexplored topic of Lean Six Sigma implementation in logistics delivery coordination, particularly in service-orientated operations.
- ❖ Contribute to the development of practical knowledge by providing a structured improvement model that can be adopted by other organisations facing similar delivery process challenges.
- ❖ Analyse and document the current state of transport coordination using real operational data and staff interviews to identify inefficiencies and areas for optimisation.
- ❖ Propose concrete, data-driven solutions to improve provider selection, communication flow, and documentation handling within the delivery process.

4 Reasons for Choosing the Topic

The reasons behind choosing this research topic are basically both personal and academic in nature.

4.1 Personal Motivation

This topic aligns closely with our academic background in project management and entrepreneurship. Throughout our studies, we've developed a strong interest in process improvement and operational efficiency.

During our internship, we had the opportunity to observe how logistics processes, especially during the delivery phase, can directly impact performance, customer satisfaction,

and internal coordination. These real-world insights motivated us to explore how complex problem resolution methods like Lean Six Sigma can bring practical value to such processes.

4.2 Academic Relevance

From a research perspective, we have noticed a clear gap in the literature when it came to the application of Lean Six Sigma in logistics delivery processes, particularly in contexts involving external transportation providers.

While LSS has been widely studied in manufacturing and production, its implementation in service-based logistics operations is still underdeveloped. By addressing this gap, our goal is to contribute both practical solutions and theoretical insights, which could serve as a foundation for future research in similar logistics environments.

5 Epistemology of the Study

This research is shaped by two core components: the epistemological posture and the research approach, both carefully selected to suit the nature and goals of our project.

5.1 Epistemological Posture

While exploring the existing literature on Lean Six Sigma and its use in logistics and transport coordination, we found that there is limited research specifically addressing how delivery processes, particularly communication and coordination with transportation providers, can be optimised using structured methodologies like DMAIC. Most studies tend to focus on production environments or broader supply chain systems, leaving a gap in more practical, context-specific process improvements within logistics delivery.

Given this, the study adopts a pragmatic epistemological posture, which is well suited to the applied research focused on solving real-world problems. Pragmatism holds that knowledge is valuable when it contributes to practical outcomes and is shaped by what works in specific contexts. In this research, the aim is to generate actionable insights that can lead to the optimisation of delivery coordination processes. At the same time, the study recognises the importance of stakeholder experiences in shaping process understanding. Insights gathered from warehouse operators, transport coordinators, and real-life delivery cases play a crucial role in identifying inefficiencies and proposing improvements.

This flexibility drawing on both empirical data and contextual human perspectives, is consistent with the pragmatic stance, which encourages the integration of multiple methods and viewpoints to arrive at the most effective solutions (Boukaira & Daamouch, 2021).

5.2 Research Approach

This study follows an inductive research approach. Rather than starting from a fixed theory or hypothesis, we began by observing the delivery coordination process in the field, engaging with the people who work in it daily, reviewing internal documents, and analysing delivery performance data.

While the research as a whole follows an inductive approach, beginning from field observations and stakeholder input, the DMAIC methodology used for process improvement reflects a structured, deductive logic. This combination reflects the pragmatic stance of the study, where tools are chosen based on their usefulness for addressing real-world challenges

Patterns and recurring issues emerged from these observations: missed shipments, unclear communication with providers, and a lack of standard procedures. These practical insights enabled a clearer understanding of the root causes behind the inefficiencies.

This approach is aligned with the pragmatic epistemology of the study, as it seeks to generate solutions tailored to the operational realities of the logistics environment. Lean Six Sigma is thus not treated merely as a theoretical model but as a flexible and adaptive toolset to address real challenges and propose data-informed, people-aware improvements.

6 .Relevance of the Study

The choice of this research topic is the result of deep reflection and sustained observation within a real organisational environment. It was motivated by our desire to understand how structured improvement methods like Lean Six Sigma can bring meaningful change to logistics delivery processes, particularly in how organisations select and communicate with transportation providers. This study aims to offer insights that are relevant both theoretically and practically.

6.1 Theoretical Relevance

While Lean Six Sigma has been widely explored in production and manufacturing environments, its application in logistics delivery coordination, especially in service-heavy contexts, remains underdeveloped. Few studies have focused on the practical challenges involved in selecting transport providers, managing communication flows, and ensuring consistent delivery performance.

This research seeks to fill that gap by offering a field-based analysis of delivery coordination, enriched by Lean Six Sigma tools such as DMAIC, SIPOC, and root cause

analysis. By doing so, it contributes to the existing body of knowledge by exploring a real-world logistics scenario and developing a model that can be adapted in similar contexts. It offers a more nuanced understanding of process inefficiencies in logistics, highlighting the role of human factors, communication challenges, and decision-making under pressure.

6.2 Managerial Relevance

From a managerial perspective, this study provides practical recommendations for improving the coordination of transport services, an area often marked by last-minute decisions, communication delays, and inconsistent procedures. The insights gathered through interviews, process mapping, and data analysis can help logistics managers:

- ❖ Standardize the process for selecting transport providers
- ❖ Improve communication between warehouse teams, clients, and external partners
- ❖ Reduce delivery delays and cancellations
- ❖ Increase customer satisfaction and operational efficiency

The proposed improvement model can serve as a guide for decision-makers aiming to optimise delivery workflows and reduce operational risks. It offers a structured way to identify which parts of the process need attention and how Lean Six Sigma tools can be applied to address them effectively.

In the long run, the study supports the development of more reliable, responsive, and sustainable delivery operations, aligning with both customer expectations and internal performance goals.

7 Context and Description of the Study Site

In this part, we will present an overview of the company that adopted our Lean Six Sigma project. The focus will be on key aspects such as the company's history, current challenges, quality policy, and the specific elements that are directly related to the scope of our project.

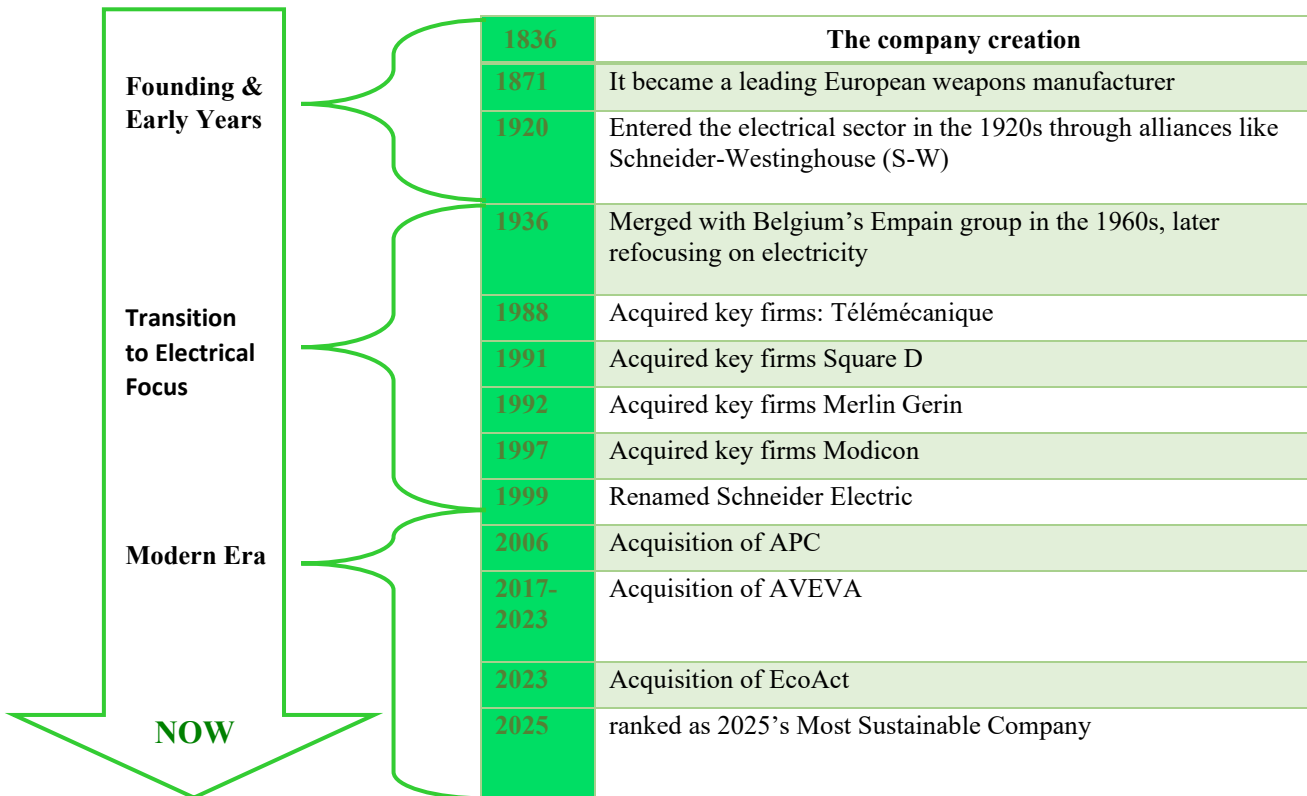
7.1 Overview of Schneider Electric

7.1.1 Schneider Electric's History & Global Presence

The company was founded in 1836 by brothers Adolphe and Joseph-Eugène Schneider under the name Schneideret Cie. Initially, it specialised in steel production, heavy machinery, and armaments.

To better understand how the company evolved over time, the following timeline shows some of the major steps in its journey.(Schneider Electric Algérie | Le spécialiste mondial en gestion de l'énergie et en automatisation, 2024)

Figure 1: Schneider Electric's history.



Source: Prepared by the authors

7.1.2 Global Presence

Figure 2: Schneider electric's global presence



Source: (2024-Document-Enregistrement-Universel, n.d.)

Schneider Electric is a world-renowned company specialising in energy management and automation. Headquartered in Rueil-Malmaison, France, it operates in more than 100 countries, supporting a wide range of sectors, including residential, commercial, industrial, and infrastructure. The company is best known for its innovative solutions like EcoStruxure, a smart platform that connects IoT-enabled technologies to improve efficiency, safety, and sustainability in operations.

Driven by a strong commitment to digital transformation and sustainable development, Schneider Electric continues to invest significantly in research and development. It also ensures the highest quality and environmental standards, holding certifications such as ISO 9001, ISO 14001, and ISO 50001. Its mission, captured by the slogan “Life Is On”, reflects its goal to make energy accessible, safe, and reliable, empowering both people and organisations to do more with less, while also protecting the planet. (2024-Document-Enregistrement-Universel, n.d.)



7.2 Schneider Electric Algeria (SEA)

Schneider Electric Algeria (SEA) is a key subsidiary of the global Schneider Electric group, contributing significantly to Algeria’s industrial modernisation and energy transition. Established to support the country's growing infrastructure and economic development, SEA delivers advanced energy management and automation solutions adapted to local market needs.

7.2.1 Key Areas of Operation

➤ Industrial Solutions :

SEA provides automation and control systems for critical sectors like oil and gas, water treatment, and manufacturing. These solutions are designed to enhance operational efficiency and reduce energy consumption.

➤ Energy Management:

The company supports Algeria’s shift toward sustainable energy by offering smart grid technologies, as well as low and medium voltage electrical distribution systems, including renewable energy options.

➤ Smart Buildings:

SEA delivers IoT enabled automation systems, such as EcoStruxure, for both commercial and residential buildings, to help improve energy efficiency, safety, and comfort.

7.2.2 Commitment to Local Development

➤ Strategic Partnerships :

SEA works closely with public institutions, state-owned companies such as Sonelgaz and Sonatrach, and private sector actors to modernise and digitalise Algeria's infrastructure.

➤ Skills Development & Employment:

The company actively invests in local talent through training programmes and partnerships with universities, helping develop Algeria's next generation of energy and automation professionals.

➤ Sustainability Focus :

Aligned with Schneider Electric's global environmental goals, it promotes green technologies, including solar power integration and energy-efficient systems for industrial use.

7.2.3 Compliance & Quality Assurance

SEA operates under Schneider Electric's Integrated Management System (IMS), which ensures that all processes adhere to both international and national standards. And these include:

- ISO 9001 – Quality Management
- ISO 14001 – Environmental Management
- ISO 45001 – Occupational Health and Safety

This commitment guarantees that its products and services meet global benchmarks while respecting Algerian regulatory frameworks.

And basically, with a strong local footprint and a focus on innovation, Schneider Electric Algeria plays a central role in driving digital transformation and sustainability in the region, continuing the company's global mission.

7.3 Schneider Electric's Logistics Centre in Algeria “ Warehouse & Delivery Process ”

The Logistics Centre of Schneider Electric Algeria (DC) plays a central role in the company's national supply chain, managing the reception, storage, and distribution of goods. Strategically located in Tipaza (Sidi Rached), the facility spans 3,200 m² and handles an average of 60,000 inbound and outbound lines per year, including approximately 2,000 inbound and 3,000 outbound lines daily. This section focuses on the delivery process, which is at the core of this study.

7.3.1 Overview of the Logistics Centre

Certifications:

- ✓ ISO 9001 – Quality Management
- ✓ ISO 45001 – Occupational Health & Safety

Infrastructure:

- ✓ storage racks, offering 1,000 storage positions and 2,000 picking positions;
- ✓ 4 loading/unloading docks, supported by 2 electric reach trucks and 2 forklifts;
- ✓ Dedicated operational zones for receiving, storage, preparation, quality control, and dispatching;

Figure 3: Schneider Electric's Global Presence

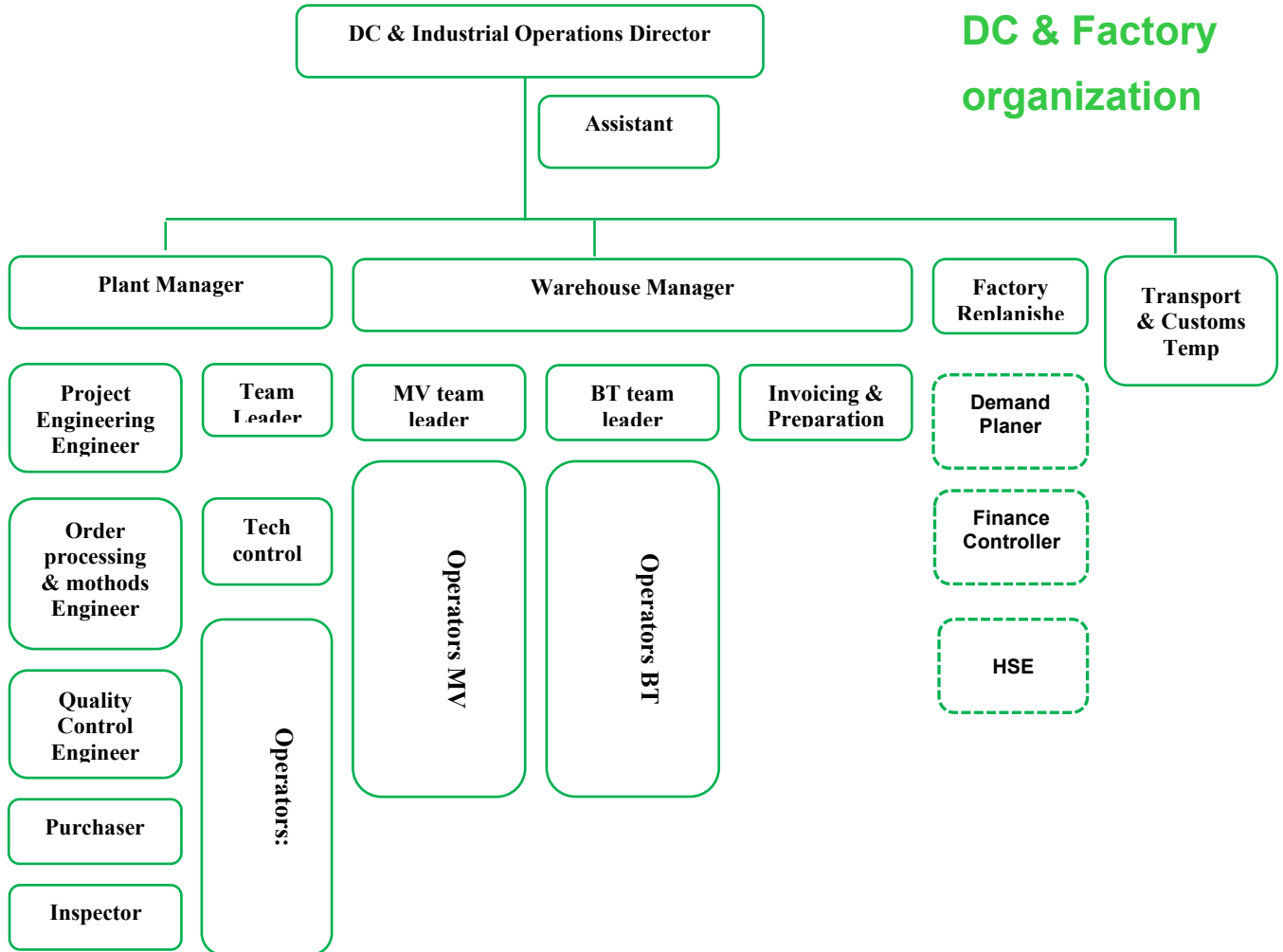


Source: internal documents

Workforce:

- ✓ Managed by Warehouse Manager Aziz Belkacem;
- ✓ Support from team leaders and operators across the various stages (as presented in the Organizational Chart).

Figure 4: DC and factory structure



Source: internal documents

7.3.2 Studied Workflow: Delivery Process

The delivery process follows a five-step operational workflow, aimed at ensuring speed, accuracy, and traceability:

a. Reception

- Incoming goods are unloaded at the docks.
- Products are checked for quantity, quality, and proper documentation (e.g., purchase orders).
- Items are scanned into the inventory system and labelled for tracking.

b. Storage

- Products are stored in racks based on type, turnover rate, and specific storage needs.
- The use of barcode or RFID systems ensures real-time inventory accuracy.

c. Order Preparation:

- Items are picked according to daily order priorities (e.g., urgent, bulk orders).
- Operators use digital or printed pick lists and double-check selections for accuracy.

d. Verification

- Orders are reviewed by the Quality Control Engineer to ensure alignment with customer specifications.
- Goods are then packed, labelled, and matched with the shipping documents.

e. Delivery

- A final review is performed (quantity, packaging, and destination).
- Goods are loaded onto trucks under the supervision of the transport team.
- Customers receive real-time tracking updates via Schneider Electric's logistics platform.

7.3.3 Performance Indicators & Ongoing Challenges

a. Key Performance Metrics (KPIs)

- Delivery Complaint Rate (DCR): 3,324 incidents recorded year-to-date (target: continuous reduction)
- Productivity: 12% efficiency at the DC compared to 9.3% at the manufacturing site
- Workplace Safety: 587 days without an accident

b. Areas of Focus for Improvement

- Reduction of Risk Priority Numbers (RPN), with a target to lower scores by the end of 2024
- Increased Automation, especially the use of RFID technology to reduce human error

7.3.4 Relevance to This Study

We focused on this process in our research because we found it crucial to the study, as the delivery phase is where delays, errors, and communication issues often emerge. By analysing this workflow and the actors involved (warehouse staff, quality control, transport coordinators), we can identify:

- Pain points and bottlenecks
- Opportunities for Lean Six Sigma tools (in our case, it's the DMAIC)
- Impact of current performance indicators (for example: DCR, productivity)

This detailed understanding will serve as a foundation for developing optimisation proposals which will be mentioned in the later chapters.

Chapter 02: Theoretical Framework

This chapter provides the theoretical foundation for the present research. It has two main sections: the literature review and the conceptual framework. The literature review explores key academic and professional contributions related to Lean Six Sigma (LSS), transport process optimisation, and communication with transport providers. Emphasis is placed on identifying existing methodologies, tools, and challenges within logistics and supply chain management.

Building on the literature, the conceptual framework presents the core constructs and relationships relevant to the research problem. It guides the development of the research methodology and informs the application of LSS tools within the Schneider Electric logistics centre. This chapter aims to establish a solid theoretical base to support the analysis and improvement of transport and communication processes using the DMAIC approach.

Section 01: Literature Review

Lean Six Sigma (LSS) has been widely implemented in supply chain management as a methodology for process improvement, waste reduction, and quality enhancement. This literature review is made of two sections; the first section explores previous studies that applied LSS in different process contexts, examining their methodologies, findings, and conclusions to gather more context about the use of the methodology; meanwhile, the second section analyses the use of LSS specifically in the supply chain processes. The focus is on how LSS contributes to optimising various processes, improving efficiency, and addressing recurring challenges.

1 Lean Six Sigma and process improvement:

This section presents previous research on the application of Lean Six Sigma (LSS) in different processes, examining its impact across different projects, phases and industries. It explores methodologies, key findings, and conclusions from existing studies to assess how LSS contributes to process efficiency, waste reduction, and continuous improvement.

By analysing how LSS has been integrated into various management processes, this review aims to provide a foundation for understanding its role in optimising project performance. The specific process examined in this study will be determined based on recurring challenges identified during the upcoming internship, ensuring that the research is directly relevant to a real-world issue.

Across the literature, there is a consistent emphasis on the strategic benefits of integrating Lean and Six Sigma methodologies, especially when aligned with structured project management practices. (Yasmina Delleci, 2023) highlights the complementary nature of Lean's waste reduction and Six Sigma's precision show how their synergy drives efficiency, agility, and quality across various sectors. Building on this, (Zanezi & Carvalho, 2023) extend the discussion by examining how project management principles, particularly stakeholder engagement, scope definition, and portfolio management, strengthen the effectiveness of Lean Six Sigma (LSS) initiatives. Their findings suggest that while cost and quality gains are well-documented, aspects like scheduling and risk management still need deeper exploration. (Tenera & Pinto, 2014) offer a practical illustration of this integration in action, using LSS tools like DMAIC and VSM to improve project scheduling and control within a telecommunications firm and collecting data from 33 projects executed between 2006 and 2010. Their case shows how data-driven approaches can tackle inefficiencies and enhance predictability in complex projects. Together, these studies underscore the importance of combining LSS with solid project management frameworks to optimise processes, especially in environments where precision and timing are critical.

A growing body of research showcases how Lean and Six Sigma methodologies, often together under the Lean Six Sigma (LSS) umbrella, significantly enhance operational performance across diverse sectors. (Rodrigues & Alves, 2024) demonstrate how Lean principles alone, when mapped onto project management frameworks in IT settings, reduce waste and boost agility, even without the full Six Sigma suite. Similarly, (Bhargava & Gaur, 2021) and (A. Gooma, 2024b) apply LSS tools like DMAIC, control charts, and process capability analysis to manufacturing, showing tangible improvements in sigma levels, defect rates, and cycle times. These studies underscore how structured, data-driven interventions can stabilize processes and increase throughput. In a complementary context, (Soltani & Agarwal, 2024) highlight the power of proactive maintenance and standardisation through LSS in reducing test equipment failures in SMEs. Together, these studies point to a common thread: whether in digital projects or physical production lines, LSS provides a flexible, effective framework for identifying inefficiencies, standardising best practices, and driving sustainable performance improvements.

Both (Edouard, 2016) and (Halim, 2024) illustrate how Lean Six Sigma can be adapted to diverse industries, pharmaceutical manufacturing and aquaculture, with impressive results. Auzémery's study applied the DMAIC framework to streamline a vaccine packaging

line, addressing equipment downtime and production inconsistencies. By using tools like VSM, Pareto analysis, and SPC, the project achieved measurable gains: reduced micro-stoppages, higher equipment utilisation, and improved production output. In contrast, Halim focused on a Moroccan aquaculture firm, uncovering inefficiencies rooted in weak process governance and staff training gaps. By integrating practical tools like 5S and QRQC boards, along with employee training, the company boosted productivity and reduced cycle time. Despite operating in vastly different sectors, both studies underscore the value of combining technical LSS tools with people-centric strategies to drive lasting operational improvements and foster a culture of continuous development.

(Amjad et al., 2024) demonstrated how Lean Six Sigma (LSS) contributes to the optimisation of engineering project management through enhanced operational control and defect reduction. By comparing datasets related to quality assurance, maintenance, and delivery timelines, the study showed that LSS practices not only reduced the defect rate from 5.2% to 1.8%, but also generated substantial annual cost savings of approximately \$250,000. Improved scheduling and milestone adherence were also achieved through the integration of SPC and real-time monitoring. This research underscores the role of LSS in facilitating data-informed project decisions, enhancing standardisation, and minimising operational risks in engineering settings.

In a distinct context, (Vashishth et al., 2024) explored LSS deployment within the financial services industry, assessing how organisational motives, methodology selection, and implementation barriers influence performance outcomes. Drawing on data from nearly 200 professionals across multiple countries, the study employed structural equation modelling to evaluate links between LSS practices and key performance metrics. The results highlighted a 22% drop in cycle time, an 18% improvement in cost efficiency, and a 27% rise in customer satisfaction. Nevertheless, obstacles such as ineffective project selection and internal resistance were noted. These insights confirm LSS's adaptability beyond traditional industrial applications, positioning it as a valuable strategy for driving efficiency and strategic alignment in service-orientated sectors.

2 Lean Six Sigma and supply chain enhancement :

In this section, we delve deeper into the implementation of the Lean Six Sigma (LLS) methodology within supply chain management processes. The objective is to explore how LLS has been applied in previous studies to improve operational efficiency, reduce waste,

and enhance overall process quality. This review will provide a clearer understanding of how LLS can be integrated into our research context and will help anticipate potential outcomes, benefits, or challenges that may arise during implementation.

(Sundram et al., 2023) investigated how Lean Six Sigma (LSS), via the DMAIC methodology, could streamline recruitment workflows within a logistics department, demonstrating its versatility beyond traditional manufacturing domains. By gathering data through interviews, process mapping, and statistical tools such as control charts and capability analysis, the study uncovered inefficiencies in hiring processes. Lean instruments like Fishbone diagrams and Pareto analysis were then used to develop targeted improvements. As a result, the lead time for recruitment was reduced by 25%, workflows were standardised, and both recruiter efficiency and employee satisfaction increased. This research reinforces LSS's applicability to administrative logistics functions and highlights its potential for broader HR process optimization, such as onboarding and retention.

In a complementary study, (Gutierrez-Gutierrez et al., 2016) explored the integration of LSS within logistics services at a multinational electronics company. Their case study assessed two key processes, the payment system and the request-to-ship cycle, illustrating how DMAIC can improve both internal efficiency and external customer responsiveness. Through tools such as Value Stream Mapping and Voice of the Customer (VOC) analysis, the study identified bottlenecks and reduced delays in order fulfilment. The findings confirmed that structured application of LSS methodologies can standardise transport operations while also refining customer communication channels. Despite the limitations of a single-case context, the research offers strong support for LSS as a dynamic and practical framework in complex logistics environments.

(Jayaram, 2016), (Prof. Dr. A. H. Gomaa, 2025) and (Pardamean Gultom & Wibisono, 2019) all emphasise the strategic integration of Lean Six Sigma (LSS) with broader supply chain initiatives to optimise transport processes and enhance operational performance. Jayaram highlights the fusion of LSS with Industry 4.0 technologies, such as IoT-enabled sensors, RFID tracking, and real-time analytics, demonstrating how these tools support dynamic logistics decisions, predictive maintenance, and greater visibility across the supply chain. Similarly, (Prof. Dr. A. H. Gomaa, 2025) showcases how DMAIC, combined with tools like Value Stream Mapping (VSM) and Just-In-Time (JIT), enabled an Egyptian manufacturing firm to reduce procurement lead times and improve inventory turnover, aligning transport efficiency with long-term business goals. Complementing these

perspectives,(Pardamean Gultom & Wibisono, 2019) propose a theoretical framework linking Lean practices (for example: JIT, employee involvement) and Six Sigma's process control methods key supply chain KPIs such as delivery speed and logistics reliability. Across all three studies, there is a shared emphasis on using LSS not only as a problem-solving tool but also as a strategic enabler for transport process standardisation, waste reduction, and real-time decision-making.

(Renzo Melgar Torres et al., 2022) carried out a systematic literature review to assess how Lean Six Sigma (LSS) tools are utilised in retail logistics, particularly in improving efficiency and customer satisfaction. Analysing 28 peer-reviewed studies, they found that the DMAIC methodology appeared in 43% of cases, with reported benefits including a 30% reduction in customer complaints, a 33% drop in lead times, and up to \$600,000 in annual cost savings. Most implementations were in internal logistics environments, especially supermarkets, where inventory control and process streamlining were key. Similarly, (A. Gomaa, 2024a) explored the integration of LSS and supply chain management, emphasising how tools such as DMAIC, VSM, and 5S addressed inefficiencies across logistics, procurement, and production. This review echoed similar benefits, such as a 33% reduction in lead times and a 10% improvement in inventory turnover, while proposing a strategic framework for aligning LSS with business objectives. Both studies underline the strategic relevance of LSS in logistics optimisation, though they also identify gaps in tool diversity and the need for sector-specific case studies and standardised performance metrics.

(Zhang et al., 2016) provided empirical data on LSS adoption in Singapore's logistics sector through a pilot survey of 410 companies. The results showed that while 37.5% of firms had adopted Lean, often in combination with Six Sigma, pure Six Sigma usage was absent. Benefits reported included modest cost reductions, improved delivery timelines, and cycle time improvements. Nonetheless, the study also uncovered significant barriers to implementation, including resistance to change and limited employee awareness, particularly within small and medium-sized enterprises (SMEs). Larger logistics providers were more likely to adopt LSS tools, suggesting a link between firm size, service expectations, and innovation capacity. The research adds practical insights into sector-specific challenges and confirms the potential of LSS to improve transport and logistics operations.

(Bin Md Saad, 2023) investigates the application of Lean Six Sigma (LSS) in the transportation sector, highlighting its potential to optimise logistics efficiency and customer-

centric processes in a study published in the International Journal of Empirical Research Methods. The research synthesises evidence from air, sea, and land transportation, demonstrating how LSS methodologies like DMAIC can reduce delays, standardise workflows, and enhance on-time delivery performance since it's a critical factor in customer satisfaction. Notably, the study identifies process mapping and root cause analysis as key tools for streamlining transport operations while also underscoring challenges such as resistance to change and data scarcity in dynamic logistics environments. For instance, case studies from maritime and aviation sectors reveal how LSS improved delivery accuracy and safety, indirectly strengthening customer trust through reliable service. Though the study acknowledges limitations (e.g., reliance on secondary data), its findings align with our thesis by advocating for LSS as a framework to harmonise transport efficiency and customer communication in logistics hubs. The paper further recommends stakeholder engagement and continuous improvement.

3 Critical analysis :

The reviewed literature in the first axis demonstrates Lean Six Sigma's (LSS) versatility in optimising processes across diverse industries, from manufacturing (Bhargava & Gaur, 2021) to IT (Rodrigues & Alves, 2024) and services (Vashishth et al., 2024) with consistent improvements in efficiency (e.g., 22% cycle time reduction), cost savings, and customer satisfaction. However, the focus remains skewed toward manufacturing, leaving gaps in logistics-specific applications, particularly in integrating LSS with digital tools (e.g., IoT for real-time tracking) and addressing human factors like change resistance (Halim, 2024); (Vashishth et al., 2024) .

While methodologies like DMAIC and tools such as VSM and SPC are well-validated, their blind adoption risks "tool overload" without contextual adaptation (Soltani & Agarwal, 2024). Notably, few studies explore LSS's role in customer communication optimisation or B2B logistics, nor do they critically assess long-term sustainability of improvements beyond immediate results (Edouard, 2016) is an exception. For Schneider Electric's logistics centre, this underscores an opportunity to tailor LSS by prioritising service-orientated KPIs (e.g., delivery accuracy over defect rates), hybridising DMAIC with agile communication technologies, and addressing cultural barriers through training in order to fill the gaps left by prior research while leveraging the methodology's proven structured approach.

Meanwhile, the second axis reviewed literature that underscores Lean Six Sigma's (LSS) transformative potential in supply chain management (SCM), particularly in logistics optimisation, waste reduction, and customer satisfaction. Studies like (Renzo Melgar Torres et al., 2022) and (A. Gomaa, 2024a) empirically validate LSS's impact, demonstrating measurable outcomes such as 30% reductions in lead times (Renzo Melgar Torres et al., 2022) and 10% improvements in inventory turnover (A. Gomaa, 2024a) through tools like DMAIC and Value Stream Mapping (VSM). Notably, (Jayaram, 2016) and (Prof. Dr. A. H. Gomaa, 2025) highlight the synergy between LSS and Industry 4.0 technologies (for example: IoT, RFID), which enhance real-time decision-making and resilience; that could be a critical insight for Schneider Electric's tech-driven logistics centre. However, gaps persist in the literature. First, while LSS applications in retail and manufacturing are well-documented for example: (Pardamean Gultom & Wibisono, 2019), its adaptation to B2B logistics (like Schneider's operations) remains underexplored, particularly in balancing efficiency with complex stakeholder communication. Second, challenges such as change resistance (Zhang et al., 2016) and data fragmentation (Bin Md Saad, 2023) are frequently cited but lack actionable mitigation strategies. Third, studies like (Zhang et al., 2016) reveal disparities in LSS adoption between large firms and SMEs, suggesting that scalability depends on organisational readiness, which could be a key consideration for multinationals like Schneider.

The literature also identifies methodological gaps. For instance, (A. Gomaa, 2024a) calls for standardisation to assess LSS in SCM, while (Gutierrez-Gutierrez et al., 2016) emphasise the need for flexible DMAIC adaptations in dynamic logistics environments. These critiques align with (Bin Md Saad, 2023) finding that rigid LSS frameworks may falter in transport sectors with high variability (like last-mile delivery). For our research, this presents an opportunity to tailor LSS tools to Schneider's hybrid B2B logistics model, integrate digital traceability (for example: IoT sensors for transport monitoring) with LSS's defect-reduction focus, and develop communication-specific metrics (for example: response time to customer enquiries) to bridge the gap between operational efficiency and service quality.

Table 01: Summery for the critical analysis

Author(s) & Year	Field	Process Studied	LSS Tools / Techniques	Methodology	Limitations
Amjad, Shovon, & Hasan (2024)	Engineering Project Management	Defect reduction, process optimization	SPC, Regression Analysis, Root Cause Identification	Comparative analysis, quantitative approach	Limited to defect-related improvements
Tenera & Pinto (2014)	Telecommunications	Project scheduling inefficiencies	DMAIC, VSM, Root Cause Analysis, SPC	Case study	Focused only on a single company, limited generalizability
Rodrigues & Alves (2024)	IT Project Management	Waste reduction, workflow optimization	Kanban, VSM, Root Cause Analysis	Systematic literature review, case study	Does not integrate Six Sigma aspects
Delleci (2023)	Business Process Improvement	LSS application in various Sectors	DMAIC, Lean Principles, SPC, VSM	Systematic Literature Review	Broad analysis slacks empirical validation
Auzémery, E. (2016)	Pharmaceutical Manufacturing	Continuous improvement project on a secondary vaccine packaging line	- DMAIC framework; Value Stream Mapping (VSM); Statistical Process Control (SPC); Pareto analysis; Taux de Rendement Synthétique (TRS); Root Cause Analysis; Standardized Work.	DMAIC methodology	Scope limitation

Melgar Torres, Plasencia Machuca, and Villanueva Flores (2022)	Retail logistics	supermarkets: inventory & process optimisation	DMAIC (as the most frequent approach) VSM Kaizen	Systematic literature review	Limited research on VSM and Kaizen; supermarket focus
Jayaram (2016)	Global Supply Chain Management	Global supply chains (tracking, coordination, predictive maintenance)	DMAIC, RFID, real-time data, automation	Conceptual framework/model development	Theoretical model; lacks empirical validation
Gomaa (2025)	manufacturing supply chains	Strategic alignment of supply chain processes	DMAIC, VSM, JIT, RFID, predictive analytics	Case study	Context-specific; resource constraints; resistance to change
Gomaa (2024)	Supply Chain Management	Procurement, production, logistics	DMAIC, VSM, 5S	Systematic Literature Review	Lack of industry-specific case studies; no standardised KPIs
Gultom and Wibisono (2019)	Manufacturing Supply Chains	Supplier selection, production, delivery, logistics, warehouse operations	Lean (JIT, quality, involvement), DMAIC	Framework development (8 hypotheses)	No empirical testing; conceptual stage
Zhang et al. (2016)	Logistics Industry (Singapore)	Lean Six Sigma adoption in logistics firms	Lean + Six Sigma (combined); delivery & cycle time	Pilot survey (32 usable responses)	Small sample size; implementation barriers (resistance, lack of training)
Gutiérrez, L. J., De Leeuw, S., and Dubbers, R. (2016)	Logistics Services (electronics company)	Payment process; request-to-ship cycle time	DMAIC, VSM, VOC	Single-case study	Single-case focus; limited generalisability
Saad (2023)	Transportation (air, sea, land)	Transport operations & customer satisfaction (on-time delivery)	DMAIC, process mapping, root cause analysis	Synthesis of sectoral case studies	Reliance on secondary data; data scarcity; change resistance
Sundram, Ghapar, Lian & Muhamma	HR / Recruitment	Recruitment process optimization	DMAIC, VSM, Fishbone Diagram, Control Charts	Case study, interviews	Industry specific study, limited cross sector applicability

d (2023)					
Vashishth et al. (2024)	Financial Services	Process cycle optimization, cost reduction	SEM, Process Control Tools, Regression Analysis	Quantitative (Survey based, SEM)	Limited to financial industry, lacks hands-on implementation
Bhargava & Gaur (2021)	Manufacturing	Quality control and defect reduction	DMAIC, MINITAB, Control Charts, Ishikawa, Pareto Analysis	Case study, statistical analysis	Manufacturing specific, not adaptable to service industries
Zanezi & Carvalho (2023)	Project Management	Impact of PM principles on LSS projects	Bibliometric Analysis, Portfolio Management, Risk Management	Systematic literature review	Theoretical analysis lacks empirical validation
Soltani & Agarwal (2024)	Manufacturing	Operational efficiency in transformer production	DMAIC, SOPs, Minitab Statistical Tools	Case Study (4-year data analysis)	Focus on specific industry lacks cross sector validation
Gomaa (2024)	Mechanical Engineering	Productivity improvement in machining	DMAIC, SIPOC, VSM, 7QC, OEE, DOE, ANOVA	Case Study	Limited to spare parts manufacturing, lacks generalizability
Halim (2024)	Aquaculture Industry	Process improvement in fish farming	DMAIC, Lean Waste Reduction, Value Stream Mapping	Case Study	Lack of previous studies in aquaculture, limited comparative data

Source: Prepared by the authors

Section 02: Key Theoretical Concepts Underpinning the Project

This section outlines the key concepts and terminologies that underpin the foundation of our study and by defining and clarifying these critical terms we aim to establish a shared understanding of the constructs that guided our research design, data collection, and analysis. This conceptual framework does not only provide a theoretical lens which through the research problem is examined, but it also illustrates the relationships between the main variables of interest. This framework also serves as a roadmap for interpreting the findings and positioning them within the broader academic course.

1 Process Improvement

1.1 What Is Process Improvement?

Process improvement refers to a structured approach aimed at optimising organisational activities in terms of quality, performance, and operational efficiency. It involves identifying inefficiencies, eliminating waste, and aligning processes with strategic business goals. According to Boutros and Purdie (2014), process improvement is “*an integrated management model that combines Lean, Six Sigma, and Business Process Management tools to enable sustainable performance*” (Boutros & Purdie, 2014) Similarly, Susan Page (2016) defines it as “*a ten-step logical method that helps businesses reduce errors, improve productivity, and increase organisational transparency*” (Page, 2016) From a more radical perspective, Hammer and Champy (1994) introduced Business Process Reengineering (BPR), which they define as “*the fundamental rethinking and radical redesign of business processes to achieve dramatic improvements in performance*” (Hammer & Champy, 1994) Finally, Imai (1986) developed the concept of Kaizen, a Japanese management philosophy grounded in “*continuous improvement involving all employees and aiming for small, incremental changes in everyday processes*” (Imai, 1986) .

These viewpoints offer complementary perspectives on process improvement. While Imai (1986) emphasizes a participatory culture of ongoing enhancement, Page (2016) provided a straightforward and replicable operational framework. In contrast, Hammer and Champy (1994) advocate for disruptive transformation suited for crisis or deep organizational change. Boutros and Purdie (2014) provide a pragmatic synthesis by integrating multiple methodologies within a performance-driven system. Combining these approaches in a transformation project allows for a process that is at once incremental, systemic, and when necessary radically transformative.

1.2 Tools for Process Improvement

While process improvement conceptually rooted in the pursuit of operational excellence, it is brought to life through a variety of tools and methodologies that translate theory into actionable results.

- Process Mapping;
- SIPOC Diagram;
- 5 Whys;
- Ishikawa Diagram (Cause-and-Effect Diagram);
- PDCA Cycle (Plan–Do–Check–Act);
- Value Stream Mapping.

While these tools are valuable on their own, they become even more powerful when embedded within structured problem-solving methodologies, especially when addressing multifaceted challenges that cannot be resolved through intuition or trial and only error. This naturally leads us to the next essential concept: methods for solving complex problems, which go beyond basic troubleshooting and require systematic, evidence-based frameworks.

2 Methods for Solving Complex Problems

(George, 2005) Effectively addressing complex problems requires structured methods that go beyond intuition and guesswork. Among the most recognized is the Kepner-Tregoe method, which offers a logical framework for problem and decision analysis in managerial settings (Jackson & Sass, 1984). The DMAIC approach from Six Sigma is also widely applied, especially in process improvement, as it emphasizes data collection, root cause analysis, and iterative control (George, 2002). Another noteworthy method is Root Cause Analysis (RCA), which helps identify underlying causes of failure by using tools like the 5 Whys or fishbone diagrams (Andersen, B & Fagerhaug, T, 2006).

While each of these techniques brings unique advantages, their effectiveness often depends on the context and nature of the problem. As problem-solving became more integrated with process enhancement, this naturally led to the combined approach of Lean Six Sigma, the next concept in our framework.

3 Lean Six Sigma

3.1 Definition of Lean Six Sigma

Lean Six Sigma is a hybrid management approach that integrates Lean's focus on waste elimination with Six Sigma's emphasis on variation reduction and quality improvement. It emerged in the late 1990s as a strategic response to the need for faster, more reliable, and cost-effective processes (George, 2002). According to (George, 2005), Lean Six Sigma combines the speed and flow efficiency of Lean with the statistical rigor of Six Sigma, offering a powerful framework for both incremental and breakthrough improvement. (Snee & Hoerl, 2003). highlight that this integration creates a comprehensive methodology capable of improving process capability, reducing cycle times, and enhancing customer satisfaction simultaneously.

By aligning both philosophies under a single umbrella, Lean Six Sigma enables organizations to address process waste and quality defects concurrently. It uses tools like Value Stream Mapping, DMAIC, Kaizen events, and statistical control charts to drive systematic changes. This dual-focused approach is especially valuable in complex environments such as manufacturing, logistics, and healthcare, where speed and quality are both critical.

Understanding this synergy provides a strong foundation for examining Lean and Six Sigma individually, two essential components that when well understood on their own, they enhance the effectiveness of their integration.

3.2 Lean Management

“All we are doing is looking at the time line, from the moment the customer gives us an order to the point when we collect the cash. And we are reducing that time line by removing the non-value-added wastes.” Taiichi Ohno

3.2.1 Definition and Origin of Lean Management

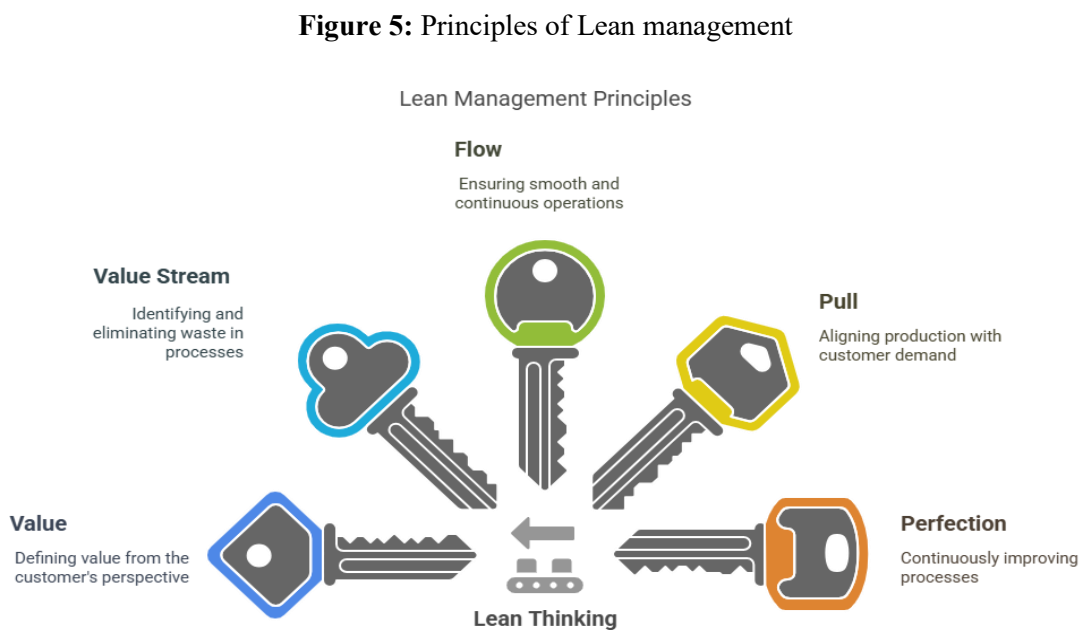
Lean Management, rooted in Japan's post-war era through the Toyota Production System (TPS), was initially created to tackle limited resources by cutting waste and improving workflow. Today, it represents a mature, systemic approach focused on engaging collective intelligence to boost customer satisfaction and long-term performance (Le grand guide du lean management, 2023). Central to Lean is the ongoing effort to eliminate non-value-added activities, reflecting its cultural foundation in the Japanese pursuit of perfection.

According to (Demetrescoux, 2017). Lean Management is not merely a set of tools but a transformation framework that fosters solid and sustainable performance by promoting simplicity, discipline, and respect for people. This vision is shared by (Hohmann, 2012).who defines Lean as a modular system of methods that must be adapted and contextualised according to the organisation's needs. In service-oriented sectors, Lean becomes a method of restoring meaning to work, enhancing responsiveness, and re-centering employees on value-added tasks (René, 2022). (Lyonnet, 2015) reinforces this perspective by highlighting Lean as both a method and a managerial posture, grounded in frontline problem-solving and team empowerment.

More recently, (Castagné, 2012) highlights how this framework apply effectively to service settings, where smooth processes, customer satisfaction, and minimal friction are key. Evolving beyond its industrial origins, it became a universal approach to continuous improvement and performance focused on the client. From manufacturing to healthcare and public services that it now offers a versatile, value-driven method for reducing waste across diverse sectors.

3.2.2 Principles of Lean Management

According to Womack and Jones (2003), Lean Thinking is based on five core principles that guide organizations in eliminating waste and maximizing customer value. These principles form the foundation of the Lean approach and represent a universal roadmap for operational excellence.











Source: Prepared by the authors

This step includes the classification and removal of eight types of waste, or muda as outlined in Lean literature (Piercy & Rich, 2009):

Figure 6: Types of waste

Eight Types of Waste

Waste Type	Description
 Defects	Errors needing correction
 Overproduction	Producing too much, too soon
 Waiting	Idle time, no value added
 Unnecessary Transportation	Excessive movement of goods
 Excess Inventory	Stockpiling products or materials
 Unnecessary Motion	Inefficient worker movements
 Overprocessing	Doing more than required
 Underutilized Talent	Failing to use employee skills

Source: Prepared by the authors

3.3 Six Sigma Fundamentals

“Six Sigma is a disciplined, data-centric methodology for eliminating process defects and achieving operational excellence through statistical reasoning and evidence-based management.” (Laureani & Antony, 2017)

3.3.1 Historical Background of Six Sigma

The origin of Six Sigma goes back to the early 1980s at Motorola, where then-CEO Bob Galvin and his engineering team recognized that traditional quality measurement metrics, based on defects per thousand opportunities, were insufficient for driving high-performance results. This realization led to the development of a new metric focused on defects per million opportunities (DPMO), and the creation of a statistically rigorous improvement

methodology grounded in data-driven decision-making and cultural transformation (Snee & Hoerl, 2003) Six Sigma gained momentum in the mid-1990s when General Electric, led by Jack Welch, made it a core part of its strategy. By training over 100,000 employees, GE achieved notable financial results and became known for operational excellence (Antony, 2006) . In the 2000s, the methodology expanded beyond manufacturing into fields like healthcare, finance, and public services, driven by a global shift toward data-driven management and continuous improvement (De Koning & De Mast, 2007).

Academically, Six Sigma has developed into a robust theoretical framework rooted in statistical process control and continuous improvement. Its tools, such as control charts, regression analysis, Pareto diagrams, and root cause analysis, support a data-driven approach. *“Viewed as a refined extension of Total Quality Management (TQM), it emphasizes measurable results and reducing process variation”* (Schroeder et al., 2008). Today, Six Sigma is both a disciplined methodology and a strategic philosophy aimed at precision, customer satisfaction, and operational excellence.

3.3.2 Principles of Six-Sigma

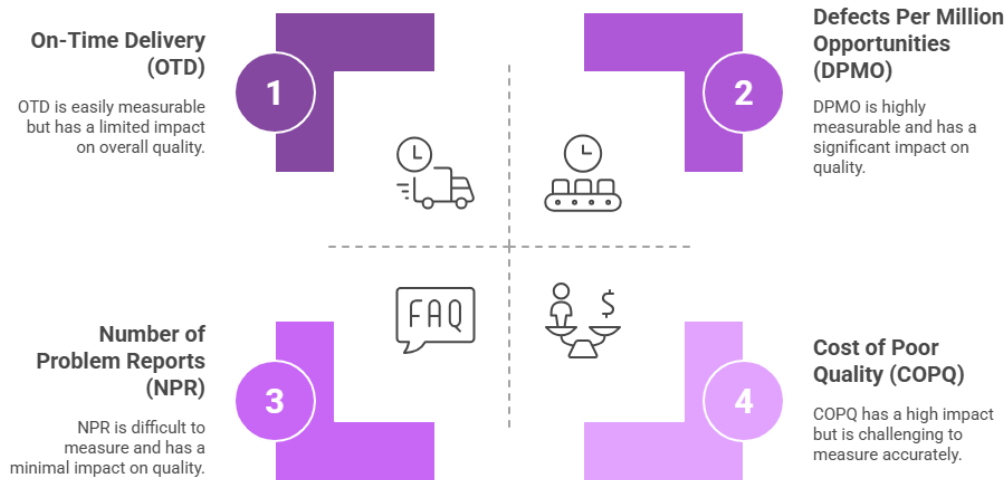
Six Sigma is both, a scientific approach to quality management, and a structured method for continuous improvement. It focuses on reducing process variation and defects through a rigorous, data-driven methodology.

A. Six Sigma as a Scientific Quality Approach

In Six Sigma numbers matter. Quantitative metrics are key to understanding how a process is performing and where it can be improved. These measurements help teams see the current state, spot problems, and track the results of any changes made. According to (ISO13053-1.2011, n.d.) there are several standard indicators that guide and support Six Sigma projects, helping ensure progress is measured clearly and accurately.

Figure 7: Types of waste

Six Sigma Metrics Prioritization

*Source: Prepared by the authors***a. Defects Per Million Opportunities (DPMO)**

DPMO is a core metric in Six Sigma that expresses the frequency of defects relative to one million possible defect opportunities. It is calculated by analysing the number of critical-to-quality characteristics (CTQCs) across surveyed units and normalizing this to a base of one million opportunities. This metric provides a benchmark for process quality and is often used to derive the Sigma level of a process, which quantifies how well it meets specifications (ISO13053-1.2011, n.d.).

DPMO is calculated using the formula:

$$Y_{DPMO} = \frac{c}{n_{\text{units}} \times n_{\text{CTQC}}} \times 1\,000\,000$$

The potential number of CTQC defects (non-conformities) is counted from the units surveyed. It measures the achieved quality performance and it is expressed as a rate per million of all such CTQC defects. The value can then be later used to estimate a “sigma score” (or Z-value).

Table 02 : Sigma scores

Calculated value of DPMO (Y_{DPMO})	Sigma score (Z_{value})
308 538,0	2
66 807,0	3
6 210,0	4
233,0	5
3,4	6

NOTE 1 A full table of sigma scores can be found in Annex A.
NOTE 2 Calculations are based on a 1,5 sigma shift of the mean.

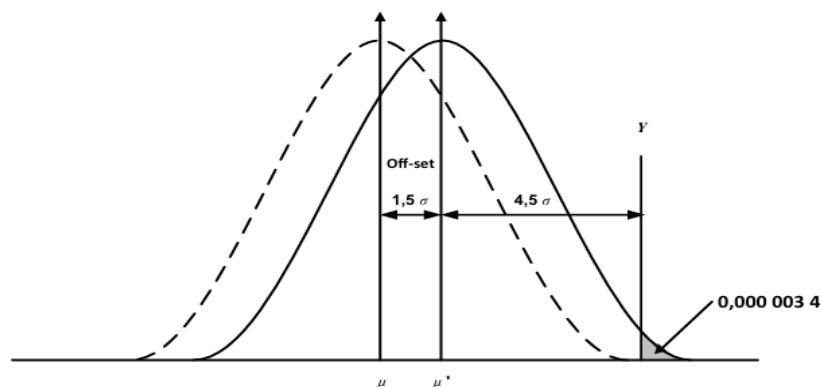
Source: (ISO13053-1.2011, n.d.)

A process operating at a Six Sigma level corresponds to a DPMO of approximately 3.4, reflecting near-perfect quality. However, due to cumulative probabilities across many CTQCs in complex products, even a Six Sigma score does not guarantee defect-free batches, underscoring the need for continual improvement beyond this baseline.

b. Sigma Score

The Sigma score, also referred to as the Z-value, translates the DPMO into a standardized quality index based on the normal distribution. A traditional 1.5 sigma shift is applied to account for process drift over time, making a Sigma score of 6 equivalent to 4.5 standard deviations from the mean. This metric offers a statistical foundation for assessing long-term capability and identifying improvement thresholds (ISO13053-1.2011, n.d.)

Figure 8: Derivation of the sigma scores



Source: (ISO13053-1.2011, n.d.)

c. On-Time Delivery (OTD)

OTD is a measure of a company's ability to meet customer delivery schedules. It is defined as the percentage of deliveries made within the agreed timeframe. This metric not only reflects logistical efficiency but also directly impacts customer satisfaction and trust (*ISO13053-1.2011*, n.d.).

d. Cost of Poor Quality (COPQ)

COPQ encompasses all internal and external costs incurred due to defects. It includes rework, scrap, warranty claims, failure diagnosis, and other remediation efforts. Notably, this metric does not account for intangible costs such as reputational damage or lost customer goodwill. Reducing COPQ is often a key objective of Six Sigma projects due to its direct influence on profitability (*ISO13053-1.2011*)

e. Number of Problem Reports (NPR)

This measure counts customer-reported issues during a given timeframe, whether related to hardware, software, or services. These reports are typically classified by severity, critical, major, and minor, which facilitates prioritized corrective actions and root cause analyses (*ISO13053-1.2011*.)

B. Six Sigma as a Structured Process Improvement System

The Six Sigma methodology is primarily structured around two core frameworks: DMAIC and DMADV. The DMAIC method (Define, Measure, Analyse, Improve, and Control) is used to enhance existing processes by diagnosing root causes and applying data-driven solutions (**McCarty, 2005**). In contrast, the DMADV approach (Define, Measure, Analyse, Design, and Verify) is employed when developing new processes or redesigning poorly performing ones, with a strong focus on meeting customer requirements (**Six Sigma, 2018**).

The two approaches differ in both purpose and orientation. DMAIC is corrective and process-focused, ideal for improving efficiency and eliminating defects in existing workflows. On the other hand, DMADV is proactive and customer-oriented, suited for the creation of innovative, defect-free processes. A comparative summary of the two is presented in the table below.

Table 03: comparative summary of DMAIC and DMADV approaches

Comparison	DMAIC	DMADV
Process Scope	Improve or correct an existing process	Design and implement a new process
Objective	Focused on business process performance	Focused on meeting customer needs
Approach	Corrective	Proactive

Source: (Singhisodhi, 2020)

3.4 Integrated Use of Lean and Six Sigma for Process Excellence

Lean Six Sigma is a combined methodology that merges the strengths of Lean, focused on waste elimination and speed, with Six Sigma's focus on quality and reducing variation. Together, they support continuous improvement, customer satisfaction, and operational efficiency across all process stages **(George, 2002)**

This integration enhances performance by using Lean to streamline workflows and Six Sigma to provide data-driven decision-making. While Lean accelerates processes, it lacks tools to analyse variation, this is where Six Sigma complements it. Conversely, Six Sigma benefits from Lean's ability to simplify and speed up operations **(Pyzdek & Keller, 2014)**.

Both methods require leadership support, skilled teams, and share tools for problem-solving. Their complementarity enabled organisations to reduce waste, control defects, and deliver higher value to customers. As **(Pillet, 2013)** highlights, Lean and Six Sigma are most powerful when applied together, combining speed and precision to achieve sustainable improvement.

The table below summarises why Lean and Six Sigma are mutually reinforcing:

Table 04 : complementarity between Lean and Six Sigma

Lean Needs Six Sigma	Six Sigma Needs Lean
Cannot quantify process variation	Helps identify waste and speed up processes
Lacks strong analytical and measurement tools	Gains from Lean's focus on flow and value stream mapping
Focuses on speed but may miss root cause precision	Lean helps eliminate non-value-added steps rapidly
Less effective at sustaining long-term improvements	Lean reinforces continuous improvement culture (Kaizen)

Source: Prepared by the authors, inspired by:pillet 2013

As illustrated, the application of Lean and Six Sigma provides a more comprehensive improvement strategy. Their synergy offers flexibility and adaptability, making it a valuable tool across a wide range of industries, from manufacturing to healthcare and urban systems.

4 Six Sigma project: DMAIC methodology

The DMAIC method is a structured data-driven approach to continuous process improvement, originating from the Six Sigma methodology. It aims to enhance quality, efficiency, and performance by identifying and eliminating defects or inefficiencies. The acronym DMAIC stands for the five phases of the process: *Define, Measure, Analyse, Improve, and Control*. Widely used in quality management and process engineering, the DMAIC approach relies on factual evidence and statistical tools to guide decision-making.

The Five Phases of DMAIC

4.1 Phase : Define

The Define phase is the foundational step in the Six Sigma DMAIC methodology. It involves clearly outlining the project framework to ensure its alignment with the organisation's strategic objectives. During this phase, the primary focus is to accurately identify the problem to be addressed, understand who the customer is, and determine their specific needs or dissatisfactions, the key element of this step is selecting a critical output variable (Y) that quantifies the customer's dissatisfaction and that will guide future improvements.

This phase is generally broken down into two main components:

- Selecting a project that is strategically relevant and feasible within the company's operational context;
- Framing the project scope, which includes defining objectives, identifying stakeholders, and determining the boundaries of the improvement effort. **(Pillet, 2013)**

4.1.1 Defining CTQs (Critical To Quality)

Defining CTQs helps identify and understand the customer's real needs. Some CTQ tools include:

A. Listening to the Voice of the Customer (VoC)

The primary goal of the Define phase is to capture and interpret the Voice of the Customer (VoC). This requires a systematic exploration of customer needs through various tools and methods. Among these are:

- Identifying the different categories of potential customers;
- Analysing the products or services in question;
- Engaging with all stakeholders who are directly or indirectly affected;
- Clarifying the explicit and implicit expectations of the customer.

This analysis is typically conducted through classic research techniques such as interviews, focus groups, and surveys. According to Michael L. **(George, 2003)**, an in-depth understanding of the VoC is a decisive factor in the success of any Six Sigma project.

B. The CTQ (Critical To Quality) Diagram

To translate customer needs into measurable quality characteristics, Six Sigma practitioners use CTQ trees. These visual tools help break down broad customer requirements into specific, actionable elements. According to **(Breyfogle, 2003)**, the process involves:

- Identifying the customer of the process or product;
- Defining the customer's general needs;
- Breaking down those needs into primary and secondary requirements;
- Continuing decomposition into detailed specifications when necessary.

This structured breakdown ensures that improvement efforts are tightly aligned with customer-defined value.

Table 05 presents the VOC approach:

Table 05: CTQ

Entity	Need	Requirement	Characteristic	Specification
Client	The underlying motivation or objective that drives the customer to use the product or process.	A condition that must be fulfilled to ensure customer satisfaction.	A measurable aspect that reflects whether the requirement is being met.	The quantitative limit or threshold (e.g., min, max, >, <) defining acceptable performance.

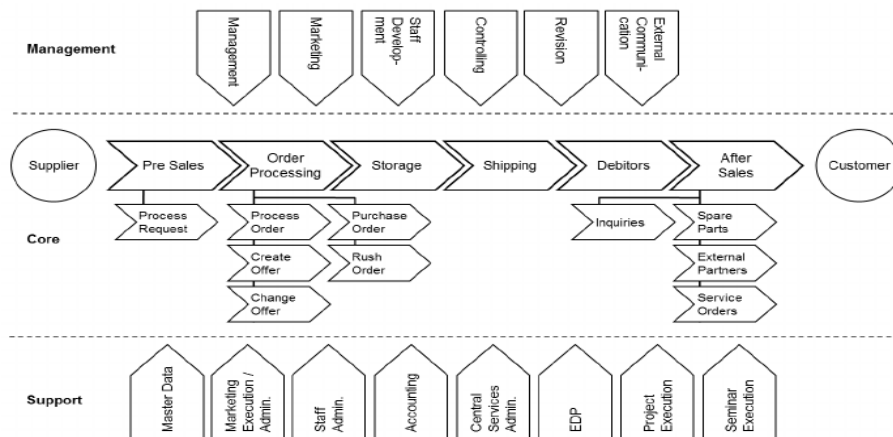
Source: Prepared by the authors inspired by BreyFogle2003

4.1.2 Process Mapping

Process mapping is a visual representation of the sequence of steps in a process. It helps identify redundancies, delays, and bottlenecks.

According to (George, 2005) "a process map displays the workflow of a process and helps teams understand how work gets done, allowing them to identify areas for improvement"

Figure 9 : an example of a process map



Source : (Fig. 1. Example Process Map, Adapted from [36])

Among the tools used for process mapping are the following:

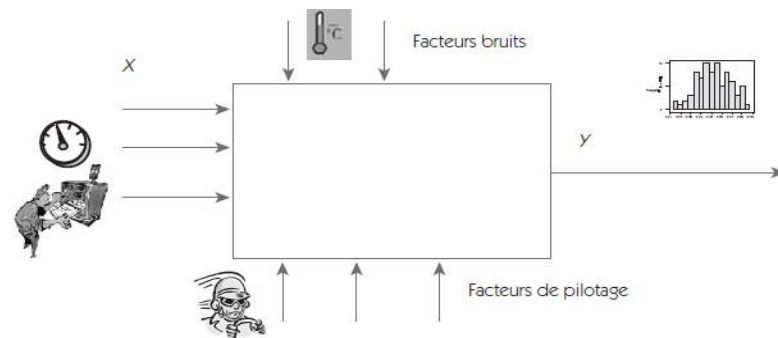
A. The "Black Box" Diagram

According to (Pillet, 2013), a basic approach to process mapping is the Black Box model. This model uses a simple rectangle to represent the process and includes:

- Input variables (X);
- Output variables (Y);
- Noise factors, which are external variables that cannot be controlled but may impact performance;
- Control factors, which are variables that can be adjusted to influence outputs.

This representation allows teams to focus on the relationship between process inputs and outcomes, and to identify potential levers for improvement.

Figure 10 : Black box



Source : (Six Sigma, 2013)

B. SIPOC Diagram

SIPOC stands for Suppliers, Inputs, Process, Outputs, and Customers. It offers a high-level view of a process and its environment.

It is commonly used in the Define phase of DMAIC. "SIPOC is a structured tool that helps define project scope and align stakeholder understanding" (George, 2005)

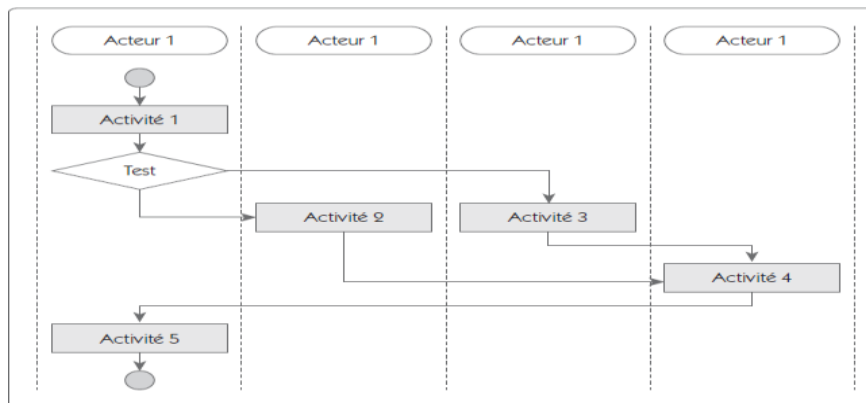
Figure 11: SIPOC Diagram

Suppliers	Inputs	Process	Outputs	Customers
<ul style="list-style-type: none"> • IT department • Systems Engineering • Marketing • Caller 	<ul style="list-style-type: none"> • Caller's ID info • Caller's location • Existing customer info (CRM) • Computer/phone equipment • New information provided by caller • Information Systems 		<ul style="list-style-type: none"> • Updated caller info • Caller problem/need details 	<ul style="list-style-type: none"> • Caller • Agent

Source : (Pyzdek, 2019)

C. Flowcharts (Logigrammes)

Figure 12: Logigramme (flowchart)



Source: (Pillet, 2013)

Flowcharts, also known as process flow diagrams, are matrix-based visual tools that represent the relationship between activities and the individuals or roles involved in a process. This type of diagrams presents a clear visualisation of the chronological sequence of steps, making it easier to understand how tasks are executed and by whom within the workflow.

As described by (Pillet, 2013) flowcharts are particularly useful for illustrating the interaction between different stakeholders and for identifying potential bottlenecks or inefficiencies in the process.

Figure 12 illustrates a flowchart that outlines a given process along with the actors involved at each stage.

4.1.3 Defining Project Boundaries:

A. The 5 Whys Technique

The 5 Whys is a root cause analysis tool used to drill down into the cause of a problem by repeatedly asking "why". Toyota first introduced this tool to ensure continuous problem solving (Liker, 2013).

B. The Project Charter

The project charter is a structured document that summarises the key outcomes of the Define phase in a Six Sigma DMAIC project. It serves as a foundational reference for the team and stakeholders by outlining the core elements of the improvement initiative.

According to (Pillet, 2013), a well-formulated project charter should include the following components:

- A clear definition of the problem to be addressed;
- The identification of Critical to Quality (CTQ) characteristics from the customer's perspective;
- A comparison between the current state and the desired state, which helps to clarify the scope and boundaries of the project;
- The formation of the project team and the commitment of key stakeholders involved.

More than just a summary, the project charter represents a formal engagement. It commits the team not only to specific results but also to deadlines and performance expectations. It is a reference point for tracking progress and ensuring accountability throughout the project lifecycle.

4.2 Phase : Measure

The Measure phase represents the second step in the Six Sigma DMAIC methodology. Its main objective is to collect reliable and relevant data in order to accurately quantify the current performance of the process and to develop a deeper understanding of how the process functions under normal operating conditions.

As stated by (Pillet, 2013) the goal of this phase is to move from subjective assumptions to objective measurements by grounding all future decisions in solid and validated data. The collected data serves as a basis for identifying the root causes of the problem and determining the potential for improvement.

More specifically, this phase aims to:

- Identifying and validating a measurement system for the Critical to Quality (CTQ) characteristics;
- Evaluating the process sigma level (z-score) to quantify its current capability in meeting customer requirements;
- Conducting a measurement campaign to establish the relationship between input variables (X) and output variables (Y) of the process. This relationship is essential to identify the factors that significantly impact process performance and customer satisfaction.

This structured approach ensures that all subsequent analysis and improvements are based on accurate and statistically sound data, which is a cornerstone of the Six Sigma philosophy.

4.2.1 Phase Flow:

Once the project is approved by the project team, the team moves on to the measurement phase, during which they collect data on the problem, when they primarily use data collection tools, process mapping, execution charts, etc. This phase is divided into three actions:

A. Measurement System Analysis (MSA)

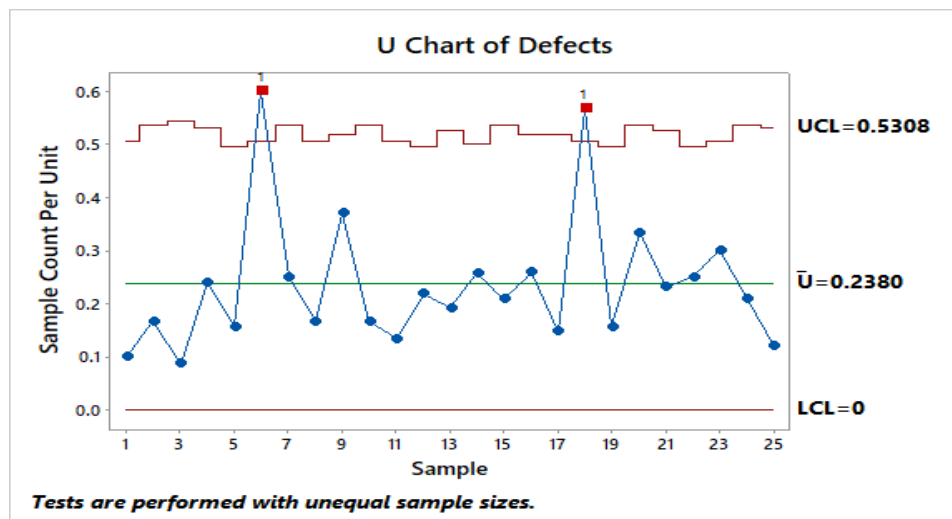
Within the Measure phase of Six Sigma, a key objective is to ensure that the measurement system accurately captures the customer's perception of quality. This involves implementing a reliable process to assess Critical to Quality (CTQ) characteristics. Measurement is itself one of the potential sources of process variability, and must therefore be treated as a process with its own sources of variation commonly described by its own 5Ms: Method, Machine, Medium, Measurement Item, and Manpower. As such, the performance of the measurement system must be thoroughly evaluated and validated before relying on its results for further analysis.

B. Control Charts

According to (Hennion, 2017) a control chart is a graphical tool used to monitor a time series, where the vertical axis (Y) represents the measurement of interest and the horizontal axis (X) corresponds to time or a temporal factor. It includes three statistically derived lines: the centerline (mean or \bar{X}), the upper control limit (UCL), and the lower control limit (LCL). These control limits are calculated from the process data itself, making them reflective of the Voice of the Process (VOP) rather than customer-defined specifications (Voice of the Customer, VOC).

When data points fall outside the control limits, or when non-random trends and patterns emerge, it signals the presence of special cause variation. Identifying and addressing these specific causes is essential to restoring process stability.

Figure 13: an example of a control chart



Source: ('What Is a Control Chart?')

C. Process Capability

Process capability is a key concept in the Measure phase of the Six Sigma methodology. It evaluates whether a process can consistently produce outputs that meet specified quality standards.

According to (Pyzdek & Keller, 2024), capability is the ability of a process to meet specifications and continuously achieve the desired quality level. We calculated the “Cp” index using the ratio of the specification range to the process variation:

$$\text{Where: } Cp = \frac{USL - LSL}{6\sigma}$$

- USL = Upper Specification Limit
- LSL = Lower Specification Limit
- σ = Standard deviation of the process

A capable process has a variation that fits well within the customer-defined limits, indicating that the process is both stable and predictable.

As highlighted by (Hennion, 2017), capability is the ratio between the actual performance of a process and the required performance. It is closely linked to the sigma level; the higher the sigma level, the better the performance. A Six Sigma process typically aims for fewer than 3.4 defects per million opportunities (DPMO).

Two commonly used indicators are:

- **Cp**: Measures potential capability assuming the process is centered.
- **Cpk**: Measures actual capability, taking into account the centering of the process.

$$C_p = \min \left(\frac{X - LSL}{3\sigma}, \frac{USL - X}{3\sigma} \right)$$

Where X is the process mean. additional indicators such as Pp and Ppk are also used to assess long-term capability. These metrics help to identify dispersion and misalignment in the process, often linked to poor settings or inherent variability.

4.3 Phase : Analyse

The Analyse phase in the DMAIC methodology is designed to interpret and give meaning to the data collected during the Measure. It helps identify the root causes of defects, delays, waste, or customer dissatisfaction.

According to (Pillet, 2013), it aims to reduce data complexity, validate hypotheses, and establish cause-and-effect relationships within the process. The team must rely on facts and data to determine why undesirable outcomes occur and to confirm the key process inputs influencing the output.

In Six Sigma logic, the output (Y) of a process is considered a function of its inputs (X). This is mathematically expressed as:

$$Y = f(X_1, X_2, X_3, \dots, X_n)$$

Where:

- **Y** is the dependent variable or output (Critical to Quality),
- **X_i** represents independent input variables or factors influencing the process.

The objective is to identify the significant X variables that most impact Y, thereby enabling targeted improvements in the process.

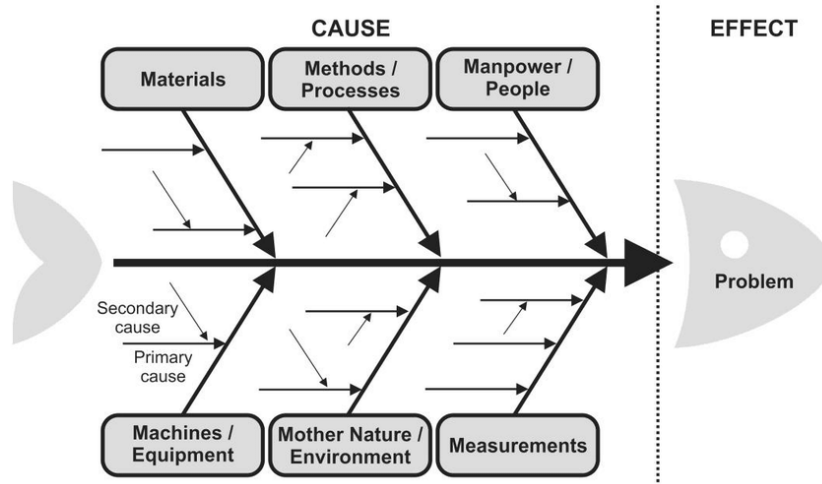
A variety of analytical tools can be effectively employed during the Analyse phase to identify root causes and validate process inefficiencies:

A. Ishikawa Diagram (Cause-and-Effect Diagram)

Also known as the fishbone diagram, it categorises potential causes of a problem under headers such as Methods, Machines, People, and Materials.

"It is widely used to visualize and analyse the potential causes of an issue" (George, 2005).

Figure 14: A generic representation of the Ishikawa diagram aka Fishbone diagram



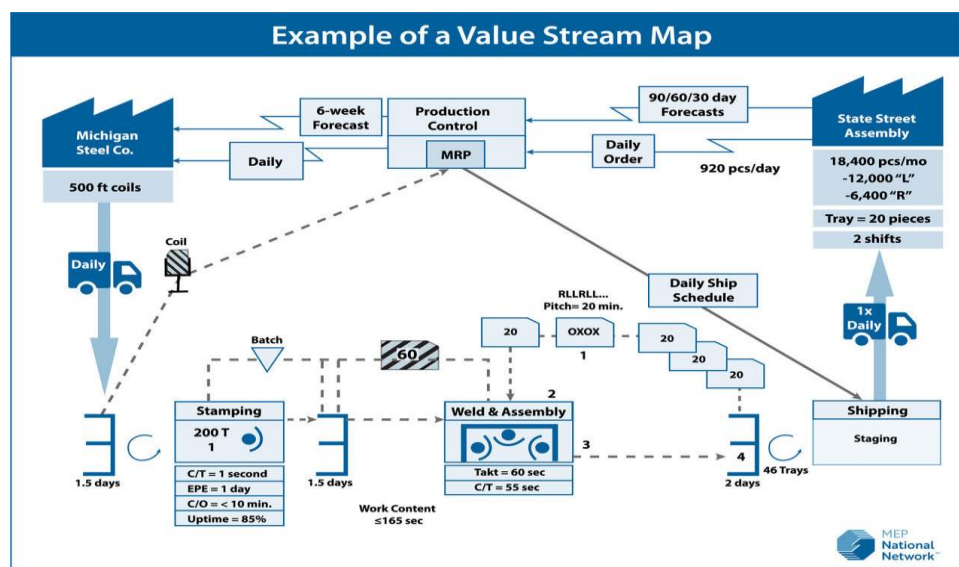
Source : (Figure 1. A Generic Representation of the Ishikawa Diagram Aka Fishbone..., n.d.)

B. Value Stream Mapping

Value stream mapping is a Lean tool that visualises the flow of materials and information in a process.

"It helps identify value-added and non-value-added activities" (Rother & Shook, 2018).

Figure 15: Example of a Value Stream Mapping



Source: ('Value Stream Mapping', 2022)

4.4 Phase : Improve

If the analyse phase has been conducted thoroughly, the Improve phase of DMAIC can proceed quickly and effectively.

The primary objective of the Improve phase is to develop and implement an appropriate solution to the problem identified in the previous phases. This typically involves three key steps:

- Brainstorming, which aims to generate ideas capable of resolving the issue;
- Pilot testing the proposed solutions;
- Evaluating the results of the implemented actions to ensure effectiveness.

The tools commonly used during this phase include solution matrices, which align brainstormed ideas with customer requirements and project objectives, as well as implementation planning methods that facilitate the deployment of selected improvements (Pillet, 2013).

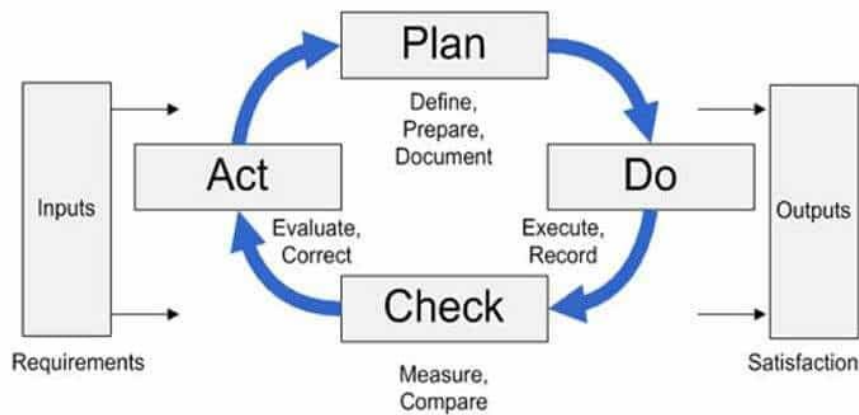
A. Action Plan

Action plans are designed to formalise the necessary tasks and responsibilities required to achieve the company's annual quality objectives. Their primary focus is to schedule the required actions by clearly answering the question: "Who does what, and by when?" These plans may also include the tools and resources essential for successful implementation.

They are typically summarised in a document that outlines the allocated resources, specific tasks, and the monitoring of actions (Gillet-Goinard & Seno, 2020).

B. PDCA Cycle (Plan, Do, Check, Act)

A continuous improvement model that encourages iterative problem solving. Deming popularised it as a key quality management principle: "*It provides a disciplined approach for process enhancement*" (Deming, 2000).

Figure 16: PDCA (Plan Do Check Act) Cycles refers

Source : (Anderson, 2021)

4.5 Phase: Control

Once the process has been improved during the Improve phase, it becomes essential to implement all necessary measures to ensure these improvements are sustained over time and that the process does not regress. The primary objective of the Control phase is to establish a framework that keeps the process under control

The most commonly used tool at this stage is the control chart, which allows continuous monitoring and detection of deviations (Pillet, 2013); (Hennion, 2017) .

DMAIC is a data-driven methodology that aims at improving, optimising, and stabilising processes and their design. It constitutes the core foundation of any Lean Six Sigma initiative. The five DMAIC phases follow a logical sequence. Before implementing this method, it is crucial to select the most relevant improvement candidates, verify the availability and consistency of data for informed decision-making, and ensure that the return on investment is justified (Hennion, 2017) .

5 Transport Management as a Strategic Function in the Supply Chain

Transport management is a critical component of the supply chain that focuses on planning, implementing, and controlling the movement of goods from one location to another. Its primary objective is to ensure timely, cost-effective, and efficient transportation while maintaining service quality. According to (Bowersox et al., 2013) , transportation represents the largest component of logistics costs, often accounting for more than 50% of total logistics expenditures. Therefore, effective transport management has a direct impact on customer satisfaction and supply chain performance.

Several authors highlighted the strategic importance of transport planning. For instance, (Christopher, 2016) emphasises that transportation should not be seen merely as a cost centre, but as a value-adding process that can improve responsiveness and flexibility within the supply chain. Similarly, (Fawcett et al., 2007) underlines the need for integrating transportation decisions into overall logistics strategies, considering factors such as mode selection, route optimization, carrier performance, and environmental impact.

Advanced transport management systems (TMS) have further enhanced the ability of companies to manage transportation dynamically. These systems provide tools for shipment planning, freight auditing, real-time tracking, and analytics, which allow firms to optimise routes, reduce transit times, and manage risks effectively (Rushton et al., 2017).

In summary, transportation management is a vital function that contributes to cost reduction, service level improvement, and overall supply chain efficiency. It requires coordination between various actors, including shippers, carriers, and customers, and must align with broader logistics and business objectives.

6 Logistics Service Provider (LSP) Management: Coordinating Outsourced Logistics for Competitive Advantage

Managing logistics service providers (LSPs) is a strategic component of modern supply chain management. It involves the selection, coordination, and performance evaluation of external partners who handle functions such as transportation, warehousing, inventory control, and distribution. As logistics outsourcing becomes more common, organisations rely on LSPs not just for operational efficiency, but also for agility, scalability, and access to specialised expertise (Langley, C. J. & Capgemini, 2016).

According to (Murphy & Knemeyer, 2018), managing LSPs requires establishing clear service level agreements (SLAs), monitoring key performance indicators (KPIs), and fostering strong collaboration through communication and trust. The alignment of LSP capabilities with organizational goals is essential for achieving supply chain integration and responsiveness. Effective LSP management also involves risk sharing, innovation partnerships, and continuous improvement.

(Christopher, 2016) argues that companies should treat their LSPs as strategic partners rather than transactional vendors. This shift from a cost-based to a value-based perspective enables long-term relationships that contribute to resilience and customer satisfaction.

Moreover, the integration of digital platforms and real-time data sharing has transformed how companies monitor and manage third-party logistics operations.

In conclusion, LSP management is not just about outsourcing logistics functions, but about building high-performance partnerships that enhance service quality, reduce costs, and increase supply chain competitiveness.

Chapter 03:

Methodological Framework

This chapter outlines the research approach adopted to conduct this study, detailing the methods used for data collection and the analytical tools employed. Based on insights from the literature review, a mixed-methods approach was chosen, combining both qualitative and quantitative methods for their synergistic ability to capture diverse dimensions of the data within the Lean Six Sigma DMAIC framework as it was adopted in most of the presented works. This methodology allows for a comprehensive understanding of the research problem by integrating statistical analysis with contextual insights.

The section also highlights the complementary nature of these approaches, describes the types of data examined for each, and specifies the tools used for their analysis.

1 Qualitative approach

This section presents the tools and methods used to collect qualitative data, as well as the techniques applied to analyse and interpret it.

1.1 Qualitative data collection methods and tools

Qualitative data can be collected through a variety of tools and methods. In this study, and in alignment with the data requirements of the DMAIC approach, particularly those relevant to the “Define” phase, we used appropriate techniques to gather the necessary information.

1.1.1 Documentary analysis

As part of our internship, we were granted access to the company's internal documentation, allowing us to conduct a detailed analysis of several key resources. This included contracts with transportation service providers, process mapping documents, and formalised operational procedures. These documents were essential in helping us understand the current state of the transport and communication processes, as well as identifying areas for improvement in alignment with the DMAIC “Define” and “Measure” phases.

1.1.2 Semi-structured interview

To collect data, we had also conducted semi-structured interviews with warehouse operators, specifically those who were in charge of the delivery process and had direct contact with transportation providers over the past four months. The objective was to gain deeper insights into the criteria and methods used for selecting providers, as well as the key considerations involved in this decision-making process. The average duration of each

interview was approximately 12 minutes. A summary of the interview details is provided in the table below. The full interview guide is available in “Appendix 01”.

Table 06: The interviewees list

The interviewed	Duration	Role
OUAHIB.W	10 minutes	Shipping operator February 15th - March 15th
HADJADJ.M	13 minutes	Shipping operator January 15th - February 15th
SID AZARA.N	14 minutes	Shipping operator April 15th - May 15th
DJAITH.N	9 minutes	Shipping operator March 15th - February 15th

Source: Prepared by the authors

1.1.3 Focus groups

To define the core issues during the Define phase of the DMAIC methodology, focus group sessions were conducted to explore the main challenges affecting the transport and communication process with service providers. These sessions brought together warehouse operators, the warehouse manager, and process supervisors to reflect collectively on operational difficulties. The objective was to establish a shared understanding of the recurring problems within the current process.

The discussions were open in nature and guided by broad, open-ended questions, encouraging participants to express their perspectives freely. Key themes and recurring issues that emerged during the sessions were documented for deeper analysis in the subsequent phases.

1.1.4 Brainstorming

In the Improve phase of the DMAIC cycle, brainstorming sessions were held to find practical solutions to the problems identified earlier. These sessions involved the same participants from the focus groups, including warehouse staff and supervisors, who were familiar with the daily challenges. The goal was to generate ideas for improving the selection of transport providers, reducing delivery issues, and strengthening communication with external partners. Everyone was encouraged to share suggestions freely, and all ideas were noted down

1.1.5 Stakeholder Meeting Participation

As part of the data validation and solution development process, we took part in a formal meeting between one of the transportation providers and the warehouse manager, along with other key personnel. The purpose of this meeting was to present some of the findings and data gathered during the earlier phases of the project. This interaction allowed us to share key points from our analysis and support our observations with concrete examples.

The provider's responses and the discussion that followed gave us valuable insights that supported the refinement of our understanding during the Define and Measure phases and contributed to shaping practical solutions in the Improve phase. This exchange also helped align internal perspectives with those of external partners.

1.2 Qualitative data analysis methods and tools

After collecting the needed quantitative data for our research, we used the following methods and tools to analyse it, which led us to get to a well-organised structure that helped us build our future analysis.

1.2.1 Thematic analysis

To analyse the qualitative data, thematic analysis was used across multiple sources, including brainstorming sessions, stakeholder meetings, provider contracts, and internal process documentation. This method allowed us to systematically identify recurring ideas, patterns, and key themes related to decision-making, communication practices, and operational challenges.

The data was organised into meaningful categories to better understand the context and structure of the transport and communication processes. Applying thematic analysis of both verbal and written data ensured consistency and depth in the qualitative evaluation carried out during the Define, Measure, and Improve phases of the DMAIC cycle.

1.2.2 5W1H

The 5W1H method (short for Who, What, When, Where, Why, and How) was used in the Define phase to better understand and structure the problem we were addressing. This tool helped us ask the right questions about the situation with transport and communication processes: who is involved, what is happening, when and where the problems occur, why they happen, and how they are currently handled. Using this approach gave us a clearer view of the overall context and helped us describe the problem in a more detailed and organised

way. It also made it easier to explain the issue to the different stakeholders involved in the project.

1.2.3 Cause-and-Effect (Ishikawa/Fishbone) Diagram

At the start of the Measure phase, we used a cause-and-effect diagram, also known as the Ishikawa or fishbone diagram, to help identify and organise the possible causes behind the problems observed in the transport and communication processes.

This tool allowed us to group causes into key categories such as People, Methods, Machines, Materials, and Environment. By visually mapping out the potential root causes, it became easier to see how different factors might be contributing to delivery delays, provider mismatches, and communication breakdowns. This structured analysis helped guide the data collection that followed and ensured we focused on the most relevant areas.

1.2.4 NVivo

To help us make sense of the interviews we conducted, we used “NVivo”, a software designed for analysing qualitative data like transcripts, notes, or open-ended responses. It helped us organise and code the interviews with the warehouse staff by highlighting key words, recurring ideas, and common themes.

This made it easier to spot patterns and compare the points and the followed steps raised by different participants. Using NVivo also helped us stay organised and avoid missing important details during the analysis. The matrix created through NVivo, which summarises the themes and their frequency, is included in the appendix for reference, “Appendix 02”.

2 Quantitative approach

This section presents the tools and methods used to collect quantitative data, as well as the techniques we applied to analyse and measure it to get the refined results we needed.

2.1 Quantitative data collection:

During our internship, we collected quantitative data by analysing internal documents, specifically the invoices from the past three months. These invoices provided detailed information about the transport operations carried out during that period.

The following variables were extracted from the invoices:

- Number of transport operations;
- Distance covered per shipment;

- Type and tonnage of truck used;
- Total cost per transport operation;
- Identity of the transport provider;
- Operator (warehouse staff) responsible for the selection;
- Client receiving the delivery.

This data formed the basis for measuring the current performance of the transport process and identifying potential inefficiencies.

2.2 Quantitative data analysis methods and tools

2.2.1 Power BI

To support data analysis, and mainly during the “Measure” phase, Power BI was selected as the primary visualisation and business intelligence tool.

Power BI is a Microsoft platform designed to transform raw data into meaningful insights through interactive dashboards and clear visual representations. It allows users to import, process, and visualise large volumes of data in a dynamic and accessible way. In our study, Power BI was used to organise and present the quantitative data extracted from the invoices of the past three months, and it included:

- The number of times each provider (AET and CTL) was used;
- The types of trucks employed;
- The distances covered per delivery;
- The cost of each transport operation;
- The distribution of clients served by each provider.

Power BI allowed us to filter, compare, and highlight key trends, which made it easier to identify usage patterns and cost inefficiencies between AET and CTL.

2.2.2 MiniTAB

To support statistical analysis within the DMAIC framework, Minitab was employed as a quantitative tool during the “Measure” and “Analyse” phases. Minitab facilitated the processing of operational data to identify patterns, correlations, and performance gaps in the transport process. Key functions used included descriptive statistics, Pareto charts, and histograms, which helped quantify the frequency of provider usage and visualise cost variations across different transporter types.

Additionally, process capability analysis was conducted to assess the consistency of transporter performance in terms of delivery times and compliance rates. By applying these statistical techniques, we were able to validate the root causes identified in the qualitative analysis and provide a more objective foundation for selecting improvement strategies.

Chapter 04:

Presentation and Analysis of
Results

This chapter presents the practical application of the DMAIC methodology (Define, Measure, Analyse, Improve, and Control) within the delivery process of Schneider Electric's logistics centre. The primary objective was to enhance the communication flow between the company and its transportation service providers, a critical element often overlooked in the logistics chain. By identifying inefficiencies and inconsistencies in the selection and coordination of transport resources, particularly with regard to truck type and distance, this study applies “Lean Six Sigma” tools to drive measurable improvements. Drawing on both quantitative data and field observations, the chapter outlines each phase of the DMAIC cycle, supported by real process indicators and actionable insights.

The findings aim not only to reduce logistical delays and costs but also to establish a more agile and reliable communication system ultimately reinforcing the customer satisfaction focus central to Schneider Electric's operational excellence.

1 Pre-Six Sigma Phase: Problem Selection

The Pre-Six Sigma phase precedes the DMAIC cycle and serves as a strategic exploratory step aimed at identifying, analysing, and selecting the most critical issue to be addressed through a continuous improvement project. Its purpose is to ensure that the selected project is grounded in real operational needs, as expressed through the Voice of the Customer (VOC), and aligns with criteria of urgency, feasibility, and organisational impact. This phase supports the targeted focus of improvement efforts, guaranteeing the relevance and added value of the Lean Six Sigma project to be deployed.

The key outcome of this phase is the formal selection of the Six Sigma project. This is based on a systematic evaluation process, including:

1.1 Define and Classify General Customers

1.1.1 Project Location Overview

The project was implemented at the Logistics Distribution Centre (CDL) of Schneider Electric Algeria, located in Sidi Rached, Tipaza. As outlined in Chapter One, this facility plays a strategic role in Schneider Electric's national logistics chain, serving as a central platform for the distribution of low-voltage solutions.

The site functions as an integrated logistics and production hub, bringing together storage, local assembly (particularly for medium-voltage systems), and accelerated delivery

services under a single operational framework. Its position enables optimized service coverage across key Algerian cities, including Algiers, Oran, and Constantine.

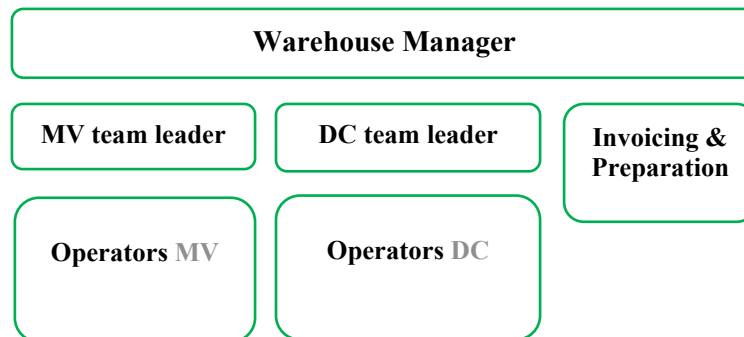
1.1.2 Department Organization Chart.

To classify and engage the relevant internal customers involved in the logistics and transport communication process, we examined the internal structure of the site. The organization chart used in this step represents a subset of the complete institutional structure already detailed in Chapter One of this thesis.

Key roles considered during this phase included:

- ❖ Warehouse Manager: responsible for overall site operations.
- ❖ Team Leaders: for the Distribution Centre and Medium Voltage (MV) units.
- ❖ Invoicing and Preparation teams: handling final-stage processing and delivery coordination.
- ❖ Operators: working across BT and MT production lines.

Figure 17 : the internal organisational mapping that's concerned with the studied process



Source: Prepared by the authors

This organisational mapping was essential for identifying the internal stakeholders most impacted by the efficiency and accuracy of logistics communication. It also helped to define the scope of the project in terms of customer involvement and process flow.

1.2 Collect and Classify the VOC (Voice of the Customer)

This phase aims to identify, group, and analyse the issues faced by internal customers of the logistics process through the Voice of the Customer (VOC). During our internship we conducted several team meetings.

After conducting these sessions in the form of brainstorming workshops and focus groups with all the concerned internal customers and synthesising their responses, we were able to clearly express and formulate the customers' needs. Table N°7 presents the four (4) identified needs along with their explanations.

Table 07 : Needs' analysis

No.	Problem Category	Problem Description
1	Transport and Communication with Carriers	Lack of communication to the client about the type of carrier
2		Some trucks do not meet required standards
3		Some drivers are unable to use GPS or locate destinations accurately
4		Absence of precise delivery time notifications
5		Weak coordination between the distribution centre, drivers, and clients
6	Delays and Claims Management	Delays in order deliveries
7		Complaints are not handled promptly (may take up to two months)
8		Missing items or components upon delivery
9		Delivered products sometimes have manufacturing defects
10	Client Relationship Issues	Clients are not provided with updated delivery/shipping information
11		Delay in responding to customer complaints
12		No clear policy or procedure for resolving complaints
13	Medium Voltage Stock Management Issues	Poor addressing system within the warehouse (no structured location labeling)

14	Difficulty in accurately locating stored items
15	High chance of order preparation errors due to internal disorganization
16	Direct negative impact on the speed and quality of order fulfilment

Source: Prepared by the authors

1.3 Prioritisation of the VOC

In order to identify the most critical issues to address within the logistics system, the Voice of Customer (VOC) was systematically analysed using three prioritisation tools.

First, the Eisenhower Matrix was applied to categorise problems based on urgency and importance. Second, a Risk Assessment Matrix was used to evaluate each issue according to its likelihood and potential impact. Finally, the ISO 13053:2011 Prioritisation Matrix was used to rank problems based on criteria critical to quality (CTQ), including importance to the customer, measurability, improvement potential, and overall impact. This structured approach ensures objective prioritisation and guides the selection of the core problem to be addressed using the Lean Six Sigma methodology

1.3.1 Priority Matrix (Eisenhower, Stephen Covey, Paul J. Meyer)

The Eisenhower Matrix is a decision-making tool that helps prioritise issues based on two key dimensions: urgency and importance. It classifies problems into four categories:

- Urgent and Important: Should be addressed immediately.
- Not Urgent but Important: Requires planning and strategic attention.
- Urgent but Not Important: Can be delegated to others.
- Not Urgent and Not Important: Can be postponed or ignored.

a. Methodology:

Each problem is evaluated using a 1–5 scale for both urgency and importance. Based on their combined scores, problems are categorised into one of the four quadrants of the matrix to determine their treatment priority.

b. Outcome:

This matrix provides a clear visual prioritisation of customer-related problems. It enables the identification of issues that are both urgent and important, which are ideal candidates for immediate action and potential

Table 08: Risk Prioritization Matrix: Application of the Eisenhower, Stephen Covey, and Paul J. Meyer Methods

	Not Urgent	Urgent	
IMPORTANT	<p>Important, but not Urgent.</p> <hr/> <hr/> <hr/> <hr/> <hr/> <hr/> <hr/> <hr/> <hr/> <hr/> <p>← 2 ← 9 ← 10 ← 11 ← 12 ← 13 ← 14</p>	<p>Urgent and Important.</p> <hr/> <hr/> <hr/> <hr/> <hr/> <hr/> <hr/> <hr/> <hr/> <hr/> <hr/> <hr/> <hr/> <hr/> <hr/> <hr/> <p>← 1 ← 3 ← 4 ← 5 ← 6 ← 7 ← 8 ← 11 ← 15 ← 16</p>	
	NOT IMPORTANT	<p>Not Urgent and Not Important.</p> <hr/> <hr/> <hr/> <hr/> <p>← ← ←</p>	<p>Urgent, but not Important.</p> <hr/> <hr/> <hr/> <hr/> <p>← ← ←</p>

Source: Prepared by the authors

c. Results

The problems identified as both urgent and important, and therefore requiring immediate attention, are: Problems 1, 3, 4, 5, 6, 7, 8, 11, 15, and 16. These issues represent critical operational challenges and are prioritized for direct intervention and improvement initiatives.

1.3.2 Risk Assessment Matrix / For Urgent and Important VOC.

Used to estimate the risk level of each issue based on:

- Likelihood
- Impact

These are placed in a matrix to identify critical issues (High Risk).

Method:

A scale of 1–5 is used for both Likelihood and Impact.

The Risk Level is calculated as: Risk Score = Likelihood × Impact

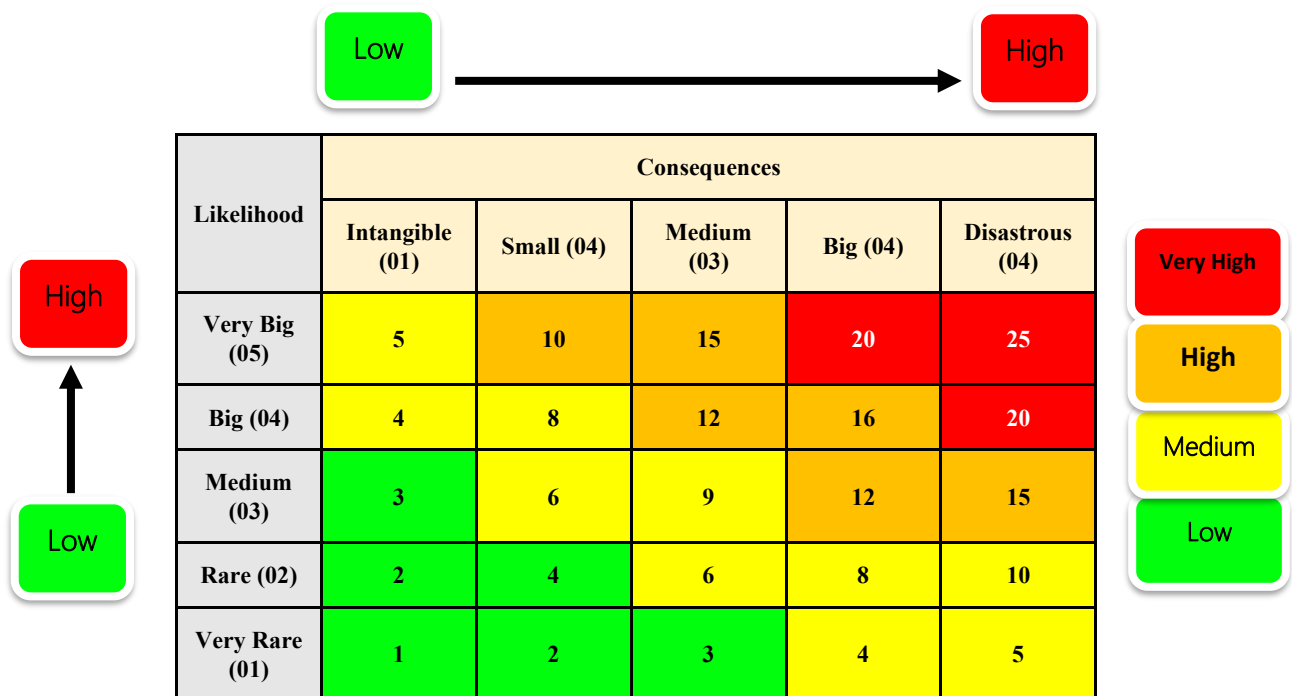


Table 09: Risk Prioritization Matrix: Risk Assessment Matrix

No.	Problem	Likelihood	Impact	Risk Score	Risk Level
1	Lack of carrier communication	5	5	25	High
3	Driver GPS issues	4	5	20	High

4	No delivery time	4	4	16	High
5	Poor coordination	5	5	25	High
6	Delays in delivery	4	5	20	High
8	Missing items	4	5	20	High
15	Order errors	4	4	16	High

Source: Prepared by the authors

Conclusion: The most critical issues are related to coordination, communication, and distribution.

1.3.3 Prioritisation Matrix as per ISO 13053:2011 for CTQ post VOC

The ISO 13053:2011 Prioritization Matrix is a decision-making tool used within the Lean Six Sigma methodology to identify the most impactful improvement opportunities derived from the Voice of the Customer (VOC).

This tool evaluates each potential project using five key criteria: customer importance, estimated project cost, likelihood of success, expected contribution to profit, and applicability to other areas of the business.

The final project score is calculated by multiplying the ratings across all five criteria, allowing for an objective and strategic ranking of improvement initiatives.

In the context of this graduation project, the matrix was applied to prioritize issues affecting transportation and communication processes within a new logistics center at Schneider Electric. It helped identify the project with the highest potential impact on operational efficiency and customer satisfaction for Lean Six Sigma implementation.

- NOTE 1: The ranks are on a 1 to 10 scale with 1 being the worst and 10 the best.
- NOTE 2: The value in column (F) is the product of the ranks in columns (A) to (E)
- NOTE 3: The project order in column (G) is the ranking of the values in column (F)

A- Customer Importance, project will solve the for the customer (Kano Model)									
1	2	3	4	5	6	7	8	9	10
Delighters / Exciters		Satisfiers / Performance				Must Be / Basic			

(C) Likelihood of success									
1	2	3	4	5	6	7	8	9	10
Unachievable		Achievable		Achievable		Achievable		Achievable	
		Future		Future		Now		Now	
		With Modification		Without Modification		With Modification		Without Modification	

(E) Applicability to other areas									
1	2	3	4	5	6	7	8	9	10
01 Department	02 Department	03 Department	04 Department	05 Department	06 Department	07 Department	08 Department	09 Department	10+ Department

(D) Expected Contribution to Profit (the higher the better)	
0-1000	1
1000-2000	2
2000-3000	3
3000-4000	4
4000-5000	5
5000-6000	6
6000-7000	7
7000-8000	8
8000-9000	9
9000-10000+	10

(B) Expected Total Project Cost, Cost table (the lesser the better)	
0-1000	10
1000-2000	9
2000-3000	8
3000-4000	7
4000-5000	6
5000-6000	5
6000-7000	4
7000-8000	3
8000-9000	2
9000-10000+	1

Source : (ISO13053-1.2011, n.d.)

Table 10: Prioritisation Matrix as per ISO 13053:2011 for CTQ post VOC

ISO 13053:2011								
Six Sigma Projects		(A) Customer Importance	(B) Expected Total Project Cost	(C) Likelihood of Success	(D) Expected Contribution to Profit	(E) Applicability to other areas	(F) Project Priority number	(G) Project Order
5	Poor coordination	10	8	6	8	8	30,720	1st
1	Lack of carrier communication	10	8	6	8	7	26,880	2nd
6	Delays in delivery	9	8	6	8	7	24,192	3rd
3	Driver GPS issues	9	7	6	7	6	15,876	4th
8	Missing items	9	7	6	7	6	15,876	4th
4	No delivery time	8	7	6	6	6	12,096	6th
15	Order errors	8	7	6	6	6	12,096	6th

Source: Prepared by the authors

According to the ISO 13053:2011 prioritization matrix, the project with the highest strategic and operational value is:

"Poor coordination between distribution centre, drivers, and clients", scoring 30,720 points, and ranking 1st in overall priority.

This confirms its suitability as the main Six Sigma project for this final-year thesis, aiming to optimize communication and transport processes in Schneider Electric’s logistics operations.

2 DEFINE

The “Define” phase is the first step of the DMAIC approach. This one mainly includes the identification of the problem, it also identifies the customer of the project so that the objectives can be appropriately set, along with the project scope and the necessary resources for its implementation: These resources include the project team and the other costs incurred throughout the project. A good estimation of these costs allowed us to critically assess the project’s potentials.

As we begin the Define phase, we build on the results of the initial pre-Six Sigma analysis, which helped us better understand the main problems affecting logistics operations at Schneider Electric. This early investigation highlighted several recurring issues that impact the efficiency and quality of the delivery process. These include slow and delayed communication with transport providers, often causing longer delivery times; frequent mistakes in transport orders due to missing or unclear information; and limited tracking tools that make it difficult to follow shipments in real time. In addition, poor coordination between internal teams leads to disorganised information sharing, and transport providers often fail to send timely updates or confirmations about deliveries. These problems are the starting point for this phase, where we aim to clearly define the project's goals and focus on improving communication and coordination with transport providers to make deliveries more reliable, efficient, and cost-effective.

As a result of the phase, we’ll have the project charter, which will present the project’s goal, the stakeholders, the objectives and all the other needed information so that we could move on to the next phase.

2.1 Process Mapping definition

To clearly frame the project and gain a solid understanding of the current situation, a detailed process mapping was conducted during the “Define” phase. This mapping outlines the main activities, key stakeholders, and information flows involved in transport and communication operations at Schneider Electric’s logistics centre. It provides a crucial foundation for identifying weaknesses in the existing process, setting improvement priorities, and ensuring that the project remains aligned with the expectations and needs of all stakeholders.

2.1.1 SIPOC Diagram

Based on the interviews and the documentary analysis, we were able to make the SIPOC diagram for the delivery process in the company, and it helped us to clearly identify the key stakeholders and elements involved. It outlines the suppliers, inputs, main process steps, expected outputs, and the internal and external customers impacted by the process. Figure N illustrates the different components of the studied process's SIPOC, from invoice verification to delivery confirmation, covering steps such as customer notification, transport request, and goods handover.

Table 11: SIPOC diagram for the delivery process in SEA

Supplier	inputs	process	outputs	Customer
Billing function	invoices	Identify transport needs (volume, destination, nature of goods).	transport requirement specification	Transport coordinator
Transport coordinator	transport requirement specification	Evaluate fitting transport providers based on cost, availability, and vehicle suitability.	Shortlist of suitable providers	Transport coordinator
Transport coordinator	Shortlist of suitable providers	Contact the selected provider to confirm vehicle availability.	vehicle availability confirmed	Transport coordinator
Transport provider	Vehicle availability info	Inform the client and confirm whether the vehicle type is acceptable for their location	Client feedback on vehicle	Transport coordinator / Client
Transport coordinator / Client	Confirmation from client and shipment documents	Confirm the shipment with the transport provider (vehicle, time, documents).	Shipment booking confirmation	Transport provider
Transport coordinator	Shipment confirmation	Confirm the shipment date with the client and share expected delivery details.	Delivery schedule and details shared	Client/transport coordinator
transport coordinator	Final shipment plan	Notify internal teams (warehouse, billing...) of confirmed shipment.	Internal teams informed	warehouse operators

Source: Prepared by the authors

Line 1: The process begins with analysing the shipping requirements. This involves checking the volume of goods to be shipped, their destination, and any special characteristics (for example: fragile, temperature-sensitive...).

Line 2: Once the shipment needs are defined, available transport providers are assessed. The evaluation considers factors such as transportation cost, provider availability, and whether the vehicles offered are suitable for the type and size of goods.

Line 3: After identifying the best-suited provider, the transport coordinator contacts them to confirm if a vehicle is available for the required date and time.

Line 4: Once the provider's availability is confirmed, the client is informed of the transport details, including the vehicle type. This step ensures the client's location can accommodate the vehicle (for example, access restrictions) and that the arrangement meets their expectations.

Line 5: With the client's approval, the shipment is officially confirmed with the transport provider.

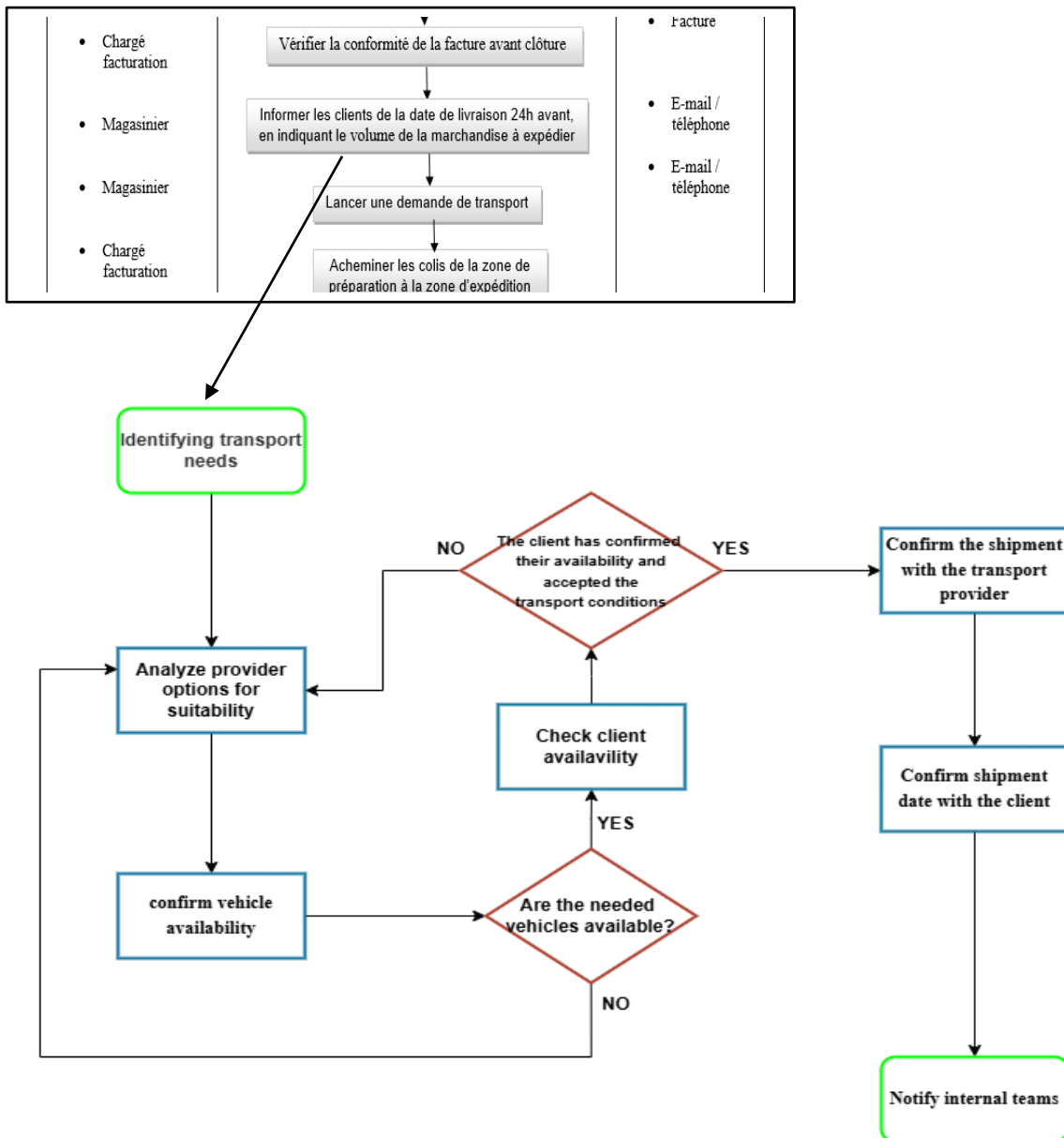
Line 6: The finalised shipment plan is communicated to the client, including the confirmed date and estimated time of delivery.

Line 7: Internal stakeholders such as the warehouse team and billing department are informed of the confirmed shipment schedule. This allows them to coordinate their tasks, such as preparing goods for dispatch and issuing final invoices, ensuring a smooth shipping process.

2.1.2 Current State Flowchart

In addition to the SIPOC, a flowchart (process flow diagram) was made to visualise the actual steps and decision points.

Figure 18: Logigram flowchart for the studied process



Source: Prepared by the authors

2.2 Critical To Quality (CTQ)

Following the process mapping and the development of the SIPOC diagram, the next step involves identifying the Critical-to-Quality (CTQ) elements. These elements represent the essential, measurable aspects of a process or service that directly influence customer satisfaction and operational efficiency. In the case of Schneider Electric’s logistics centre, the CTQs were determined by combining insights from the Voice of the Customer (VOC) with findings from the analysis of the current delivery and communication workflow.

2.2.1 CTQ Definition and Purpose

CTQs translate customer requirements into measurable criteria, that can guide process improvement efforts. Identifying these elements ensures that the project targets what truly matters to internal and external stakeholders. CTQs also serve as benchmarks for evaluating the success of the improvement initiative.

2.2.2 CTQ Identification methods

The CTQ elements were identified using two main data sources:

- ✚ Interviews and process observation: Insights gathered during interviews with warehouse operators, billing officers, and logistics planners helped highlight the recurring pain points in the current process.
- ✚ Process analysis (SIPOC and flowchart): These tools helped reveal where delays, errors, or miscommunications were most likely to occur, thus indicating which aspects were most critical to control.

2.2.3 Identified CTQ Elements

Based on this analysis, the following CTQs were defined:

Table 12: CTQs of the studied process

CTQ Element	Problem Detected	Target Objective
Carrier Communication Accuracy	Customers not informed of the type of carrier or changes in delivery schedule	Ensure 100% of shipments include pre-notification
Delivery Time Notification	Lack of precise delivery time shared with clients	Provide delivery time at least 24h in advance
Driver Location Competency	Some drivers unable to locate destination due to lack of GPS or poor instructions	100% of drivers equipped and informed properly
Order Preparation and Dispatch Errors	Errors due to internal disorganization or missing items during shipment	Reduce preparation errors to below 2%
Feedback Delay on Complaints	Complaints take up to two months to process	Respond to 90% of complaints within 5 working days
Coordination with Carriers and DC	Weak coordination between the distribution centre, drivers, and clients	Improve coordination and reduce missed communications by 50%

Source: Prepared by the authors

2.3 Problem Definition

In this section, the project scope is clarified using the 5W1H (Who, What, When, Where, Why, How) method. This structured approach allowed us to frame the root problem observed in the delivery and transport coordination process.

The table below summarizes the key elements of the problem:

Table 13: Problem Definition Based on the 5W1H Method

Question	Answer
Who?	The logistics centre team at Schneider Electric and external transport providers.
What?	There is no standardized process for selecting transport providers or matching the appropriate type of vehicle to the volume of goods, resulting in inefficiencies and increased transportation costs.
When?	The issue is ongoing and is mainly observed during the delivery phase of operations.
Where?	At Schneider Electric's logistics centre, specifically within the transport management and dispatching process.
Why?	Due to the absence of structured selection criteria and limited communication during provider selection and truck allocation, which leads to frequent mismatches and cost overruns.
How?	Deliveries are currently managed through non-standardized decision-making, often involving oversized vehicles or high-cost providers, without alignment to the actual shipment volume or delivery requirements.

Source: Prepared by the authors

2.4 Project Charter

Based on the information we collected, we prepared the following project charter that outlines the main points of our DMAIC project.

SIX SIGMA PROJECT CHARTER



GENERAL PROJECT INFORMATION

PROJECT NAME	PROJECT TEAM
Optimization of Transportation Service Performance Using the Lean Six Sigma Approach at Schneider Electric	M. Meriem S. Abdelkader Ishak

EMAIL	PHONE	ORGANIZATIONAL UNIT
Meriem.mssw@gmail.com sellafabdelkaderishak@gmail.com	0795191090 0790002068	Logistics Center

GREEN BELTS ASSIGNED	EXPECTED START DATE	EXPECTED COMPLETION DATE
BELKACEM Aziz	23/03/2025	15/05/2025

PROJECT OVERVIEW

PROBLEM STATEMENT	The current transport process at the logistics center is affected by inefficient vehicle allocation, inadequate customer communication, and frequent delivery delays, impacting approximately 30% of shipments monthly. These issues largely stem from poor coordination between internal logistics teams and third-party transport providers, as well as fragmented communication systems. Consequently, the company incurs increased logistics costs (estimated to rise by 12% annually), experiences a decline in customer satisfaction, and suffers from reduced control over delivery operations.
PURPOSE OF PROJECT	The purpose of this project is to optimize the transport and customer communication process within Schneider Electric's logistics centre by applying the Lean Six Sigma methodology. The goal is to reduce delivery delays, improve vehicle allocation efficiency, and enhance customer communication, thereby decreasing logistics costs and increasing overall customer satisfaction.

PROJECT OVERVIEW *continued*

BUSINESS CASE	The delivery process at Schneider Electric’s logistics center lacks a standardised system for transportation provider selection and truck allocation. This has led to inefficient use of high-cost providers, truck mismatches, and excessive transport costs. Optimizing these processes will reduce costs, increase service efficiency, and improve transparency in decision-making.
GOAL STATEMENT	The improvement initiative aims to reduce overall transport costs by at least 15% through the implementation of a standardized provider selection process. In parallel, the project seeks to lower the truck mismatch rate by 25%, ensuring better alignment between vehicle capacity and shipment volume. Enhancing on-time delivery performance is also a key objective, to be achieved by applying predefined selection criteria for both transport providers and truck types. Ultimately, the project will deliver a documented and repeatable process for transport coordination by the end of the implementation phase.
EXPECTED DELIVERABLES	The expected deliverables of this project include a clear mapping of the current transport and communication process, an analysis of the main problems causing delays, and reliable data to support decision-making. The project will also provide an improved process model, a plan to reduce costs and improve customer satisfaction, and a set of performance indicators to monitor results. Finally, a full project report and a presentation will be delivered to summarize all the work done.

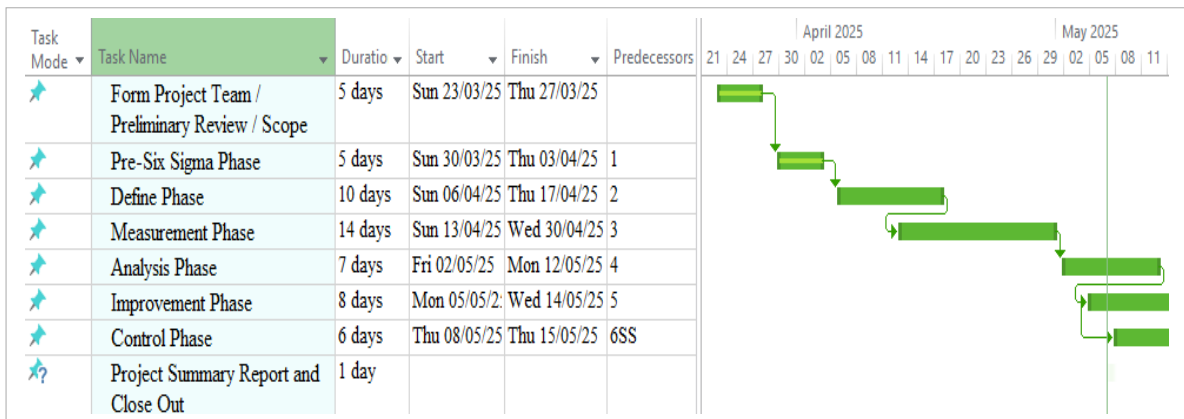
PROJECT SCOPE

IN SCOPE	<ul style="list-style-type: none"> ➤ Provider performance analysis ➤ Cost tracking and optimization ➤ Truck type matching ➤ Communication and process flow improvement
OUT OF SCOPE	<ul style="list-style-type: none"> ➤ Provider negotiation strategy ➤ Warehouse internal processes ➤ Upstream supply chain

TOOLS:

PRE-SIX SIGMA PHASE	Brainstorming ;focus groups ;Priority Matrix Eisenhower ;Risk Assessment Matrix ; Prioritisation Matrix as per ISO 13053:2011 for CTQ post VOC
DEFINE	SIPOC Diagram ; Current State Flowchart ; 5W1H ; project charter
MEASURE	Microsoft Power BI and Excel ; Minitab ; Box Plot ;MSA ; Capability Graph
ANALYSE	VSM, Process capability, Ishikawa, 5Whys
IMPROVE	Excel/Power BI ; Action plan ; Brainstorming ; PDCA ; Risk analysis
CONTROL	Power BI

TENTATIVE SCHEDULE



3. MEASURE

Following the “Define” phase, in which the main issue was identified as a lack of coordination between transport providers during the delivery process, the “Measure” phase focuses on assessing the current state of this system through a structured and data driven approach. The goal at this stage is to examine how the coordination gap influences key operational factors such as cost management, efficiency, and decision-making. To support this analysis, two complementary tools were used: Power BI, for visualizing and organizing the data, and Minitab, for conducting statistical evaluations. Together, they provided the analytical foundation for understanding the process in measurable terms and preparing for the next stages in our DMAIC structured plan.

3.1 Data Collection Methodology

3.1.1 Data Source

The data used for this phase was obtained from transport invoices covering a three-month period. These documents provided detailed operational records for each delivery carried out by external transport providers during that timeframe.

3.1.2 Data Preparation and Organization

Once the data was extracted, it was cleaned and structured using Microsoft Excel. Redundant and incomplete entries were removed, and all values were standardised for consistency. To support performance analysis, a key metric was calculated:

- **Cost per tonne-kilometre**, obtained by dividing the transport cost by the product of the distance and the truck’s capacity.

This indicator was used throughout the Measure phase to evaluate cost efficiency across different providers and transport configurations.

Table 14: Types of Data Collected

Data Type	Description
Transport Provider	The company assigned to carry out the shipment (e.g., CTL, AET)
Distance (km)	Distance travelled per delivery, as indicated on the invoice
Truck Tonnage (tn)	Capacity of the vehicle used for transport
Transport Cost (DA)	Total cost charged for the shipment
Cost per tonne-km	Performance indicator used to normalize cost
Operator	Warehouse staff member responsible for selecting the provider

Source: Prepared by the authors

3.1.3 Sample Size

This study is based on a dataset of 264 transport operations recorded over a three-month period. The sample was not arbitrarily selected but rather reflects the full set of available and relevant data within the defined timeframe. A sample of this size is statistically sufficient for performing comparative and inferential analyses, particularly for techniques such as ANOVA and MANOVA, which typically require a minimum of 30 observations per group to ensure validity and reliability of the results.

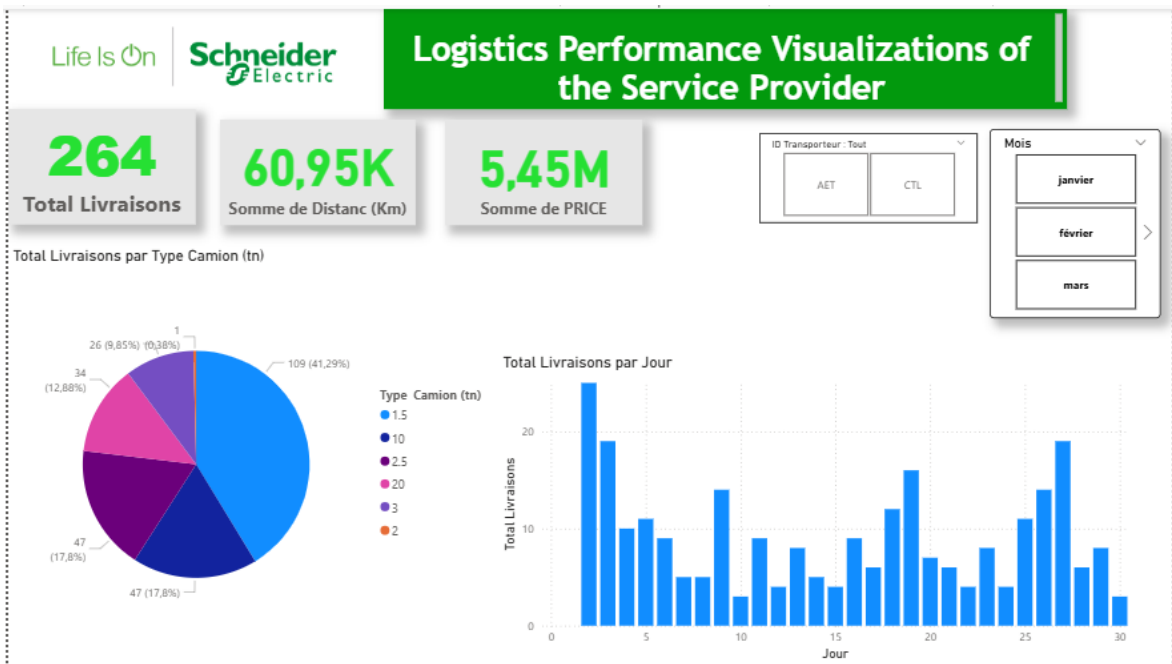
3.2 Data Visualization

To support the analysis carried out in the Measure phase, a dashboard was developed using Microsoft Power BI in order to transform raw transport data into clear, structured, and interactive visual insights. The goal of this visualization step was twofold: first, to obtain an overview of operational activity during the observed period, and second, to identify patterns related to delivery frequency, transporter usage, truck types, and invoice behaviour without disclosing any sensitive numerical values. These visual tools also helped in selecting the most relevant time periods for deeper statistical analysis and measuring fluctuations that might relate to cost efficiency.

3.2.1 Key Visual Elements and Extracted Metrics

Each visual component contributed to the measurement process by providing a specific data output:

Figure 19: Visualisation of the service providers' performance



Source: Prepared by the authors

Table 15: Key Visual Elements and Extracted Metrics

Visualisation	Extracted Metric	Use in Subsequent Analysis
KPI Cards	- 264 total deliveries- 60.95K km covered- 5.45M total cost (anonymised)	Used as baseline references for workload and cost volume
Pie Chart (Truck Types)	% share of each truck type used	Assess alignment between truck capacity and load volume
Column Chart (Daily Ops)	Number of deliveries per day	Identify consistent vs. irregular days for sampling
Slicers (Month/Provider)	Filtered metrics by month and transporter	Compare performance trends by period and provider

Source: Prepared by the authors

These metrics served to define the scope and focus of statistical tests in the next steps particularly for identifying sources of cost variation, evaluating provider efficiency, and isolating stable timeframes for capability analysis.

3.3 Statistical Validation of the Process

3.3.1 Measurement System Analysis (MSA)

To ensure the reliability of the measurements used in the statistical evaluation of the transport process, a Measurement System Analysis (MSA) was performed. This analysis aimed to determine whether the observed variation in transport cost originated from the process itself or from inconsistencies in the measurement system.

A. Method Used: Gage R&R (ANOVA Method)

Due to the nature of the available data, the ANOVA-based Gage R&R method was applied, evaluating two main sources of variability:

- Repeatability (within-operator consistency);
- Reproducibility (between-operator and transporter consistency).

The study was based on:

- 15 distinct routes (ID Lien), grouping orders with similar characteristics in terms of distance and truck type.
- 2 transport providers (ID Transport) operating on each route.
- Each combination was repeated multiple times to obtain comparable cost measurements.

Table 16 : Two-Way ANOVA Results with Interaction

Source	DF	Sum of Squares	Mean square	F	P-value
Link ID	14	3,60728E+09	257662645	14,800	0,000
Transport ID	1	6,39591E+09	6395911704	367,374	0,000
Link ID *Transport ID	14	2,43737E+08	17409793	2,687	0,011
Repeatability	30	1,94344E+08	6478130		
Total	59	1,04413E+10			

Source: Prepared by the authors Minitab output "Gage R&R (ANOVA Method)"

All effects are statistically significant ($p < 0.05$), including the interaction between route and transporter, which indicates that the impact of the transporter choice depends on the delivery context (distance and truck type).

Gage R&R**Table 17: Variance Components Analysis**

Source	CompVar	% contribution (of CompVar)
R&R de l'instrumentation totale	224560692	78,90
Repeatability	6478130	2,28
Reproducibility	218082562	76,62
Transport ID	212616730	74,70
Transport ID *Link ID	5465831	1,92
Part-to-Part	60063213	21,10
Total variation	284623905	100,00

Source: Prepared by the authors Minitab output "Gage R&R (ANOVA Method)"

- The variability related to transporter selection accounts for over 75% of the total variance.
- Repeatability (i.e., internal process stability) is low, meaning the issue is not execution-related.
- Therefore, the selection of the transporter is the main source of cost variability.

Table 18 : Gage Evaluation

Source	Standard Deviation	Study Variation (6 × SD)	% Study Variation (%SV)
Total Gage R&R	14985,3	89912	88,82
Repeatability	2545,2	15271	15,09
Reproducibility	14767,6	88606	87,53
Transport ID	14581,4	87488	86,43
Transport ID*Link ID	2337,9	14027	13,86
Part-to-Part	7750,0	46500	45,94
Total variation	16870,8	101225	100,00

Source: Prepared by the authors Minitab output "Gage R&R (ANOVA Method)"

Number of Distinct Categories = 1

- The transporter selection process introduces nearly 89% of the cost variability.
- This justifies a thorough revision of the selection procedure, incorporating objective criteria such as average cost by distance and truck type.

B. MANOVA Validation

To further validate whether variability came from human decision-making or the process itself, a MANOVA test was performed on Cost per Tonne-Kilometre, using:

- Warehouse Operator (Magasinier) as a factor,
- Transport Provider as a factor.

Table 19: Effect of the Warehouse Operator (Magasinier)

Test Criterion	Statistic	DF	Numerator	Denominator	P
Wilks' Lambda	0,97809	1,333	4	238	0,258
Lawley-Hotelling	0,02240	1,333	4	238	0,258
Pillai's Trace	0,02191	1,333	4	238	0,258
Roy's Largest Root	0,02240				

Source: Prepared by the authors Minitab output "MANOVA method"

$s = 1 \quad m = 1 \quad n = 118$

- Since p-value = 0.258 > 0.05, the operator (warehouse staff in charge of selecting the carrier) does not have a statistically significant effect on the variation in transport cost per tonne-kilometre.
- Cost differences are not directly attributable to the individual making the carrier selection, at least, not in a statistically measurable way.

Table 20 : Effect of the Carrier (Transporter)

Test Criterion	Statistic	DF	Numerator	Denominator	P
Wilks' Lambda	0,74455	81,658	1	238	0,000
Lawley-Hotelling	0,34310	81,658	1	238	0,000
Pillai's Trace	0,25545	81,658	1	238	0,000
Roy's Largest Root	0,34310				

Source: Prepared by the authors Minitab output "MANOVA method"

$s = 1$ $m = -0,5$ $n = 118$

- Since $p\text{-value} = 0.000 < 0.05$, the choice of transporter has a statistically significant effect on cost per tonne-kilometre.
- The selected carrier significantly influences transport costs, regardless of the operator making the selection.

✚ Summary of the results

The Measurement System Analysis (MSA) confirmed that the major source of variability in transport costs originates not from the measurement system itself, but from the process of transporter selection. This finding is crucial for our research, as it highlights a structural weakness in the decision making process that directly impacts logistical costs. By identifying that over 75% of cost variability stems from the choice of transporter rather than from operational execution or human error the study provides strong justification for redesigning the selection criteria.

Note: A full Gage R&R study report and Minitab outputs are provided in the appendices to support this analysis (appendix 4).

3.3.2 Box Plot of Transport Costs

- Analysis of Box Plot for Transporter CTL

The box plot shown in Figure 20 provides descriptive statistics of the prices observed for transporter CTL. Key observations include:

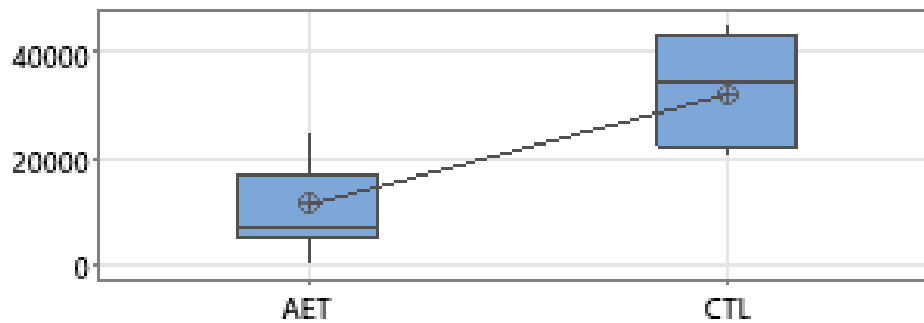
- The first quartile (Q1) is 22,000, meaning that 25% of the recorded values fall below this threshold.
- The median (second quartile) is 34,000, indicating that half of the observations are below this value.
- The third quartile (Q3) stands at 43,000, suggesting that 75% of prices are less than this amount.
- The interquartile range (IQR), representing the middle 50% of the data, is 21,000 (Q3 - Q1), indicating moderate price dispersion.
- The whiskers range from 20,000 to 45,000, showing no clear presence of outliers outside this interval.
- Total sample size: $N = 30$.

- Analysis of Box Plot for Transporter AET

Figure illustrates the price distribution for transporter AET:

- The first quartile (Q1) is 4,923.58, meaning 25% of the data falls below this point
- The median is 7,000, positioning the central value of the dataset.
- The third quartile (Q3) is 16,949.4, meaning that 75% of the values lie below this price.
- The interquartile range is approximately 12,025.8, reflecting significant variability in the central price range.
- The whiskers span from 0 to 24,856.8, with no apparent outliers beyond this scope.
- Total sample size: N = 30.

Figure 20: Price in function of transporter ID



Source: Prepared by the authors , Minitab output "Gage R&R (ANOVA Method)"

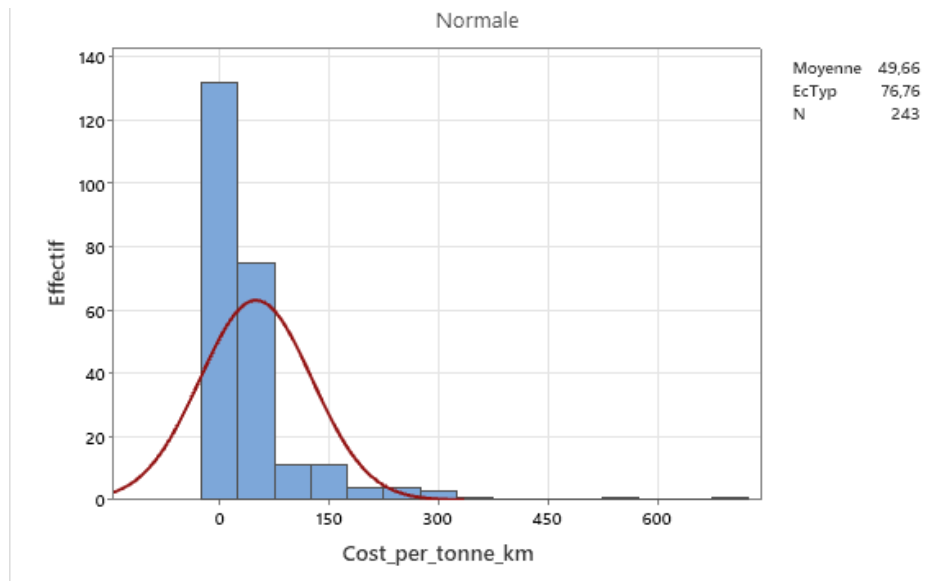
Based on the comparative box plot analysis, the transport cost distribution for the AET provider demonstrates greater consistency and a lower median. Therefore, AET's data will be used as the reference baseline for process cost optimization in the subsequent phase of this study.

3.3.3 Normal Distribution

To evaluate the stability and efficiency of the transport coordination process, a normal distribution analysis was conducted on the **cost** per tonne-kilometre, selected as the key performance indicator. This metric was chosen because it standardizes transport costs across different shipment sizes and distances, making it a reliable basis for comparing provider performance. The histogram generated from 243 observations shows a right-skewed **distribution**, with most values concentrated below 100 DA/tonne-km and a mean of 49.66. However, the presence of several outliers above 300 DA/tonne-km increases the standard deviation (**76.76**) and indicates variability in cost control. These results highlight

inefficiencies related to inconsistent vehicle allocation and provider selection, justifying the need for standardization and further capability analysis.

Figure 21: Process capability



Source: Prepared by the authors, Minitab

3.3.4 Process capability and Sigma Level Analysis

This section aims to assess the current performance level of the logistics process by analysing its capability and calculating its sigma level. The focus is placed on the **cost per tonne-kilometre**, which serves as the key performance indicator. The objective is to determine whether the process is statistically capable of operating within the company's defined expectations.

A. Indicator and Specification Limit Justification

The **cost per tonne-kilometre** was selected as the primary performance metric, as it standardizes transport cost across shipments of varying sizes and distances. It directly reflects operational efficiency in the selection and usage of transport resources.

The specification limits were defined based on historical data and boxplot analysis of the most stable provider (AET):

- **USL (Upper Specification Limit):** 59.27 cost/t·km – the maximum acceptable cost threshold.
- **LSL (Lower Specification Limit):** 6.13 cost/t·km – the minimum viable cost before compromising service quality.

These values reflect the realistic operating range observed in the company’s logistics records and were validated in collaboration with the operations team.

B. Current State of the Process

The analysis was based on a dataset of 243 transport operations. The key parameters of the process are summarized below:

Table 21: Current State of the Process

Parameter	Value
Process Mean	49.66 cost /t·km
LSL	6.13 cost /t·km
USL	59.27 cost /t·km
Standard deviation (global)	76.76
Std deviation (within)	43.18
Sample Size	243 operations

Source: Prepared by the authors, Minitab

C. Capability Indices

The capability results calculated in Minitab are as follows:

Table 22: Capability and Performance Indices

Capability Index	Global (long-term)	Within (short-term)
Cp	—	0.21
Cpk	—	0.07
Pp	0.12	—
Ppk	0.04	—

Source: Prepared by the authors, Minitab

Interpretation:

- The low **Cp** and **Pp** values (< 0.33) indicate that the process has **very poor capability**.
- The **Cpk = 0.07** confirms that the process is not centered and operates too close to the upper limit.
- The discrepancy between global and short-term indicators reveals significant process instability and variability.

D. Sigma Level and Defect Rate

Using the Defects Per Million Opportunities (DPMO) method, the performance level of the process is evaluated as follows:

Table 23 : Sigma Level

Indicator	Value
Total defect rate (PPM)	209,876 per M
DPMO	209,876
Estimated Sigma Level (Z)	≈ 1.2 Sigma

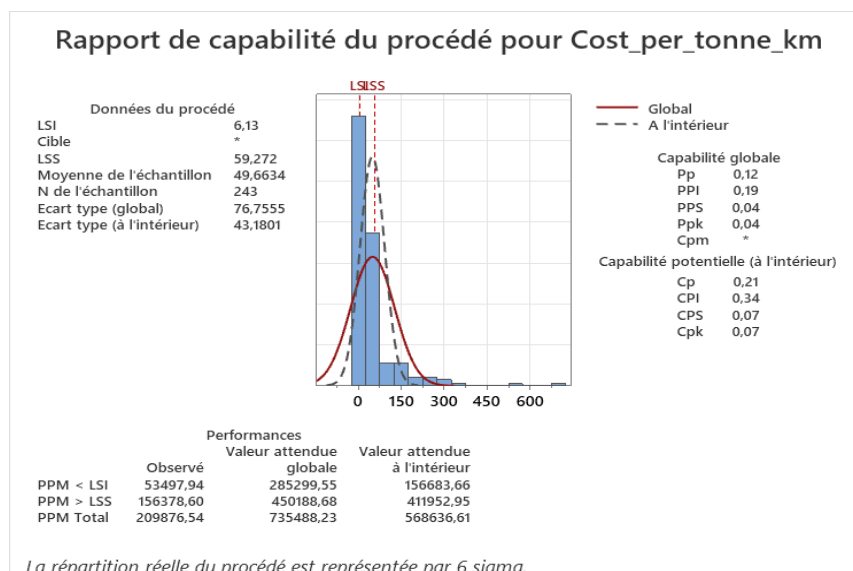
Source: Prepared by the authors, Minitab

Interpretation:

A sigma level of only **1.2** indicates extremely poor performance. Over **20%** of operations fall outside the acceptable cost limits, reflecting high inefficiency and poor cost control in the current transport process.

E. Process Capability Graph

Figure 22: Process Capability for Cost_per_tonne_km



Source: Prepared by the authors, Minitab

The graph shows two distribution curves: the red curve (overall variation) and the dashed grey curve (within-group variation). The mean is dangerously close to the upper limit, and the process exhibits a high degree of dispersion, confirming its lack of capability.

Conclusion

The current transport process is statistically incapable, with a very low Cpk (0.07) and a Sigma level of only 1.2. This confirms a high level of cost deviation and process inconsistency, mainly due to the lack of standardized criteria in transporter selection and poor control over truck assignment. Immediate corrective actions are required to improve the process and align its performance with business expectations.

4 ANALYSE

Following the Define and Measure phases, which identified and quantified the critical characteristics of the transport coordination process at Schneider Electric's logistics centre, the "Analyse" phase seeks to identify the root causes of inefficiencies, excessive cost variability, and underperformance in transport operations particularly the selection and usage of third-party providers.

4.1 Transport Process Analysis

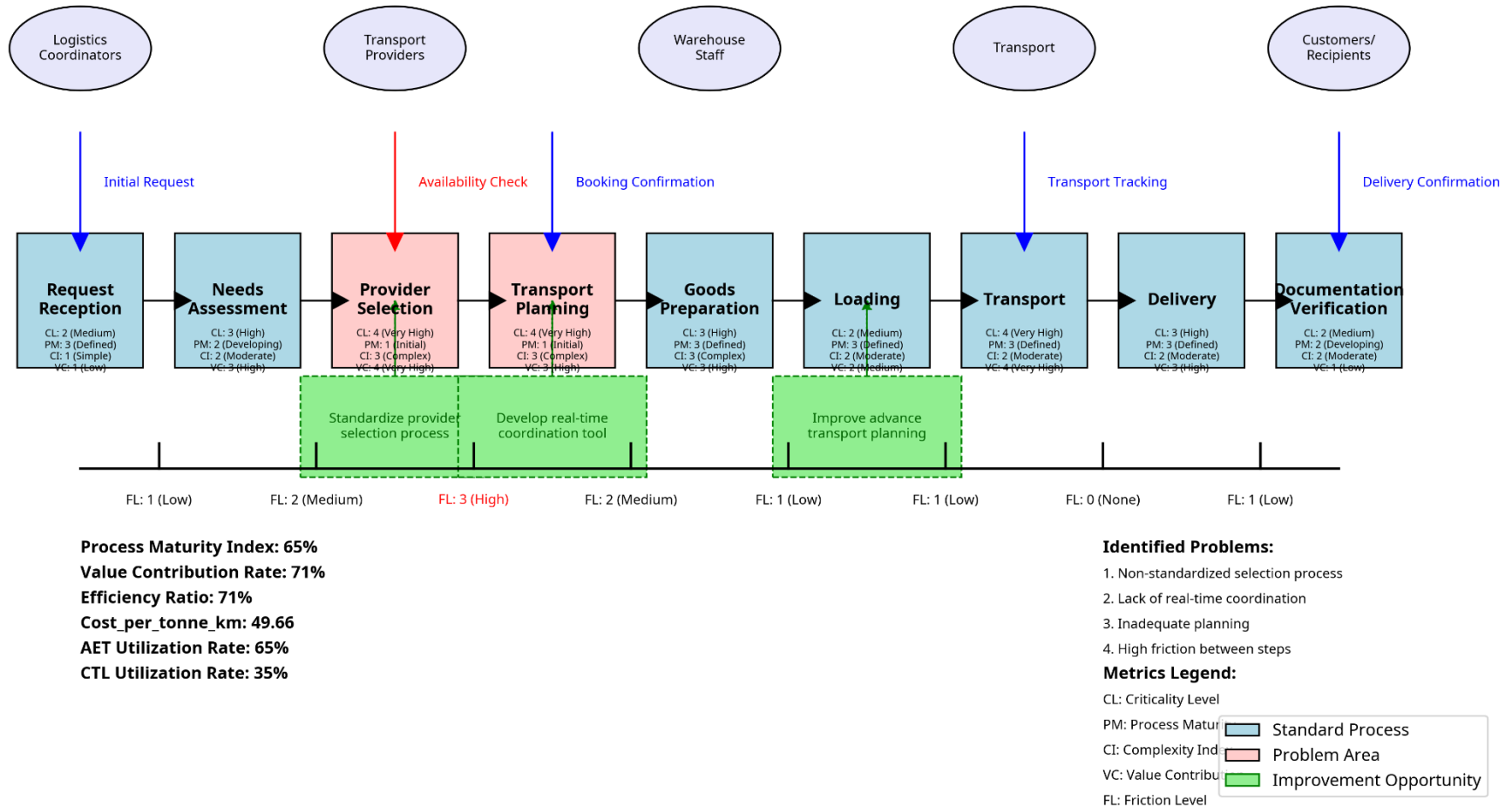
4.1.1 Value Stream Mapping (VSM)

We created a Value Stream Map of the transport coordination process to identify value-added (VA) and non-value-added (NVA) steps. The process was broken down into three main sub-processes:

- **SP:** Provider Selection (from request to confirmation)
- **PT:** Transport Preparation (planning to loading)
- **RL:** Realisation and Delivery (execution to documentation)

The VSM helped us visually identify delays and waste in the process. A correlation test was then conducted to determine which sub-process contributes most to overall process cycle time variability.

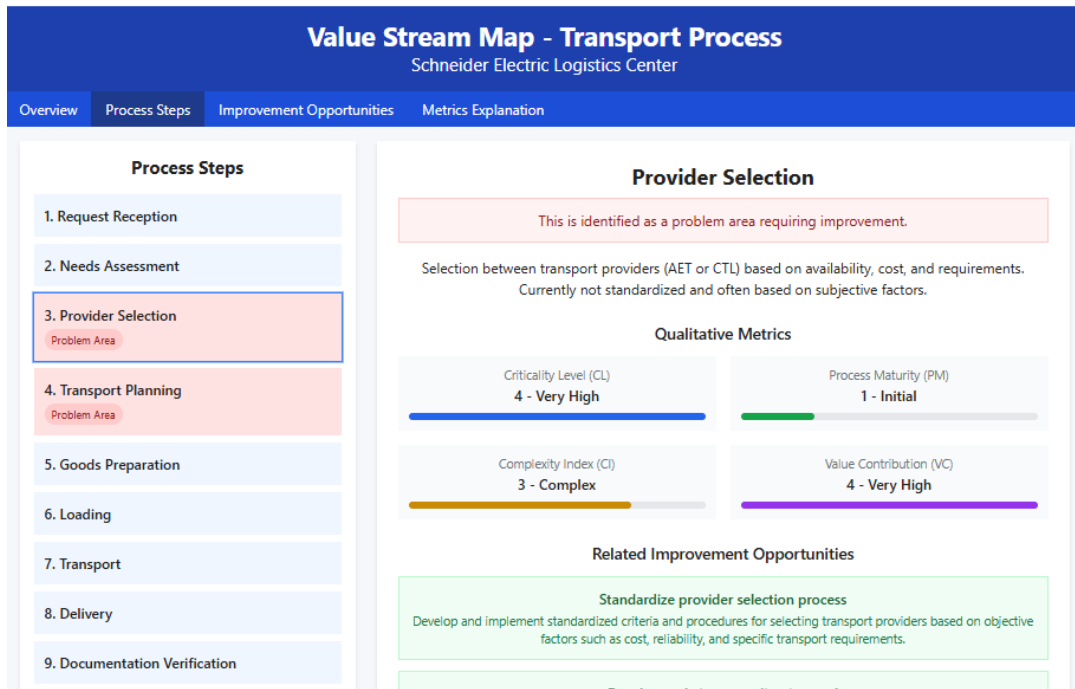
Figure 23: VSM for the transport process



Source: Prepared by the authors

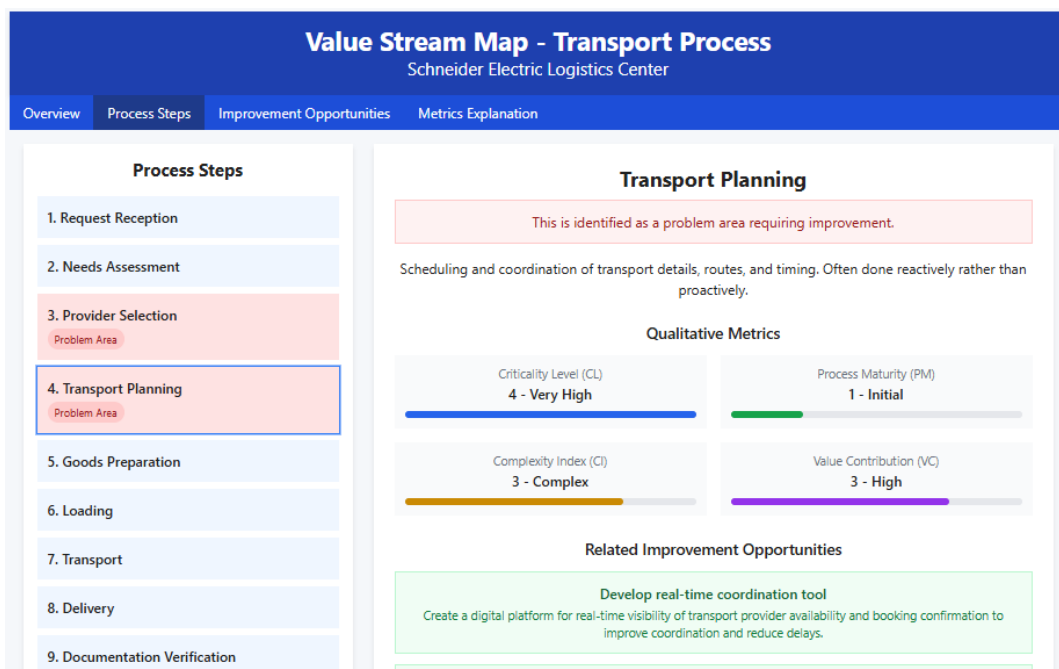
In order to analyse the VSM collected data, we created a website to help us visualise the results we gathered, this got us some hypothesis that we currently are delving into. The rest of the used documents are in the “appendix 06”.

Figure 24: Value stream mapping for provider selection



Source: Prepared by the authors throughout the created website

Figure 25: Value stream mapping for transport planning



Source: Prepared by the authors throughout the created website

Table 24: Correlation Between Sub-Process and Global Cycle Time

Relationship	Correlation Coefficient	P-value	Interpretation
Y - X1 (SP)	0.904	0.000	Strong positive correlation
Y - X2 (PT)	0.247	0.141	Weak correlation
Y - X3 (RL)	0.454	0.005	Moderate correlation

Source: Prepared by the authors

- ✚ The strongest source of variability is the Provider Selection step (X1), which significantly influences the overall cycle time (Y).

4.1.2 Process Flow Mapping

A detailed process flow diagram was created, based also on the interviews, to categorise each step by its function: operation, control, transport, delay, or storage. Time values were assigned to each activity.

Table 25 : Process Steps Breakdown

Step	Category	Avg. Duration (hrs)	% of Total Cycle Time
Selection of provider (X1)	Operation	1.5	21.43%
Transport execution (X3)	Transport	4.0	100% (of transport)
Planning transport (X2)	Operation	2.0	28.57%
Preparing goods (X2)	Operation	3.0	42.86%

Source: Prepared by the authors

- ✚ Most of the process time is concentrated in the Preparation and Execution phases, while Provider Selection introduces the highest variability

4.2 Capability Report Analysis

We used Minitab to evaluate the capability of the Cost per tonne-kilometre metric. The statistical outputs revealed the following:

Table 26: Capability Indices (Short-term and Long-term)

Metric	Value
Cp	0.21
Cpk	0.07
Pp	0.12
Ppk	0.04
DPMO	209,876
Sigma Level	1.2

Source: Prepared by the authors

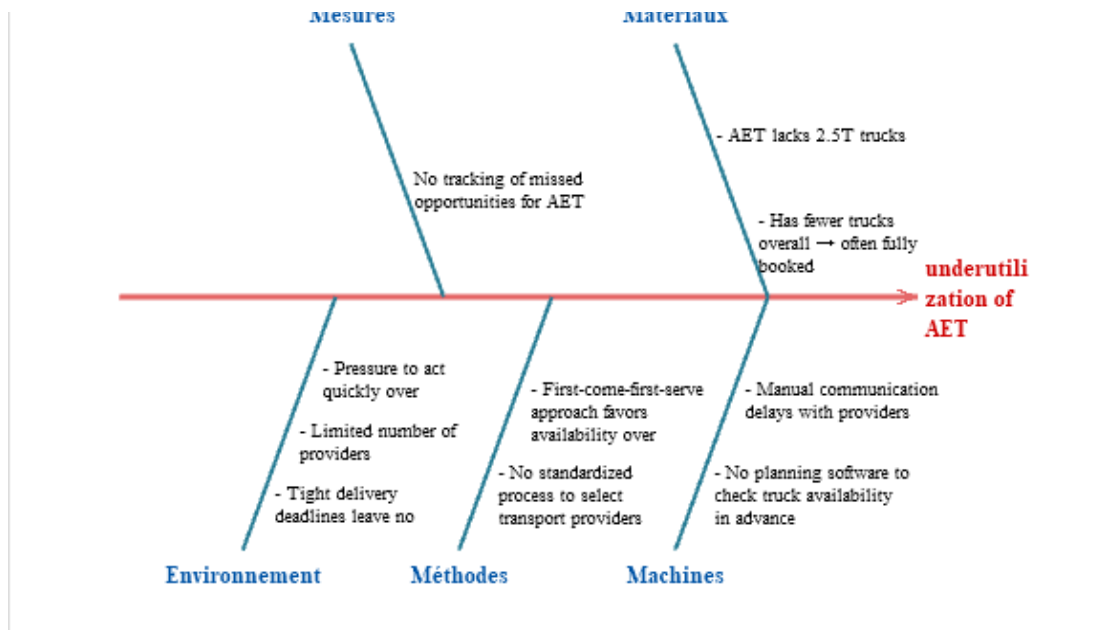
✚ These values confirm that the process is incapable, both short and long-term. The Cpk (0.07) indicates a process mean very close to the USL, and 21% of operations exceed the cost limit, demonstrating the urgency of corrective actions.

4.3 Root Cause Analysis

4.3.1 ISHIKAWA diagram (fishbone diagram)

To better understand the main causes of the underutilisation of AET we used a Fishbone (Ishikawa) diagram. This tool helped us organise potential causes under the 5Ms categories: Manpower, Method, Machine, Material, and Measurement, our objective was to identify what prevents the more frequent use of AET despite its better pricing and service quality. The results are presented below.

Figure 26: fishbone diagram (ishikawa)



Source: Prepared by the authors, Minitab

4.3.2 5 WHYS

For more understanding we also used the 5 whys tool to analyse the root cause of our chosen problem, which is “what prevents the more frequent use of “AET” and we ended up with the following results that we were able to present in this table:

Table 27: 5 WHYS

WHY	CTL used instead of AET? Is AET not available for those requests? Does AET lack the truck types or have limited availability? Isn't there a planning system in place? Decisions made manually and without planning?	BECAUSE	AET is not available for certain transport requests. AET doesn't have 2.5T trucks, and their overall fleet is often fully booked. The company doesn't plan or forecast provider needs in advance. Transport decisions are made manually and reactively, based on immediate availability There is no standardised process or digital tool to optimise provider selection and schedule transports ahead of time.
------------	---	----------------	--

Source: Prepared by the authors

To conclude, the Analyse phase allowed us to deeply investigate the main weaknesses of the transport coordination process at Schneider Electric. By combining Value Stream Mapping, process flow analysis, capability measurements, and root cause identification tools like the Ishikawa diagram and the 5 Whys method, we found that the selection of transport providers is the most critical source of variability and cost inefficiency. The results showed that the current process is statistically incapable, with a sigma level of only 1.2 and over 20% of operations exceeding acceptable cost limits. These findings confirm that the lack of standardisation, real-time coordination, and digital tools are key obstacles to performance. This phase clearly highlights the areas where improvement efforts must be focused in the next stage of our project.

5 IMPROVE

Based on the “Analyse” phase, we were able to identify the root cause for our chosen problem, which was “the absence of a planning system and standardised selection process leading to the frequent use of CTL, even when AET would be the more cost-effective option”, and we can split that into three separate problems:

- The absence of a standardised selection process
- The lack of visibility into truck types and costs;
- The limited communication with providers.

And we’ll be proposing an action plan to improve them in this phase.

5.1 Objectives of the project

The objectives of our proposed project could be concluded in the following points:

- Review and revise existing transport contracts to ensure alignment with cost-efficiency, delivery performance, and environmental standards, incorporating clauses that promote accountability and flexibility.
- Develop a coordination and planning application interface to centralise shipment schedules, real-time transporter availability, and truck assignment, improving visibility and reducing miscommunication.
- Expand the pool of transport providers by benchmarking local and regional carriers, introducing a prequalification system, and evaluating them based on price, reliability, and sustainability metrics.
- Enhance coordination with transporters through digital tools by implementing a shared digital calendar or alert system for pick-up scheduling and confirmations.
- Ensure all improvements align with Lean Six Sigma’s DMAIC methodology, particularly with the Improve phase, and set up indicators to measure impact before transitioning to the Control phase.

5.2 Proposed solutions

For better and more practical solutions when it comes to our project, which is “the absence of a planning system and standardised selection process leading to the use of more cost-effective options”, we proposed three well-defined solutions that, based on our analysis,

would be effective when it comes to reducing costs, improving delivery reliability and better provider selection.

5.2.1 Review and Revision of Transport Contracts

An in-depth review of the existing contracts with AET and CTL revealed several gaps which included:

- Vague terms around availability;
- No clear service level expectations;
- No flexibility for real-time planning.

So we managed to propose a revised version, “Appendix 03”, that held the same objectives but cleared, or basically, refined the following point:

- Clarified expectations and service levels, such as the drivers’ qualities and behaviour on the site;
- Improved and enhanced the terms to avoid the risks that the site was exposed to in the first place ;
- Opportunities for real-time updates and transparency.

5.2.2 Development of a Coordination App (Planning Interface Proposal)

To resolve the core issue of fragmented and inefficient communication between the logistics centre and transport providers, we propose the development of a digital coordination platform. This tool, designed as a mobile and/or desktop application, will enable real-time planning, visibility, and interaction between Schneider Electric’s logistics team and all registered transport providers. This application aims to streamline the transport scheduling process, reduce the time spent on manual coordination, and ensure that trucks are assigned according to cargo requirements, availability, and cost-efficiency.

A. Key Functionalities of the Tool

The proposed interface will consist of the following core modules as a start and would include the modules marked as “phase 02” in future updates if it has been well maintained.

Table 28: Key Functionalities of the proposed app

Functionality	Purpose
Input Fields	Number of pallets, size/volume, delivery distance, required truck type
Transporter Availability Module	Real-time status of trucks and drivers across all registered providers
Smart Selection Algorithm	Auto-recommendation of best provider based on cost/km, availability, and compliance (prioritizing AET when applicable)
Schedule Planning Calendar	Visualization of upcoming deliveries and available transporter slots
Driver Identification (phase 02)	Display of assigned driver’s name, contact, and associated truck type
Live Tracking (phase 02)	GPS-based tracking of deliveries, estimated time of arrival (ETA) updates
In-App Messaging (phase 02)	Real-time chat between logistics operator and transporter

Source: Prepared by the authors

B. Technical Feasibility

Our app can be developed in-house using a lightweight front-end framework with data sourced from the same Excel/Power BI backend already used in current dash-boarding efforts. Initial development may start with a basic interface focusing on availability and input forms and evolve to include more advanced features such as driver tracking and messaging.

5.3 Other solutions

5.3.1 Expansion of the Transport Provider Pool

To reduce the overreliance on CTL and cover cases when AET is unavailable, we also recommend contracting 1 or 2 additional transport providers who should possess the following criteria:

- Offer better prices than CTL;
- Meet Schneider Electric's quality standards;
- Are compatible with the digital planning tools.

5.3.2 Defining cards

To improve traceability and accountability during the delivery phase, we recommend using defining cards (badges) for regular drivers employed by contracted transport providers. These identification cards will serve both operational and compliance purposes and should include the following elements:

- Full name and photo of the driver;
- Name of the associated transport provider;
- QR code linked to driver records (contact, HSE compliance history, assigned routes);
- Visual colour code indicating access level or cargo authorisation type.

5.4 Action plan

Based on the given descriptions for the proposed solutions, the following action plan was elaborated to present the constructed framework

Table 29: Action plan for improving transport planning and provider coordination

Action	Owner	Expected Timeline	Resources Needed	Expected Outcomes
Review and revise transport contracts with AET and CTL	Logistics Supervisor + Legal	1 week	Existing contracts, contract review template, meetings with providers	Clear service level expectations, better legal protection, and readiness for planning
Develop and launch a basic version of the coordination app	IT+ Intern Team	1 month (Phase 1)	Power BI data model, Excel backend, front-end framework	Real-time visibility of provider availability Automated selection, faster planning
Add Phase 2 modules: live tracking, in-app messaging, driver display	IT	2 to 3 months (Phase 2)	GPS API, chat module integration, driver database	Full coordination platform with real-time updates, tracking, and communication
Identify and contract 1–2 new transport providers	Procurement + Logistics Manager	2 weeks	Benchmark list, provider evaluation matrix, contract templates	Reduced dependency on CTL, better pricing options, flexibility in transporter choice

Create and distribute defining cards for provider drivers	HSE Department + Logistics Team	1 week	Badge templates, QR code system, driver database	Improved site access control, driver traceability, and HSE compliance monitoring
--	---------------------------------	--------	--	--

Source: Prepared by the authors

By improving coordination through digital tools, formalising clearer contracts, and diversifying providers, Schneider Electric is expected to increase AET usage by at least 5–10%, which is considered our main goal. That would also reduce the overall transportation costs, avoid emergency reliance on CTL for their high price and lower quality, and improve planning accuracy and delivery satisfaction for all the stakeholders.

5.5 Risk analysis for the improvement phase

To ensure that our proposed improvements do not introduce new risks to the logistics system, we conducted a basic risk analysis using an adapted FMEA (Failure Modes and Effects Analysis) approach. Each solution was evaluated for potential failure modes, their causes, and their effects.

Based on severity, likelihood, and detectability, we calculated a Risk Priority Number (RPN) to prioritise mitigation efforts. The results are summarised in the following table.

Table 30 : FMEA risk analysis for the improvement plan

Proposed Solution	Potential Risk	Cause	Effect	S	O	D	RPN	Mitigation / Control Measure	S	O	D	RPN
Coordination app	Low adoption by transporters	Poor digital literacy or resistance	App not used, wasted resources	4	4	3	48	Provide training and testing phase with feedback; involve providers in early design	4	2	2	16
Transport contract revision	Providers disagree with new terms	Misalignment with their expectations	Delay in implementation	3	3	2	18	Conduct negotiation meetings; compare terms with industry standards	3	1	1	3
Coordination app	App malfunctions or bugs	Lack of testing	Planning errors or disruptions	4	2	2	16	Perform QA testing; start with MVP version	2	1	2	4
Provider expansion	New providers fail to meet standards	Poor qualification screening	Delivery issues, delays	3	3	2	18	Implement strict prequalification and performance reviews	3	1	2	6
Driver badges	Cards not used or get lost	No enforcement or weak badge design	Low traceability and security	2	4	2	16	Enforce badge checks at entry; reissue policy; use lanyards or permanent stickers	2	3	1	6

Source: Prepared by the authors

The following criteria have been used:

Scored from 1 (low) to 5 (high):

- Severity (S)
- Occurrence (O)
- Detection (D)

RPN	0-10	11-25	26-50	51-75
Risk level	low	medium	high	Very high

The risk analysis confirms that while each proposed solution carries potential risks, these have been identified early and addressed with appropriate mitigation strategies. By proactively managing these risks through provider engagement, pilot testing, and enforcement of standard procedures, we aim to ensure that the implementation phase progresses smoothly. These mitigation actions will also support the sustainability of improvements during the upcoming “Control” phase. With this structured approach, the solutions are expected to deliver long-term value in terms of cost efficiency, coordination, and transport provider reliability.

Having established a comprehensive improvement strategy and risk mitigation plan, the next phase will focus on sustaining these gains through consistent monitoring and standardised procedures, as outlined in the Control phase.

6 CONTROL

Although the “Control” phase has not yet been implemented at the time of writing, a preliminary control plan has been developed to ensure sustainability of the improvements introduced. This plan includes monitoring key transport and coordination metrics via the Power BI dashboard, issuing driver identification cards to track HSE compliance, and maintaining updated SOPs for transporter selection. Each responsible team member has been assigned specific control tasks, and a corrective action system will be used in case of performance degradation. The Control phase will be fully launched once the improvements from the Improve phase are operational and stable.

The goal of the Control phase is to sustain the improvements achieved during the Improve phase, ensure standardisation of the new processes, and prevent a return to previous inefficiencies.

6.1 Monitoring plan

Table 31: the control’s monitoring plan (schedules)

Metrics/KPIs	Tool/Source	Frequency
Cost per delivery	Power BI Dashboard	Weekly
Truck type to cargo match rate	Coordination App Reports	Weekly
Provider usage ratio (AET vs CTL)	Delivery Logs	Monthly
HSE Compliance per provider	Driver Badges & Reports	Monthly

Source: Prepared by the authors

The proposed monitoring plan establishes a structured schedule for observing and tracking critical metrics that reflect the efficiency and compliance of the transport coordination system. Each metric was selected based on its relevance to the objectives of the Improve phase and its ability to provide early signals of performance variation. Monitoring will be conducted through digital tools already integrated into the improvement plan, primarily the Power BI dashboard and the coordination application. These tools enable real-time visibility, simplify data collection, and reduce the risk of manual reporting errors. Regular reviews of these metrics will help sustain process improvements and guide continuous optimisation efforts.

6.2 Control Tools

For maintaining stability, we suggested using each of the following tools:

- Power BI dashboards for ongoing performance tracking;
- Standard Operating Procedures (SOPs) for transporter selection;
- Audit checklists for contract and delivery compliance;
- Provider performance score-cards.

The tools selected for the “Control” phase are intended to ensure the standardisation and sustainability of the new processes. The Power BI dashboard provides a centralised visual interface for tracking key metrics in real time, promoting data-driven decision-making. Standard Operating Procedures (SOPs) will formalise the revised transporter selection process, ensuring that staff follow a consistent, objective method. Audit checklists will support periodic reviews of contract and delivery compliance, while provider performance scorecards will offer a structured way to evaluate and compare transporter efficiency and reliability over time. Together, these tools create a robust control system aligned with Lean Six Sigma principles.

6.3 Responsibilities

Table 32: assigning responsibilities for the control phase

Responsible Party	Task
Warehouse manager	Weekly dashboard review, provider feedback
HSE	Badge validation and HSE audit
Internals	Monthly reporting and KPI alerts

Source: Prepared by the authors

To ensure accountability and clarity, tasks have been delegated to specific roles within the organisation. The warehouse manager will be responsible for reviewing dashboard data weekly and engaging with providers based on performance insights. The HSE team will oversee badge validation and ensure that all drivers maintain safety and environmental compliance. Interns or junior analysts will support the process by generating monthly reports and triggering alerts when KPIs deviate from expected targets. This distribution of responsibilities ensures both operational oversight and continuous performance assessment.

6.4 Response plan for deviations

In the event that a monitored KPI deviates from the desired standard, a corrective action protocol will be initiated. The responsible party will first validate the data and investigate the cause of the deviation. And depending on the severity and root cause, responses may include additional training for staff, temporary adjustment of transporter allocation, or escalation to the procurement team for contract review. A short feedback loop and regular cross-functional meetings will support quick resolutions. The objective is not only to correct deviations but also to integrate lessons learnt into future SOP updates to prevent recurrence

6.5 Future control activities

Beyond the immediate control plan, additional measures are envisioned to further enhance the sustainability of the improvements. These include the development of automatic KPI alerts within the Power BI dashboard, the integration of a feedback mechanism from transport providers and clients, and the institutionalisation of monthly review meetings. These activities will foster a culture of continuous improvement and allow for agile responses to changes in logistics needs or external market conditions. As the system matures, the control mechanisms can be refined and adapted to support broader operational excellence goals within Schneider Electric's logistics operations.

7 Results' discussions

7.1 Integration of Lean Six Sigma in Supply Chain Communication: Bridging Theory and Practice

This discussion examines the application of Lean Six Sigma (LSS) methodology to improve communication flow between Schneider Electric's logistics centre and its transportation service providers. By analysing the results in light of existing literature, we can better understand how LSS principles contribute to optimizing logistics processes, particularly in the context of communication and coordination challenges.

7.2 Alignment with Existing LSS Research in Supply Chain Management

The implementation of the DMAIC methodology at Schneider Electric's logistics centre aligns with the growing body of research demonstrating LSS's effectiveness in supply chain optimization. As highlighted in our literature review, (Sundram et al., 2023) demonstrated how LSS could streamline workflows within logistics departments, resulting in a 25% reduction in lead times and improved standardization. Similarly, our project identified critical inefficiencies in the communication flow between the company and its transportation providers, particularly regarding truck type selection and coordination, which directly impacted delivery performance.

The prioritization approach used in our study, employing tools such as the Eisenhower Matrix and the ISO 13053:2011 Prioritization Matrix, reflects the structured, data-driven decision-making emphasized by (Bhargava & Gaur, 2021) and A. (A. Gomaa, 2024b) These authors demonstrated how LSS tools like DMAIC and process capability analysis could be applied to identify inefficiencies and drive sustainable performance improvements. Our findings confirm this approach's validity, as the systematic evaluation of customer needs through Voice of Customer (VOC) analysis led to the identification of "poor coordination between distribution centre, drivers, and clients" as the highest-priority issue to address.

7.3 Communication as a Critical Factor in Supply Chain Efficiency

Our study's focus on communication flow represents an important contribution to LSS literature in supply chain management. While much existing research, such as (Zhang et al., 2016), has concentrated on operational aspects like cost reduction and cycle time improvements, our findings highlight communication as a fundamental enabler of logistics efficiency. This aligns with Bin (Bin Md Saad, 2023) research, which identified process

mapping and root cause analysis as key tools for streamlining transport operations while emphasising challenges such as resistance to change in dynamic logistics environments.

The SIPOC diagram developed during our Define phase revealed the complex web of interactions between suppliers, inputs, processes, outputs, and (Gutierrez-Gutierrez et al., 2016) findings that structured application of LSS methodologies can standardize transport operations while refining customer communication channels. By clearly identifying the key stakeholders and information flows, our study provides a practical framework for addressing communication gaps in logistics processes.

7.4 Technology Integration in LSS Implementation

Our findings regarding driver GPS issues and the lack of precise delivery time notifications echo (Jayaram, 2016) emphasis on the strategic integration of LSS with Industry 4.0 technologies. Jayaram highlighted how IoT-enabled sensors, RFID tracking, and real-time analytics could support dynamic logistics decisions and greater visibility across the supply chain. While our study did not implement advanced technological solutions, it identified the critical need for better technological integration to address communication challenges, particularly in tracking and coordinating deliveries.

This technological dimension of LSS implementation is increasingly important in modern supply chains, as noted by (Prof. Dr. A. H. Gomaa, 2025), who demonstrated how DMAIC combined with tools like Value Stream Mapping enabled an Egyptian manufacturing firm to reduce procurement lead times and improve inventory turnover. Our study contributes to this growing body of knowledge by highlighting specific technological gaps in the communication flow between logistics centres and transportation providers.

7.5 Customer-Centric Approach to Process Improvement

A key strength of our study is its customer-centric approach, beginning with a comprehensive Voice of Customer analysis to identify and prioritize issues. This approach aligns with (Renzo Melgar Torres et al., 2022) systematic literature review, which found that LSS implementations in retail logistics led to significant improvements in customer satisfaction, including a 30% reduction in customer complaints. By focusing on communication flow as a critical factor in customer satisfaction, our study addresses what (Bin Md Saad, 2023) identified as a key factor in building customer trust through reliable service.

The prioritization matrices used in our study, particularly the ISO 13053:2011 matrix, enabled a systematic evaluation of improvement opportunities based on customer importance, project cost, likelihood of success, contribution to profit, and applicability to other areas. This multi-dimensional approach to prioritization ensures that LSS initiatives are aligned with both operational efficiency goals and customer needs, addressing a gap identified by (A. Gomaa, 2024a) regarding the need for strategic frameworks that align LSS with business objectives.

7.6 Organizational Challenges in LSS Implementation

Our study also sheds light on the organizational challenges of implementing LSS in logistics settings. The detailed organizational mapping conducted during the Pre-Six Sigma phase identified key roles and responsibilities within the logistics centre, providing valuable context for understanding how communication flows (or fails to flow) between different stakeholders. This organizational dimension of LSS implementation is often underexplored in the literature, with (Zhang et al., 2016) noting significant barriers to implementation, including resistance to change and limited employee awareness, particularly within small and medium-sized enterprises.

By explicitly addressing the organizational structure and stakeholder relationships, our study contributes to a more holistic understanding of LSS implementation challenges in supply chain management. This approach aligns with (Pardamean Gultom & Wibisono, 2019) theoretical framework linking Lean practices, such as employee involvement, with key supply chain KPIs, emphasizing LSS not only as a problem-solving tool but also as a strategic enabler for process standardization and real-time decision-making.

7.7 Methodological Contributions

From a methodological perspective, our study demonstrates the value of combining multiple prioritization tools (Eisenhower Matrix, Risk Assessment Matrix, and ISO 13053:2011 Prioritization Matrix) to ensure objective prioritisation of improvement opportunities. This multi-tool approach provides a more robust foundation for project selection than relying on a single prioritization method, addressing a limitation noted by (Renzo Melgar Torres et al., 2022) regarding the need for standardized performance metrics in LSS implementations. The SIPOC diagram developed during our Define phase also represents a methodological contribution, providing a clear framework for mapping complex logistics processes and identifying key stakeholders and information flows. This systematic

approach to process mapping aligns with (Tenera & Pinto, 2014) findings regarding the importance of combining LSS tools like DMAIC and Value Stream Mapping to improve project scheduling and control.

7.8 Practical Implications for Supply Chain Management

Our study has several practical implications for supply chain management. First, it highlights the critical importance of communication flow in logistics operations, suggesting that companies should invest in improving communication channels and protocols between logistics centres, transportation providers, and customers. Second, it demonstrates the value of a systematic, data-driven approach to identifying and prioritizing improvement opportunities, using tools such as Voice of Customer analysis and multi-dimensional prioritization matrices. Third, our findings suggest that LSS implementations in logistics should explicitly address both operational and communication aspects of the supply chain, recognising that inefficiencies in communication can have significant impacts on delivery performance and customer satisfaction. This holistic approach aligns with (A. Gomaa, 2024b) proposed strategic framework for aligning LSS with business objectives across logistics, procurement, and production.

7.9 Limitations and Future Research Directions

While our study provides valuable insights into the application of LSS in improving communication flow in logistics operations, it has several limitations that suggest directions for future research. First, our study focused on a single logistics centre within Schneider Electric, limiting the generalizability of our findings to other contexts. Future research could explore the application of LSS to improve communication flow in different logistics settings, such as e-commerce fulfillment centers or cross-border logistics operations.

Second, our study did not fully explore the technological dimensions of communication improvement, such as the integration of real-time tracking systems or digital communication platforms. Future research could investigate how digital technologies can be leveraged within an LSS framework to enhance communication flow in logistics operations, building on (Jayaram, 2016) work on the integration of LSS with Industry 4.0 technologies.

Finally, our study focused primarily on the Define phase of the DMAIC cycle, with limited implementation of improvement initiatives. Future research could track the full implementation of LSS-based communication improvements in logistics operations,

measuring the impact on key performance indicators such as delivery time, customer satisfaction, and operational costs.

7.10 Discussion's synthesis

This study contributes to the growing body of research on the application of Lean Six Sigma in supply chain management by highlighting the critical role of communication flow in logistics operations. By applying the DMAIC methodology to improve communication between Schneider Electric's logistics centre and its transportation service providers, we have demonstrated how LSS tools and principles can be used to identify, prioritize, and address communication challenges in complex supply chains.

Our findings align with existing research on the benefits of LSS in logistics, while also highlighting the importance of a customer-centric, data-driven approach to process improvement. By focusing on communication as a critical enabler of logistics efficiency, our study addresses a gap in the literature and provides practical insights for logistics managers seeking to enhance coordination between distribution centres, transportation providers, and customers.

As supply chains become increasingly complex and customer expectations for delivery speed and reliability continue to rise, the ability to effectively communicate and coordinate across the logistics network will become even more critical. Lean Six Sigma, with its structured approach to process improvement and waste reduction, offers a valuable framework for addressing these challenges and building more agile, responsive supply chains.

| General Conclusion

This research aimed to optimise the transport and communication processes with transportation providers within the logistics operations of Schneider Electric. Faced with challenges such as inconsistent transport provider selection, inefficient communication flows, and the frequent use of costly or inappropriate transport options, the study applied the Lean Six Sigma (LSS) methodology (specifically the DMAIC cycle) as a structured framework for process improvement.

Through a detailed analysis of the current situation, supported by relevant academic literature and internal company data, the study identified key inefficiencies in the delivery phase. The implementation of LSS tools, including cause-and-effect analysis, process mapping, and prioritisation matrices, enabled the identification of root causes and the development of actionable solutions. The study's findings led to clearer criteria for transport provider selection, streamlined communication protocols, and improved alignment between shipment types and transport modes.

From a theoretical standpoint, the research contributes to the growing body of knowledge on the application of LSS in logistics and supply chain management, especially in the underexplored area of last-mile delivery optimisation. It also illustrates how combining LSS tools with field-specific insights can support effective decision-making in complex operational environments.

On the managerial level, the study offers Schneider Electric a concrete and adaptable roadmap for improving delivery operations. By introducing standardisation and visibility into the transport planning process, the company can reduce costs, increase reliability, and enhance collaboration with external partners.

However, the study also presents certain limitations. It was conducted within a single logistics centre, with limited access to external provider data, and under time constraints typical of a student research project. As such, the results may not be fully generalisable to other sites or organisations.

Future research could explore the long-term impacts of the implemented improvements or apply the DMAIC approach to other areas of the supply chain. Further studies might also examine how digital tools (for example: real-time tracking platforms or integrated transport management systems) could complement LSS practices for even greater efficiency.

In conclusion, this study demonstrates the practical value of Lean Six Sigma as a tool for optimising transport and communication processes in industrial logistics. By addressing real operational pain points and proposing structured improvements, it supports both academic inquiry and operational excellence.

Bibliography

- *2024-document-enregistrement-universel*. (n.d.).
- Amjad, M. H. H., Shovon, M. S. S., College of Graduate and Professional Studies, Trine University, USA, Hasan, A. S. M. M., & College of Graduate and Professional Studies, Trine University, USA. (2024). Analyzing Lean Six Sigma Practices In Engineering Project Management: A Comparative Analysis. *Innovatech Engineering Journal*, 1(01), 245–255. <https://doi.org/10.70937/itej.v1i01.27>
- Andersen, B & Fagerhaug, T. (2006). *Root Cause Analysis: Simplified Tools and Techniques*.
- Anderson, C. (2021, September 18). What Is Plan Do Check Act? | How Do You Use PDCA? *Bizmanualz*. <https://www.bizmanualz.com/improve-quality/what-is-plan-do-check-act.html>
- Antony, J. (2006). Six sigma for service processes. *Business Process Management Journal*, 12(2), 234–248. <https://doi.org/10.1108/14637150610657558>
- Bhargava, M., & Gaur, S. (2021). Process Improvement Using Six-Sigma (DMAIC Process) in Bearing Manufacturing Industry: A Case Study. *IOP Conference Series: Materials Science and Engineering*, 1017(1), 012034. <https://doi.org/10.1088/1757-899X/1017/1/012034>
- Bin Md Saad, N. A. (2023). Deployment of Lean Six Sigma in Transportation Sector. *International Journal of Empirical Research Methods*, 1(2), 74–80. <https://doi.org/10.59762/ijerm205275791220231205140246>
- Boukaira, S., & Daamouch, M. (2021). *Quel choix épistémologique pour une recherche en sciences économiques et de gestion ? 9*.
- Boutros, T., & Purdie, T. (2014). *The process improvement handbook: A blueprint for managing change and increasing organizational performance*. McGraw-Hill Education.
- Bowersox, D. J., Closs, D. J., Cooper, M. B., & Bowersox, J. C. (Eds.). (2013). *Supply chain logistics management* (4. ed., international ed). McGraw-Hill.
- Breyfogle, F. W. (2003). *Implementing six sigma: Smarter solutions using statistical methods* (2nd ed). Wiley.
- Castagné, T. (2012). *Le lean management dans les services: Méthode d'excellence opérationnelle*. AFNOR éd.
- Christopher, M. (2016). *Logistics & supply chain management* (Fifth Edition). Pearson Education.
- De Koning, H., & De Mast, J. (2007). The CTQ Flowdown as a Conceptual Model of Project Objectives. *Quality Management Journal*, 14(2), 19–28. <https://doi.org/10.1080/10686967.2007.11918023>

- Demetrescoux, R. (2017). *Lean management: Pour une performance solide et durable*. Dunod.
- Deming, W. E. (2000). *Out of the Crisis*. MIT Press.
- Edouard, A. (2016). *Mise en place d'un projet d'amélioration continue sur une ligne de conditionnement secondaire de vaccins, à l'aide de l'outil Lean Six Sigma*.
- Fawcett, S. E., Ellram, L. M., & Ogden, J. A. (2007). *Supply chain management: From vision to implementation*. Pearson Prentice Hall.
- *Fig. 1. Example Process Map, adapted from [36]*. (n.d.). ResearchGate. Retrieved 11 May 2025, from https://www.researchgate.net/figure/Example-Process-Map-adapted-from-36_fig1_277326577
- *Figure 1. A generic representation of the Ishikawa diagram aka Fishbone...* (n.d.). ResearchGate. Retrieved 11 May 2025, from https://www.researchgate.net/figure/A-generic-representation-of-the-Ishikawa-diagram-aka-Fishbone-diagram_fig1_317196193
- George, M. L. (2002). *Lean Six Sigma: Combining Six Sigma quality with lean speed*. McGraw-Hill.
- George, M. L. (2003). *Lean Six Sigma for service: How to use Lean Speed and Six Sigma Quality to improve services and transactions*. McGraw-Hill.
- George, M. L. (Ed.). (2005). *The lean six sigma pocket toolbox: A quick reference guide to nearly 100 tools for improving process quality, speed, and complexity*. McGraw-Hill.
- Gillet-Goinard, F., & Seno, B. (2020). *La boîte à outils de la qualité* (4e éd). Dunod.
- Gomaa, A. (2024a). Boosting Supply Chain Effectiveness with Lean Six Sigma. *American Journal of Management Science and Engineering*, 9(6), 156–171. <https://doi.org/10.11648/j.ajmse.20240906.14>
- Gomaa, A. (2024b). Improving Productivity and Quality of a Machining Process by Using Lean Six Sigma Approach: A Case Study. *Engineering Research Journal (Shoubra)*, 53(1), 1–16. <https://doi.org/10.21608/erjsh.2023.226742.1194>
- Gomaa, Prof. Dr. A. H. (2025). Optimizing Manufacturing Supply Chains Using a Strategic Lean Six Sigma Framework: A Case Study. *International Journal of Inventive Engineering and Sciences*, 12(3), 20–33. <https://doi.org/10.35940/ijies.F8211.12030325>
- Gutierrez-Gutierrez, L., De Leeuw, S., & Dubbers, R. (2016). Logistics services and Lean Six Sigma implementation: A case study. *International Journal of Lean Six Sigma*, 7(3), 324–342. <https://doi.org/10.1108/IJLSS-05-2015-0019>
- Halim, K. (2024). LE LEAN IX SIGMA DANS L'AQUACULTURE : MISE EN PLACE DU DMAIC AU SEIN DE L'INDUSTRIE D'ÉLEVAGE AU. *Management Control*, 1.

- Hammer, M., & Champy, J. (1994). *Reengineering the corporation: A manifesto for business revolution* (1. paperback ed). Harper Business.
- Hennion, A. M. R. (2017). *Les fiches outils—Focus du Lean Six Sigma*. Eyrolles : Eyrolles.
- Hoerl, R., & Snee, R. (2020). An Overview of Lean Six Sigma*. In J. Antony (Ed.), *Lean Six Sigma in Higher Education* (pp. 1–11). Emerald Publishing Limited. <https://doi.org/10.1108/978-1-78769-929-820201002>
- Hohmann, C. (2012). *Lean management: Outils, méthodes, retours d'expériences, questions-réponses*. Eyrolles.
- Imai, M. (1986). *Kaizen (Ky'zen): The key to Japan's competitive success* (1. ed., print). McGraw-Hill.
- *ISO13053-1.2011*. (n.d.).
- Jackson, B. A., & Sass, N. L. (1984). A rational approach to decision making in toxicology. *Regulatory Toxicology and Pharmacology: RTP*, 4(2), 130–137. [https://doi.org/10.1016/0273-2300\(84\)90035-7](https://doi.org/10.1016/0273-2300(84)90035-7)
- Jayaram, A. (2016). Lean six sigma approach for global supply chain management using industry 4.0 and IIoT. *2016 2nd International Conference on Contemporary Computing and Informatics (IC3I)*, 89–94. <https://doi.org/10.1109/IC3I.2016.7917940>
- Langley, C. J. & Capgemini. (2016). *Third-Party Logistics Study: The State of Logistics Outsourcing*. Capgemini.
- Laureani, A., & Antony, J. (2017). Leadership characteristics for Lean Six Sigma. *Total Quality Management & Business Excellence*, 28(3–4), 405–426. <https://doi.org/10.1080/14783363.2015.1090291>
- *Le grand guide du lean management: Approche classique revisitée* (with Driss Bouami). (2023). Afnor éditions.
- Liker, J. K. (2013). *Toyota way: 14 management principles from the world's greatest manufacturer* (First edition). McGraw-Hill Education.
- Lyonnet, B. (2015). *Lean management: Méthodes et exercices*. Dunod.
- McCarty, T. (Ed.). (2005). *The Six Sigma black belt handbook*. McGraw-Hill.
- Murphy, P. R., & Knemeyer, A. M. (2018). *Contemporary logistics* (Twelfth edition). Pearson.
- Page, S. (2016). *Power of Business Process Improvement: 10 simple steps to increase effectiveness, efficiency,... and adaptability*. AMACOM.
- Pardamean Gultom, G. D., & Wibisono, E. (2019). A framework for the impact of lean six sigma on supply chain performance in manufacturing companies. *IOP*

Conference Series: Materials Science and Engineering, 528(1), 012089.
<https://doi.org/10.1088/1757-899X/528/1/012089>

- Piercy, N., & Rich, N. (2009). Lean transformation in the pure service environment: The case of the call service centre. *International Journal of Operations & Production Management*, 29(1), 54–76. <https://doi.org/10.1108/01443570910925361>
- Pillet, M. (2013). *Six sigma: Comment l'appliquer* (2e éd.). Eyrolles.
- Pyzdek, T. (2019, April 26). *What Are SIPOC Maps and How Do You Use Them?* | Pyzdek Institute. <https://www.pyzdek institute.com/blog/six-sigma/what-are-sipoc-maps-and-how-do-you-use-them.html>
- Pyzdek, T., & Keller, P. (2014). *Six sigma handbook: A complete guide for green belts, black belts, and managers at all levels* (4th ed). McGraw-Hill Education LLC.
- Pyzdek, T., & Keller, P. A. (2024). *The Six Sigma handbook: A complete guide for green belts, black belts, and managers at all levels* (Sixth edition). McGraw Hill.
- René, O. (2022). *Le Lean management au cœur des services*. Alisio.
- Renzo Melgar Torres, Néstor Javier Plasencia Machuca, & Rafael Mauricio Villanueva Flores. (2022). A Systematic Review of the Implementation of Lean Six Sigma Tools to Improve the Logistics of Retail Businesses. *Proceedings of the International Conference on Industrial Engineering and Operations Management*, 2349–2361. <https://doi.org/10.46254/AU01.20220506>
- Rodrigues, I., & Alves, W. (2024). Integrating Lean Thinking into Project Management: A Conceptual Model for the IT Sector. *Procedia Computer Science*, 239, 1604–1611. <https://doi.org/10.1016/j.procs.2024.06.336>
- Rother, M., & Shook, J. (2018). *Learning to see: Value-stream mapping to create value and eliminate muda* (Version 1.5 ; 20th Anniversary Edition). Lean Enterprise Inst.
- Rushton, A., Croucher, P., & Baker, P. (2017). *The handbook of logistics and distribution management* (Sixth edition). Kogan Page.
- *Schneider Electric Algérie | Le spécialiste mondial en gestion de l'énergie et en automatisation*. (n.d.). Retrieved 3 May 2025, from <https://www.se.com/dz/fr/>
- Schroeder, R. G., Linderman, K., Liedtke, C., & Choo, A. S. (2008). Six Sigma: Definition and underlying theory*. *Journal of Operations Management*, 26(4), 536–554. <https://doi.org/10.1016/j.jom.2007.06.007>
- Singhisodhi, H. (2020). *A Systematic Comparison between DMAIC and DMADV Approaches of Six Sigma*. 29(10).
- *Six Sigma: A complete step-by-step guide*. (2018). Harmony Living LLC.
- *Six Sigma: Comment l'appliquer* (2e édition) (with Pillet, M.). (2013). Eyrolles.

- Snee, R. D., & Hoerl, R. W. (2003). *Leading Six Sigma: A step-by-step guide based on experience with GE and other Six Sigma companies*. Financial Times Prentice Hall.
- Soltani, H., & Agarwal, K. (2024, April 23). Optimizing Efficiency and Standardization: A Lean Six Sigma Approach in US Small and Medium-Sized Manufacturing—A Case Study of Magnelab Inc. *Proceedings of the International Conference on Industrial Engineering and Operations Management*. 5th African International Conference on Industrial Engineering and Operations Management, Johannesburg/Pretoria, South Africa. <https://doi.org/10.46254/AF05.20240176>
- Sundram, V. P. K., Gharpar, F., Lian, C. L., & Muhammad, A. (2023). Engaging Lean Six Sigma Approach Using DMAIC Methodology for Supply Chain Logistics Recruitment Improvement. *Information Management and Business Review*, 15(1(I)SI), 46–53. [https://doi.org/10.22610/imbr.v15i1\(I\)SI.3401](https://doi.org/10.22610/imbr.v15i1(I)SI.3401)
- Tenera, A., & Pinto, L. C. (2014). A Lean Six Sigma (LSS) Project Management Improvement Model. *Procedia - Social and Behavioral Sciences*, 119, 912–920. <https://doi.org/10.1016/j.sbspro.2014.03.102>
- Value Stream Mapping. (2022). *NIST*. <https://www.nist.gov/mep/value-stream-mapping>
- Vashishth, A., Lameijer, B. A., Chakraborty, A., Antony, J., & Moormann, J. (2024). Implementing Lean Six Sigma in financial services: The effect of motivations, selected methods and challenges on LSS program- and organizational performance. *International Journal of Quality & Reliability Management*, 41(2), 509–531. <https://doi.org/10.1108/IJQRM-05-2022-0154>
- What is a Control chart? | Types of Control chart | Examples. (n.d.). <https://Qsutra.Com/>. Retrieved 11 May 2025, from <https://qsutra.com/explore/knowledge-base/control-chart/>
- Yasmina Delleci. (2023). *Lean Six Sigma: A New Powerful Process Improvement Methodology Lean Six Sigma: Une Nouvelle Méthodologie Puissante pour l'Amélioration des Processus*.
- Zanezi, A. C., & Carvalho, M. M. D. (2023). How project management principles affect Lean Six Sigma program and projects: A systematic literature review. *Brazilian Journal of Operations & Production Management*, 20(1), 1564. <https://doi.org/10.14488/BJOPM.1564.2023>
- Zhang, A., Luo, W., Shi, Y., Chia, S. T., & Sim, Z. H. X. (2016). Lean and Six Sigma in logistics: A pilot survey study in Singapore. *International Journal of Operations & Production Management*, 36(11), 1625–1643. <https://doi.org/10.1108/IJOPM-02-2015-0093>

Appendices

- **Appendix 01 : Full interview guide**
- **Appendix 02 : Interview Summary Matrix (NVivo Style)**
- **Appendix 03 : Shipping Procedure**
- **Appendix 04 : R&R (ANOVA) Report for Price Measurement Instrumentation**
- **Appendix 05 : Contrat Transport SE (proposition)**
- **Appendix 06 : Website for VSM analysing**

- **Appendix 01 : Full interview guide**

Interviews guide

Introduction

The objective of the interview is to define the key stages of the process, identify how stakeholders are contacted, and examine the aspects and conditions considered in their transactional relationship. It also aims to explore the challenges encountered and the strategies implemented to address them.

- Estimated time: **10 mins**

First: Information about the interviewers

1. Can you introduce yourself and what you do?

Second: Description of the delivery process

1. Can you give a description of the actions you do from the checking (expedition) till the product reaches the customer
2. What are the requirements for the delivery process to start?
3. Who or where those requirements come from
4. What are the elements of the end of the process (the outputs)
5. Where will the end elements go?
6. How much time does this process take

Third: the providers

1. How do you contact your providers? (Phone? Email?..)
2. What are the aspects (characteristics) that you take into consideration when choosing a specific provider?
3. Are there any cases where the provider you chose did not align with SEA's expectations? If yes, are there any examples?
4. Who is the most go-to provider usually?

Forth: The challenges

1. What are the occurring problems with the customers?
2. What are the occurring problems with the providers?

Fifth: Improvement advice

1. Is there any other challenges/problems in the delivery process

2. Up to you. Are there any steps to add or remove or basically change to enhance the process's method?

• **Appendix 02 : Interview Summary Matrix (NVivo Style)**

Axis / Respondent	OUAHIB W. (Shipping, Jan–Feb)	HADJADJ M. (Warehouse Operator)	DJAITH N. (Shipping – Low Voltage)	SID AZARA N. (Shipping, Apr–May)
Transporter selection criteria	Based on availability and truck type	Based on tonnage: AET for small trucks, CTL for large shipments	AET preferred for small volumes	Based on equipment and availability
Communication method	Phone call followed by email	Phone confirmation, followed by email	Phone or email	Phone and email
Delivery triggering	Once all documents (invoice + delivery note) are ready	After receiving billing documents	When delivery notes and invoices are available	After invoice and delivery note are issued
Estimated delivery time	24h – 48h depending on distance	24h for nearby clients, 48h for distant ones	1 to 2 days depending on location	Depends on customer availability
Reported issues	Occasional quantity errors	Delays due to road or weather conditions	Transporter sometimes doesn't show up after confirmation	Truck breakdowns causing delays
Improvement suggestions	No change needed	Set contractual requirements for transport capacity	No significant improvements needed	No modifications proposed for now

• Appendix 03 : Shipping Procedure

Responsable	Logigramme	Document
<ul style="list-style-type: none"> • Chargé facturation • Chargé facturation • Magasinier • Magasinier • Chargé facturation • Magasinier • Transporteur 	<pre> graph TD A([Finalisation de la préparation]) --> B[Déclencher la facturation : Editer 2 Factures et 3] B --> C[Vérifier la conformité de la facture avant clôture] C --> D[Informer les clients de la date de livraison 24h avant, en indiquant le volume de la marchandise] D --> E[Lancer une demande de] E --> F[Acheminer les colis de la zone de préparation à la zone] F --> G[Renseigner le bordereau] G --> H[Emarger le bordereau d'expédition en 4] H --> I([Livraison de la marchandise]) </pre>	<ul style="list-style-type: none"> • BL & Facture • Facture • E-mail / téléphone • E-mail / téléphone • Bordereau d'expédition • Bordereau d'expédition signé

- Appendix 04 : Gage R&R (ANOVA) Report for Price Measurement Instrumentation

Rapport de R&R (ANOVA) de l'instrumentation pour Price

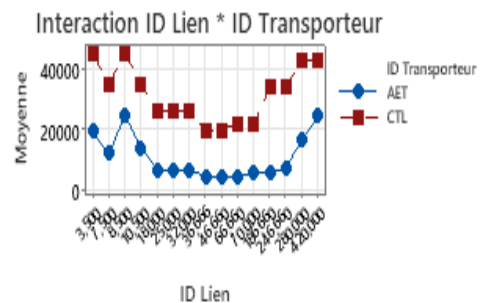
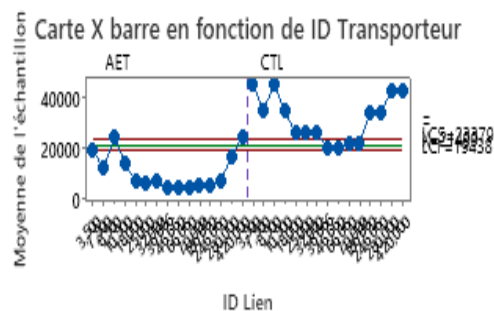
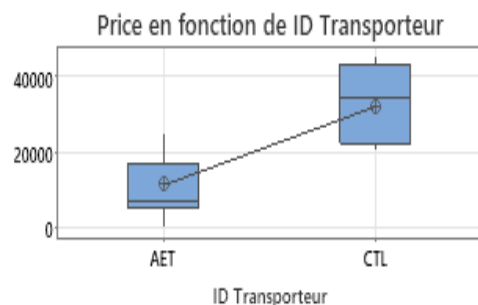
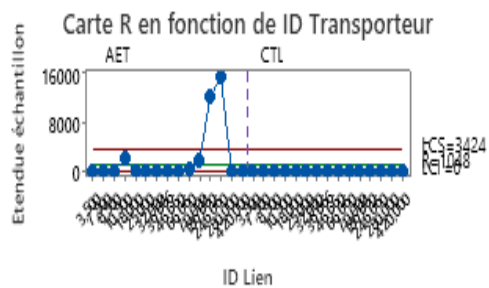
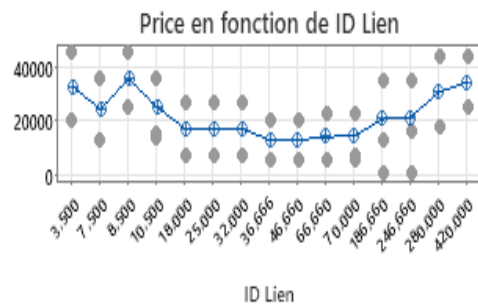
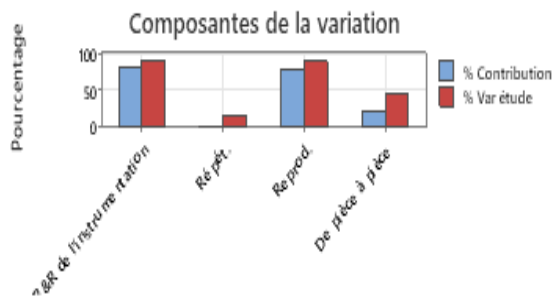
Nom de l'instrumentation :

Date de l'étude :

Auteur :

Tolérance :

Divers :



• **Appendix 05 : Contrat Transport SE (proposition)**

TRANSPORTATION CONTRACT

This contract is made between:

SCHNEIDER ELECTRIC ALGERIA SARL

Located at: Cheraga Office, Route de Ouled Faget, Délg Brahim, 16320 Algiers

Represented by its General Manager,

Mr. CHARA Anouar

Referred to as: "CLIENT" on the one hand,

And

XXXXXXXXXXXX

Located at: XXXXXXXXXXXXXXXXXXXXXXXX

Represented by its Manager,

Mr. XXXXXXXXXXXXXXXXXXXXXXXX

Referred to as: "SERVICE PROVIDER" on the other hand.

ARTICLE 1: PURPOSE OF THE CONTRACT

The purpose of this contract is to define the terms and conditions governing the transportation services provided by "XXXXXXXXXX" for the materials and equipment of the client, "SCHNEIDER ELECTRIC ALGERIA". These services involve transporting goods from the client's industrial site located in Sidi Rached to its clients and partners across the entire Algerian national territory. **The service provider agrees to perform deliveries as and when requested by the client, based on the client's operational needs and instructions.**

ARTICLE 2: SERVICE FEE

Schneider Electric Algeria agrees to pay the service fee according to the rates annexed to this contract. The service fee is fixed and non-revisable for two years from the effective date of the contract. In case of service on multiple sites simultaneously, a flat rate will be charged for each additional site beyond the third delivery:

- XXXXXX DA for light vehicles under 1.5 tons.
- XXXXXX DA for vehicles from 1.5 tons to 3 tons.
- XXXXXX DA for vehicles from 3 tons to 10 tons.
- XXXXXX DA for vehicles from 10 tons to 20 tons.

ARTICLE 3: INSURANCE

The goods transported by the service provider are covered by an insurance policy for all vehicles up to the amount of one million dinars (XXXX) per vehicle. Beyond this amount, any additional insurance coverage shall be the responsibility of the client, who will provide a certificate of non-recourse from their insurer.

The service provider is required to maintain an all-risk insurance policy covering the entirety of its fleet for the full duration of the contract. **In addition, the service provider must ensure that all drivers assigned to the client's operations possess:**

- **A valid and appropriate driver's license,**
- **Clean and updated vehicle registration and technical inspection certificates,**
- **A clean criminal record,**
- **Compliance with all legal and regulatory requirements applicable to the transportation of goods in Algeria.**

Proof of the above, including insurance certificates, driver licences, vehicle documentation, and criminal records, **must be maintained and made available to the client's shipping department upon request at any time during the contract period. The presence of these certificates and documents is mandatory, and their verification may be conducted at the discretion of the client without prior notice.**

ARTICLE 4: RESPONSIBILITIES

The service provider agrees to make trucks available to the client within the required timeframes according to the client's needs. The client agrees to pay for the services rendered within the timeframes described in Article 6.

Truck drivers are strictly prohibited from handling the goods during loading and/or unloading operations. Their responsibility is limited to securing the goods properly before transport. Straps **must be systematically used to secure the load**; failure to comply gives the client the right to cancel the shipment without any compensation to the service provider. Trucks provided must have a flat surface and be fully equipped with **functional** straps.

Handling of goods at the Sidi Rached site, including loading operations onto trucks, remains entirely the responsibility of the client.

In cases where the service provider resorts to subcontracting or intermediary services for the execution of the transportation tasks, the service provider remains solely and fully responsible for any risks, damages, losses, or delays affecting the goods. Subcontracting does not release the service provider from their contractual obligations towards the client.

ARTICLE 5: CONTRACT OPERATION

The service provider will receive from the client, at least 24 hours in advance, an order specifying the number and type of trucks to be made available. This order may be communicated by fax, **email, or any other official means of communication agreed upon by the parties.**

The client will also provide the service provider with a provisional delivery schedule; this schedule is indicative and does not bind the client regarding the accuracy of delivery dates.

Any damage to the goods during transit (including loss, degradation, **theft**, or any other incident) shall be the sole and exclusive responsibility of the service provider.

ARTICLE 6: PAYMENT TERMS

The service provider shall present all invoices corresponding to the transport operations carried out during the previous month. **These invoices must be submitted to the client no later than the 10th day of each month.**

Each invoice must be accompanied by all necessary supporting documents, including but not limited to delivery notes, transport documents, and any evidence required by the client to validate the service. All invoices must bear the written mention "Service Rendered" validated by the client's authorised representative.

The client agrees to pay the validated invoices within sixty (60) days from the date of receipt of a complete and compliant invoice file. **Invoices submitted after the deadline, or incomplete invoices lacking the required documentation, may lead to a delay in payment without liability to the client.**

ARTICLE 7: DISPUTE CLAUSE

In the event of any dispute or disagreement arising from the interpretation, execution, or termination of this contract, the parties agree to first seek an amicable resolution through good-faith negotiation.

If no agreement is reached within a period of time mutually agreed upon by both parties from the date one party formally notifies the other of the existence of a dispute, either party may propose to submit the dispute to mediation before a mediator mutually agreed upon.

If mediation fails or if the parties do not agree to mediate, the dispute shall be referred exclusively to the jurisdiction of the Cheraga Court (Tribunal de Chéraga), which shall have sole competence.

ARTICLE 8: CONTRACT MODIFICATION

Any modification, amendment, or supplement to this contract must be made in writing and signed by duly authorised representatives of both parties.

Requests for modification must be submitted in writing, specifying the reasons and proposed changes.

No oral agreement, practice, or communication between the parties shall be deemed to modify the terms of this contract.

Any amendment shall only enter into force after formal approval by both parties through a signed addendum. the contract continues normally until the amendment is officially signed.

ARTICLE 9: EFFECT AND DURATION OF THE CONTRACT

This contract shall take effect from the date of its signature by both parties and shall remain in force until [XX/XX/XXXX].

At least XX calendar days prior to the expiration of the contract, either party may notify the other in writing of its intention not to renew the contract.

In the absence of such notification, the contract shall automatically renew for a period of time to be mutually specified in the renewal agreement, under the same terms and conditions, unless otherwise agreed by the parties in writing. In the event that no renewal agreement is signed before the expiration date and no renewal period is specified, the contract shall automatically terminate without liability to either party. Each party acknowledges that it bears its own risk for any interruption of services due to failure to negotiate and finalise a renewal in a timely manner.

ARTICLE 10: ENVIRONMENT

The service provider shall perform its obligations under this contract in full compliance with all applicable environmental laws and regulations in force.

The service provider commits to:

- Not use or transport hazardous substances except in strict compliance with legal and regulatory requirements;
- Properly manage and dispose of all by-products generated by its activity (such as oils, filters, tires, and fuels) through approved recycling or waste treatment channels;
- Prevent any accidental release, spill, or environmental damage during the execution of the services;
- Maintain all necessary authorisations, licences, and certifications relating to environmental protection and provide them to the client upon request.

Any environmental incident attributable to the service provider shall be its sole responsibility, and the service provider shall take, at its own cost, all necessary corrective measures.

The service provider also undertakes to cooperate fully with the client's environmental policies, audits, and any improvement actions requested during the performance of the contract.

ARTICLE 11: HSE

Driver Responsibilities Inside the Site

- **Adherence to Site Rules:** Follow all site and Schneider Electric-specific rules and regulations, including speed limits, designated routes, and parking areas.
- **Safety Protocols:** Comply with all safety protocols, including wearing appropriate PPE and following site safe loading and unloading procedures.
- **Vehicle Inspection:** Conduct a thorough inspection of the vehicle before entering and after leaving the site to ensure it is in safe operating condition.
- **Communication:** Maintain clear communication with site personnel, including reporting arrival, departure, and any issues encountered during operations.
- **Emergency Procedures:** Be familiar with and adhere to the site's emergency procedures, including evacuation routes and emergency contact numbers.
- **Environmental Protection:** Ensure that no hazardous materials are spilt or improperly disposed of on site.

- **Documentation:** Keep all necessary documentation, such as delivery notes and safety data sheets, readily available and ensure they are properly filled out.
- **Behaviour:**
 - Always exhibit professional behaviour, including respecting site personnel and other drivers and avoiding any actions that could cause disruptions or safety hazards.
 - Drivers are required to hand over the keys of their trucks to security guards or Schneider Electric employees and to wait in the drivers' waiting room while their trucks are being unloaded/loaded.
 - Drivers are asked to wear work clothing appropriate to the workplace; no illegal work clothing is accepted on site.
 - Other operations not related to the task in question (unloading/loading) are not permitted on site (e.g., maintenance, etc.).
 - Drivers
 - **Vehicle Operation:** Operate the vehicle in a safe and controlled manner, avoiding any reckless driving or manoeuvres that could endanger site personnel or property.

Safety Controls:

- **Vehicle Maintenance:** Regular maintenance and safety checks of all vehicles to ensure they are in good working condition.
- **Personal Protective Equipment (PPE):** Provision and mandatory use of PPE (high-visibility vest, safety shoes, in some cases a helmet and protective gloves) for all personnel involved in loading, unloading, and transit operations.
- **Incident Reporting:** Immediate reporting and thorough investigation of any accidents or incidents.
- **Emissions Control:** Ensure all vehicles comply with local and international emissions standards to minimise environmental impact.
- **Waste Management:** Respect Schneider Electric's proper waste disposal methods for hazardous and non-hazardous materials and ensure generated waste inside the site is treated according to site rules.
- **Hazardous Products:** Prohibit the introduction of hazardous substances in the performance of this contract.
- **Mandatory Legal Papers:** Some mandatory papers need to be presented at the guard's post and at other checkpoints when requested by Schneider Electric employees:
 - **Driver's License:** A valid driver's license appropriate for the type of vehicle being operated.
 - **Vehicle Registration:** Current vehicle registration documents (Carte Grise).
 - **Insurance Certificate:** Proof of valid vehicle insurance and goods insurance.
 - **Transport Permits:** Any special permits required for transporting specific types of goods (e.g., hazardous materials, oversized loads).

Other requirements:

- **Driver Experience:** Only drivers with a minimum of 3 years of experience in operating trucks are permitted. Fresh drivers without experience are not allowed.

- **Prohibition of non-related to work persons:** Access to the site is strictly reserved for the drivers; those accompanying them in a non-executive role are not authorised to access or carry out any work on the site.

additionally: ARTICLE 11: Appendices (ANNEXES)

The appendices listed below form an integral and indivisible part of this contract. They have the same legal value as the main body of the contract. The parties acknowledge having read and accepted the appendices and agree that they may be modified, updated, or supplemented by mutual agreement in writing.

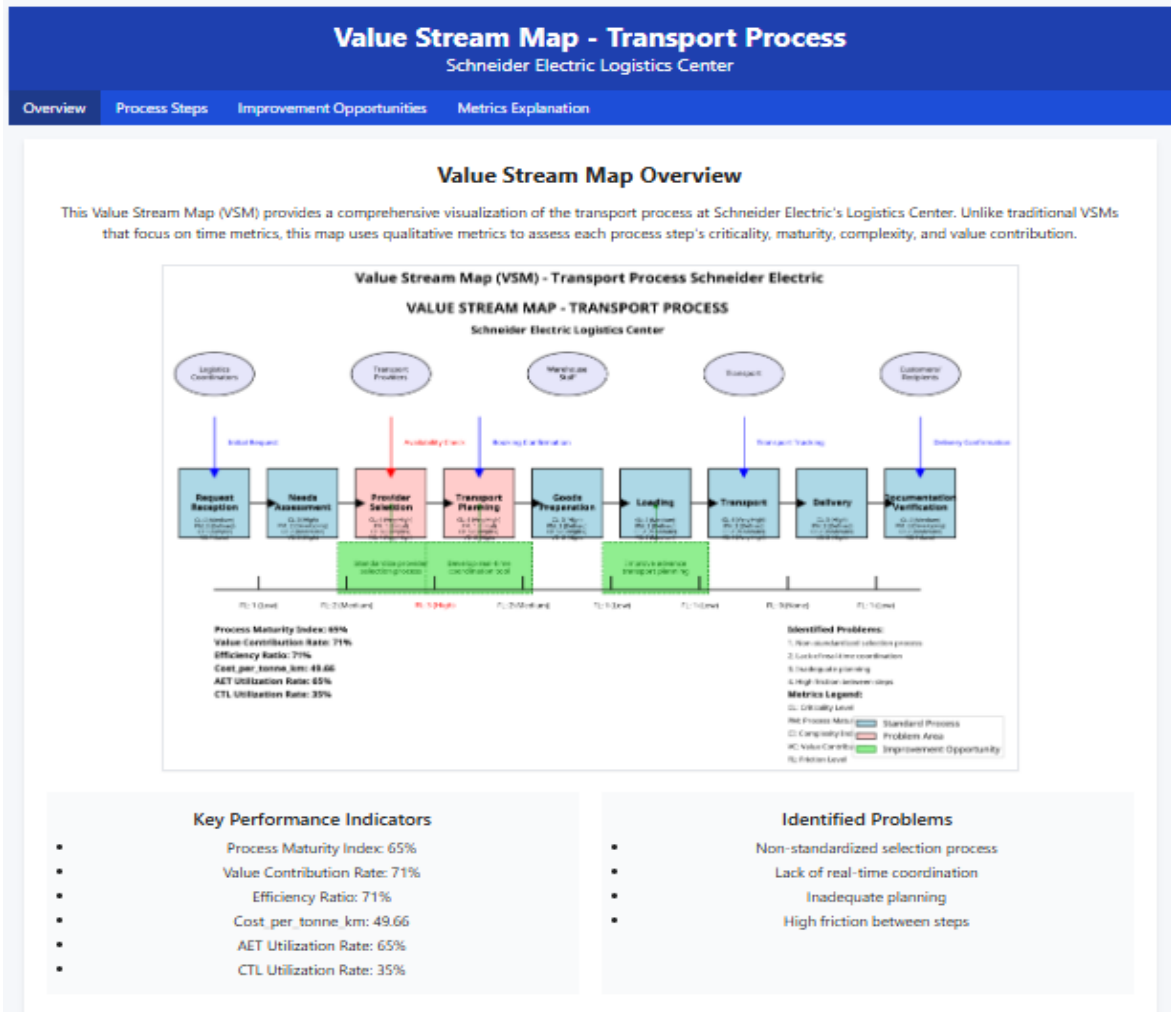
The appendices include, but are not limited to:

Appendix 01 example: "Environmental Management Compliance"

Appendix 02 example: "Tariffs and Pricing Terms"

- Appendix 06 : Website for VSM analysing

1. First interface :



Key Performance Indicators

- Process Maturity Index: 65%
- Value Contribution Rate: 71%
- Efficiency Ratio: 71%
- Cost_per_tonne_km: 49.66
- AET Utilization Rate: 65%
- CTL Utilization Rate: 35%

Identified Problems

- Non-standardized selection process
- Lack of real-time coordination
- Inadequate planning
- High friction between steps

Academic Value

This qualitative VSM approach provides deeper insights than traditional time-based VSMs by:

- Highlighting maturity gaps in critical processes
- Identifying friction points between process steps
- Prioritizing improvements based on multiple dimensions (criticality, maturity, complexity)
- Providing a holistic view of process performance beyond time measurements

This approach aligns with advanced Lean Six Sigma methodologies that recognize the multidimensional nature of process optimization beyond time efficiency alone.

Value Stream Map - Transport Process

Schneider Electric Logistics Center

Created for academic purposes as part of a PFE (Projet de Fin d'Études)

2. Second interface :

Value Stream Map - Transport Process

Schneider Electric Logistics Center

Overview
Process Steps
Improvement Opportunities
Metrics Explanation

Process Steps

1. Request Reception
2. Needs Assessment
3. Provider Selection
Problem Area
4. Transport Planning
Problem Area
5. Goods Preparation
6. Loading
7. Transport
8. Delivery
9. Documentation Verification

Request Reception

Initial reception of transport requests from internal departments or customers. This step involves receiving and logging the request details.

Qualitative Metrics

<p>Criticality Level (CL)</p> <p>2 - Medium</p> <div style="width: 50%; height: 10px; background: linear-gradient(to right, #0056b3, #ccc);"></div>	<p>Process Maturity (PM)</p> <p>3 - Defined</p> <div style="width: 75%; height: 10px; background: linear-gradient(to right, #008000, #ccc);"></div>
<p>Complexity Index (CI)</p> <p>1 - Simple</p> <div style="width: 25%; height: 10px; background: linear-gradient(to right, #b8860b, #ccc);"></div>	<p>Value Contribution (VC)</p> <p>1 - Low</p> <div style="width: 15%; height: 10px; background: linear-gradient(to right, #800080, #ccc);"></div>

Value Stream Map - Transport Process

3. Third interface :

Value Stream Map - Transport Process

Schneider Electric Logistics Center

Overview Process Steps Improvement Opportunities Metrics Explanation

Improvement Opportunities

- Standardize provider selection process
- Develop real-time coordination tool
- Improve advance transport planning

Select an improvement opportunity to view details

Value Stream Map - Transport Process
Schneider Electric Logistics Center
Created for academic purposes as part of a PFE (Projet de Fin d'Études)

Value Stream Map - Transport Process

Schneider Electric Logistics Center

Overview Process Steps Improvement Opportunities Metrics Explanation

Improvement Opportunities

- Standardize provider selection process
- Develop real-time coordination tool
- Improve advance transport planning

Standardize provider selection process

Develop and implement standardized criteria and procedures for selecting transport providers based on objective factors such as cost, reliability, and specific transport requirements.

Related Process Steps

3. Provider Selection
Selection between transport providers (AET or CTL) based on availability, cost, and requirements. Currently not standardized and often based on subjective factors.

Value Stream Map - Transport Process
Schneider Electric Logistics Center
Created for academic purposes as part of a PFE (Projet de Fin d'Études)

Value Stream Map - Transport Process

Schneider Electric Logistics Center

Overview Process Steps Improvement Opportunities Metrics Explanation

Improvement Opportunities

Standardize provider selection process

Develop real-time coordination tool

Improve advance transport planning

Develop real-time coordination tool

Create a digital platform for real-time visibility of transport provider availability and booking confirmation to improve coordination and reduce delays.

Related Process Steps

3. Provider Selection

Selection between transport providers (AET or CTL) based on availability, cost, and requirements. Currently not standardized and often based on subjective factors.

4. Transport Planning

Scheduling and coordination of transport details, routes, and timing. Often done reactively rather than proactively.

Value Stream Map - Transport Process

Schneider Electric Logistics Center

Created for academic purposes as part of a PFE (Projet de Fin d'Études)

Value Stream Map - Transport Process

Schneider Electric Logistics Center

Overview Process Steps Improvement Opportunities Metrics Explanation

Improvement Opportunities

Standardize provider selection process

Develop real-time coordination tool

Improve advance transport planning

Improve advance transport planning

Implement proactive planning processes to anticipate transport needs and schedule resources more efficiently.

Related Process Steps

4. Transport Planning

Scheduling and coordination of transport details, routes, and timing. Often done reactively rather than proactively.

5. Goods Preparation

Preparation of goods for transport including packaging, labeling, and documentation.

Value Stream Map - Transport Process

Schneider Electric Logistics Center

Created for academic purposes as part of a PFE (Projet de Fin d'Études)

4. Forth interface :

Value Stream Map - Transport Process

Schneider Electric Logistics Center

Overview Process Steps Improvement Opportunities Metrics Explanation

Metrics Explanation

Process Step Metrics

Criticality Level (CL)

Indicates how critical each step is to the overall process success.

- 1 - Low: Minimal impact on overall process
- 2 - Medium: Moderate impact on process outcomes
- 3 - High: Significant impact on process success
- 4 - Very High: Critical to process success

Process Maturity (PM)

Measures how mature/optimized each process step is.

- 1 - Initial: Ad hoc, poorly defined processes
- 2 - Developing: Basic processes defined but inconsistent
- 3 - Defined: Well-documented, consistent processes
- 4 - Optimized: Continuously improved, efficient processes

Complexity Index (CI)

Reflects the complexity of executing each step.

- 1 - Simple: Straightforward, minimal variables
- 2 - Moderate: Some complexity, manageable variables
- 3 - Complex: Multiple variables and dependencies
- 4 - Very Complex: Highly complex with many variables

Value Contribution (VC)

Measures how much value each step adds to the overall process.

- 1 - Low: Minimal direct value to customer
- 2 - Medium: Moderate value contribution
- 3 - High: Significant value contribution
- 4 - Very High: Essential value to customer

Transition Metrics

Friction Level (FL)

Indicates resistance or inefficiency between process steps.

Transition Metrics

Friction Level (FL)

Indicates resistance or inefficiency between process steps.

- 0 - None: Seamless transition between steps
- 1 - Low: Minor delays or inefficiencies
- 2 - Medium: Noticeable delays or coordination issues
- 3 - High: Significant delays or handoff problems

Overall Process Metrics

Process Maturity Index: 65%

Overall maturity of the process, calculated as a weighted average of individual process maturity scores.

Value Contribution Rate: 71%

Percentage of process steps that add significant value to the overall process.

Efficiency Ratio: 71%

Ratio of value-adding activities to total activities in the process.

Cost_per_tonne_km: 49.66

Average cost per tonne-kilometer for transport operations.

AET Utilization Rate: 65%

Percentage of transports using AET as the provider.

CTL Utilization Rate: 35%

Percentage of transports using CTL as the provider.

Value Stream Map - Transport Process

Schneider Electric Logistics Center

Created for academic purposes as part of a PFE (Projet de Fin d'Études)

Table of contents

Acknowledgments	I
Abstract.....	II
Résumé.....	III
الملخص.....	IV
Summary.....	V
List of Tables	VII
List of Symbols and Abbreviated Terms	XI
General Introduction.....	1
Chapter 01: Context and Research Problem	1
1 Context Of The Study	2
2 Research Question	3
3 Objectives of the Study	4
4 Reasons for Choosing the Topic	4
4.1 Personal Motivation	4
4.2 Academic Relevance.....	5
5 Epistemology of the Study	5
5.1 Epistemological Posture.....	5
5.2 Research Approach.....	6
6 .Relevance of the Study	6
6.1 Theoretical Relevance	6
6.2 Managerial Relevance.....	7
7 Context and Description of the Study Site	7
7.1 Overview of Schneider Electric.....	7
7.1.1 Schneider Electric’s History & Global Presence	7
7.1.2 Global Presence.....	8
7.2 Schneider Electric Algeria (SEA)	9
7.2.1 Key Areas of Operation.....	9
7.2.2 Commitment to Local Development	10
7.2.3 Compliance & Quality Assurance	10

7.3	Schneider Electric’s Logistics Centre in Algeria “ Warehouse & Delivery Process ”	11
7.3.1	Overview of the Logistics Centre	11
	<i>Source: internal documents</i>	11
7.3.2	Studied Workflow: Delivery Process	13
7.3.3	Performance Indicators & Ongoing Challenges	14
7.3.4	Relevance to This Study	14
Chapter 02: Theoretical Framework		15
Section 01: Literature Review		15
1	Lean Six Sigma and process improvement:	15
2	Lean Six Sigma and supply chain enhancement :	17
3	Critical analysis :	20
Section 02: Key Theoretical Concepts Underpinning the Project		25
1	Process Improvement	25
2	Methods for Solving Complex Problems	26
3	Lean Six Sigma	27
3.1	Definition of Lean Six Sigma	27
3.2	Lean Management	27
3.2.1	Definition and Origin of Lean Management	27
3.2.2	Principles of Lean Management	28
3.3	Six Sigma Fundamentals	29
3.3.1	Historical Background of Six Sigma	29
3.3.2	Principales of Six-Sigma	30
A.	Six Sigma as a Scientific Quality Approach	30
B.	Six Sigma as a Structured Process Improvement System	33
3.4	Integrated Use of Lean and Six Sigma for Process Excellence	34
4	Six Sigma project: DMAIC methodology	35
4.1	Phase : Define	35
4.1.1	Defining CTQs (Critical To Quality)	36
A.	Listening to the Voice of the Customer (VoC)	36
B.	The CTQ (Critical To Quality) Diagram	36
4.1.2	Process Mapping	37
A.	The "Black Box" Diagram	37
B.	SIPOC Diagram	38
C.	Flowcharts (Logigrammes)	39

4.1.3	Defining Project Boundaries:	39
A.	The 5 Whys Technique	39
B.	The Project Charter	39
4.2	Phase : Measure	40
4.2.1	Phase Flow:	41
A.	Measurement System Analysis (MSA)	41
B.	Control Charts	41
C.	Process Capability	42
4.3	Phase : Analyse	43
A.	Ishikawa Diagram (Cause-and-Effect Diagram)	44
B.	Value Stream Mapping	44
4.4	Phase : Improve	45
A.	Action Plan	45
B.	PDCA Cycle (Plan, Do, Check, Act)	45
4.5	Phase: Control	46
5	Transport Management as a Strategic Function in the Supply Chain	46
6	Logistics Service Provider (LSP) Management: Coordinating Outsourced Logistics for Competitive Advantage	47
Chapter 03:		49
1	Qualitative approach	49
1.1	Qualitative data collection methods and tools	49
1.1.1	Documentary analysis	49
1.1.2	Semi-structured interview	49
1.1.3	Focus groups	50
1.1.4	Brainstorming	50
1.1.5	Stakeholder Meeting Participation	51
1.2	Qualitative data analysis methods and tools	51
1.2.1	Thematic analysis	51
1.2.2	5W1H	51
1.2.3	Cause-and-Effect (Ishikawa/Fishbone) Diagram	52
1.2.4	NVivo	52
2	Quantitative approach	52
2.1	Quantitative data collection:	52
2.2	Quantitative data analysis methods and tools	53
2.2.1	Power BI	53

2.2.2	MiniTAB	53
Chapter 04: Presentation and Analysis of Results		55
1	Pre-Six Sigma Phase: Problem Selection	55
1.1	Define and Classify General Customers.....	55
1.1.1	Project Location Overview.....	55
1.1.2	Department Organization Chart.....	56
1.2	Collect and Classify the VOC (Voice of the Customer).....	57
1.3	Prioritisation of the VOC.....	58
1.3.1	Priority Matrix (Eisenhower, Stephen Covey, Paul J. Meyer).....	58
1.3.2	Risk Assessment Matrix / For Urgent and Important VOC.....	60
1.3.3	Prioritisation Matrix as per ISO 13053:2011 for CTQ post VOC	61
2	D E F I N E	64
2.1	Process Mapping definition	64
2.1.1	SIPOC Diagram	65
2.1.2	Current State Flowchart	66
2.2	Critical To Quality (CTQ).....	67
2.2.1	CTQ Definition and Purpose	68
2.2.2	CTQ Identification methods	68
2.2.3	Identified CTQ Elements	68
2.3	Problem Definition	69
2.4	Project Charter.....	69
3.	M E A S U R E	73
3.1	Data Collection Methodology.....	73
3.1.1	Data Source	73
3.1.2	Data Preparation and Organization	73
3.1.3	Sample Size.....	74
3.2	Data Visualization	74
3.2.1	Key Visual Elements and Extracted Metrics	74
3.3	Statistical Validation of the Process	76
3.3.1	Measurement System Analysis (MSA).....	76
A.	Method Used: Gage R&R (ANOVA Method).....	76
B.	MANOVA Validation	78
3.3.2	Box Plot of Transport Costs.....	79
3.3.3	Normal Distribution	80
3.3.4	Process capability and Sigma Level Analysis.....	81

A.	Indicator and Specification Limit Justification.....	81
B.	Current State of the Process	82
C.	Capability Indices.....	82
D.	Sigma Level and Defect Rate	83
E.	Process Capability Graph	83
4	A N A L Y S E	84
4.1	Transport Process Analysis	84
4.1.1	Value Stream Mapping (VSM).....	84
4.1.2	Process Flow Mapping.....	87
4.2	Capability Report Analysis	87
4.3	Root Cause Analysis.....	88
4.3.1	ISHIKAWA diagram (fishbone diagram)	88
5	I M P R O V E	90
5.1	Objectives of the project.....	90
5.2	Proposed solutions.....	90
5.2.1	Review and Revision of Transport Contracts	91
5.2.2	Development of a Coordination App (Planning Interface Proposal)..	91
A.	Key Functionalities of the Tool.....	92
B.	Technical Feasibility	92
5.3	Other solutions.....	92
5.3.1	Expansion of the Transport Provider Pool.....	92
5.5	Risk analysis for the improvement phase	94
6	C O N T R O L	96
6.1	Monitoring plan.....	96
6.2	Control Tools	97
6.3	Responsibilities	97
6.4	Response plan for deviations.....	98
6.5	Future control activities.....	98
7	R e s u l t s' d i s c u s s i o n s	99
7.1	Integration of Lean Six Sigma in Supply Chain Communication: Bridging Theory and Practice	99
7.2	Alignment with Existing LSS Research in Supply Chain Management	99
7.3	Communication as a Critical Factor in Supply Chain Efficiency	99
7.4	Technology Integration in LSS Implementation	100
7.5	Customer-Centric Approach to Process Improvement.....	100

7.6	Organizational Challenges in LSS Implementation.....	101
7.7	Methodological Contributions	101
7.8	Practical Implications for Supply Chain Management	102
7.9	Limitations and Future Research Directions.....	102
7.10	Discussion's synthesis.....	103
	General Conclusion	104
	Appendices.....	110
	Table of contents	115