

PEOPLE'S DEMOCRATIC REPUBLIC of ALGERIA
MINISTRY OF HIGHER EDUCATION AND SCIENTIFIC RESEARCH
MOHAMED KHEIDER UNIVERSITY OF BISKRA
FACULTY OF ECONOMIC, COMMERCIAL AND MANAGEMENT SCIENCES
DEPARTMENT OF COMMERCIAL SCIENCES



Thesis Title

Exploring the Role of Artificial Intelligence in Enhancing Air Freight Efficiency

CASE STUDY: DHL EXPRESS, FedEx EXPRESS, UPS

A Thesis Submitted to the Department of Commercial Sciences as Partial Fulfilment for the Master's Degree in Commercial Sciences. Option: Finance and International Trade.

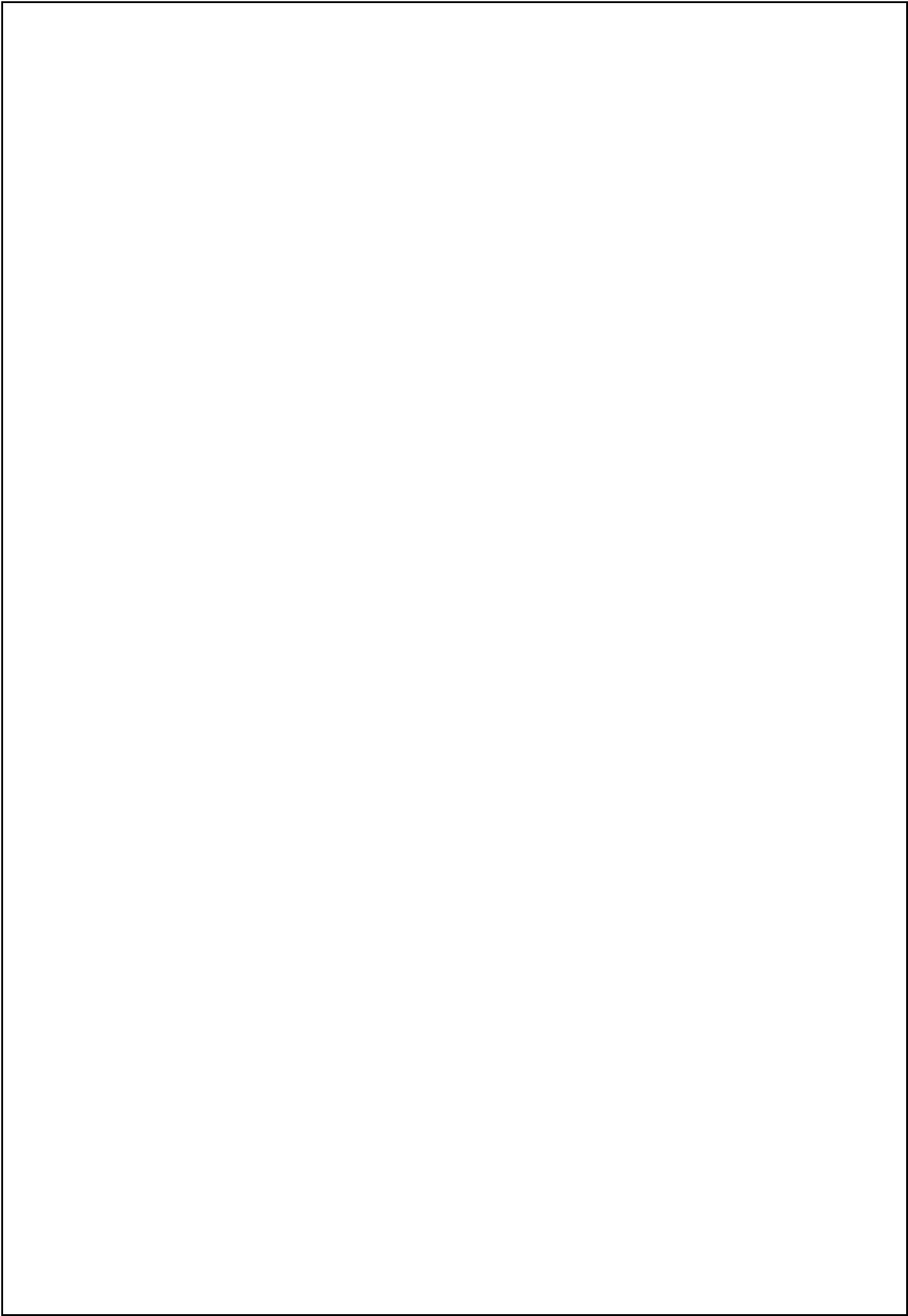
Submitted by: Ameer Lina

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Academic year 2024/2025



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Acknowledgements

Prophet Muhammed, peace be upon him said:

“ whoever does not thank people does not thank god, whoever does you a favor, reward them. If you cannot, then pray for them”

First and foremost, all praise and thanks are due to Allah, the highest, the lord of the worlds— the one who bestowed upon me the ability, strength, and guidance to complete this work. By his infinite mercy and wisdom, he opened doors of knowledge and illuminated my path. Glory be to him, the all-knowing, the all-wise, without whose blessings no effort succeeds and no knowledge is attained.

*it is said that years of effort, no matter how long, will pass— they have an end, and every end has its conclusion. With this humble work, I express my deepest gratitude and appreciation to the esteemed professor, my supervisor **Mr. Ben Abid Farid**. To you and your efforts. Though all words of thanks cannot fully capture what you deserve, this acknowledgement reflects your unwavering dedication.*

Thank you to everyone who has taught me even a single letter in this journey, to all the teachers of the department of commercial sciences at the university of Biskra. A special thanks to my teachers who were with me through the university path, the knowledge and wisdom you have imparted to me will always be with me, and I am deeply thankful to each and every one of you.

Thank you sincerely,

Ameur Lina

Dedication

To my incredible mother, the one who made paradise shine on this earth and facilitated my path with her kindness and selfless support, my queen and heroine of all times. The one who played two roles with strength, grace, and unconditional love (Kibaa Yamina). You are the reason I stand here today – this success is as much yours as it is mine. Thank you for every sacrifice, every prayer, every sleepless night.

To the memory of my beloved father, to the one who left the world too soon, to the one who left us physically but still lives in my heart., to the one whose name is deeply linked to mine, whom I proudly carry like a crown. Today, I dedicate this academic victory to you, may Allah have mercy on my father (Ameur Ali).

To my dear sisters, my first and forever supporters (Israa and Khaoula), who believed in me even when I doubted myself – I dedicate this to you, with all my love.

To my best friends, who stood beside me through the joys and the struggles, who lifted me when I was down and celebrated every step forward – thank you for being my chosen family.

Above all, my beloved Allah, the one who never fails, the one who was my strength when I faltered, to the invisible presence that holds the depth of human feelings. Thank you for all the blessings and guidance you gave me.

Finally, in heartfelt dedication, I extend my deepest appreciation for the unwavering determination, resilience, and countless sacrifices made throughout this journey. My relentless pursuit of excellence is a testament to my strength, courage, and unwavering commitment to personal growth. Here's to celebrating the resilience and perseverance within me.

L.A.N.A

Abstract

Abstract

International transportation, amidst the expansion of global trade, is undergoing a pivotal transformation driven by rapid advancements in artificial intelligence (AI). Recognizing the critical importance of efficient air freight operations in this evolving landscape, this study seeks to address operational inefficiencies, reliability risks, customer needs, and environmental challenges through innovative AI solutions, with the aim of enhancing global trade and connectivity. Specifically, the research investigates AI's role in enhancing the efficiency, reliability, customer service, and sustainability of leading international air freight companies, focusing on optimizing logistics, improving service reliability, and promoting sustainability in key players such as DHL, FedEx, and UPS. The research method consisted of applying a descriptive analytical approach, assessing AI adoption and integration across air freight operations. By evaluating AI applications such as automated warehouse management, route optimization, and customer service automation, the research provides insights into their impact on air freight operations. The findings from this research show that AI applications enhance efficiency by streamlining cargo handling, improving delivery processes, and bolstering reliability through predictive maintenance and smarter scheduling. Furthermore, AI supports better customer service by streamlining communication and order tracking. Additionally, AI contributes to sustainability by reducing energy consumption and emissions through optimized routing and load planning. The main conclusions drawn from this research affirm that integrating AI into air freight operations yields substantial benefits in efficiency, reliability, customer service, and sustainability. Leveraging best practices from leading companies such as DHL, FedEx, and UPS offers insights for global improvement of air cargo logistics. This study provides strategic recommendations for effective AI implementation, advancing knowledge in air freight logistics and operations.

Key words: International Transportation, Air Freight, Global Trade, Artificial Intelligence (AI).

ملخص

يشهد النقل الدولي، في ظل توسع التجارة العالمية، تحولاً محورياً مدفوعاً بالتطورات السريعة في الذكاء الاصطناعي. وإدراكاً للأهمية البالغة لكفاءة عمليات الشحن الجوي في هذا السياق المتغير، تسعى هذه الدراسة إلى معالجة أوجه القصور التشغيلية، ومخاطر الموثوقية، واحتياجات العملاء، والتحديات البيئية من خلال حلول مبتكرة قائمة على الذكاء الاصطناعي، بهدف تعزيز التجارة والاتصال العالمي. تركز هذه الدراسة بشكل خاص على دور الذكاء الاصطناعي في تعزيز الكفاءة، والموثوقية، وجودة خدمة العملاء، والاستدامة لدى كبرى شركات الشحن الجوي الدولية، من خلال التركيز على تحسين سلاسل الإمداد، وتعزيز موثوقية الخدمات، ودعم الاستدامة لدى شركات رئيسية مثل دي إتش إل (DHL)، وفيديكس (FedEx)، ويوناييتد بارسل سيرفيس (UPS) وقد تمثلت منهجية البحث في استخدام المنهج الوصفي التحليلي، من خلال تقييم تبني ودمج الذكاء الاصطناعي عبر عمليات الشحن الجوي. ومن خلال دراسة تطبيقات الذكاء الاصطناعي مثل إدارة المخازن الآلية، وتحسين المسارات، وأتمتة خدمة العملاء، تقدم هذه الدراسة رؤى حول تأثير هذه التطبيقات على عمليات الشحن الجوي. تشير نتائج هذا البحث إلى أن تطبيقات الذكاء الاصطناعي تسهم في تعزيز الكفاءة من خلال تبسيط عمليات مناولة البضائع وتحسين عمليات التسليم، وتدعم تعزيز الموثوقية عبر الصيانة التنبؤية وتحسين جداول العمل. كما يسهم الذكاء الاصطناعي في تحسين خدمة العملاء من خلال تبسيط الاتصال وتتبع الطلبات. علاوة على ذلك، يدعم الذكاء الاصطناعي الاستدامة عبر تقليل استهلاك الطاقة والانبعاثات من خلال تحسين المسارات وخطط التحميل. وتؤكد النتائج النهائية لهذه الدراسة أن دمج الذكاء الاصطناعي في عمليات الشحن الجوي يحقق فوائد ملموسة في مجالات الكفاءة، والموثوقية، وخدمة العملاء، والاستدامة. ويوفر الاستفادة من أفضل الممارسات لدى شركات رائدة مثل (DHL) و (FedEx) و (UPS) رؤى مهمة لتحسين اللوجستيات العالمية للشحن الجوي. وتقدم هذه الدراسة توصيات استراتيجية للتطبيق الفعال للذكاء الاصطناعي، مما يسهم في تطوير المعرفة في مجال لوجستيات وعمليات الشحن الجوي.

الكلمات المفتاحية: النقل الدولي، الشحن الجوي، التجارة العالمية، الذكاء الاصطناعي

Contents

Acknowledgment.....	I
Dedication.....	II
Abstract.....	III
Contents.....	VI
List of Figures.....	VIII
List of Tables.....	VIII
List of Abbreviations and acronyms.....	IX
General Introduction.....	1
CHAPTER ONE: THE THEORETICAL PART	
Introduction.....	6
TOPIC ONE: Basic Concepts About Artificial Intelligence.....	7
1.1 Introduction.....	9
1.2 Definition of Artificial Intelligence.....	9
1.3 The History of Artificial Intelligence.....	9
1.4 Major Subfields of Artificial Intelligence.....	14
1.5 Applications of Artificial Intelligence.....	16
1.6 Advantages of Artificial Intelligence.....	17
1.7 Disadvantages of Artificial Intelligence.....	18
1.8 The Role of Artificial Intelligence in Transportation.....	19
1.9 Conclusion.....	20
TOPIC TWO: Basic Concepts about Air Freight.....	21
2.1 Introduction.....	22
2.2 Definition of Air Freight.....	22
2.3 History of Air Freight.....	22
2.4 The Air Freight Process.....	27
2.5 Types of Air Freight Shipments.....	29
2.6 Benefits of Air Freight.....	31
2.7 Challenges of Air Freight.....	32
2.8 Airport Connections.....	32
2.9 Key Trends in Air Freight.....	34
2.10 Conclusion.....	36
TOPIC THREE: Applications of Artificial Intelligence in Air Freight Industry.....	37
3.1 Introduction.....	38

3.2	Automated Warehouse Management.....	38
3.3	Route Optimization.....	41
3.4	Predictive Maintenance.....	42
3.5	Cargo Space Optimization.....	44
3.6	Dynamic Pricing Models.....	46
3.7	Enhanced Security and Surveillance.....	47
3.8	Customer Service Automation.....	49
3.9	Conclusion.....	51
	Summary of the Chapter.....	52
CHAPTER TWO: THE PRACTICAL PART		
	Introduction.....	54
	TOPIC ONE: An Overview of DHL, FedEx, and UPS in Air Freight.....	55
1.1	Introduction.....	56
1.2	DHL Express: An Overview.....	56
1.3	FedEx Express: An Overview.....	57
1.4	UPS: An Overview.....	58
1.5	Conclusion.....	60
	TOPIC TWO: AI Applications in DHL, FedEx, and UPS.....	61
2.1	Introduction.....	62
2.2	AI Applications in DHL.....	62
2.3	AI Applications in FedEx.....	66
2.4	AI Applications in UPS.....	70
2.5	Conclusion.....	73
	TOPIC THREE: A Comparative Study of AI Innovations in DHL, FedEx, and UPS.....	74
3.1	Introduction.....	75
3.2	Analysis of Strengths and Weaknesses of DHL, FedEx, and UPS.....	75
3.3	Changes in Financial and Sustainability Performance Following AI Adoption.....	78
3.4	Points of Similarities.....	82
3.5	Points of Differences.....	83
3.6	Conclusion.....	84
	Summary of the Chapter.....	85
	General Conclusion.....	86
	Bibliography.....	90
	Appendices.....	96

List of Figures

Figure (01): Subfields of Artificial Intelligence.....	15
Figure (02): An Early B747 Freighter.....	25
Figure (03): Boeing 777.....	27
Figure (04): Loading Heavy Outsized Shipment.....	28
Figure (05): The Complete Process of Air Freight.....	30
Figure (06): Process Flow for Predictive Maintenance Using AI.....	44
Figure (07): AI-CARGO Process.....	45
Figure (08): AI Dynamic Pricing Based on Real-Time Factors.....	49
Figure (09): Air Freight Shipping Process.....	59
Figure (10): DHL GREEN PLAN for Efficient Route Optimization.....	65
Figure (11): DHLBot.....	66
Figure (12): FedEx Sorting Arm.....	71
Figure (13): UPS Automated Sorting Hub.....	73
Figure (14): DHL's Key Indicators of AI's Impact on Air Freight Operations.....	81
Figure (15): FedEx Key Indicators of AI's Impact on Air Freight Operations.....	83
Figure (16): UPS Key Indicators of AI's Impact on Air Freight Operations.....	84

List of Tables

Table (01): DHL Financial and Sustainability Key Figures.....	81
Table (02): FedEx Financial and Sustainability Key Figures.....	82
Table (03): UPS Financial and Sustainability Key Figures.....	84

List of Abbreviations and Acronyms

AI: Artificial Intelligence.

LISP: List Processing.

NLP: Natural Language Processing.

AAAI: Association for the Advancement of Artificial Intelligence.

XCON: Expert Configurer.

UX: User Experience.

SVM: Support Vector Machines.

PNN: Probabilistic Neural Network.

ANN: Artificial Neural Networks.

ICAN: The International Commission of Air Navigation.

ULDs: Unit Load Devices.

CCS: Cargo Community Systems.

EDI: Electronic Data Interchange.

CRAF: Contracts for Civilian Freighters.

NCA: Nippon Cargo Airlines.

ABC: Air Bridge Cargo.

FAA: Federal Aviation Administration.

CAA: Civil Aviation Authority.

AS/RS: Automated Storage/Retrieval Systems.

AMRs: Autonomous Mobile Robots.

AGVs: Automated Guided Vehicles.

WMS: Warehouse Management Systems.

OCR: Optical Character Recognition.

DMV: Disguised Missing Volume.

BKVOL: Booked Volume.

BKWT: Booked Weight.

SHC: shipment code.

RCSVOL: received volume.

DHL: Dalsey Adrian, Hillblom Larry, Lynn Robert

3PL: third party logistics.

FedEx: Federal Express Corporation

UPS: United Parcel Service.

MyGTS: My Global Trade Services platform.

HS: harmonized systems.

TMS: transportation management systems.

ML: machine learning.

IT: information technology.

BLE: Bluetooth low energy.

SPAC: south pacific.

CAAS: civil aviation authority of Singapore.

ORION: on-road integrated optimization and navigation.

EBIT: Earnings Before Interest and Taxes.

SAF: sustainability aviation fuel.

MMT: million metric tons.

General Introduction

General Introduction

In an era marked by rapid technological advancement, modern innovations are reshaping the foundations of international trade. Digital technologies have become inseparable from global commerce, influencing how goods are exchanged, tracked, and delivered across borders. This wave of transformation continues to accelerate, driven by the growing demands of a connected global market that values speed, efficiency, and adaptability. International trade is no longer confined to traditional processes; it is evolving into a dynamic system where technology plays a central role in enabling competitiveness and growth.

At the heart of this transformation lies transportation, an indispensable element of international trade. As the physical link between producers and consumers worldwide, transportation systems have had to evolve in response to rising trade volumes, tighter delivery windows, and increased expectations for reliability. The pursuit of faster, more flexible, and more resilient transport solutions has pushed the sector toward embracing digital innovation, setting the stage for fundamental changes in how goods move across the world.

This technological shift has not been solely motivated by progress; it has also been shaped by global disruptions that exposed critical weaknesses in international trade systems. The COVID-19 pandemic stands as a pivotal moment, testing the resilience of transportation networks and prompting urgent adaptation. The crisis accelerated the integration of technology across various sectors as companies faced unpredictable disruptions, capacity constraints, and changing regulatory landscapes. Technology adoption, which might have unfolded gradually, became a necessary response to ensure continuity and stability during a period of intense global uncertainty.

Among the emerging technologies influencing this transformation, artificial intelligence has captured significant attention. As it has begun to influence global trade by enabling smarter processes, improving responsiveness to challenges, and creating new opportunities for innovation. It represents not only a technological advancement but also a strategic approach to navigating complexity in a rapidly changing world.

As the integration of artificial intelligence advances across industries, the pursuit of enhanced performance, reduced delays, and greater agility has fueled interest in AI as a means to rethink operations and prepare for future challenges. The air freight industry emerges as a critical player embracing AI. Responsible for delivering time-sensitive and high-value goods globally, air freight operates under intense expectations for speed, precision, and reliability.

As international trade expands and faces new challenges, air freight companies are increasingly turning to artificial intelligence to support their operations and sustain competitiveness.

Thus, technological development, artificial intelligence, and international transportation are all interconnected elements that influence each other in complex and multifaceted ways.

In this research, we will explore how these elements interact, their mutual impacts, and their role in shaping our shared future. Part of this research remains shrouded in mystery, inviting us to continue exploring this intricate and intriguing relationship.

Problem Statement

The air freight industry has long faced challenges such as delays, high costs, limited visibility, and operational inefficiencies. These issues have hindered its ability to meet the growing demands for international trade, creating a need for innovative solutions to enhance performance and reliability. Thus, our primary research question is: "**How can Artificial Intelligence be**

General Introduction

integrated to enhance the efficiency and reliability of air freight while improving customer service and promoting sustainability?".

From this central inquiry, we derive several secondary questions:

- 1) In what ways can Artificial Intelligence (AI) strengthen the reliability of air freight operations?
- 2) How can AI-driven innovations enhance customer satisfaction and improve service quality in the air freight industry?
- 3) What role can Artificial Intelligence play in advancing environmental sustainability within air freight through optimized resource use and reduced carbon emissions?
- 4) How have companies like DHL, FedEx, and UPS benefited from implementing Artificial Intelligence (AI) in their operations?

Hypotheses

Building upon the aforementioned questions, we formulate the following hypotheses:

General hypothesis: the integration of AI in air freight operations significantly transforms the industry by driving exceptional improvements in efficiency, reliability, customer service and sustainability.

Secondary Hypotheses:

- 1) AI-enabled route optimization will strengthen the reliability of air freight by minimizing delays, operational disruptions, resulting in reduced delivery time.
- 2) Customer service automation is one of AI-driven innovations that will enhance customer satisfaction and improve service quality by streamlining communication and order tracking.
- 3) AI-enabled optimization algorithms will minimize energy consumption and carbon emissions by optimizing resource allocation and routing within air freight operations.
- 4) AI-driven innovations has enabled companies such as DHL, FedEx, and UPS to achieve significant advancements in operational efficiency, reliability, and customer service. Thereby, positioning them for sustained growth and enhanced competitiveness in the global market.

Significance of the Study

The study holds significant implications for the air freight industry, airport authorities, policymakers, and stakeholders. By elucidating the potential of AI in enhancing air freight operations, this research aims to inform strategic decision-making processes and facilitate the adoption of innovative technologies to address pressing challenges.

Objectives

- To evaluate the strategic implications of AI adoption in the air freight industry.
- To examine AI's impact in enhancing operational efficiency, reliability and reducing risks.
- To investigate AI's contribution to customer service improvement, and sustainability in air freight.
- To identify best practices from industry leaders.
- To provide recommendations for AI integration in air freight operations.
- To contribute to academic literature by advancing knowledge on the role of AI in air freight logistics.

General Introduction

Methodology

Our study adopts a descriptive-analytical methodology to examine the adoption of Artificial Intelligence (AI) in the air freight operations of leading companies such as DHL, FedEx, and UPS. By identifying key operational parameters, evaluating AI applications, and assessing their impact, we aim to gain a comprehensive understanding of AI integration in air freight. This approach allows us to explore how AI solutions address specific challenges in air cargo logistics, providing valuable insights into the effectiveness of AI in enhancing operational efficiency, reliability, customer service, and sustainability. Ultimately, this methodology will uncover best practices in AI implementation for optimizing air freight operations across these major industry players.

Literature Reviews

During our research for this study, we have conducted extensive literature reviews, uncovering several themes closely related to our topic. These themes are elucidated below:

Study No.1: Leveraging Artificial intelligence to Maximize Efficiency in Supply chain process optimization

Odumbo and Nimma (2021), in this article explore the implementation of AI in optimizing Supply Chain activities. The study emphasizes the use of predictive analytics, automated scheduling, and real-time monitoring to enhance decision-making, operational efficiency, and cost reduction across supply chains. Their findings demonstrate how AI-driven solutions contribute to more agile, streamlined, and data-informed supply chain management processes. (Oluwole & Sani, 2025)

Study No.2: Artificial Intelligence in Airport Security: How AI Can Increase Airport Safety?

Diaz Moreno (2021), in this article examines the application of AI technologies in enhancing airport security measures, the study focuses on AI-driven solutions such as facial recognition, biometric verification, and automated threat detection, highlighting their role in improving screening processes and risk management. By integrating these AI-driven solutions, airports can achieve more accurate, efficient, and proactive security operations, ultimately contributing to safer and more secure environments for passengers and staff. (Moreno, 2024)

Study No.3: AI in Business Aviation Route Optimization: Reducing Fuel Consumption and environmental impact

Mgbachi (2022), in this article investigates the application of artificial intelligence in optimizing flight routes within the business aviation sector, the study highlights how AI algorithms contribute to reducing fuel consumption, minimizing emissions, and enhancing overall operational efficiency. By leveraging advanced data analytics and predictive modeling, AI supports more sustainable and cost-effective flight planning, contributing to environmentally responsible practices in aviation. By leveraging advanced data analytics and predictive modeling, AI supports more sustainable and cost-effective flight planning, contributing to environmentally responsible practices in aviation. This research reinforces the role of AI in achieving sustainable outcomes in air transportation. (Mgbachi, 2024)

General Introduction

Study No.4: A data-driven air cargo revenue management system

Rizzo and Lucas (2020), in their article explore the development of an AI-powered system designed to optimize pricing and capacity management in air cargo operations. The study emphasizes the integration of data analytics, machine learning, and predictive models to enhance revenue maximization and decision-making in cargo booking and allocation. This research directly contributes to understanding how AI-driven revenue management can improve financial performance, resource utilization, and service quality in the air freight sector. (STEFANO, JI, & ZOI, 2019)

Comparison between our Study and the Previous Studies:

Aspect	Our Study	Study No. 1	Study No. 2	Study No. 3	Study No. 4
Focus Area	the integration of AI in air freight, using DHL, FedEx, and UPS as examples, emphasizing reliability, customer satisfaction, and sustainability.	Emphasizing the use if AI to enhance decision-making, operational efficiency, and cost reduction across supply chains.	AI-driven technologies role in achieving airport security, improving screening processes and risk management.	AI's role in enhancing operational efficiency and improving sustainability within route optimization techniques.	AI's impact on air cargo operations in improving financial performance, resource utilization, and service quality in the air freight sector.
Specific applications	Route optimization, predictive analytics, warehouse automation, sustainability tools.	AI-powered demand forecasting, inventory management, logistics optimization.	Facial recognition, biometric verification, automated threat detection.	AI-based flight route optimization for fuel savings.	AI-driven pricing optimization, predictive capacity management.
Methodology	Descriptive-analytical; case studies on DHL, FedEx, UPS.	Quantitative analysis using case examples.	Literature review and technological analysis.	Empirical analysis and simulation modeling.	Model development and data-driven approach.
Contributions	Insights into how leading companies use AI to achieve reliability, customer satisfaction, and	Shows how AI improves supply chain efficiency and decision-making; offers insight into AI's operational impacts	Highlights AI's role in improving security screening and risk management; indirectly informs air	Shows how AI reduces fuel consumption and emissions; transferable to air freight route planning for sustainability.	Demonstrates AI's impact on revenue maximization and capacity allocation in air cargo operations.

General Introduction

	sustainability in air freight.	relevant to air freight logistics.	freight security measures.		
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Source: student's elaboration

Contents

To conduct this study effectively, we've structured our thesis as follows: a theoretical part comprising three topics, and a practical part comprising three topics as well.

- ❖ **Chapter One: The Theoretical Part (Artificial Intelligence & Air Freight Conceptual Framework)**
 - ❖ **Topic One:** Introduction to Artificial Intelligence (AI): This topic provides an overview of AI, from its definition to its applications in various sectors, highlighting its transformative potential.
 - ❖ **Topic two:** Air Freight in Global Trade and Logistics: This topic explores the crucial role of air freight in global trade and logistics operations.
 - ❖ **Topic Three:** AI Applications in Air Freight operations: Here, we examine various applications of AI in air freight operations, showcasing its impact on this growing industry.
- ❖ **Chapter Two: The Practical Part (case study: a comparative study of AI innovations in DHL, FedEx, and UPS)**
 - ❖ **Topic One:** Introduction to DHL, FedEx, and UPS: This topic provides an overview of the three companies, focusing on their history and growth in the air freight industry.
 - ❖ **Topic Two:** AI Applications in DHL, FedEx, and UPS: This topic delves into the practical use of AI in these companies, showcasing its impact on air freight services.
 - ❖ **Topic Three:** A Comparative study between DHL, FedEx, and UPS: This topic offers valuable insights into AI implementation at DHL, FedEx, and UPS. Examining their strengths and weaknesses, evaluating the financial and sustainability impacts, and identifying key similarities and differences in their approaches.

CHAPTER ONE:

THE THEORITICAL PART

Introduction

The rapid expansion of global trade has placed immense pressure on the air freight industry to deliver faster, safer, and more efficient logistics solutions. However, traditional air freight operations have long been constrained by challenges such as complex route planning, cargo management inefficiencies, and security concerns. As demand grows, the need for innovation becomes more pressing than ever.

In response, artificial intelligence (AI) has emerged as a transformative tool, revolutionizing various aspects of air freight. This chapter unfolds in three sections: first, we explore the fundamental principles of AI, providing a foundation for understanding its capabilities. Next, we examine the core functions and significance of air freight in global trade. Finally, we analyze how AI is being applied within the industry, demonstrating its role in optimizing processes, enhancing security, and driving efficiency. Through this discussion, we aim to highlight the profound impact of AI on the future of air freight.

TOPIC ONE:

**Basic Concepts About
Artificial Intelligence**

1.1 Introduction:

Artificial intelligence has become a transformative force across various industries, revolutionizing the way tasks are performed and decisions are made. In this section, we provide an overview of AI, beginning with its definition, followed by a brief look at its historical development and key subfields. We also explore the practical applications of AI in different sectors, highlighting both its advantages and disadvantages. Finally, we conclude with AI's impact on transportation, showcasing its growing role in modern mobility and logistics.

1.2 Definition of Artificial Intelligence:

There are many definitions of artificial intelligence, here we review some:

- 1.2.1 **Definition 01:** "a system's ability to correctly interpret external data, to learn from such data, and to use those learnings to achieve specific goals and tasks through flexible adaptation". (Bartneck & Wagner, 2021)
- 1.2.2 **Definition 02:** "the ability of a machine or computer system to simulate and perform tasks that would normally require human intelligence, such as logical reasoning, learning, and problem solving". (Ahuerma, 2022)
- 1.2.3 **Definition 03:** "the study of [intelligent] agents that receive precepts from the environment and take action. Each such agent is implemented by a function that maps percepts to actions, and we cover different ways to represent these functions, such as production systems, reactive agents, logical planners, neural networks, and decision-theoretic systems". (Russell & Norvig, 2010)

Thus, Artificial Intelligence is defined as the study of systems that either think humanly, by mimicking human cognition, or think rationally, by applying logical reasoning. It also includes systems that act humanly, by simulating intelligent behavior, or act rationally, by making optimal decisions to achieve specific goals.

1.3 The History of Artificial Intelligence:

The idea of "artificial intelligence" goes back thousands of years, to ancient philosophers considering questions of life and death. In ancient times, inventors made things called "automations" which were mechanical and moved independently of human intervention. The word "automation" comes from ancient Greek, and means "acting of one's own will." One of the earliest records of an automation comes from 400 BCE and refers to a mechanical pigeon created by a friend of the philosopher Plato. Many years later, one of the most famous automations was created by Leonardo da Vinci around the year 1495.

So while the idea of a machine being able to function on its own is ancient, we're going to focus on the 20th century, when engineers and scientists began to make strides toward our modern-day AI. (What is the history of artificial intelligence (AI)?, 2025)

1.3.1 Groundwork for AI: 1900-1950

In the early 1900s, there was a lot of media created that centered around the idea of artificial humans. So much so that scientists of all sorts started asking the question:

is it possible to create an artificial brain? Some creators even made some versions of what we now call "robots" (and the word was coined in a Czech play in 1921) though most of them were

relatively simple. These were steam-powered for the most part, and some could make facial expressions and even walk.

Dates of note:

- **1921:** Czech playwright Karel Čapek released a science fiction play "Rossum's Universal Robots" which introduced the idea of "artificial people" which he named robots. This was the first known use of the word.
- **1929:** Japanese professor Makoto Nishimura built the first Japanese robot, named Gakutensoku.
- **1949:** computer scientist Edmund Callis Berkley published the book "Giant Brains, or Machines that Think" which compared the newer models of computers to human brains. (What is the history of artificial intelligence (AI)?, 2025)

1.3.2 Birth of AI: 1950-1956

This range of time was when the interest in AI really came to a head. Alan Turing published his work "Computer Machinery and Intelligence" which eventually became The Turing Test, which experts used to measure computer intelligence. The term "artificial intelligence" was coined and came into popular use.

Dates of note:

- **1950:** Alan Turing published his work "Computer Machinery and Intelligence" which proposed a test of machine intelligence called The Imitation Game.
- **1952:** A computer scientist named Arthur Samuel developed a program to play checkers, which is the first to ever learn the game independently.
- **1955:** John McCarthy, held a workshop at Dartmouth on "artificial intelligence" which is the first use of the word, and how it came into popular usage. (What is the history of artificial intelligence (AI)?, 2025)

1.3.3 AI Maturation: 1957-1979

The time between when the phrase "artificial intelligence" was created, and the 1980s was a period of both rapid growth and struggle for AI research. The late 1950s through the 1960s was a time of creation. From programming languages that are still in use to this day to books and films that explored the idea of robots, AI became a mainstream idea quickly.

The 1970s showed similar improvements, such as the first anthropomorphic robot being built in Japan, to the first example of an autonomous vehicle being built by an engineering grad student. However, it was also a time of struggle for AI research, as the U.S. government showed little interest in continuing to fund AI research.

Notable dates include:

- **1958:** John McCarthy created LISP (acronym for List Processing), the first programming language for AI research, which is still in popular use to this day.
- **1959:** Arthur Samuel created the term "machine learning" when doing a speech about teaching machines to play chess better than the humans who programmed them.

- **1961:** The first industrial robot Unimate started working on an assembly line at General Motors in New Jersey, tasked with transporting die castings and welding pattern cars (which was deemed too dangerous for humans).
- **1965:** Edward Feigenbaum and Joshua Lederberg created the first "expert system" which was a form of AI programmed to replicate the thinking and decisions-making abilities of human experts.
- **1966:** Joseph Weizenbaum created the first "chatterbot" (later shortened to chatbot), ELIZA, a mock psychotherapist, that used natural language processing (NLP) to converse with humans.
- **1968:** Soviet mathematician Alexey Ivakhnenko published "Group Method of Data Handling" in the journal "Avtomatika ", which proposed a new approach to AI that would later become what we now know as "Deep Learning".
- **1973:** An applied mathematician named James Lighthill gave a report to the British Science Council, underlining that strides were not as impressive as those that had been promised by scientists, which led to much-reduced support and funding for AI research from the British government.
- **1979:** James L. Adams created The Stanford Cart in 1961, which became one of the first examples of an autonomous vehicle. In '79, it successfully navigated a room full of chairs without human interference.
- **1979:** The American Association of Artificial Intelligence which is now known as the Association for the Advancement of Artificial Intelligence (AAAI) was founded. (What is the history of artificial intelligence (AI)?, 2025)

1.3.4 AI Boom: 1980-1987

Most of the 1980s showed a period of rapid growth and interest in AI, now labeled as the "AI boom". This came from both breakthroughs in research, and additional government funding to support the researchers. Deep Learning techniques and the use of Expert System became more popular, both of which allowed computers to learn from their mistakes and make independent decisions.

Notable dates in this time period include:

- **1980:** First conference of the AAAI was held at Stanford.
- **1980:** The first expert system came into the commercial market, known as XCON (expert configurator). It was designed to assist in the ordering of computer systems by automatically picking components based on the customer's needs.
- **1981:** The Japanese government allocated \$850 million (over \$2 billion dollars in today's money) to the Fifth Generation Computer project. Their aim was to create computers that could translate, converse in human language, and express reasoning on a human level.
- **1984:** The AAAI warns of an incoming "AI Winter" where funding and interest would decrease, and make research significantly more difficult.
- **1985:** An autonomous drawing program known as AARON is demonstrated at the AAAI conference.

- **1986:** Ernst Dickmann and his team at Bundeswehr University of Munich created and demonstrated the first driverless car (or robot car). It could drive up to 55 mph on roads that didn't have other obstacles or human drivers.
- **1987:** Commercial launch of Alacrity by Alactrious Inc. Alacrity was the first strategy managerial advisory system, and used a complex expert system with 3,000+ rules. (What is the history of artificial intelligence (AI)?, 2025)

1.3.5 **AI Winter: 1987-1993**

As the AAI warned, an AI Winter came. The term describes a period of low consumer, public, and private interest in AI which leads to decreased research funding, which, in turn, leads to few breakthroughs. Both private investors and the government lost interest in AI and halted their funding due to high cost versus seemingly low return. This AI Winter came about because of some setbacks in the machine market and expert systems, including the end of the Fifth Generation project, cutbacks in strategic computing initiatives, and a slowdown in the deployment of expert systems.

Notable dates include:

- **1987:** The market for specialized LISP-based hardware collapsed due to cheaper and more accessible competitors that could run LISP software, including those offered by IBM and Apple. This caused many specialized LISP companies to fail as the technology was now easily accessible.
- **1988:** A computer programmer named Rollo Carpenter invented the chatbot Jabberwacky, which he programmed to provide interesting and entertaining conversation to humans. (What is the history of artificial intelligence (AI)?, 2025)

1.3.6 **AI agents: 1993-2011**

Despite the lack of funding during the AI Winter, the early 90s showed some impressive strides forward in AI research, including the introduction of the first AI system that could beat a reigning world champion chess player. This era also introduced AI into everyday life via innovations such as the first Roomba and the first commercially-available speech recognition software on Windows computers.

The surge in interest was followed by a surge in funding for research, which allowed even more progress to be made.

Notable dates include:

- **1997:** Deep Blue (developed by IBM) beat the world chess champion, Gary Kasparov, in a highly-publicized match, becoming the first program to beat a human chess champion.
- **1997:** Windows released a speech recognition software (developed by Dragon Systems).
- **2000:** Professor Cynthia Breazeal developed the first robot that could simulate human emotions with its face, which included eyes, eyebrows, ears, and a mouth. It was called Kismet.
- **2002:** The first Roomba was released.

- **2003:** Nasa landed two rovers onto Mars (Spirit and Opportunity) and they navigated the surface of the planet without human intervention.
- **2006:** Companies such as Twitter, Facebook, and Netflix started utilizing AI as a part of their advertising and user experience (UX) algorithms.
- **2010:** Microsoft launched the Xbox 360 Kinect, the first gaming hardware designed to track body movement and translate it into gaming directions.
- **2011:** An NLP computer programmed to answer questions named Watson (created by IBM) won Jeopardy against two former champions in a televised game.
- **2011:** Apple released Siri, the first popular virtual assistant. (What is the history of artificial intelligence (AI)?, 2025)

1.3.7 Artificial General Intelligence: 2012-present

- **2012:** Two researchers from Google (Jeff Dean and Andrew Ng) trained a neural network to recognize cats by showing it unlabeled images and no background information.
- **2015:** Elon Musk, Stephen Hawking, and Steve Wozniak (and over 3,000 others) signed an open letter to the worlds' government systems banning the development of (and later, use of) autonomous weapons for purposes of war.
- **2016:** Hanson Robotics created a humanoid robot named Sophia, who became known as the first "robot citizen" and was the first robot created with a realistic human appearance and the ability to see and replicate emotions, as well as to communicate.
- **2017:** Facebook programmed two AI chatbots to converse and learn how to negotiate, but as they went back and forth they ended up forgoing English and developing their own language, completely autonomously.
- **2018:** A Chinese tech group called Alibaba's language-processing AI beat human intellect on a Stanford reading and comprehension test.
- **2019:** Google's AlphaStar reached Grandmaster on the video game StarCraft, outperforming all but .2% of human players.
- **2020:** OpenAI started beta testing GPT-3, a model that uses Deep Learning to create code, poetry, and other such language and writing tasks. While not the first of its kind, it is the first that creates content almost indistinguishable from those created by humans. (What is the history of artificial intelligence (AI)?, 2025)
- **2021-2023:** OpenAI launches DALL-E, followed by DALL-E 2 and DALL-E 3, generative AI models capable of generating highly detailed images from textual descriptions. These models use advanced deep learning and transformer architecture to create complex, realistic and artistic images based on user input. DALL-E 2 and 3 expand the use of AI in visual content creation, allowing users to turn ideas into imagery without traditional graphic design skills.
- **2024:**
 - **February:** Google launches Gemini 1.5 in limited beta, an advanced language model capable of handling context lengths of up to 1 million tokens. The model can process and understand vast amounts of information in a single prompt, improving its ability to maintain context in complex conversations and tasks over extended text.

OpenAI publicly announces Sora, a text-to-video model capable of generating videos up to one-minute-long from textual descriptions. This innovation expands the use of AI-generated content beyond static images, enabling users to create dynamic, detailed video clips based on prompts. Sora is expected to open new possibilities in video content creation.

StabilityAI announces Stable Diffusion 3, its latest text-to-image model. Like Sora, Stable StabilityAI announces Stable Diffusion 3, its latest text-to-image model. Like Sora, Stable Diffusion 3 uses a similar architecture for generating detailed and creative content from text prompts.

- **May:** Google DeepMind unveils a new extension of AlphaFold that helps identify cancer and genetic diseases, offering a powerful tool for genetic diagnostics and personalized medicine.

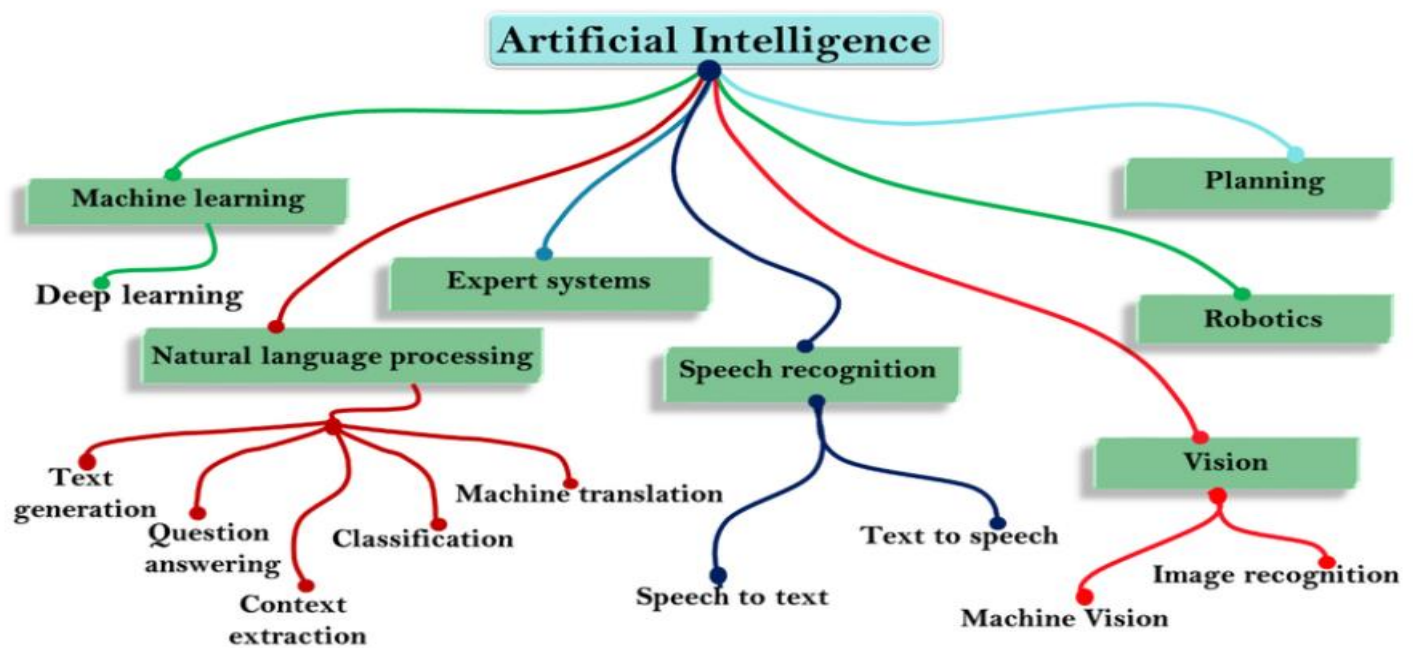
IBM introduces the Granite™ family of generative AI models as part of its watsonx™ portfolio of AI products. Ranging 3–34 billion parameters, Granite models are designed for tasks such as code generation, time-series forecasting and document processing. Open-sourced and available under the Apache 2.0 license, these models are lightweight, cost-effective and customizable, making them ideal for a wide range of business applications.

- **June:** Apple announces Apple Intelligence, an integration of ChatGPT into new iPhones and Siri.⁴⁶ This integration allows Siri to perform more complex tasks, hold more natural conversations and better understand and execute nuanced commands.
- **September:** NotebookLM introduces DeepDive, a new multimodal AI capable of transforming source materials into engaging audio presentations structured as a podcast.⁴⁷ DeepDive's ability to analyze and summarize information from different formats, including webpages, text, audio and video, opens new opportunities for creating personalized and automated content across various platforms. This capability makes it a versatile tool for media production and education.

Current AI trends point to new evolutions of generative AI operating on smaller, more efficient foundation models and the rise of agentic AI, where specific AI models work together to complete user requests faster. Further into the future, autonomous vehicles will be cruising the highways, multimodal AI will create audio, video, text and images in a single platform and AI assistants will help users navigate their personal lives and careers. (The history of AI, 2024)

1.4 Major Subfields of Artificial Intelligence:

AI has a several subfields, each focusing on different aspects of artificial intelligence, some prominent subfields include:



Subfields of Artificial intelligence

Figure (01): Subfields of artificial intelligence (The role of artificial intelligence in future technology, 2020)

1.4.1 Machine Learning:

Machine learning involves the development of algorithms and models that enable computers to learn and make predictions or decisions based on data, without being explicitly programmed. It aims to create systems that can automatically improve and adapt their performance through experience. (Discover the 7 Subfields of Artificial Intelligence, 2024)

1.4.2 Natural Language Processing (NLP):

NLP focuses on enabling computers to understand, interpret, and generate human language. It involves tasks such as speech recognition, language translation, text analysis, sentiment analysis, and question answering. (Discover the 7 Subfields of Artificial Intelligence, 2024)

1.4.3 Computer Vision:

Computer vision deals with teaching computers to see and interpret visual information from images or videos. It involves tasks such as object recognition, image segmentation, facial recognition, and scene understanding. (Discover the 7 Subfields of Artificial Intelligence, 2024)

1.4.4 Robotics:

Robotics combines AI with physical systems to create intelligent machines that can interact with and manipulate the physical world. It includes areas such as robotic perception, motion

planning, control systems, and human-robot interaction. (Discover the 7 Subfields of Artificial Intelligence, 2024)

1.4.5 Expert Systems:

Expert systems aim to replicate the decision-making capability of human experts in specific domains. They use knowledge and rules programmed into the system to provide expert-level advice or recommendations. (Discover the 7 Subfields of Artificial Intelligence, 2024)

1.4.6 Neural networks:

Neural networks are a computing system inspired by the structure and function of the human brain. They learn and recognize patterns in data, making them a key component of machine learning algorithms. (Discover the 7 Subfields of Artificial Intelligence, 2024)

1.4.7 Deep Learning:

Deep learning is a subset of machine learning that uses artificial neural networks with multiple layers to process and understand complex data. It has achieved significant success in computer vision, speech recognition, and natural language processing. (Discover the 7 Subfields of Artificial Intelligence, 2024)

1.5 Applications of Artificial Intelligence:

Artificial intelligence has a wide range of practical applications in many different industries, including healthcare, finance, transportation, and more. Some of the key applications of AI include:

1.5.1 Healthcare:

AI is being used to develop new medicaments, analyze medical images, and help diagnose diseases. For example, machine learning algorithms have been trained to detect cancer in mammograms with high accuracy. (Słapczyński, 2020)

1.5.2 Medical diagnosis and treatment:

AI can be also used to analyze patient data, such as medical images or lab results, to make more accurate diagnoses and provide personalized treatment plans. (Słapczyński, 2020)

1.5.3 Finance:

AI is being used to analyze financial data and make predictions about future trends, as well as to detect fraud and other financial crimes. For example, many financial institutions use AI to monitor transactions for signs of fraudulent activity. In the example of fraud detection, in the finance industry, AI can be used to notice fraud by analyzing data and identifying patterns that may indicate dishonest activity. (Słapczyński, 2020)

1.5.4 Transportation:

AI is being used to improve traffic flow, optimize ways of delivery, and support self-driving cars. For example, companies like Tesla and Waymo are using AI to develop autonomous vehicles, and this trend is growing. Autonomous vehicles, when AI is a key component in the development of self-driving cars, which use sensors and algorithms to navigate roads and make decisions in real-time. (Słapczyński, 2020)

1.5.5 Predictive maintenance in manufacturing:

where AI can be used to predict machinery failure, allowing for preventative maintenance to be scheduled in advance. Customer service, where AI is being used to develop chatbots (like Chabot GTP etc.) and other virtual assistants that can cooperate with customers and help them find the information they need. For example, many businesses use chatbots to handle customer inquiries and support requests. (Słapczyński, 2020)

1.5.6 Education:

where AI is being used to improve personalized learning experiences that can adapt to the needs of individual students. For example, AI-powered tutoring systems can provide feedback and support to students with their problems. Also, natural language processing, when AI can be used to understand and process human language, which has applications in fields such as customer service and virtual assistants. (Słapczyński, 2020)

1.6 Advantages of Artificial Intelligence:

- 1.6.1 A.I. can significantly change the workplace efficiency and augment the work done by a human. This means that all the repetitive and dangerous tasks to human life are taken over by the A.I. systems, thus freeing up the workforce of human beings to involve themselves in the works that they are better equipped. This consists of the creation and empathetically works, among many others. Happiness and satisfaction in the workplace are enhanced when people are engaged in more engaging jobs. (Sikender, Jan 2020)
- 1.6.2 A.I. offers monitoring and diagnostic capabilities that are better hence influencing healthcare dramatically. A.I. reduces the costs of operation, therefore saving money by improving the healthcare facilities and the organization of medicals. The U.S. annual financial statement indicates that A.I. saves medicinal and pharmaceuticals up to \$100 billion annually. Patient care will, therefore, incur a significant impact. Plans for personalized treatments and protocols for drugs provide better information access across medicine facilities to help inpatient care information. (Sikender, Jan 2020)
- 1.6.3 With the A.I. influence on autonomous transportation, the Society will gain hours of productivity that are countless. This is because A.I. helps to address the issues of traffic congestion and also improves the productivity of jobs. Due to the effects of stressful commuting being addressed, humans will now be able to spend their time on different ways of improving their lives. (Sikender, Jan 2020)
- 1.6.4 The uncovering of crimes and solving criminal related issues will become comfortable with A.I. systems. A.I. presents many opportunities in the justice system as it helps in figuring out how to adapt the use of technology effectively without affecting the privacy of an

individual. A.I. now impacts our lives in all the means unless someone opts to live in a remote area and never gain interaction with the modern world. Learning experiences and the challenges that are faced due to the technology, cannot limit the advancement of A.I. since it has a far-reaching impact on the positive way that on the negative way in the Society. (Sikender, Jan 2020).

1.7 Disadvantages of Artificial Intelligence:

Although artificial intelligence (AI) has a wide range of practical applications, it also poses potential risks and challenges, that must be addressed to ensure its safe and responsible development and deployment. Some of the risks of using AI include:

1.7.1 Bias and discrimination:

AI systems are only as unbiased as the data they are trained on. If the data is biased or incomplete, the AI system may produce biased or discriminatory outcomes. For example, a study found that facial recognition technology had higher error rates for people with darker skin tones, which could lead to discriminatory outcomes in law enforcement and other contexts. Biases and discrimination can also appear in data and decision-making, leading to unequal treatment of certain groups. This can have significant implications in areas such as criminal justice, hiring, and for example lending money. (Słapczyński, 2020).

1.7.2 Job displacement:

As AI and automation technologies improve, they may replace human workers in many different industries. This could lead to widespread job displacement and unemployment, particularly in low-skill and manual labor industries. Tasks that are currently performed by humans, potentially in the future will lead to job displacement and economic disruption. (Słapczyński, 2020).

1.7.3 Security and privacy:

AI systems may be vulnerable to cyberattacks and data breaches, which could compromise sensitive information and cause significant harm. For example, hackers could manipulate an AI system to produce incorrect results, leading to errors or disruptions in critical systems. AI systems often rely on large amounts of personal data, which can be vulnerable to cyberattacks and misappropriation. Additionally, AI-powered surveillance systems can raise concerns about privacy and civil liberties. (Słapczyński, 2020).

1.7.4 Ethical concerns:

There are many ethical concerns associated with the use of AI, including issues related to transparency, accountability, and control. For example, it may be difficult to determine who is responsible if an AI system produces a harmful outcome, or to ensure that the system is being used in an ethical and responsible way. (Słapczyński, 2020).

These are just a few examples of the potential risks and challenges associated with the use of AI. As AI technologies continue to evolve, it will be important to address these risks and work to ensure that AI is being used in a safe, ethical, and responsible manner. To address these risks, researchers and policymakers are working to develop ethical guidelines and regulations for the development and use of AI. This includes efforts to ensure transparency and accountability in AI systems, prevent bias and discrimination, and promote the responsible use of AI. (Słapczyński, 2020).

1.8 The Role of Artificial Intelligence in Transportation:

The transportation sector stands on the brink of a quiet revolution, where the familiar ways of moving people and products are being quietly reshaped. Emerging AI-driven technologies are subtly transforming the landscape, gradually replacing old methods with new, innovative approaches that promise to change everything. So here are some AI applications in transportation:

1.8.1 AI for Mobility Demand Prediction:

AI is being increasingly used to predict mobility demand in transportation systems, such as public transport and shared mobility services. In Switzerland, for example, demographic and geographic data are used with machine learning algorithms like decision trees and support vector machines (SVM) to predict future mobility demand. Similarly, AI models are used for predicting demand in ridesharing services like Uber and Didi Chuxing, using large-scale data and deep learning models to optimize routes and avoid congestion. (Rusul , Hussein, & Sohani , 2019)

1.8.2 Public Transport Demand Forecasting:

AI helps optimize public transport operations by predicting passenger waiting times and improving service scheduling. For instance, AI models can analyze real-time data to better manage bus arrivals, reducing waiting times and enhancing the passenger experience. (Rusul , Hussein, & Sohani , 2019)

1.8.3 AI in Accident Prediction:

AI plays a critical role in predicting and preventing traffic accidents by analyzing spatial-temporal patterns from historical accident data. Machine learning techniques, such as deep recurrent neural networks and support vector machines, can predict traffic risks and enable real-time accident mitigation. (Rusul , Hussein, & Sohani , 2019).

1.8.4 AI in Aviation:

In aviation, AI is applied to improve safety and operational efficiency. Machine learning models like support vector machines (SVM) and probabilistic neural networks (PNN) help optimize flight routes, detect turbulence, and monitor engine performance during flights. AI has the potential to enhance safety, reduce fuel consumption, and improve the overall flight management system. (Rusul , Hussein, & Sohani , 2019)

1.8.5 Autonomous Vehicles and Shared Mobility:

Autonomous vehicles are transforming shared mobility systems, such as ridesharing (e.g., Uber) and car-sharing services. By integrating AI with autonomous vehicle technology, these systems can predict passenger demand, optimize routes, and improve operational efficiency. Autonomous vehicles offer a promising future for reducing traffic congestion and energy consumption, with AI playing a key role in making autonomous fleets more profitable and efficient. (Rusul , Hussein, & Sohani , 2019)

1.8.6 AI in Buses and Public Transport:

AI is also enhancing the reliability of buses in public transportation. AI technologies such as hybrid ant colony algorithms and artificial neural networks (ANNs) optimize bus schedules, reduce passenger wait times, and even enable autonomous bus systems. Cities like China and Singapore are testing autonomous buses, and flexible, on-demand bus services are being introduced to offer more personalized and efficient public transport options. (Rusul , Hussein, & Sohani , 2019)

In many cases, it is hard to fully understand the relationships between the characteristics of the transportation system; therefore, AI methods can be presented as a smart solution for such complex systems that can't be managed using traditional methods. Many researchers have demonstrated the advantages of AI in transport. An example of that includes transforming the traffic sensors on the road into a smart agent that detects accidents automatically and predicts future traffic conditions.

1.9 Conclusion:

In this section, we have explored the fundamentals of artificial intelligence, beginning with its definition and historical development, diving deeper into its key subfields, including machine learning and natural language processing (NLP), as well as its applications in areas such as healthcare and business. We also highlighted both its advantages and disadvantages, providing a balanced view of its potential and challenges. Finally, we touched on AI's growing role in transportation, from autonomous vehicles to traffic management, showcasing its impact on modern mobility.

TOPIC TWO:
**Basic Concepts About Air
Freight**

2.1 Introduction:

Air freight is a vital component of global trade, ensuring fast and efficient cargo transportation. In this section, we define air freight, explore its historical development, and outline its key processes. We also discuss the main types of air shipments, along with their benefits and challenges. Additionally, we highlight the role of airport connections in cargo movement and examine key trends shaping the future of air freight.

2.2 Definition of Air Freight:

2.1.1 Definition 01: "Air freight, or air cargo, refers to the transportation of goods via aircraft. This mode of shipping is ideal for time-sensitive deliveries and goods with a high value-to-weight ratio, such as electronics, pharmaceuticals, and luxury products. Cargo is loaded onto dedicated freight planes or commercial aircraft, depending on volume and urgency, and transported to various global destinations". (Logistics, 2024)

2.1.2 Definition 02: "Air freight is another term for air cargo that is, the shipment of goods through an air carrier. Air transport services are the most valuable when it comes to moving express shipments around the globe. Just like the commercial or passenger airlines, air freight flies in the same gateways.

Air freight, on the other hand, means the amount to be paid for the transportation of goods by air. When goods are shipped from one place to the other, the amount paid for the movement of the goods is called freight. Therefore, air freight means the charges paid for air transport". (Air Freight, s.d.)

Generally, air freight is the shipment of goods via aircraft, either on dedicated cargo planes or in the cargo hold of passenger flights, used for fast and efficient transportation.

2.3 History of Air Freight:

Commercial aviation began around 1910/11 when the U.S. Post Office saw the potential of aircraft for mail transport. However, early aircraft had limited capacity and range, making them impractical for transportation. World War I led to improved aircraft, and after the war, many tried to launch airlines using ex-military planes, but high operating and maintenance costs made them unsustainable.

To establish regular air services, essential ground infrastructure like airports, repair facilities, and navigation systems were needed but took years to develop. Between 1918 and 1939, mail transport was the primary source of revenue, but commercial aviation relied on subsidies and high postal fees to remain financially viable. Additionally, international operations required standardized regulations to function legally. (Sales, Air cargo history, 2016)

2.3.1 Regulations and Agreements :

Key Events in Air Freight History:

- **1922** – The Paris International Air Convention established sovereign control of national airspace and addressed regulations for aircraft nationality, airworthiness, and landing permissions.

- **1925** – The International Commission of Air Navigation (ICAN) introduced legal, technical, and meteorological regulations, marking progress in aviation standardization.
- **1926** – Lufthansa transported 1,000 tons of cargo and 6,000 passengers, integrating with the German railway system for ground feeder services.
- **1929** – The Warsaw Convention set liability rules for international air transport of passengers, luggage, and cargo, later amended by The Hague Protocol (1955) and eventually replaced by the Montreal Convention (1999) to unify international air transport regulations.
- **World War II (1939–1945)** – Aviation technology saw significant advancements for military and cargo transport, enhancing aircraft capabilities for post-war civil aviation.
- **Post-WWII** – Initial long-haul cargo mainly consisted of priority airmail, newspapers, gold, perfume, and live animals. KLM pioneered large animal transport, while Lufthansa and Air France expanded cargo services.
- **1950s–1960s** – Demand for cargo capacity increased due to post-war rebuilding efforts, leading to the development of turboprop and jet-powered commercial aircraft, influenced by military aviation advancements. (Sales, Air cargo history, 2016)

2.3.2 The Berlin Airlift:

Following World War II, Germany was divided among the Allied forces, with Berlin split into sectors controlled by the United States, the United Kingdom, France, and the Soviet Union. In 1948, the Soviet Union blockaded West Berlin, cutting off all road, rail, and canal access, leaving over 2 million residents without essential supplies. In response, the United States and the United Kingdom launched the Berlin Airlift, a massive operation to supply food, fuel, and medicine by air.

This event became a pivotal moment in air freight history, demonstrating the logistical capabilities of large-scale cargo transport. Over 15 months, more than 2.3 million tons of supplies were flown into Berlin, with aircraft operating on a tight, continuous schedule. At its peak, nearly 8,000 tons of goods were delivered daily, highlighting the efficiency and reliability of air transport for urgent logistics.

The airlift accelerated advancements in cargo handling, aircraft efficiency, and supply chain coordination, principles that later influenced modern commercial air freight operations. Lessons from this operation contributed to the development of dedicated cargo aircraft, improved air logistics planning, and the integration of air transport into global trade networks. (Sales, Air cargo history, 2016)

2.3.3 The Growth of Air Freight:

The Berlin Airlift demonstrated the potential of air freight on a large scale, highlighting both operational challenges and valuable lessons for future commercial air cargo. Throughout the 1950s and 1960s, air freight gained importance as a commercial industry, but the need for specialized aircraft became evident. Features such as reinforced floors, roller beds, and large cargo doors were essential for efficient loading and unloading, as idle aircraft meant financial losses. Initially, airports were hesitant to invest in cargo infrastructure, but as freight traffic proved its value,

leading airports like Hong Kong, Singapore, Miami, New York, and Dubai prioritized cargo facilities. Over the last two decades, advancements in customs procedures and electronic documentation have further streamlined air freight, making it faster and more competitive. (Air cargo history, 2016)

- **The Jet Age:**

The air freight industry was transformed by the introduction of jet aircraft like the DC-8 and Boeing 707, which enabled faster speeds and larger payloads. The development of Unit Load Devices (ULDs) improved cargo handling efficiency, while specialized containers were introduced for perishable goods and live animals. The Boeing 747, originally designed as a military freighter, became a cornerstone of commercial aviation, with various freighter versions enhancing cargo operations. The 747-8F remains in use, but rising fuel costs and improved two-engine aircraft, like the Boeing 777F, have made them more economically viable for many airlines. (air cargo history, 2016)



Figure (02): an early B747 freighter (air cargo history, 2016, p. 24)

The aviation industry faces challenges from economic fluctuations, fuel prices, and global events, while manufacturing hubs like China, Germany, and India, along with transport centers such as Dubai and Frankfurt, have reshaped supply chain dynamics. Airlines must view air cargo as a core business, balancing cost efficiency with service quality. Strategic fleet choices, including the integration of freighters with passenger aircraft belly cargo, are crucial for maximizing profitability and sustaining air cargo operations. (air cargo history, 2016, p. 25)

- **The Major Contributors:**

Major integrators like FedEx, UPS, DHL, and TNT have thrived by offering seamless door-to-door logistics with complete in-house operations, allowing for better package tracking, fewer delays, and minimal losses. Their close collaboration with Customs, including on-site officers at major hubs, has given them a competitive edge over traditional brokers. Another key innovation was the "on-board courier" system, where high-priority parcels were transported as passenger baggage, bypassing traditional freight channels. This strategic approach allowed integrators to dominate the premium parcel market, outpacing conventional airline-forwarder partnerships. (air cargo history, 2016, pp. 25-26)

- **The Airlines:**

Express and courier services have pushed traditional air cargo players—legacy airlines and freight forwarders—to adopt modern technologies like tracking systems, product segmentation, and e-freight for improved efficiency and reliability. However, many legacy carriers and forwarders have been slow to invest in these advancements, leading to competitive disadvantages. The biggest challenge remains logistics chain fragmentation and a lack of trust among stakeholders, including airlines, airports, forwarders, customs, and government authorities. Customers now prioritize reliable delivery performance over outdated industry metrics like "flown as booked." (air cargo history, 2016, p. 26)

- **Electronic Systems:**

To remain competitive, airlines, forwarders, airports, and customs have had to invest in computer-based systems for better communication and cargo process control. IATA and TIACA have led efforts to promote these technologies, including Cargo Community Systems (CCS) and Electronic Data Interchange (EDI), which standardized cargo messaging and improved efficiency. In response to integrators' full-service freight control, traditional carriers have introduced door-to-door services with online tracking. However, slow adoption of these digital solutions threatens industry players who resist change, risking lower profits and a continued downward spiral in competitiveness. (air cargo history, 2016, pp. 26-27)

2.3.4 **The Air Freight Market Today:**

Since 2008, air cargo has struggled due to global economic crises, while passenger travel has surged, especially with the rise of online booking and low-cost options. Though air cargo declined in Europe and the Americas, emerging markets in Asia, Africa, the Gulf, and South America continued to grow.

Wide-body aircraft now offer unprecedented cargo capacity, with over 2,400 new aircraft on order—the majority for Asia and the Gulf region. However, cargo capacity is expected to exceed demand for at least a decade, threatening the profitability of all-cargo aircraft unless new business stimulation strategies are implemented. (air cargo history, 2016, p. 27)

2.3.5 **Business models of air freight:**

- **All Cargo Operators:**

With the decline of U.S. military contracts for civilian freighters (CRAF), the all-cargo market—especially in the U.S.—has faced significant challenges. Airlines like Evergreen Aviation and World Airways have shut down, while ACMI providers have been forced to rethink their business strategies.

To stay competitive, cargo airlines may need to form alliances with passenger airlines, leveraging combined strengths to create attractive network coverage, quality service, and cost efficiency. Some ACMI providers, like Southern Air, now focus exclusively on integrators, while others, such as Atlas and Kalitta Aviation, offer a mix of services, including scheduled commercial flights.

All-cargo carriers like Cargolux, Nippon Cargo Airlines (NCA), and AirBridgeCargo (ABC) are struggling due to flat demand and low profitability. To survive, they must target underserved

routes or specialized cargo requiring main-deck capacity. Since shippers prioritize network coverage, all-cargo airlines often face price competition against combination carriers that offer both passenger and freighter services. (air cargo history, 2016, p. 29)

- **Combination Carriers:**

Combination carriers, which operate both passenger and cargo aircraft, were once common among U.S. airlines like American, Northwest, United, and Air Canada. However, with deregulation and industry consolidation, these airlines abandoned freighter operations, allowing integrators (FedEx, UPS, DHL, TNT) to dominate high-yield cargo.

European airlines were historically stronger in this sector, with KLM, Lufthansa, and Air France leading the market. Other notable freighter operators included British Airways, SAS, Swissair, and Sabena. However, over the past few decades, most major European and U.S. airlines have shifted away from dedicated freighters, with Lufthansa being one of the few still fully committed to the model.

The 777F provides significant cost savings through commonality with passenger variants, improving crew utilization, maintenance, and operating economics. Qatar Airways achieves similar benefits with both the 777F and A330F, leveraging efficiencies from its mixed fleet. (air cargo history, 2016, p. 31)



Figure (03): Boeing 777 (air cargo history, 2016, p. 31)

- **Aircraft, Crew, Maintenance, Insurance (ACMI):**

Combination carriers face challenges in sourcing large freighters when profitable opportunities arise. ACMI operators like Atlas Air and Kalitta can fill this niche, but they must keep costs low to attract airlines. Factors like traffic rights and seasonal demand may help ACMI remain relevant, while smaller freighters favored by integrators are likely to stay viable unless further consolidation occurs. (air cargo history, 2016, p. 32)

- **Large heavy lift aircraft:**

The AN-124, originally designed for Soviet military transport, became a dominant heavy-lift cargo aircraft thanks to Volga-Dnepr Group's commercial efforts. Antonov Airlines and Ruslan International formed a successful cargo alliance, operating modified versions like the AN-124-150 (150-ton capacity) and the AN-225 (250-ton capacity). While highly capable for unique missions, these aircraft are outdated and costly to operate, limiting them to specialized air cargo. Western-built military aircraft like the C-130, C-17, and KC-390 have been considered alternatives, but Antonov designs remain unmatched in this niche. (air cargo history, 2016, p. 32)



Figure (04): Loading heavy outsized shipment (air cargo history, 2016, p. 32)

2.4 The Air Freight Process:

The air freight process involves several stages, each essential for the successful transportation of goods via aircraft. Let's explore the typical air freight process:

2.4.1 Shipment Booking and Documentation:

The process begins with the shipper (the business sending the goods) contacting an air freight forwarder or carrier to book the shipment.

Documentation such as Bill of Lading, commercial invoice, packing list, and any required permits or certificates is prepared and submitted to the carrier. (Air Freight 101- everything you need to know about shipping by air, 2024)

2.4.2 Cargo Consolidation and Packing:

The goods are packed and prepared for transportation in accordance with air cargo regulations and safety standards.

Depending on the nature of the goods, special packaging, labelling, or handling instructions may be required to ensure safe transit. (Air Freight 101- everything you need to know about shipping by air, 2024)

2.4.3 Transportation to The Airport:

Once packed, the cargo is transported to the designated departure airport, either by the shipper or a third-party logistics provider. Specialized transport vehicles, such as trucks or freight trains, may be used to transport the goods to the airport. (Air Freight 101- everything you need to know about shipping by air, 2024)

2.4.4 Loading onto The Aircraft:

At the airport, the cargo undergoes security screening and is then loaded onto the aircraft.

Cargo handlers or ground crew carefully load the shipments into the designated cargo holds or compartments of the aircraft, ensuring proper weight distribution and secure stowage. (Air Freight 101- everything you need to know about shipping by air, 2024)

2.4.5 Air Transportation:

The aircraft departs from the origin airport and flies to the destination airport, carrying the cargo onboard. During the flight, the cargo is subject to various environmental conditions, such as temperature and pressure changes, which may affect certain types of goods. (Air Freight 101- everything you need to know about shipping by air, 2024)

2.4.6 Customs Clearance (for International Shipments):

Once the air cargo has arrived at the destination airport, the cargo undergoes customs clearance procedures if it is an international shipment. Customs officials inspect the cargo, verify documentation, and assess any applicable duties, taxes, or tariffs before releasing the goods for onward delivery. (Air Freight 101- everything you need to know about shipping by air, 2024)

2.4.7 Delivery to The Consignee's Location:

Once cleared by customs, the cargo is transported from the airport to the final destination, either by the consignee (the entity receiving the goods) or a local delivery service. Depending on the agreement between the shipper and consignee, delivery may be made to a warehouse, distribution center, retail store, or directly to the end customer. (Air Freight 101- everything you need to know about shipping by air, 2024)



Figure (05): the complete process of air freight. (How Air Freight Works: The Complete Process Explained [With Flowchart], 2022)

2.5 Types of Air Freight Shipments:

Here's a glimpse into some key subcategories:

2.5.1 Temperature-Controlled Materials:

These items have a short shelf life and must be transported quickly. From life-saving pharmaceuticals to fresh produce, these goods require precise temperature regulation. (Understanding the different types of air cargo and why it matters, 2024)

2.5.2 Hazardous Goods:

These are items that pose a risk to safety, such as explosive, flammable liquids, and toxic or radioactive materials. Subject to stringent regulations – including strict packaging, labelling, and documentation requirements – dangerous goods require trained personnel to ensure efficient air freight transportation. (Understanding the different types of air cargo and why it matters, 2024)

2.5.3 Live Animals:

Pets, exotic birds, zoo animals, livestock, and racehorses require special care and handling based on their needs. Ventilation, temperature control, and adherence to animal welfare regulations are paramount during air travel. (Understanding the different types of air cargo and why it matters, 2024)

2.5.4 High-Value or Fragile Cargo:

Artworks, jewelry, precious metals and delicate instruments demand extra care due to their high value and fragility. Secure packaging, climate control, and specialized handling are crucial for safe arrival at the destination. (Understanding the different types of air cargo and why it matters, 2024)

2.5.5 Oversized or Overweight Cargo:

Time-sensitivity documents and small packages rely on special courier services for express delivery. Dedicated networks and expedited processes prioritize these shipments, ensuring they reach their destinations within tight deadlines. (Understanding the different types of air cargo and why it matters, 2024)

There are many other types of special air cargo:

2.5.6 Currency and Bullion:

Large amounts of cash and other valuables (such as bulk shipments of gold, silver or other precious metals) are transported by air due to the high level of security and careful handling required. (Understanding the different types of air cargo and why it matters, 2024)

2.5.7 Exempt Cargo:

This type of cargo is not subject to the same regulations as other freight. Certain kinds of military cargo and diplomatic mail are protected by international law, for example, and therefore fall into this category. (Understanding the different types of air cargo and why it matters, 2024)

2.5.8 Human Remains/Tissue and Organs for Transplant:

Transporting these sensitive items requires utmost respect, ethical considerations, an adherence to strict regulations. Specialized logistics providers ensure dignified and secure transportation of these materials. (Understanding the different types of air cargo and why it matters, 2024)

The selection of air freight shipment types is influenced by various modal choices, including:

- **Value:**

High-value products have a greater propensity to be shipped by air. The speed of air transport allows companies to reduce their capital tied up in in-transit inventory and provides for greater security. (Schreiber, Modal choice, 2019)

- **Physical Characteristics:**

Extremely bulky or low-density products are not suitable for air transport, either because they cannot be accommodated on an aircraft or the resulting cost per pound would be uneconomically high. (Schreiber, Modal choice, 2019)

- **Perishability:**

Perishability is a key factor in transport mode selection, as products can lose value through economic perishability (e.g., fashion trends changing rapidly, making last season's clothing less desirable) or physical perishability (e.g., strawberries spoiling within two weeks). Some goods, like roses, face both types, requiring fast transportation, especially during peak demand periods like Valentine's Day. Fresh seafood, meat, and pharmaceuticals also rely on air freight due to their short shelf life and need for swift delivery. (Schreiber, Modal choice, 2019)

- **Demand Predictability:**

The predictability of demand influences transportation choices. Products with stable demand, like infant formula, allow for advanced planning and the use of slower, cost-effective transport modes. In contrast, unpredictable demand products, such as children's toys tied to seasonal trends, may require air freight to quickly respond to surges and avoid stock-outs, balancing inventory costs and sales opportunities. (Schreiber, Modal choice, 2019)

- **Geographic Market Transportation Factors:**

Geographic market factors can greatly influence transportation mode choices. Challenges such as poor infrastructure, security concerns, customs delays, harsh terrain, or distance from transport hubs can limit viable options. For instance, remote cities in the former Soviet Union rely on air freight due to inefficient road and rail networks. Additionally, imbalances in air cargo demand, like higher westbound rates in transpacific markets, create pricing distortions. Airlines may offer discounts on return flights ("back

haul" pricing), making air freight more accessible for lower-value goods that would not typically justify the cost. (Schreiber, Modal choice, 2019)

2.6 Benefits of Air Freight:

2.6.1 Small Shipment Size:

Due to their cost, these commodities tend to move in relatively small lot sizes, which make them suitable for air transport. To use an extreme example, no one buys gold in quantities sufficient to fill a twenty-foot sea container. While less costly than gold, electronics, precision instruments, sophisticated industrial machinery and other high-value commodities also tend to be smaller in size and weight. (Schreiber, Modal choice, 2019, p. 10)

2.6.2 Time Sensitivity:

Certain products are extremely time sensitive. These could include a wide range of perishables, medical products, and seasonal products that must meet very specific delivery deadlines and whose production offers limited options other than by air. (Schreiber, Modal choice, 2019, p. 10)

2.6.3 Security:

High value commodities, by definition, require more security from loss, damage or theft than lower-value goods. Aircraft generally offer not only the fastest but also the most secure way to move cargo from point to point. (Schreiber, Modal choice, 2019, p. 10)

2.6.4 Cost of Capital:

High-value commodities justify the use of air cargo due to the high capital and interest costs they impose on owners, making speed a crucial factor. However, modal choices are influenced by multiple factors beyond value, as shippers primarily focus on delivery reliability, cost, and condition rather than the specific mode of transport. Understanding these factors requires examining how transportation modes are selected and how different elements interact in the decision-making process. (Schreiber, Modal choice, 2019, p. 10)

2.6.5 Inventory Cost:

Because air cargo operations can offer a shipper the benefit of speedy, constant resupply, inventory levels can be reduced. This element of speed allows a producer to ship select products to their customers just in time instead of having to operate large warehousing facilities. By reducing inventory levels, a firm can free up more capital, reduce inventory holding costs, and reduce obsolescence cost. (Schreiber, Modal choice, 2019, p. 10)

2.6.6 Speed:

Air freight is the fastest method of transportation, making it the ideal choice for companies needing quick deliveries. (Logistics, 2024)

2.6.7 Global Reach:

Air freight connects to almost every corner of the world, making it ideal for international shipping. (Logistics, 2024)

2.7 Challenges of Air Freight:

2.7.1 Security of Cargo:

The biggest challenge in air freight is ensuring cargo security through advanced safety measures. While airport security is commendable, it comes at a high cost. Implementing strict screening, tamper-evident seals, background checks, and secure facilities demands significant investment in both manpower and money. (Bajaj, 2024)

2.7.2 Customs Clearance Procedures:

Another major challenge in the air freight industry is navigating complex customs procedures and import/export regulations. Shippers must handle extensive paperwork and stay updated on EXIM policies to prevent delays. Any hold-ups can increase costs, disrupt shipments, and lead to customer dissatisfaction. (Bajaj, 2024)

2.7.3 Capacity Limitations of Aircraft:

Limited capacity and weight restrictions pose significant challenges in the air freight industry. Cargo is transported either in passenger aircraft bellies or dedicated freighters, but space constraints can be an issue, especially for large or heavy shipments. Factors like aircraft availability, peak seasons, and market fluctuations can further limit capacity, leading to higher freight rates and potential difficulties in meeting customer demand. (Bajaj, 2024)

2.7.4 Compliance to Regulations:

Meeting industry standards and regulatory compliance is a major challenge in air freight. Importers and exporters must stay updated on evolving regulations for hazardous materials, restricted goods, and customs requirements. Failure to comply can lead to shipment delays, cancellations, or legal issues, disrupting operations and increasing costs. (Bajaj, 2024)

2.7.5 Higher Costs:

Air freight can be costly, especially for bulky or heavy items. The price is influenced by weight, volume, and fuel prices, making it less cost-effective for large shipments. (Logistics, 2024)

2.7.6 Environmental Impacts:

Air transportation has a higher carbon footprint compared to sea or land freight, making it a less eco-friendly option. (Logistics, 2024)

2.8 Airport Connections:

Airports connect passengers and cargo to local and global markets, with major hubs like Dubai and regional airports like Liège playing key roles in freight. Some airports specialize in perishables or sorting facilities, but rising costs and reliance on passenger aircraft for cargo have made operations challenging, leading to closures like Manston in England.

2.8.1 Globalization:

Airports have evolved into multi modal logistics hubs, supporting distribution, assembly, and repairs, often within duty-free zones. They play a key role in global supply chains by facilitating just-in-time manufacturing and e-tailing. While air cargo relies on fast ground handling and security, most domestic freight in Europe and the U.S. now moves by road. In less developed countries, essential airport facilities like cool storage are prioritized to support perishable exports. (Sales, airport connections, 2016)

2.8.2 Environmental pressures:

Night restrictions are increasingly limiting 24-hour airport operations, affecting freighter and express traffic, which primarily operates at night. Airlines must carefully plan schedules, as seen with Lufthansa Cargo at Frankfurt Airport, which had to adjust due to a night curfew. Airports function as hubs when they facilitate the transfer of passengers and cargo between flights, maximizing efficiency and profitability. Dubai serves as a prime example, with Emirates leveraging its hub to connect global destinations through significant infrastructure investments. (Sales, airport connections, 2016, p. 38)

2.8.3 Airport types:

Airports can be mostly described as:

- **International hubs:**
where many different carriers operate for both passenger and cargo. Examples are London, New York, Miami and Frankfurt. Cargo may reach its local destination or be re-routed via another airline connection to a further destination.
- **Smaller airports:**
such as Munich, Mumbai, Houston and Singapore, which perform a similar role but on a smaller scale.
- **Small regional airports:**
such as Bristol in the United Kingdom, Bilbao in Spain or Halifax Stanfield in Canada, which are building up considerable passenger traffic where travelers are avoiding big hub airports.
- **Cargo-friendly airports:**
where the air freight business is the main activity. These include Liege (Belgium), Cologne and Frankfurt-Hahn in Germany. These airports welcome cargo traffic while some of the bigger hubs do not want freighters and cargo-related activities. Whatever the size or location, all airports must provide runways of 3,000 m, electronic navigation equipment, radar, beacons and perimeter fence security.

Various international organizations, as well as national ones, such as the Federal Aviation Administration (FAA) in the United States or the Civil Aviation Authority (CAA) in the United Kingdom, control these facilities. (Sales, airport connections, 2016, pp. 40-43)

2.8.4 Integrators:

Major integrators like FedEx, DHL, and UPS have developed dedicated cargo hubs to ensure speed and nighttime operations. FedEx operates a long-standing hub at Paris CDG, UPS at Cologne, and DHL at Leipzig. In the U.S., FedEx's Memphis 'Superhub' features a vast digital sorting system handling around 3.3 million packages daily with over 8,000 night-shift workers. Starting in 1973 with a single jet, FedEx Express has grown into the world's largest air cargo carrier. (Sales, airport connections, 2016, p. 43)

2.9 Key Trends in Air Freight:

2.9.1 E-commerce Growth:

The rapid rise of e-commerce has significantly boosted air cargo demand, projected to grow by 20% over the next five years. Integrated express carriers, such as FedEx and UPS, have experienced faster growth than the overall air cargo market, with an 11.5% increase in 2017 compared to the industry's 10% growth. This surge has attracted new competitors like Amazon Air, which has built a strong nationwide network using contracted freighters. While e-commerce's full impact on air cargo is still unfolding, it has already expanded market opportunities for the industry. (Schreiber, key trends in air cargo, 2019)

2.9.2 Non-traditional Cargo Airports:

North America's air cargo industry has traditionally been dominated by major gateway airports like JFK, LAX, ORD, MIA, and YYZ, along with integrator hubs such as MEM and SDF. However, e-commerce growth—driven largely by Amazon Air—has led to a surge in cargo activity at non-traditional airports like ABE, BWI, and CLT. These airports, with less congestion and proximity to consumers, are transforming the industry. Additionally, smaller airports like GSP and PIT are attracting general freight through strategic incentives, proving that non-gateway airports can effectively serve niche air cargo markets. (Schreiber, key trends in air cargo, 2019, p. 14)

2.9.3 Belly Cargo:

Air cargo is transported via dedicated freighter aircraft and the bellies of passenger planes. While freighters carry most air cargo, the growth of passenger flights has increased belly cargo capacity, especially on widebody aircraft, which efficiently handle containers and pallets. Belly cargo, often priced lower as a by-product of passenger service, generates crucial revenue, sometimes determining route profitability. New aircraft like the B787 and A350 enhance cargo capacity and enable long, thin international routes, benefiting both passengers and cargo shippers with direct, efficient services. (Schreiber, key trends in air cargo, 2019, p. 14)

2.9.4 Temperature Controlled Goods – Perishable Foods and Pharmaceuticals:

Air cargo plays a crucial role in transporting perishable goods like fresh food and pharmaceuticals, requiring strict temperature control. Rising demand for fresh foods in developed countries, driven by healthier lifestyles, population growth, and higher incomes, has spurred innovations such as specialized shipping containers and real-time temperature monitoring. E-commerce has further boosted air cargo investment in this sector.

In pharmaceuticals, poor temperature control once led to market share loss to ocean carriers. However, Brussels Airport spearheaded a quality initiative that evolved into IATA's global certification standards. Now, over 160 companies, including North American airports, have pursued certification, improving air cargo's reliability in the pharma sector. (Schreiber, key trends in air cargo, 2019, p. 15)

2.9.5 Global Trade:

Airline alliances and relaxed ownership rules have significantly benefited the air cargo industry by improving market access and enabling economies of scale. However, recent shifts in global trade policies have introduced uncertainties. The renegotiation of NAFTA into the USMCA, along with tariffs and sanctions imposed by various countries, has affected international trade dynamics. Protectionist policies could pose challenges to air cargo, restricting the flow of goods across borders. The complexities of Brexit further highlight the risks of dismantling long-standing trade agreements. Overall, any limitations on global trade are likely to have far-reaching consequences for the air cargo industry. (Schreiber, key trends in air cargo, 2019, p. 15)

2.9.6 Emerging Technology: Blockchain:

Block chain offers a decentralized and secure way to share and verify data, enhancing transparency and eliminating redundancies. Unlike traditional EDI systems, it allows all stakeholders to access unalterable transaction histories, making it useful for secure digital documents like air waybills.

In the air freight industry, block chain can digitize maintenance logs, track aircraft parts, and improve traceability. While promising, challenges like regulatory concerns and system integration remain. Its full impact is still debated, but it has the potential to boost efficiency and security. (Schreiber, key trends in air cargo, 2019, pp. 15-16)

2.9.7 Emerging Technology: Drones:

Advancements in drone technology have clear applications in the air freight industry, particularly for e-commerce deliveries. Companies like Amazon, Alphabet, and JD.com are developing drones to improve efficiency, especially in remote and urban areas with infrastructure challenges.

Regulatory hurdles remain in North America, but other countries have embraced drone deliveries. In 2019, Alphabet's Wing Aviation became the first U.S. company authorized for consumer drone deliveries. While airspace concerns exist in metropolitan areas, ongoing approvals

are paving the way for future growth and innovation. (Schreiber, key trends in air cargo, 2019, p. 16)

2.10 Conclusion:

In this section, we explored air freight's definition and history, highlighting its role in global trade. We discussed its process, from cargo handling to customs clearance, and the main shipment types, such as express and standard freight. Additionally, we examined its benefits, like speed, and challenges, such as high costs. We also emphasized the role of airport connections in cargo movement and reviewed key trends, including technological advancements and sustainability efforts, showcasing air freight's growing impact on logistics.

TOPIC THREE:

Applications of Artificial Intelligence in Air Freight Industry

3.1 Introduction:

Artificial intelligence is transforming the air freight industry by enhancing efficiency and security. This study explores key AI applications, including automated warehouse management, route optimization, predictive maintenance, cargo space optimization, dynamic pricing, enhanced security and surveillance, and customer service automation. These innovations streamline operations, reduce costs, and improve overall performance in air freight logistics.

3.2 Automated Warehouse Management:

3.2.1 Evolution of Warehouse Automation:

Warehouse automation has evolved significantly over the past century, driven by advancements in technology and the need for greater efficiency. Early innovations such as conveyor systems and forklifts revolutionized material handling, while later developments like automated storage and retrieval systems (AS/RS) and barcode scanning improved inventory management. The rise of Industry 4.0 has further transformed warehouses through IoT, cloud computing, and big data analytics, allowing for real-time monitoring, predictive maintenance, and data-driven decision-making. In the air freight industry, these advancements are critical for managing high cargo volumes, ensuring fast processing times, and maintaining security in warehouses and cargo terminals. AI-powered robotics, computer vision, and machine learning optimize cargo sorting, automate visual inspections, and enhance demand forecasting for air shipments. Natural language processing also facilitates communication between logistics teams, improving coordination in air cargo hubs. (Sodiya & Umoga, 2024)

3.2.2 Application of AI in Warehouse Automation Management:

- AI enhances inventory management by optimizing stock levels and streamlining operations. Through demand forecasting, it predicts future needs using sales data and market trends, reducing stock outs and improving replenishment. In air freight, AI helps cargo facilities manage inventory efficiently, ensuring timely shipments, minimizing delays, and optimizing storage for faster processing. (Sodiya & Umoga, 2024, p. 274)
- AI-powered systems automate inventory tracking, enabling real-time monitoring of stock levels and movements. Computer vision and RFID enhance accuracy, reducing manual checks and errors. In air freight, AI optimizes cargo storage, minimizes handling times, and maximizes space utilization, ensuring faster and more efficient processing of shipments. (Sodiya & Umoga, 2024, p. 274)
- AI transforms order fulfillment by streamlining processing and enhancing accuracy. Autonomous robots (AMRs) navigate warehouses, retrieving products and reducing manual labor. Machine learning optimizes pick paths and prioritizes orders, improving efficiency. In air freight, AI accelerates cargo handling by automating sorting and retrieval, minimizing delays, and ensuring faster, more efficient shipment processing. (Sodiya & Umoga, 2024, p. 274)
- AI enhances packing and sorting by optimizing packaging based on size, weight, and fragility. AI-powered sorting systems classify items by destination and shipping method, ensuring fast, accurate processing. Machine learning improves efficiency through predictive maintenance and process optimization. In air freight, AI automates cargo sorting

and packing, reducing handling times and ensuring efficient load distribution for quicker, more reliable shipments. (Sodiya & Umoga, 2024, p. 274)

- AI-driven predictive maintenance minimizes warehouse downtime by analyzing equipment data to detect early signs of failure. Machine learning monitors temperature, vibration, and energy usage, enabling proactive repairs and reducing costs. Reinforcement learning optimizes operations by continuously improving efficiency based on real-time data. In air freight, predictive maintenance ensures uninterrupted cargo handling by preventing equipment failures in automated warehouses, keeping operations smooth and reducing delays in shipment processing. (Sodiya & Umoga, 2024, p. 274)

3.2.3 Key AI-Driven Warehouse Automation Systems:

- AI-powered Autonomous Mobile Robots (AMRs) enhance warehouse efficiency by navigating autonomously using SLAM technology and AI-driven path planning. These robots adapt to obstacles, optimize routes, and streamline material transport, order picking, and replenishment tasks. In air freight, AMRs accelerate cargo handling by efficiently moving shipments between storage zones, sorting areas, and loading docks. This reduces manual labor, improves turnaround times, and ensures faster, more precise processing of air cargo. (Sodiya & Umoga, 2024, p. 275)
- AI-powered robotic arms are revolutionizing warehouse automation by enhancing precision, speed, and efficiency in material handling. Equipped with AI-driven vision systems and adaptive grippers, they optimize tasks such as picking, packing, palletizing, and assembly, reducing errors and increasing throughput. In air freight warehouses, robotic arms improve cargo handling efficiency by automating the sorting, stacking, and loading of shipments. They ensure secure palletization for air transport, minimize damage risks, and accelerate order fulfillment, contributing to faster and more reliable air cargo operations. (Sodiya & Umoga, 2024, p. 275)
- Automated Guided Vehicles (AGVs) enhance warehouse automation by efficiently transporting goods between storage areas, production zones, and shipping docks. Equipped with sensors and AI-driven navigation, AGVs autonomously move through complex warehouse layouts, reducing reliance on manual forklifts and improving safety. In air freight warehouses, AGVs optimize cargo handling and transfer processes, ensuring swift and precise movement of
- Shipments integrated with AI-powered systems, they adapt to real-time demand, coordinate with warehouse management systems (WMS), and enhance overall efficiency and workflow synchronization in air cargo operations. (Sodiya & Umoga, 2024, pp. 275-276)

3.2.4 Challenges in AI-enhanced Warehouse Automation:

While AI-driven warehouse automation systems offer numerous benefits, they also present several challenges that must be addressed to ensure successful implementation and operation:

- AI-driven automation systems play a crucial role in handling and managing cargo in air freight warehouses, processing vast amounts of data from sensors, cameras, RFID tags, and IoT devices to enhance efficiency. Protecting shipment details, inventory levels, and operational insights is essential, requiring strong encryption, access controls, and

cybersecurity measures to prevent unauthorized access and cyber threats. Additionally, compliance with data privacy regulations like GDPR and CCPA ensures the protection of sensitive information in AI-powered air freight logistics. (Sodiya & Umoga, 2024, p. 277)

- AI algorithms in air cargo warehouse automation can unintentionally reinforce bias if trained on incomplete or skewed datasets. For instance, AI systems used in workforce management or operational decision-making may reflect past biases in task assignments or evaluations. To address this, warehouse operators must ensure diverse and representative training data, conduct fairness assessments, and implement bias detection techniques to promote transparency and prevent discriminatory outcomes in automated processes. (Sodiya & Umoga, 2024, p. 277)
- Ensuring safety and security in AI-driven automation systems is essential to prevent accidents, protect workers, and secure sensitive information. Automated technologies must operate reliably to avoid cargo mishandling, security breaches, and operational disruptions. Strict safety protocols, risk assessments, and compliance with aviation regulations are necessary for maintaining secure and efficient processes. Advanced AI-driven measures, including anomaly detection, automated inspections, and real-time monitoring, help enhance overall safety and security standards. (Sodiya & Umoga, 2024, p. 277)
- Cybersecurity threats pose significant risks to AI-driven automation systems, as cyberattacks like malware, ransomware, and hacking can disrupt operations and compromise data integrity. Strong security measures, such as firewalls, intrusion detection systems, and routine security audits, are essential to safeguard these systems. Additionally, securing AI algorithms against adversarial attacks requires encryption, authentication mechanisms, and secure coding practices to prevent unauthorized access and manipulation, ensuring the protection of automated processes and sensitive data. (Sodiya & Umoga, 2024, p. 277)
- The integration of AI-driven robots in air freight operations presents challenges in communication, coordination, and trust between humans and machines. Intuitive human-robot interfaces are essential for seamless interaction, allowing workers to monitor performance, provide feedback, and understand robot intentions through visual, auditory, and haptic cues. Proper training is also crucial to ensure safe and efficient collaboration. Air cargo personnel must receive ongoing education on robot operation, maintenance, troubleshooting, and emergency protocols to stay updated with evolving automation technologies and work effectively in AI-driven environments. (Sodiya & Umoga, 2024, pp. 277-278)

In conclusion we can say that AI-driven systems in air freight warehouses are increasingly being used to automate inventory management and handling processes. Robotics powered by AI algorithms can pick, sort, and store goods, significantly reducing human error and increasing efficiency. For instance, autonomous robots can navigate through warehouses to retrieve items and prepare them for shipment, which streamlines operations and speeds up the processing times.

3.3 Route Optimization:

3.3.1 AI Work for Route Optimization:

Artificial intelligence works with a bigger amount of information than a human can do. AI algorithms rumble through historical or real-time data and bring out the findings. Although the principle of work is single: the super-fast analysis of huge amounts of data, the outcomes can be used in different instances. (AI-Powered Route Optimization for air cargo, 2024)

3.3.2 AI Applications in Air Freight Route Optimization:

- **Machine learning:**

Aviation companies have collected tons of high-quality statistical data for decades. Yet, most of the documentation was previously stored on paper and was inapproachable for digital analytic tools. Now, with the rise of AI-powered optical character recognition, things have changed. The newer OCR tools trained with deep learning algorithms can read and process documentation in handwritten, printed, or typed format, as well as images. After, this information gets sorted, grouped, and systematized as needed. New OCR technology unlocks years of historical data for analysis on behalf of AI tools. Deep learning algorithms process historical data to spot previously unknown patterns. An algorithm can check the history of winds in a certain area, as well as flight duration under different weather conditions, etc. By spotting historical trends, AI offers the most efficient scenarios and predictions. (AI-Powered Route Optimization for air cargo, 2024)

- **Predictive analytics:**

Air cargo route planning depends on a huge amount of data. This includes whether there is any military training in the area, if there will be other planes landing there if some of the planned flights were canceled, etc. The analysis of all the data is quite complicated. Sometimes, two planes are scheduled to come to one place at the same time. Then, one of the aircraft gets ordered to circle around a certain area, which uses additional fuel consumption. AI system scraps all the data in one place. Then, it analyzes all the data, which humans can sometimes skip. Then, based on a huge amount of real-time data, AI makes accurate predictions to avoid flight overlays and other similar situations. (AI-Powered Route Optimization for air cargo, 2024)

- **Real-time data analytics for incident-caused data adjustments:**

AI can process data in real time. Therefore, AI tools can send alerts on incidents right as they occur. This gives a dispatch officer time to make adjustments faster and more accurately. For example, if an airport gets closed due to an incident, the flights scheduled to land there may be redirected faster. (AI-Powered Route Optimization for air cargo, 2024)

3.3.3 The Benefits of AI in Air Freight Route Optimization:

- **Cost Savings:**

By making operations more efficient, air cargo companies cut unnecessary spending. For example, optimizing about 50% of the flights, using AI analysis to switch planes effectively as customer demand changes. Thus, using smaller planes for flights with lower demands. That saves costs on fuel and maintenance. Also, the AI tools determine whether the planes have

leased engines or those owned by Lufthansa. Thus, they prefer planes with company-owned engines, which also save costs. (AI-Powered Route Optimization for air cargo, 2024)

- **Environmental Impact:**

By making flights more efficient and shorter, the airlines save on fuel and maintenance costs and reduce carbon emissions. For example, on average, by saving 2.7 minutes per flight, Alaskan Airlines avoided 6,866 metric tons of carbon dioxide emissions. Also, since Swiss International Air Lines has adopted artificial intelligence and Google Cloud technology to enhance its flight operations, it considerably cut carbon dioxide emissions. For example, their fuel consumption per person per 100 km decreased by 28% compared to 2003 and was 3.15 liters in 2022. It was less compared to 4.1 liters in 2021. In 2022, the Swiss managed to save 8,700 tons of CO₂. By partnering with Google Cloud, Lufthansa Group plans to reduce up to 50,000 tons of CO₂ emissions yearly. (AI-Powered Route Optimization for air cargo, 2024)

- **Customer Satisfaction:**

With flights coming on time and incidents managed promptly, air cargo clients trust their delivery vendors more. This doesn't just lead to repeated contracts but also improves the brand's reputation and serves as an additional marketing channel since satisfied clients are more likely to recommend the vendors they are happy to work with. (AI-Powered Route Optimization for air cargo, 2024)

- **Better Decision Making:**

Correct decisions are based on the data available, and since AI for air cargo route planning increased the amount of data analyzed, it became easier to make the right decisions. (AI-Powered Route Optimization for air cargo, 2024)

In conclusion, AI is pivotal in optimizing flight routes and schedules. By analyzing vast amounts including weather patterns, air traffic, and fuel consumption, AI algorithms can propose the most efficient routes and flight schedules. This not only helps in reducing fuel consumption and emissions but also ensures timely deliveries, even in the face of unexpected disruptions.

3.4 Predictive Maintenance:

3.1.1 How Predictive AI Works in Operations:

Mechanisms of AI predictive maintenance make use of data provided by sensors installed in crucial aircraft systems. These could track the functioning of different parts, from engines to landing gear, avionics, and airframes. Machine learning algorithms analyze such data to develop the model capable of finding patterns or trends indicative of a probable failure in each of these components. (Mgbachi, 2024)

3.1.2 Process Flow for Predictive Maintenance Using AI:

- **Data Collection:**

Sensors on the aircraft continuously collect data on component health, including temperature, vibration, pressure, and usage cycles. (Mgbachi, 2024, p. 54)

- **Data Transmission:**

This data is transmitted to ground-based servers or cloud platforms for real-time analysis. (Mgbachi, 2024, p. 54)

- **Data Analysis:**

AI algorithms assess this data to detect deviations from normal operational patterns. Machine learning models are trained on historical data to identify wear and tear, corrosion, or other factors that might lead to failure. (Mgbachi, 2024, p. 54)

- **Failure Prediction:**

Based on the analysis, AI systems can predict when a component is likely to fail, allowing maintenance crews to schedule repairs before a breakdown occurs. (Mgbachi, 2024, p. 54)

- **Actionable Insights:**

Operators receive actionable insights from the AI system, including which components require immediate attention and which ones are operating within acceptable parameters. (Mgbachi, 2024, p. 54)

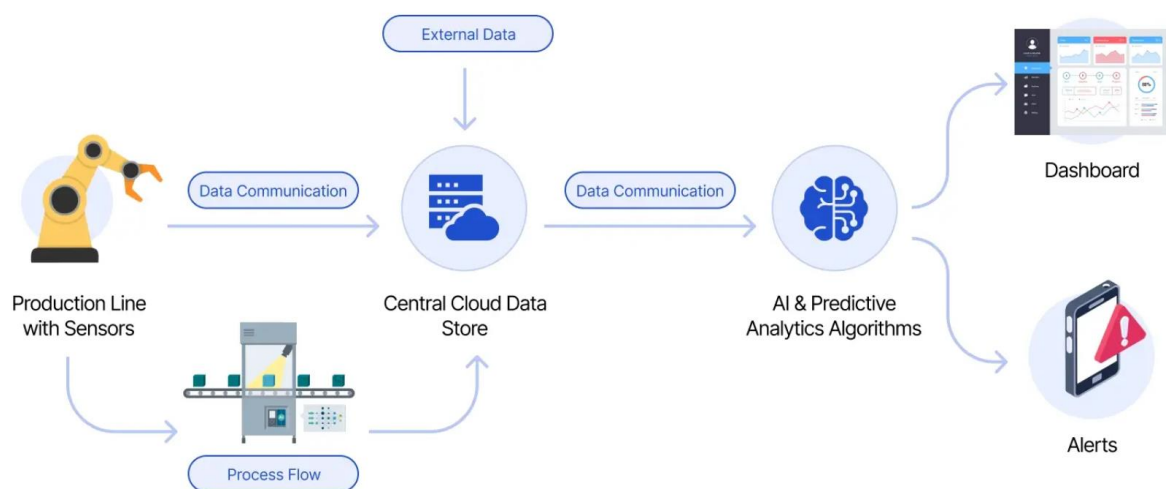


Figure (06): Process Flow for Predictive Maintenance Using AI. (SHARMA, 2025)

3.1.3 Benefits of AI Predictive Maintenance:

- **Reduced Downtime:**

By forecasting component failures before they occur, aircraft operators can schedule maintenance during planned downtimes, avoiding unscheduled maintenance events. This ensures that aircraft are more readily available for use, improving operational efficiency. (Mgbachi, 2024, p. 54)

- **Cost Efficiency:**

Traditional maintenance schedules rely on either routine or reactive maintenance, which can lead to unnecessary replacements or sudden failures. Predictive maintenance allows for more precise timing of repairs, reducing costs associated with unnecessary part replacements or operational interruptions. (Mgbachi, 2024, p. 54)

- **Improved Safety:**

Safety is paramount in air freight, and predictive maintenance plays a crucial role in preventing catastrophic failures. By identifying potential issues before they escalate, AI-based systems contribute to maintaining the highest safety standards. (Mgbachi, 2024, p. 54)

- **Prolonged Component Lifespan:**

AI can optimize the usage cycles of aircraft components, ensuring that they are not replaced prematurely. This helps to extend the lifecycle of expensive parts, reducing long-term maintenance costs. (Mgbachi, 2024, p. 54)

Thus, AI technologies facilitate predictive maintenance of aircraft used in air freight. By continuously monitoring the condition of aircraft components through sensors and data analytics, AI can predict when a part might fail or need maintenance. This preemptive approach prevents delays and cancellations caused by aircraft being out of service, thus maintaining a more reliable schedule.

.5 Cargo Space Optimization:

AI-CARGO has three components: The Disguised Missing Value (DMV) Detector, Cargo Predictor, and Decision-Maker. Given an incoming booking, the DMV Detector checks whether the booking has a DMV or not by consulting a directory of possible DMVs. Then, the Cargo Predictor gets as input the booking from the DMV Detector (i.e., the booking with a DMV indicator), extracts the relevant features from the booking (including the DMV indicator), and predicts the volume expected to be tendered by the customer. At the end of the pipeline, the Decision-Maker gets the incoming booking with the predicted volume that will be tendered and takes a decision whether to accept or not the booking via a stochastic dynamic program. (STEFANO, JI, & ZOI, 2019)

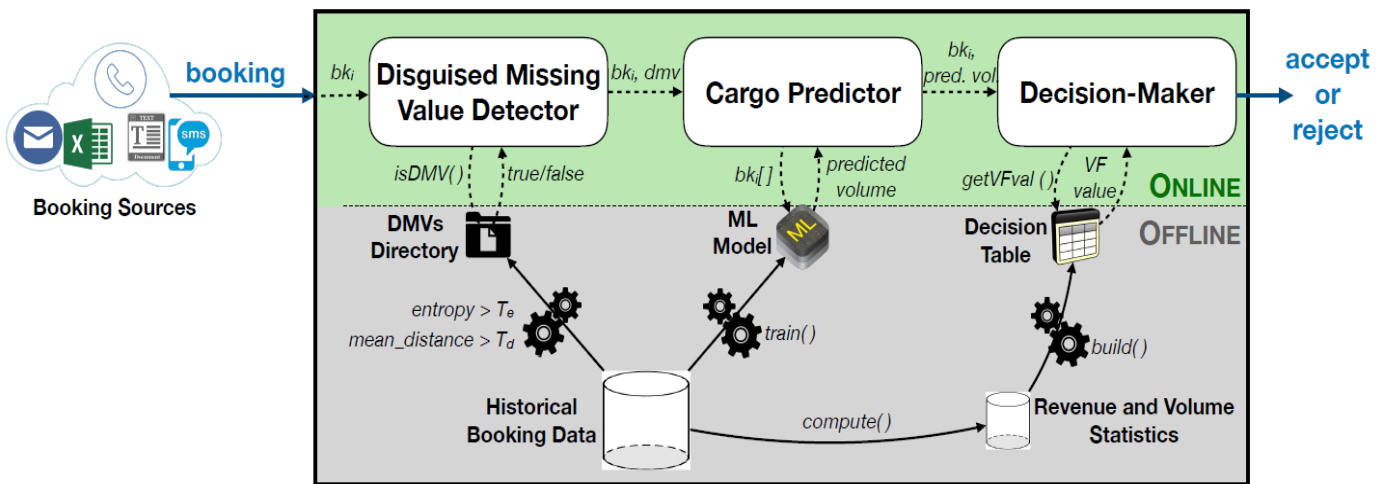


Figure (07): AI-CARGO process. (STEFANO, JI, & ZOI, 2019)

.5.1 Detecting DMVs:

The unique nature of the entire air-cargo ecosystem results in several practices that make bookings' values, e.g., booked volume ($bkvol$), not very reliable. For instance, customers send booking information via SMSs, emails, text files, or even phone calls, which also causes a natural lag between the time a customer creates the booking and the time the booking is actually reflected in the central cargo system. (STEFANO, JI, & ZOI, 2019)

.5.2 Predicting Cargo Volume:

Given an incoming booking with its DMV flag, AI-CARGO proceeds to predict rcsvol (i.e., the received volume by departure time) for the given booking. To do so we need to offline build a model using historical data. We thus need to decide on the features and decide on the algorithm to use. Predicting rcsvol is quite challenging as the bkvol is usually quite different from rcsvol. There are also other features needed to any chance to accurately predicting rcsvol, which are:

- **Days until departure:**

The most important feature by far is the number of days between the booking time and the departure time. Bookings closer to the departure time tend to be more accurate. In fact, bookings that are timestamped several days before departure day tend to show a clear pattern of overbooking from the customer side (and hence of using DMVs). It is natural for shippers to overbook as in the air-cargo business there is no penalty for that. (STEFANO, JI, & ZOI, 2019, p. 4)

- **Booked weight (BKWT):**

Contrary to bkvol, which usually tends to be a DMV, bkwt is a valuable information. This is because shipping agents have a much more accurate information of bkwt as they have access to high quality weighing machines. Indeed, instruments for accurately measuring volume are not that widespread. Thus, being easier to measure, bkwt is on average more precise. (STEFANO, JI, & ZOI, 2019, p. 4)

- **Number of pieces (PIECES):**

A shipment may consist of a number of equal units. Diagonal lines in Figure (07) suggest that bookings frequently differ from the tendered shipments in the number of pieces rather than in their volume. Thus, knowing the number of pieces is useful in predicting possible outcomes at receiving time. (STEFANO, JI, & ZOI, 2019, p. 4)

- **Booked volume (BKVOL):**

We observed that, despite of DMVs, the booked volume, bkvol, is still an important feature for predicting rcsvol. This is because when bkvol is not a DMV, it tends to be precise. (STEFANO, JI, & ZOI, 2019, p. 4)

- **Shipment code (SHC):**

This is a set of codes to instruct how the shipment must be handled, e.g., live animals or perishables. This feature ended up being important as it specifies over (or complements the) the product type explained here below. We encode the shipment code feature as a binary vector with one element for each shipment code (one-hot encoding). (STEFANO, JI, & ZOI, 2019, p. 4)

- **Product type (PRODUCT):**

We observed that the patterns in rcsvol vary with different product type. In theory product type should be a highly informative feature, but we observed that the distribution of product types is skewed. (STEFANO, JI, & ZOI, 2019, p. 4)

- **DMV flag (DMV):**

Because DMVs are frequent and must be dealt within a production environment, we decided not to remove DMV data from the training set. At the same time, giving their negative impact in the prediction, it is important to know if a booking has a DMV for bkvol. For this reason, we provide a flag, which is obtained by the DMV Detector based on historical data. (STEFANO, JI, & ZOI, 2019, p. 4)

- **Destination (DEST):**

We also consider the destination as a feature, even if the destination alone is a weak predictor for rcsvol. This is because in conjunction with product type it becomes possible to elicit subtypes within products and thus reduce the variance. (STEFANO, JI, & ZOI, 2019, p. 4)

- **Origin (ORIG):**

The origin airport of the shipment. This feature allows capturing the average behavior of booking agents from each location. (STEFANO, JI, & ZOI, 2019, p. 4)

.5.3 **Decision Making:**

Once a booking is DMV-tagged and its bkvol is predicted, the Decision-Maker creates an acceptance/rejection suggestion for the given booking. Before digging in how it does so, let us first state what the problem of decision making in the context of airline cargo booking is. For any flight, capacity is a perishable quantity, i.e., once the flight takes-off the capacity is lost. Therefore, an airline wants to accept bookings that will maximize revenue. The problem can be seen as a generalization of the classic Knapsack problem with two caveats: (i) cargo bookings appear over time and the exact volume (weight) of the shipment becomes available only at departure time. (STEFANO, JI, & ZOI, 2019, p. 5)

Thus, AI-powered tools analyze cargo loads, dimensions, and compatibility with other goods to optimize space utilization within an aircraft. This maximizes efficiency by ensuring that every flight carries an optimal load, thereby reducing costs and increasing the profitability of air freight operations.

.6 Dynamic Pricing Models:

AI plays a critical role in dynamic pricing by analyzing market conditions, demand patterns, and competitor pricing. This allows logistics companies to offer competitive and profitable pricing structure. Air Freight companies use AI models to adjust pricing based on real-time factors such as shipment volume, fuel prices, and delivery urgency. Dynamic pricing not only maximizes profitability but also helps customers choose cost-effective solutions tailored to their needs. (Oluwole & Sani, 2025)

.6.1 **Real-time Market Analysis:**

AI can monitor global air cargo demand, competitor rates, and market trends, allowing airlines and freight forwarders to adjust freight rates dynamically. (Oluwole & Sani, 2025)

.6.2 **Shipment Volume:**

Higher shipment volumes can lead to increased demand for limited cargo space, prompting airlines to adjust prices accordingly. Conversely, lower volumes may result in more competitive rates to attract shippers. (WENWEN, 2023)

The most significant cost driver in transportation is fuel. Fluctuations in fuel costs directly affect operational expenses for airlines. Increases in fuel prices often lead to higher freight rates or fuel surcharges to offset additional costs. (Lakshman, 2024)

Shipments requiring expedited delivery typically incur higher costs due to the need for prioritized handling and faster transit times. (Park, 2024)

Precise demand forecasting is a critical component in air freight cost reduction. Standard techniques may prove ineffective when confronted with unexpected disruptions and sudden market shifts. However, owing to AI-driven predictive analytics, airlines can now foresee demand trends with previously unmatched accuracy.

Figure (08): AI dynamic pricing based on real-time factors (Yan, 2025)

.7 Enhanced Security and Surveillance:

As stated before, there are many ways to show how AI has changed different types of industries. Security has not been overseen by the use of this technology, and there are examples of how the use of this has revolutionized the air freight industry. Having this background will create a better understanding of how airport security can be improved by the use of such technologies. (Moreno, 2024)

.7.1 Enhanced Surveillance Technologies:

AI has significantly improved security in air freight through enhanced surveillance technologies. AI-powered cameras and monitoring systems are deployed in air cargo terminals, warehouses, and restricted airport zones to track cargo movements in real time. These systems can detect unusual activities, unauthorized access, or security breaches and automatically alert authorities. By leveraging AI, air freight operators can enhance security measures, reduce theft risks, and ensure compliance with aviation security regulations. (Moreno, 2024)

.7.2 Predictive Analysis for Threat Detection:

Machine learning models analyze historical data on security breaches, irregular cargo patterns, and access anomalies to predict potential risks in air freight operations. AI can flag suspicious shipments based on unusual weight changes, inconsistent documentation, or deviation from standard flight routes, allowing security teams to proactively investigate and mitigate threats before they escalate. (Moreno, 2024, p. 14)

.7.3 Biometric Identification:

AI-powered biometric identification enhances security at air cargo terminals by verifying the identity of personnel accessing restricted areas. By utilizing fingerprint scanning, facial recognition, and iris detection, AI minimizes the risk of unauthorized entry, ensuring that only certified employees and logistics personnel handle sensitive cargo. This reduces the chances of identity fraud and enhances overall operational security. (Moreno, 2024, p. 14)

.7.4 AI-Powered Automated Response Systems:

AI-driven automated response mechanisms improve real-time security monitoring in air freight. If an anomaly is detected, such as an unattended package in a cargo loading zone or unauthorized vehicle movement near an aircraft, AI can instantly trigger automated security measures such as alarm activation, real-time tracking, or notification to security personnel. This ensures swift action without relying solely on human monitoring. (Moreno, 2024, p. 14)

.7.5 AI-Powered Threat Intelligence:

AI-driven threat intelligence enhances cybersecurity in air freight operations by continuously monitoring databases for potential cyber threats targeting airline cargo

management systems. These AI systems analyze hacking patterns, detect vulnerabilities in digital freight platforms, and prevent unauthorized access to shipment data. Advanced AI programs, such as CrowdStrike's Falcon Intelligence, can instantly identify cyber intrusions, mitigate risks, and adapt defenses to protect cargo booking platforms, customs clearance systems, and supply chain networks from cyberattacks. (Moreno, 2024, p. 16)

.7.6 AI-Powered Smart Access Control:

AI-driven smart access control systems are revolutionizing security in air freight by ensuring only authorized personnel can access critical areas such as cargo handling zones, airside operations, and digital freight management systems. These AI systems authenticate users by analyzing multiple factors, including geolocation, behavioral patterns, and request context. Solutions like Kisi provide real-time access monitoring, preventing unauthorized entry and reducing the risk of cargo theft, tampering, or data breaches in air freight logistics. (Moreno, 2024, p. 16)

.7.7 AI-Driven Security Compliance:

AI enhances security compliance in air freight by automating audits and ensuring adherence to regulations. Systems like OneTrust monitor security protocols, detect anomalies, and alert organizations to potential compliance risks, helping maintain up-to-date security standards in cargo handling and logistics operations. (Moreno, 2024, p. 17)

.7.8 AI-Driven Vulnerability Management:

AI enhances air freight security by detecting system vulnerabilities in cargo handling and logistics platforms. Machine learning analyzes software flaws, providing real-time recommendations to prevent cyber threats. Tools like Tenable help identify, prioritize, and resolve security gaps, ensuring robust protection for freight management systems. (Moreno, 2024, p. 17)

.7.9 AI-Powered Insider Threat Detection:

In air freight, insider threat detection AI helps logistics companies assess the reliability of business partners, freight handlers, and contractors. By analyzing historical data and behavioral patterns, AI can identify potential security risks, such as fraudulent activity or past involvement in cargo-related crimes. This ensures that only trusted entities are involved in air cargo operations, reducing the risk of smuggling, theft, or other security breaches. (Moreno, 2024, p. 18)

.8 Customer Service Automation:

- .8.1** One of the standout benefits of AI is its ability to automate complex decision-making processes. This automation allows logistics experts to focus on resolving other critical issues that may arise during a shipment, such as unexpected delays or revised customer requirements. Airspace Co-Founder and CTO, Ryan Rusnak, often says, "We let machines do what machines are good at so people can do what people are good at" and that is solving

more fluid problems and interfacing with customers who need you in that moment. (The Transformative Role of AI in Air Cargo (AI Popup #4), 2024)

Moreover, by automating routine tasks, you reduce the likelihood of human error, further enhancing the reliability and accuracy of the service. This allows an organization to simultaneously manage operational costs and build stronger customer relationships, as clients can rely on consistent and dependable service. (The Transformative Role of AI in Air Cargo (AI Popup #4), 2024)

- .8.2 AI is also transforming the customer experience in air freight by providing more personalized and responsive services. Chat-bots and virtual assistants powered by AI can handle customer inquiries, provide real-time updates on shipment status, and offer support 24/7. These AI-driven tools improve customer service by providing quick and accurate responses, reducing the need for human intervention. (Artificial Intelligence in Air Freight: Transforming the Industry, 2025)

Furthermore, AI algorithms analyze customer data to predict preferences and optimize service offerings. For example, AI can recommend the most suitable shipping options based on historical data and customer preferences. (Artificial Intelligence in Air Freight: Transforming the Industry, 2025)

- .8.3 The growth of e-commerce also elevates the importance of effective consumer interactions. Retailers can combine existing AI tools with generative AI to enhance the capabilities of chat-bots, enabling them to better mimic the interaction style of human agents—for example, by responding directly to a customer’s query, tracking or canceling an order, offering discounts, and upselling. Automating repetitive tasks allows human agents to devote more time to handling complicated customer problems and obtaining contextual information. (Hazan, Samaje, & Zimmel, 2023)

- .8.4 Digital booking platforms have changed how the air cargo industry operates. These platforms offer efficiency, transparency and accessibility, transforming the booking process from a cumbersome task into a streamlined and dynamic experience. (Sabari, 2023)

Digital booking platforms have brought about remarkable improvements in the air cargo industry, but some challenges remain — namely when a freight forwarder has a specific need. While each forwarder operates with distinct requirements and preferences, existing digital systems tend to cater to broader needs. This gap in personalization can lead to freight forwarders and airlines manually booking cargo shipments. (Sabari, 2023)

- .8.5 The emergence of conversational AI for intelligent air cargo communication can help fill the void by tailoring digital interactions to each forwarder, Here’s how conversational AI can streamline how freight forwarders and airlines collaborate:

- **Precise personalization:**

By analyzing historical data, previous interactions and individual requirements, AI-powered chatbots or virtual assistants can tailor their responses and recommendations to match each forwarder’s needs. This level of precision in

personalization builds trust and rapport, fostering a strong and lasting relationship between forwarders and airlines. (Sabari, 2023)

- **Streamlined communication:**

Conversational AI is a 24/7 virtual assistant ready to engage with freight forwarders in real time. Forwarders can now communicate instantly and efficiently with the airlines instead of waiting in long call queues or dealing with delayed email responses. Whether inquiring about flight availability, tracking shipment status or making booking changes, the conversational interface simplifies and accelerates the entire process. (Sabari, 2023)

- **Self-service empowerment:**

Conversational AI brings self-service capabilities to freight forwarders. Through the conversational interface, forwarders can easily manage bookings, track shipments, request changes and access vital information without human intervention. This self-sufficiency enhances their overall experience and frees up valuable resources and time for both forwarders and airlines. (Sabari, 2023)

This technology empowers the air freight industry to elevate customer service to unprecedented heights, fostering better collaboration between freight forwarders and airlines and paving the way for a more efficient, intelligent and customer-centric future.

.9 Conclusion:

AI-powered technologies continue to reshape air freight logistics, providing smarter, data-driven solutions across multiple areas. From warehouse automation and route planning to predictive maintenance and cargo space utilization, AI enhances efficiency at every stage. Dynamic pricing strategies and advanced security systems further strengthen industry operations, while customer service automation ensures seamless interactions. As AI adoption expands, the air freight sector is poised to achieve even greater levels of optimization, sustainability, and reliability in global trade and logistics.

Summary of the Chapter:

- This chapter explores the integration of artificial intelligence (AI) in air freight, examining its applications, benefits, and challenges.
- It starts by defining AI and its role in transportation, emphasizing its transformative impact on the logistics industry.
- The chapter also explored air freight, starting with its definition, moving to its history, benefits and challenges, concluding with key trends in air freight.
- The chapter outlines key AI tools in air freight, including automated warehouse management, route optimization, and predictive maintenance.
- It also highlights the challenges of AI adoption in air freight, such as high initial costs, data privacy concerns, and the need for ongoing system updates.
- Finally, the chapter discusses the future potential of AI in further enhancing the efficiency and sustainability of air freight operations.

CHAPTER TWO:

THE PRACTICAL PART

Introduction:

Global logistics is rapidly evolving, with industry leaders constantly innovating to enhance air freight operations. This chapter presents a case study of DHL, FedEx, and UPS, examining their services, AI applications, and competitive strategies. The first section outlines each company's role in air freight, while the second explores how AI enhances efficiency and customer experience. The final section provides a comparative study, analyzing their strengths, weaknesses, financial and sustainability changes of AI adoption, similarities, and differences. Through this analysis, the chapter highlights how AI-driven strategies shape competition and future advancements in the industry.

TOPIC ONE:

**An Overview of DHL, FedEx,
and UPS Express in air freight**

1.1 Introduction:

Global transportation has witnessed remarkable transformations over the decades, paving the way for the emergence of leading logistics companies. Among the most prominent are DHL, FedEx, and UPS. Organizations that have established themselves as key players in international shipping and freight services. In this topic, we will introduce these companies, tracing their origins and growth within global logistics landscape.

1.2 DHL Express: An Overview of DHL Express

1.2.1 Introduction to DHL:

DHL was founded in San Francisco exactly 40 years ago by 3 budding entrepreneurs- Adrian Dalsey, Larry Hillblom and Robert Lynn. It went from small company shipping papers by airplane from San Francisco to Honolulu to global company shipping EVERYTHING around the world. DHL delivers time-critical shipments as well as goods and merchandise by road, rail, air or sea. DHL transports courier and express shipments via one of the world's most extensive networks to over 220 countries and territories. The company employs more than 300,000 employees all around the world. DHL Express provides wide range of easily accessible services and solutions for their customers; from transport of letters, information to transport of parcels and goods. It operates in more than 220 countries around the world and employs more than 100,000 employees. DHL Express is number one in Europe with 25% of market share. (DHL express: Strategic planning document, 2013)

1.2.2 History and Background:

- DHL is one of the largest 3PL company in the world founded by Adrian Dalsey, Larry Hillblom and Robert Lynn in San Francisco in 1969, and DHL is a part of the Deutsche Post DHL group. According to Dirk, DHL is made of DHL Express, DHL Global Forwarding, DHL Supply chain and DHL Mails. Since 1969, DHL employees were more than 285,000 people and provides its service in 220 countries all over the world. For its contributions in past 40 years, DHL has become the global leader of the International express and logistics industry. (Ji & Wen, 2012)
- Depending on its deep understanding of global Internet and local market, DHL provides professional services in express, air freight and ocean shipping, ground transportation and international postal service areas, etc. In addition, supply chain and enterprise information solution are two important business issues which DHL deals with in connection to contract logistics and enterprise solution services. (Ji & Wen, 2012)
- According to the growing British network shopping market, DHL Mail launched a new cross-border service for American electronic retailers and mail-order companies— Track UK. As a personal parcel delivery service, Track UK offers customers a cheap, speedy, mail-tracking and customer-oriented service which fulfils the needs of American companies. Along with this service, DHL finds another way to help customers to expand their international business. Nowadays, more than 32 countries' mail-tracking service is established in DHL (DHL official website). (Ji & Wen, 2012)

1.2.3 DHL Air Freight:

Air freight logistics has become an important factor in supply chain management, keeping up the pace with the changing world market, and ensuring costly backlogs or shortages are kept to a minimum. DHL Global Forwarding carrying 12% of the air freight worldwide market, the air freight operations are managed through DHL private network that including 7,000 specialists in 600 offices from over 150 countries. According to Yun Feng Gao, DHL owns exclusive airplanes (air bus A300, Boeing 757 mainly). The core air center is in Brussels, Belgium. All air freight services are time-defined, and by working together with carefully selected preferred carriers. However, although DHL has exclusive airplanes, but sometimes these airplanes won't be arranged to delivery DHL goods or mails. (Ji & Wen, 2012)

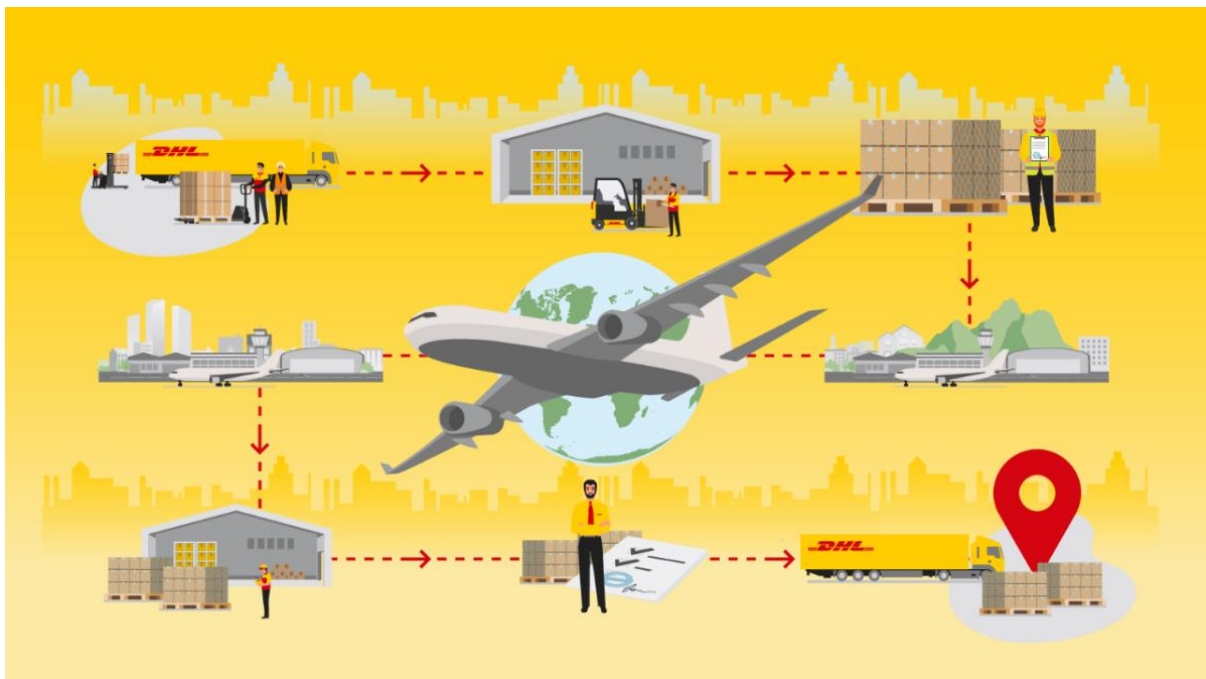


Figure (09): Air Freight Shipping Process. (DHL GLOBAL FORWARDING, n.d.)

1.3 FedEx Express: An Overview of FedEx Express

1.3.1 Introduction to FedEx:

FedEx is basically a Federal Express Corporation built on a portfolio of transportation, e-commerce, and business services propagate throughout the world. It is founded by Frederick W. Smith about 50 years ago on May 5, 1971. Its headquarters are in Memphis, Tennessee and United States. It is a public sector global industry. They provide Express Delivery, Logistics Services, Business Services and Freight Services. They are providing employment to more than 650,000 people according to 2020. They have about 684 total number of aircrafts. They have total 87.3 thousand number of fleets. FedEx provides transport of postal services in United States through FedEx Smart Post and also assist US government as a contractor. This company also provides data to SCM. It is now known as FDX Corporation. (FedEx Organization, 2023)

FedEx Express invented express distribution 50 years ago in 1973 and remains the industry leader, providing rapid, reliable, time-definite delivery of packages and freight to more than 220 countries and territories through an integrated global network. (FedEx Organization, 2023)

FedEx Express offers a wide range of U.S. domestic and international shipping services for delivery of packages and freight, connecting markets that generate more than 99% of the world's gross domestic product through door-to-door, customs-cleared service, historically with a money-back guarantee. As of July 13, 2023, the money-back guarantee remains suspended for certain FedEx Express services in order to balance the focus on service and safety. FedEx Express's unmatched air route authorities and extensive transportation infrastructure, combined with leading-edge information technologies, make it the world's largest express transportation company. As of May 31, 2023, FedEx Express employed approximately 245,000 employees and had approximately 70,000 drop-off locations (including FedEx Office stores and FedEx On Site locations, such as nearly 17,000 Walgreens, Dollar General, and Albertsons stores), 700 aircraft, and more than 82,000 vehicles in its global network. (FedEx Corporation, 2023)

FedEx Express also provides time-critical shipment services through FedEx Custom Critical, Inc. ("FedEx Custom Critical") and cross-border enablement and technology solutions and e-commerce transportation solutions. (FedEx Corporation, 2023)

1.3.2 **History and Background:**

FedEx was founded in 1971 by Frederick Smith as a revolutionary new way to ship time sensitive items. The company did not start shipments until April 17, 1973, when its 14 airplanes delivered 186 packages overnight from its first facility in Memphis, Tennessee (FedEx, 2022). Memphis was chosen for its central location and traditionally favorable weather, FedEx expanded quickly from there and went public in 1978. FedEx has dramatically enlarged its operations through twenty-six acquisitions that expanded its international network and domestic support operations (FedEx, 2022). Its first acquisition in 1984 of Gelco Express International allowed the company to expand its global network into eighty-four countries (FedEx, 2022). In 2001, FedEx rebranded its acquisitions into the familiar corporate structure of today (FedEx, 2022). Today, FedEx is one of the largest international parcel carriers and offers freight carriage, parcel delivery, retail office needs, and supply chain/logistics services. (Gates, 2022)

1.4 **UPS: An Overview of UPS**

1.4.1 **Introduction to UPS:**

UPS is the world's premier package delivery company and a leading provider of global supply chain management solutions. We operate one of the largest airlines and one of the largest fleets of alternative fuel vehicles under a global UPS brand.

UPS delivers packages each business day for 1.6 million shipping customers to 10.1 million delivery customers in over 200 countries and territories. In 2024, we delivered an average of 22.4 million packages per day, totaling 5.7 billion packages during the year. Total revenue in 2024 was \$91.1 billion. (Company Profile: Customer First, People Led, Innovation Driven, 2024)

1.4.2 History and Background:

- **Stage One: 1907-1950**

- **1907: It All Started with 100\$:**

In 1907, two teenage entrepreneurs created what would become the world's largest package delivery service. Starting in a Seattle basement with a \$100 loan, Claude Ryan and Jim Casey opened the American Messenger Company. (More Than 100 Years of Innovation, 2020)

- **1919: The Name and The Look You Know**

In 1919, the company made its first expansion beyond Seattle to Oakland, California, where the name United Parcel Service debuted. That same year, the company painted the company's cars its signature color brown, representing class, sophistication and professionalism. (More Than 100 Years of Innovation, 2020)

- **1930: East Coast Bound**

UPS makes its first expansion to the East Coast in metropolitan New York City, moving the corporate office from Los Angeles to 331 East 38th Street, New York City. (More Than 100 Years of Innovation, 2020)

- **Stage Two: 1951-1975**

- **1953: No Stopping This Service**

In 1953, UPS began common carrier operations, serving commercial and residential shippers in some cities including Chicago - the first city outside of California in which UPS offered this. The company also reintroduced air service (there was a badly-timed two-year venture started in 1929) offering two-day delivery to major East and West Coast cities. Like the first time, UPS shipments flew on regular commercial flights. (More Than 100 Years of Innovation, 2020)

- **1975: The 'Golden Link':**

In 1975, UPS became the first package delivery company to serve every address in the continental U.S. This incredible connection of service areas came to have an epic nickname within UPS - the 'Golden Link.' That same year, the company went abroad for the first time offering services in Toronto. (More Than 100 Years of Innovation, 2020)

- **Stage three: 1976-1990**

- **1985: Next Day? No Problem**

In 1985, UPS Next Day Air service became the first air delivery network to reach every address in the 48-contiguous states, Hawaii, and Puerto Rico. That same year, UPS began its first intercontinental air service between the U.S. and Europe. (More Than 100 Years of Innovation, 2020)

- **1988: An Airline is Born:**

In 1988, UPS won approval from the Federal Aviation Administration (FAA) to operate its own aircraft, launching UPS Airlines. (More Than 100 Years of Innovation, 2020)

- **1989: It's a Big, Beautiful World:**

After a decade of seeing its reach grow throughout the Americas and Europe, in 1989 UPS extended service to the Middle East, Africa, and the Pacific Rim. Currently

UPS operates in more than 220 countries and territories across the globe. (More Than 100 Years of Innovation, 2020)

- **Stage Four: 1991-today**

- **1994: A Green New Home:**

In 1994, UPS moved its corporate headquarters to Atlanta with construction emphasizing energy efficiencies and an extensive tree protection and replacement program. The location at 55 Glenlake Parkway is still its current home. This year also saw the debut of UPS.com. (More Than 100 Years of Innovation, 2020)

- **1999: A Bold Financial Step:**

During the 1990s, UPS expanded its vision to become a true enabler of global commerce. This led, to the big step of going public for the first time on Nov. 10, 1999. (More Than 100 Years of Innovation, 2020)

- **2001: Diving into Retail:**

In 2001, UPS entered the retail business acquiring Mail Boxes Etc., Inc., the world's largest franchisor of retail shipping, postal and business service centers. Within two years, approximately 3,000 Mail Boxes Etc. locations in the U.S. re-branded as The UPS Store and began offering lower UPS-direct shipping rates. (More Than 100 Years of Innovation, 2020)

- **2018: Who Doesn't Like the Weekend?**

After expanding its portfolio throughout the decade, including acquiring tech-driven freight brokerage Coyote Logistics in 2015, UPS began offering Saturday ground delivery and Saturday pickup services. It was the first time in the company's history, delivering shippers industry-leading Saturday choices. (More Than 100 Years of Innovation, 2020)

- **2020: A New Direction:**

Carol B. Tomé began her tenure as the 12th CEO of UPS on June 1, 2020, becoming the first female CEO in the company's 113-year history. (More Than 100 Years of Innovation, 2020)

1.5 Conclusion

In this topic, we explored the origins and growth of DHL, FedEx, and UPS, three of the most influential companies in the global logistics industry. By tracing their journeys from their early beginnings to becoming leaders in international transportation, we gained insight into how they built their extensive networks and established a strong presence worldwide.

TOPIC TWO:
**AI Applications in DHL,
FedEx, and UPS**

2.1 Introduction:

AI has become a transformative force in the logistics and air freight sectors, enabling industry leaders to optimize operations and improve customer experiences. In this topic, we are going to explore how AI applications are being utilized by key players DHL, FedEx, and UPS to revolutionize air freight and logistics through innovative technologies like predictive analytics, smart routing, and real-time monitoring.

2.2 AI Applications in DHL:

2.2.1 DHL's AI-powered Route Optimization:

- DHL, the world's leading provider of logistics services, has been leading the transition in its delivery operations through the deployment of AI-powered route optimization technologies. The technology developed by DHL works on constantly refining enormous amounts of data regarding traffic patterns, weather, and tracking information in real time through highly elaborate machine learning algorithms. Such elaborate analytics automatically perform the repositioning of equipment to change the delivery path, if needed, to ensure delays are at their bare minimum. (Boorova, Mijuskovic, Slobodan, & Durdic, 2024)
- The major ideas of the DHL AI route optimization system make it possible to reduce delivery time by optimizing routes with the highest fuel efficiency, hence reducing operational costs to a minimum and increasing the quality of the services. (Boorova, Mijuskovic, Slobodan, & Durdic, 2024)
- DHL uses advanced software powered by Wise Systems, which optimizes last-mile delivery routing by applying AI. It can also allow for personalization in delivery-for instance, urgent medical deliveries or deliveries at a certain time of the day or night. By offering real-time delivery updates to customers through the feature Track My Package, customer experience at DHL improves and gets closer to estimating exact delivery times. Because this AI system changes the routes on the go, DHL can quickly respond to traffic changes or any unplanned accidents that may occur and thus maintain efficient operations at high service levels. (Boorova, Mijuskovic, Slobodan, & Durdic, 2024)
- DHL's AI-powered route optimization system is built to effectively integrate into other management tools used in logistics, making it particularly valuable in air freight operations. By optimizing routes for air cargo transportation, it ensures better coordination between air freight schedules, ground handling, and customs clearance processes. This integration creates a strong and agile logistics network, capable of meeting the modern-day demands of e-commerce and global trade, while improving efficiency and minimizing delays in air freight operations. (Boorova, Mijuskovic, Slobodan, & Durdic, 2024)
- Historically and in real time, the machine learning algorithms used by the DHL system learn from the data to continuously improve the route planning accuracy and efficiency. Besides lowering operating costs-with the system's calculated routes optimized to reduce fuel consumption-it is also reducing the environmental impact of its delivery operations and therefore aligns with wider goals on sustainability. (Boorova, Mijuskovic, Slobodan, & Durdic, 2024)

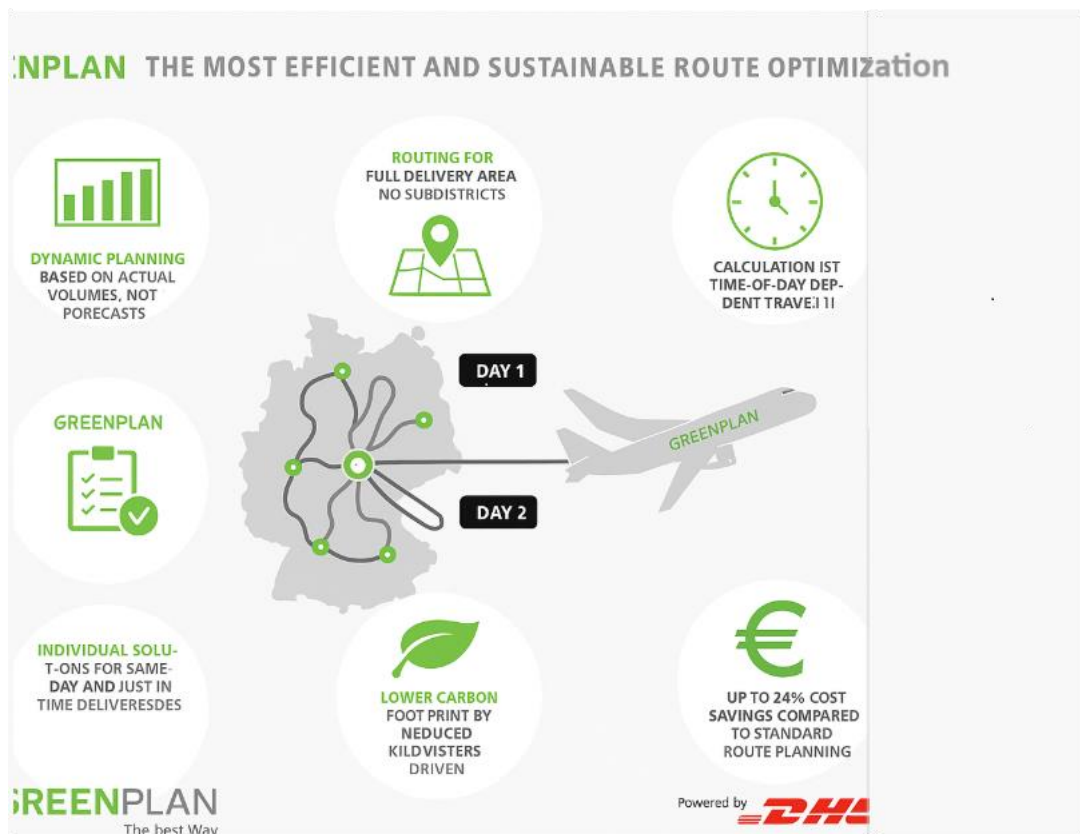


Figure (10): DHL GREEN PLAN for Efficient Route Optimization. (Greenplan from the operational point of view, n.d.)

2.2.2 DHL AI-driven robotics and enhancing customer experience:

- Amid increasing shipment volumes, DHL Express, the world's leading international express service provider, has introduced DHLBot, an AI-powered (artificial intelligence) robotic arm that automates parcel sortation, in two countries in Asia Pacific. The DHLBot will complement manual sortation of small parcels and enable hubs and gateways to handle greater volumes, particularly during peak season, while increasing overall operational efficiency by at least 40 percent. (DHL EXPRESS DEPLOYS AI-POWERED SORTING ROBOT, 2021)
- DHL Express partnered with Dorabot, an AI-powered robotic solution provider, to implement the DHLBot. This follows a successful pilot that saw a significant boost in parcel sortation productivity and service quality. This is especially critical given the consistent growth in shipment volume witnessed across Asia Pacific. In 2020, DHL Express recorded a 17.3 percent year-on-year increase in shipment volume during the peak months of November and December. Capable of sorting over 1,000 small parcels per hour with 99 percent accuracy, the DHLBot reduces the probability of mis-sorting and thereby, removes the need for secondary sorting. (DHL EXPRESS DEPLOYS AI-POWERED SORTING ROBOT, 2021)



Figure (11): DHLBot. (DHL EXPRESS DEPLOYS AI-POWERED SORTING ROBOT, 2021)

- State-of-the-art 3D and barcode cameras scan the airway bill on each package for its targeted destination as it travels through the conveyor belt. The AI-powered DHLBot, positioned at the end of the conveyor belt, then receives the package's information and its destination and intelligently sorts it into respective delivery bins that sit on racks surrounding the robot, each representing an individual courier route. This entire process reduces the dependency on employees to manually read waybills and sort parcels, allowing them to have more time for route planning. (DHL EXPRESS DEPLOYS AI-POWERED SORTING ROBOT, 2021)
- In line with Deutsche Post DHL Group's Strategy 2025 goal of delivering excellence in a digital world, the implementation of the robotics arm solution is one of many digital transformation projects that the Group is investing in to improve customer and employee experience, as well as enhance operational excellence. Till 2025, the Group would spend around EUR 2 billion on initiatives to derive greater efficiency through automation and robotics as well as advanced data analytics. (DHL EXPRESS DEPLOYS AI-POWERED SORTING ROBOT, 2021)
- The main use of AI-driven chat-bots and virtual assistants in DHL is to automate customer engagement by responding to customer inquiries immediately, comprehensively, and precisely. Applying machine learning concepts to previous interactions continuously improves the performance of these AI bots. Such facilities are immensely useful in executing some pretty complicated urgent tasks, like customs clearance of international shipments. In this regard, by automating such processes at DHL, it ensures that all incoming inquiries by customers are dealt with and responded to in a timely and expeditious manner. This accelerates response times and heightens customer satisfaction. (Boorova, Mijuskovic, Slobodan, & Durdic, 2024, p. 301)
- This is not all since AI at DHL can do much more for customer support. The chat-bots in DHL are also used to track shipments to get real-time updates and to resolve issues automatically without any human intervention. It therefore improves efficiency in the

running of the customer service and also releases human agents to attend to complex issues that may require personal touch. As this is enhanced by DHL to the capabilities of the virtual assistants, it enables them to facilitate a more seamless and better experience for the customers; information will be given out right on due time as the customers interact with it. (Boorova, Mijuskovic, Slobodan, & Durdic, 2024, p. 301)

- Chat-bots can help handle small and mid-volume call center inquiries such as requests of deliveries, editing orders, tracking shipments, and answering FAQs. The chat-bots can also present meaningful data that enable a company to better understand the needs of customers and improve the customer experience. As such, chat-bots are, at the moment, the fastest-growing brand communication channel, having a 90% customer response rate for the best chat-bots. Also, the estimated increase in sales is 67% after implementing a chat-bot, and 57% of businesses report that chat-bots drive huge ROI with minimal investment. (Boorova, Mijuskovic, Slobodan, & Durdic, 2024, p. 301)
- AI allows vehicles to be completely full, reducing trips, hence operations costs. DHL, reduces costs by minimizing the number of journeys. This saves on fuel and labor while at the same time providing a leaner operation. It is sustainable because fewer trips reduce carbon emissions, minimizing impacts on the environment while truly allowing cost-effective logistics operations. (Boorova, Mijuskovic, Slobodan, & Durdic, 2024, p. 301)

2.2.3 DHL AI-powered Online Platform My Global Trade Services (MyGTS):

- My Global Trade Services (MyGTS) is an online self-serve platform that simplifies the search for customs-relevant Harmonized Systems Codes.
- This platform simplifies international shipping for customers, and speeding up the processing of cross-border shipments. Users can learn about customs formalities and estimated landed cost and understand the official regulatory requirements before shipping. (DHL Express Introduces AI-powered Online Platform My Global Trade Services to Simplify International Shipping and Help Businesses Access New Markets, 2024)
- MyGTS is an online self-serve portal that helps users easily retrieve customs information to pre-plan shipments as they access new markets or launch new products. It uses artificial intelligence and machine learning to provide an overview of the trade agreements in place and estimated duties/taxes which are included in the landed cost of the different trade routes. Landed costs are the total cost of getting a product from the factory to a customer's door. Besides shipping fees and insurance, it includes estimated customs duties and taxes for cross-border shipments. (DHL Express Introduces AI-powered Online Platform My Global Trade Services to Simplify International Shipping and Help Businesses Access New Markets, 2024)
- DHL Express customers can use the MyGTS platform to find the Harmonized System (HS) codes required for shipping their items using keywords or the code directory. The platform uses artificial intelligence and machine learning to provide customers with the correct codes, making customs clearance faster and more accurate and minimizing delays. It also helps customers avoid surprises such as additional customs duties or taxes. (DHL Express Introduces AI-powered Online Platform My Global Trade Services to Simplify International Shipping and Help Businesses Access New Markets, 2024)

2.2.4 Optimizing Order Fulfillment:

- According to DHL, the COVID pandemic led to a steady increase in online sales, creating a problem both for electronic retailers (or “e-tailers”) and logistics companies. Household staple items like food, drugstore items, and medications were in particular demand, creating supply bottlenecks. (DeNittis, 2023)
- First, the training data probably consisted of vast amounts of individual product orders and their associated data. These may have included SKU, quantity, etc. Second, the logistical element of the algorithm would have mandated product tracking and workforce data. Workforce information would have required data such as the number of employees, locations, days and times worked, and their roles and locations. (DeNittis, 2023)
- The company states that the model data is collected via numerous input devices, including sensors and robots. The data is then centralized into warehouse management systems (WMS) and transportation management systems (TMS). (DeNittis, 2023)
- The data is then analyzed with ML algorithms. If the software detects potential insights and optimizations, the user is alerted to the actionable data via a notification system built into the software’s dashboard. (DeNittis, 2023)
- DHL states that the software is compatible with most WMS systems and can be integrated into existing IT infrastructure. DHL claims that its algorithms have helped to improve the decision-making and order-picking processes of its customers. (DeNittis, 2023)
- Regarding business outcomes, the company claims that its new algorithm has reduced the travel distance of warehouse employees by 50 percent and increased the productivity of “individual DHL locations” by up to 30 percent. (DeNittis, 2023)

2.3 AI Applications in FedEx:

2.3.1 FedEx Surround:

- The FedEx Surround monitoring and intervention tools integrate seamlessly with the company’s existing transportation network, enhancing its robust suite of shipping and tracking solutions. With three levels of service for customers to choose from that comprise of Select, Preferred and Premium, the tools support a wide range of industries including healthcare, aerospace, high-tech, providing critical updates and interventions that ensure the integrity and timely delivery of sensitive shipments. (FedEx Introduces Surround® Monitoring and Intervention Solution to Enhance Global Supply Chain Visibility, 2024)
- With the FedEx Surround® monitoring and intervention suite, FedEx provides three key benefits to its customers:
 - **Flexibility and Control:**
Surround dashboard provides near real-time global visibility and predictive analytics using AI and Sense Aware ID. (FedEx Introduces Surround® Monitoring and Intervention Solution to Enhance Global Supply Chain Visibility, 2024)
 - **Greater Value:**
Special handling code enhances operational capability, enabling prioritized boarding and handling, cold chain support and in-and out- of- network intervention. (FedEx Introduces Surround® Monitoring and Intervention Solution to Enhance Global Supply Chain Visibility, 2024)

- **Peace of Mind:**

24x7 expert support ensures proactive monitoring and intervention with dedicated teams at hubs, ramps, and stations, including customized reporting for customers. (FedEx Introduces Surround® Monitoring and Intervention Solution to Enhance Global Supply Chain Visibility, 2024)

- The FedEx Surround monitoring and intervention solution in Asia Pacific utilizes advanced sensor technology including Sense Aware ID with near real-time data analytics to provide continuous monitoring and proactive interventions for shipments worldwide. FedEx has long been a pioneer in sensor-based logistics, providing advanced tracking of urgent and high value shipments. Sense Aware ID uses a lightweight, compact sensor that transmits precise package location data every two seconds via Bluetooth Low Energy (BLE) to WiFi access points or established gateway devices throughout the FedEx network. Packages equipped with the Sense Aware ID sensor are tracked hundreds of times versus dozens of times with traditional package scanning protocols, which provides an unprecedented amount of real-time data about the location of the shipment. (FedEx Introduces Surround® Monitoring and Intervention Solution to Enhance Global Supply Chain Visibility, 2024)
- FedEx has a strong commitment to innovation demonstrated by the strategic use of AI and machine learning technologies within the FedEx Surround system. These technologies predict potential disruptions in the shipping process, allowing FedEx and its customers to swiftly make informed decisions. FedEx Surround monitoring and intervention is set to transform the way businesses manage logistics, offering enhanced visibility and control over their supply chains. (FedEx Introduces Surround® Monitoring and Intervention Solution to Enhance Global Supply Chain Visibility, 2024)

2.3.2 **AI-Powered Sorting Robots:**

- FedEx Express introduced an AI-powered intelligent sorting robot at its South Pacific (SPAC) Regional Hub in Singapore. The sorting robot represents the company's continued push in digitizing its operations and building a smart logistics network. (FedEx Introduces AI-powered Robotic Sorting Arm to Drive Operational Efficiency at its Singapore Hub, 2022)
- FedEx focus towards automation in Singapore echoes broader industry trends. Triggered by the global pandemic, logistics players are optimizing operational efficiencies, from warehouse management to last-mile delivery. (FedEx Introduces AI-powered Robotic Sorting Arm to Drive Operational Efficiency at its Singapore Hub, 2022)
- Earlier this year, FedEx also deployed a similar sorting robot at its FedEx South China E-Commerce Shipment Sorting Center in Guangzhou. This project in Singapore is supported by Aviation Development Fund – one of the key initiatives by the Civil Aviation Authority of Singapore (CAAS) that supports the development and growth of Singapore's aviation industry. (FedEx Introduces AI-powered Robotic Sorting Arm to Drive Operational Efficiency at its Singapore Hub, 2022)
- "The deployment of the sorting robot is our latest effort in leveraging automation and harnessing artificial intelligence (AI) technology, to optimize operational processes and provide better service to our customers. By investing in warehouse automation, we enhance

FedEx operational scalability,” said Eric Tan, managing director at FedEx Express Singapore. “The support we received from CAAS opens the door for further collaboration between FedEx Singapore and local government agencies and boosts our continuous push towards building a smart logistics infrastructure to better serve our customers.” (FedEx Introduces AI-powered Robotic Sorting Arm to Drive Operational Efficiency at its Singapore Hub, 2022)

- The robotic arm can sort up to 1,000 packages per hour, carry up to 5kg each time, and cover up to 100 destinations simultaneously. Equipped with a barcode reader that scans packages to obtain destination information, it has an accuracy rate of more than 98.5%, and could potentially facilitate the hub moving towards round-the-clock sort operations. (FedEx Introduces AI-powered Robotic Sorting Arm to Drive Operational Efficiency at its Singapore Hub, 2022)
- Ms. Angela Ng, CAAS Director of Aviation Industry said, “CAAS actively works with air transport companies to identify, trial and adopt technology, automation, and digitalization to enhance operational efficiency and transform jobs. FedEx’s sorting robot is one such example. The project has significantly enhanced air cargo processing productivity and has enabled job redesign for FedEx’s manpower to take on higher value-added tasks. (FedEx Introduces AI-powered Robotic Sorting Arm to Drive Operational Efficiency at its Singapore Hub, 2022)



Figure (12): FedEx Sorting Arm (FedEx Introduces AI-powered Robotic Sorting Arm to Drive Operational Efficiency at its Singapore Hub, 2022)

2.3.3 Predictive Analytics for Delivery Optimization:

- FedEx has launched “a much better machine-learning model” to provide more accurate estimates to customers about delivery times, the model factors in shipping variables such

as weather patterns and traffic conditions. (Garland, FedEx makes progress with AI to sharpen delivery time estimates, 2023)

- The company is also exploring the capabilities of generative AI technologies that power chatbots like ChatGPT. These models can improve the delivery experience by asking users questions about their shipment and predict what harmonized code that we need to provide. (Garland, FedEx makes progress with AI to sharpen delivery time estimates, 2023)
- The company's interest in machine learning underscores its transformation over the past few years to become what Subramanian called "a data-driven, digital-first company." FedEx is particularly interested in leveraging the information it gathers from the 16 million packages it delivers daily. Harnessing the power of machine learning can help FedEx maximize the value of this data. The logistics giant is currently using machine learning to develop more accurate volume forecasts in its Ground unit and provide shippers with predictive carbon emissions data through its FedEx Sustainability Insights platform. (Garland, FedEx makes progress with AI to sharpen delivery time estimates, 2023)

2.3.4 Robotic Loading system:

- FedEx is testing the use of AI-powered robots to more efficiently load its Ground unit's trailers through a collaboration with robotics company Dexterity AI. Dexterity AI's robot, DexR, autonomously moves to the back of a trailer before connecting to a powered conveyor system, which feeds the robot boxes directly from the facility's sortation system. DexR's two-arm design allows it to pick and pack boxes simultaneously, boosting throughput. (Garland, FedEx testing AI-powered, trailer-loading robots, 2023)
- FedEx has long pursued more automated package handling processes throughout its operations, including for loading and unloading, which it says frees up employees for other tasks while keeping service levels high. Loading FedEx trailers in an efficient manner can be a challenging task considering the wide variety of shipments the company encounters, as size, shape, weight and packaging material all have to be considered in crafting a stable wall of boxes. Dexterity AI touts its truck-loading robot as being able to handle this complex volume mix. (Garland, FedEx testing AI-powered, trailer-loading robots, 2023)
- Dexterity's AI software powers the DexR robot, providing it several useful truck-loading capabilities. It can quickly assess possible ways to load the trailer, has a sense of touch so it can gently nudge boxes together and improves its efficiency with every box picked through machine learning. (Garland, FedEx testing AI-powered, trailer-loading robots, 2023)

2.3.5 Investment in AI Robotics Companies:

- FedEx has invested in AI robotics and autonomous technology company Nimble to help scale up the delivery giant's Fulfillment unit which aids small and medium-sized businesses in fulfilling orders and managing inventory. (FedEx invests in AI robotics company Nimble to boost its supply chain business, 2024)
- Parcel delivery companies are ramping up investments in automation in an effort to cut down costs and boost efficiency at a time when freight demand remains subdued. FedEx said the investment would help streamline its supply chain capabilities across North

America, through Nimble's automated third-party logistics solutions. (FedEx invests in AI robotics company Nimble to boost its supply chain business, 2024).

2.4 AI Applications in UPS:

2.4.1 Network Capacity Management:

- UPS leverages AI and machine learning technologies to optimize its network capacity management and respond quickly to fluctuations in package volumes. By integrating advanced tools, UPS can dynamically adjust operations, such as rerouting volumes from non-automated to automated hubs, thereby increasing efficiency and reducing labor hours. This technology-driven adaptability allows UPS to manage unexpected changes like shifts in customer demand or disruptions due to external factors. (Garland, UPS uses AI, machine learning to match network capacity with lower volumes, 2023)
- These AI-driven capabilities are particularly valuable for managing complex logistics networks. The ability to swiftly reallocate volumes, optimize hub usage, and streamline sorting operations ensures smooth handling of air cargo. Furthermore, the deployment of RFID tags and automated scanning technology
- under UPS's smart package initiative reduces manual intervention, enhancing accuracy and throughput in air freight operations. These tools collectively demonstrate how UPS's technology innovations directly contribute to efficiency, agility, and precision in air freight logistics. (Garland, UPS uses AI, machine learning to match network capacity with lower volumes, 2023)

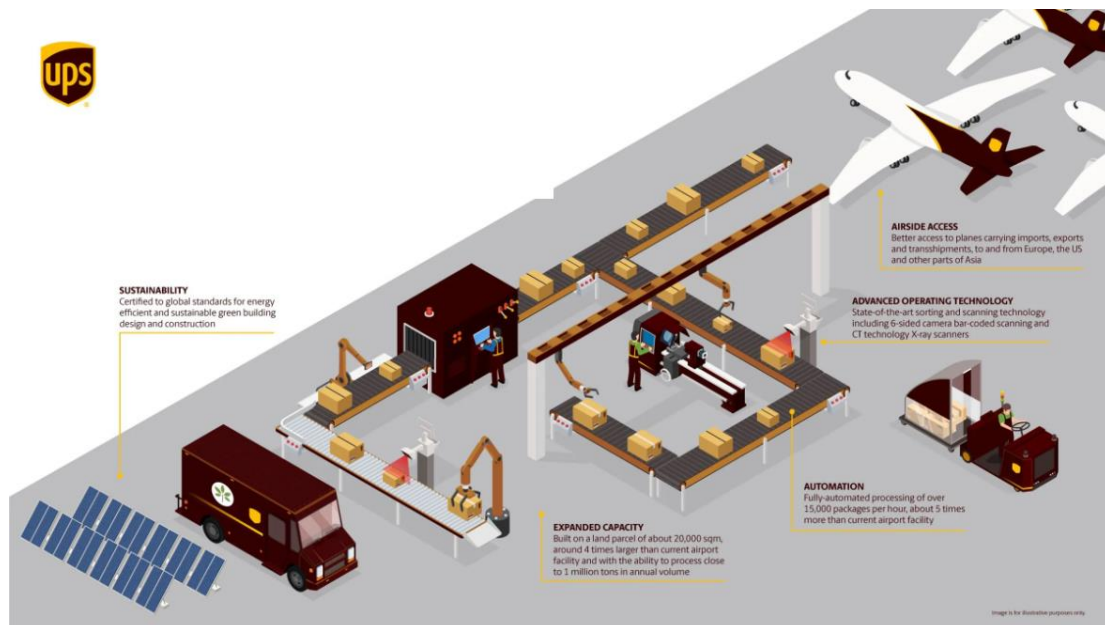


Figure (13): UPS Automated Sorting Hub. (DC, 2023)

2.4.2 Automated Sorting facilities:

- The UPS Velocity facility integrates smart automation, machine learning, and artificial intelligence, demonstrating how advanced technology can elevate operations and customer

experience. With over 700 bots powered by AI, goods-to-person and rack-to-person technologies streamline inventory management and optimize storage, increasing efficiency. This system is particularly significant for e-commerce, ensuring quick and accurate order fulfillment to meet the growing demand. (5 ways UPS Velocity orchestrates industry-leading service with AI and automation, 2024)

- These innovations translate to improved cargo handling, with AI optimizing space and throughput in warehouses that process air cargo shipments. The multilingual training program enhances workforce efficiency, ensuring seamless operations even in diverse teams. Additionally, the integration of real-time data insights through UPS Supply Chain Symphony provides customers with valuable visibility into their air freight logistics, enabling faster and more informed decision-making. These advancements highlight UPS's commitment to leveraging AI for operational excellence across all transportation modes, including air freight. (5 ways UPS Velocity orchestrates industry-leading service with AI and automation, 2024)

2.4.3 On-Road Integrated Optimization and Navigation (Orion):

- UPS has been leveraging artificial intelligence (AI) and machine learning to enhance delivery operations and improve supply chain efficiency, which can be linked to air freight operations in various ways. Their On-Road Integrated Optimization and Navigation (ORION) platform dynamically adjusts delivery routes based on live traffic conditions, pick-up commitments, and delivery priorities, reducing fuel consumption and emissions while improving service accuracy and reliability. In air freight, such dynamic routing can optimize the movement of cargo to and from airports, improving delivery timelines and efficiency. (Putzger, 2020)
- Moreover, demand-sensing tools powered by AI allow UPS to detect emerging trends and patterns in downstream activities, such as order volume or inventory shifts, and respond proactively. These tools help logistics firms, including UPS, align air freight capacity with real-time market demand, minimizing disruptions and enhancing capacity utilization. (Putzger, 2020)
- UPS also incorporates AI-driven bots for customer service and support, with the data they generate feeding into broader systems to refine operations further. Such systems can be applied in air freight for better load factor prediction, route optimization, and demand forecasting. (Putzger, 2020)
- While demand-sensing tools, like those highlighted by providers such as ToolsGroup and E2 Open, show promise in improving forecast accuracy and inventory management, the integration of such technology into air freight operations can offer enhanced visibility into shipment patterns, allowing companies like UPS to make informed decisions that boost operational efficiency. UPS's investments in these technologies demonstrate their broader applicability across transportation modes, including air freight, to meet the evolving demands of logistics and customer satisfaction. (Putzger, 2020)

2.4.4 AI-Enhanced Tracking:

- UPS has harnessed artificial intelligence (AI) and machine learning to enhance customer experience through the integration of its chatbot with the “UPS My Choice” function. This innovation allows customers to track packages without a tracking number and retrieve detailed shipment information. Initially launched on platforms like Facebook Messenger, Skype, and Amazon Alexa, the AI-enabled chatbot provides convenience by mimicking human interactions, making customer service more accessible and efficient. (UPS incorporates AI in package tracking, 2017)
- The integration of AI with UPS My Choice empowers customers to have more control over how and where their packages are delivered or rerouted. This is particularly significant for air freight operations, where seamless tracking and delivery adjustments are essential for handling time-sensitive shipments. By leveraging big data, IoT, and AI, UPS not only streamlines customer engagement but also strengthens its logistics network globally. (UPS incorporates AI in package tracking, 2017)
- In the context of air freight, such customer-facing technologies can enhance visibility and flexibility, enabling customers to track cargo movements in real-time and make informed decisions about delivery preferences. This approach illustrates how AI-driven tools are transforming traditional logistics practices, offering greater efficiency, personalization, and operational control across all transportation modes. (UPS incorporates AI in package tracking, 2017)

2.5 Conclusion:

In this topic, we examined how DHL, FedEx, and UPS utilize AI to transform air freight and logistics. From predictive analytics for demand forecasting to real-time tracking with sensor-based technologies, these industry leaders leverage AI to enhance efficiency, reliability, and sustainability. Their innovative approaches set a standard for integrating advanced technologies to meet the dynamic needs of global trade and air freight operations.

TOPIC THREE:

A Comparative Study of AI Innovations in DHL, FedEx, and UPS

3.1 Introduction:

In this topic, we delve into a comparative analysis of three leading players in the air freight industry: DHL, FedEx, and UPS. By examining their respective strengths and weaknesses, we uncover how each company leverages its capabilities while addressing operational challenges. Additionally, we explore the points of similarities that unify their approaches, such as global networks and technological integration, alongside key differences that highlight their unique strategies and market positioning. This comprehensive analysis provides valuable insights into the competitive dynamics shaping the air freight sector.

3.2 Analysis of Weaknesses and Strengths of DHL, FedEx, and UPS:

3.2.1 DHL Express:

❖ Strengths:

- **Global Air Freight Network:**

DHL Express operates one of the largest global air freight networks, covering over 220 countries and territories through its own fleet of over 300 dedicated aircraft (DHL Aviation) and partnerships with commercial airlines. This extensive network ensures comprehensive international coverage and enables DHL to deliver shipments efficiently across the globe.

- **Time-Definite Services:**

DHL specializes in time-sensitive deliveries by leveraging its well-structured hub-and-spoke model, with major hubs in Leipzig, Cincinnati, and Hong Kong, to ensure quick and reliable service. Its ability to provide next-day and same-day delivery worldwide makes it a market leader in air freight for urgent shipments.

- **Technological Advancements:**

The company utilizes AI-powered systems to optimize cargo loading, flight routing, and schedule planning, which reduces transit times and operational costs. Additionally, DHL's advanced tracking systems provide real-time shipment visibility, enhancing customer satisfaction and trust.

- **Tailored Solutions for Key Industries:**

DHL offers specialized air freight solutions for industries like healthcare, technology, and automotive, focusing on high-value and time-critical shipments such as vaccines and critical spare parts. These tailored services position DHL as a trusted provider for niche market segments.

- **Sustainability Efforts in Air Freight:**

DHL has invested heavily in sustainable aviation fuel (SAF) and carbon-neutral shipping options to reduce its environmental impact. Through its "GoGreen" initiatives, the company actively attracts environmentally conscious customers while striving to meet global sustainability goals.

❖ **Weaknesses:**

- **High Costs of Air Freight Operations:**

Air freight is inherently expensive, and DHL's reliance on premium services further increases its pricing, making it less competitive in cost-sensitive markets. Additionally, investments in sustainability and fleet expansion add significant operational costs.

- **Vulnerability to External Disruptions:**

DHL's air freight operations are highly sensitive to disruptions such as fuel price volatility, airline strikes, extreme weather, and regulatory changes. Global crises, such as the COVID-19 pandemic, have further highlighted the vulnerability of air cargo to capacity reductions and delays.

- **Intense Competition in Air Freight:**

DHL faces fierce competition from industry leaders like FedEx Express and UPS Air Cargo, which operate comparable global networks and often offer competitive pricing or specialized services, threatening DHL's market share.

- **Dependence on Major Hubs:**

While DHL's hub-and-spoke model enhances efficiency, it creates a dependency on key hubs like Leipzig and Cincinnati. Any disruptions at these major hubs can result in cascading delays throughout the entire network, impacting service reliability.

- **Capacity Limitations in High-Demand Periods:**

During peak shipping seasons, such as the holiday period, DHL's dedicated air freight capacity may become strained, affecting its ability to meet surging demand. This challenge is compounded by its reliance on its own fleet and limited access to additional cargo space from partner airlines.

By building on its strengths, such as its global air freight network and advanced technologies, DHL express can address its weaknesses by investing in fuel-efficient aircraft, optimizing secondary hubs, and adopting flexible pricing models. These strategies will enhance operational efficiency, reduce costs, and improve resilience, ensuring DHL remains competitive in the air freight market.

3.2.2 FedEx Express:

❖ **Strengths:**

- **Extensive Global Air Network:**

FedEx operates one of the largest and most sophisticated air freight networks globally, ensuring fast and reliable delivery across continents.

- **Technological Innovation:**

The company employs advanced AI and machine learning tools, such as the FedEx Surround system, to enhance supply chain visibility, predict disruptions, and optimize routes.

- **Specialized Services:**

FedEx offers tailored solutions for industries like healthcare and aerospace, including cold chain logistics and time-critical shipments.

- **SenseAware Technology:**

Advanced sensor-based tracking like SenseAware ID provides real-time shipment monitoring, ensuring higher accuracy and reliability.

- **Strong Brand Reputation:**

FedEx is widely recognized for its reliability and customer service, earning trust across industries.

- ❖ **Weaknesses:**

- **High Operating Costs:**

Maintaining its vast air fleet and implementing cutting-edge technologies lead to significant operational expenses.

- **Overdependence on the U.S. Market:**

A large portion of FedEx's business is tied to the U.S., making it vulnerable to regional economic downturns or policy changes.

- **Environmental Concerns:**

Despite advancements, the company's operations still face criticism over carbon emissions and environmental impact.

- **Competition in Emerging Markets:**

FedEx faces challenges in expanding its presence in rapidly growing regions like Asia-Pacific, where local competitors often have an advantage.

- **Complex Operations:**

Managing such a vast global network can lead to inefficiencies and delays, especially during peak seasons.

By building on its strengths, such as its expansive global air freight network and industry-leading innovations like SenseAware technology, FedEx can address its weaknesses by investing in green logistics initiatives, streamlining costs in non-core markets, and expanding partnerships in underserved regions. These strategies will enhance operational efficiency, improve sustainability, and reinforce FedEx's leadership in the air freight market.

3.2.3 UPS:

- ❖ **Strengths:**

- **Global Air Freight Network:**

UPS operates one of the largest and most efficient air cargo networks globally, enabling rapid delivery and extensive reach.

- **Innovative Technologies:**

The company employs advanced AI systems, such as its On-Road Integrated Optimization and Navigation (ORION) platform, for dynamic route optimization, reducing delivery times and environmental impact.

- **Customer-Centric Services:**

UPS My Choice enhances customer experience by providing real-time tracking and flexibility in delivery preferences.

- **Strong Brand Reputation:**

UPS is widely recognized for its reliability and high-quality logistics services.

- ❖ **Weaknesses:**

- **High Operational Costs:**

The extensive global network and use of advanced technologies come with significant costs, impacting profitability.

- **Environmental Challenges:**

Despite efforts, the company still faces scrutiny over carbon emissions and environmental sustainability in its air freight operations.

- **Dependence on Established Markets:**

UPS relies heavily on mature markets, potentially missing opportunities in emerging regions.

- **Complexity in Operations:**

Managing such a vast network can lead to inefficiencies or delays during peak seasons or disruptions.

By leveraging its strengths, such as its global air freight network, innovative technologies, and customer-centric services, UPS can maintain its leadership in the logistics industry. Addressing weaknesses through investments in green logistics, expanding into emerging markets, and streamlining operational processes will enhance efficiency and sustainability. These strategies will solidify UPS's position as a reliable and eco-conscious leader in air freight.

3.3 Changes in Financial and Sustainability Performance Following AI Adoption:

3.3.1 DHL Express:

After the adoption of AI, we can see that the company went through different financial and sustainability changes. We will address them in the following table:

Table (01): DHL Financial and Sustainability Key Figures (Group, 2025)

		2020 adjusted	2021 adjusted	2022 adjusted	2023 adjusted	2024
Financial figures						
Revenue	€m	66,716	81,747	94,436	81,758	84,186
Profit from operating activities (EBIT)	€m	4,847	7,978	8,436	6,343	5,886
Return on sales ¹	%	7.3	9.8	8.9	7.8	7.0
EBIT after asset charge (EAC)	€m	2,199	5,186	5,117	2,857	2,207
Consolidated net profit for the period ²	€m	2,979	5,053	5,359	3,675	3,332
Net cash from operating activities	€m	7,699	9,993	10,965	9,258	8,722
Free cash flow	€m	2,535	4,092	3,067	2,942	2,944
Capex ³	€m	2,999	3,895	4,123	3,370	3,066
Equity ratio ⁴	%	25.5	30.7	34.6	34.2	34.6
Net debt ⁵	€m	12,928	12,772	15,856	17,739	18,998
Net gearing ⁶	%	47.9	39.6	40.1	43.7	44.0
Stock data						
Basic earnings per share ⁷	€	2.41	4.10	4.41	3.09	2.86
Diluted earnings per share ⁸	€	2.36	4.01	4.33	3.04	2.81
Cash flow per share ^{7,9}	€	6.22	8.11	9.03	7.79	7.48
Dividend per share	€	1.35	1.80	1.85	1.85	1.85 ¹⁰
Dividend distribution	€m	1,673	2,205	2,205	2,169	2,132 ^{10,11}
Number of shares as of December 31	millions	1,239.1	1,239.1	1,239.1	1,239.1	1,200.0
Year-end closing price	€	40.50	56.54	35.18	44.86	33.98
Sustainability figures						
Logistics-related ¹² GHG emissions ¹³	million metric t CO ₂ e	33.64	40.22	36.59	33.27	33.77
Realized Decarbonization Effects	metric kt CO ₂ e	—	728	1,004	1,335	1,584
Energy consumption (Scopes 1 and 2)	GWh	27,427	30,486	34,493	35,056	32,473
of which from renewable sources	GWh	—	1,826	2,267	3,064	3,332
Number of employees ¹⁴	headcount	571,974	592,263	600,278	594,396	601,723
Staff costs	€m	22,234	23,879	26,035	26,977	28,305
Employee Engagement ¹⁵	%	83	84	83	83	82
Share of women in middle and upper management	%	23.2	25.1	26.3	27.2	28.4
Accident rate (lost time injury frequency rate, LTIFR) ¹⁶		19.5	19.5	17.0	15.6	14.5
Share of valid certificates for compliance trainings ¹⁷	%	—	96.5	98.1	98.6	99.1
Cybersecurity rating	points	—	—	700	750	750

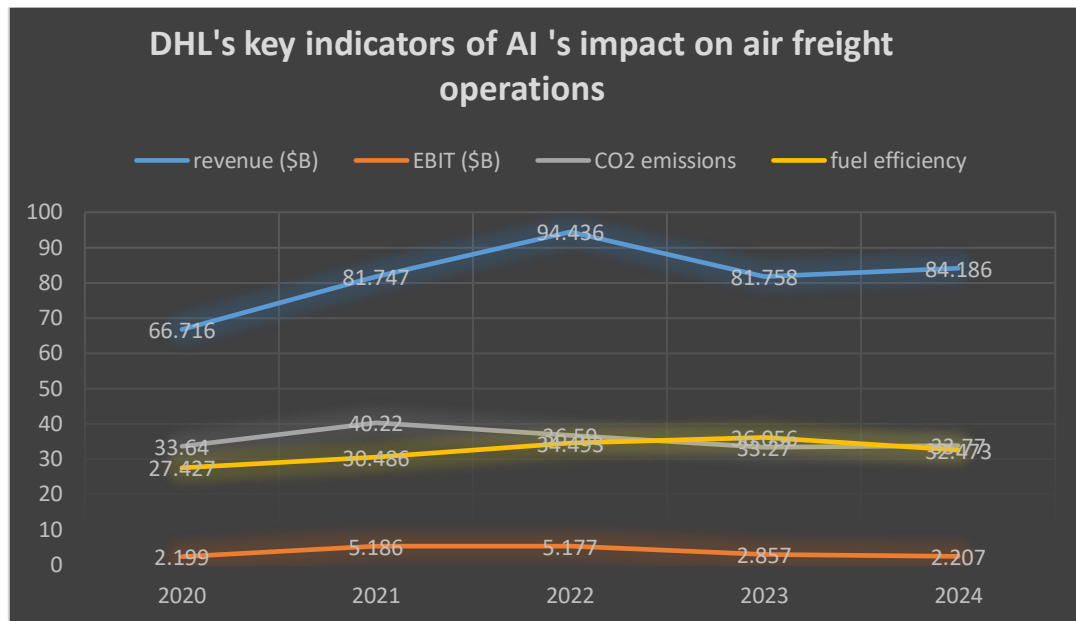


Figure (14): DHL's key indicators of AI's impact on air freight operations

Source: student's elaboration.

• **Analysis:**

The following analysis focuses on revenue, CO2 emissions, fuel efficiency and EBIT as key indicators of AI's impact on air freight operations between the years of 2020-2024:

- Revenue saw a sharp increase in 2021, reaching its peak, largely due to pandemic-related demand for air freight. However, it declined slightly by 2024 as the market stabilized.
- EBIT peaked sharply in 2021 due to increased demand during the pandemic. By 2024, EBIT declined as market conditions stabilized and air freight activity reduced.
- CO2 emissions remained high in the early years (2020-2022), reflecting increased air freight activity, but began to decline in 2023 and 2024, likely due to AI-powered route optimization and sustainable aviation fuel (SAF) usage.
- Fuel efficiency improved steadily over time. From 0,63 in 2020 down to 0,55 by 2024, showing that AI helped optimize fuel use and reduce emissions per ton-km.

DHL successfully balanced profitability with sustainability by integrating AI technologies, especially from 2022 onward.

3.3.2 **FedEx Express:**

After the adoption of AI, we can see that the company went through different financial and sustainability changes. We will address them in the following table:

Table (02): FedEx Financial and Sustainability Key Figures.

Source: student's elaboration based on FedEx annual reports 2020-2024

Indicator	2020	2021	2022	2023	2024
Revenue (B USD)	83,96	94,82	93,51	90,20	92,10

TOPIC 03**A Comparative Study of AI Innovations in DHL, FedEx, and UPS**

Operating Income (EBIT) (B USD)	4,42	6,85	4,72	4,46	4,60
Net Income (B USD)	1,29	5,23	3,83	3,61	3,70
Capex (B USD)	~ 5,1	~ 6,0	~ 6,8	~ 5,2	~ 5,0
FREE Cash Flow (B USD)	~ 1,9	~ 2,5	~ 2,3	~ 2,0	~ 2,2
CO2 Emissions (MMT)	17,4	17,1	16,7	16,3	15,9
Energy Use (GWh est.)	~30000	~30500	~31000	~30200	~29800
Fuel Efficiency (MPG)	1,48	1,55	1,61	1,65	1,7
Number of Employees	~600000	~650000	~570000	~530000	~500000

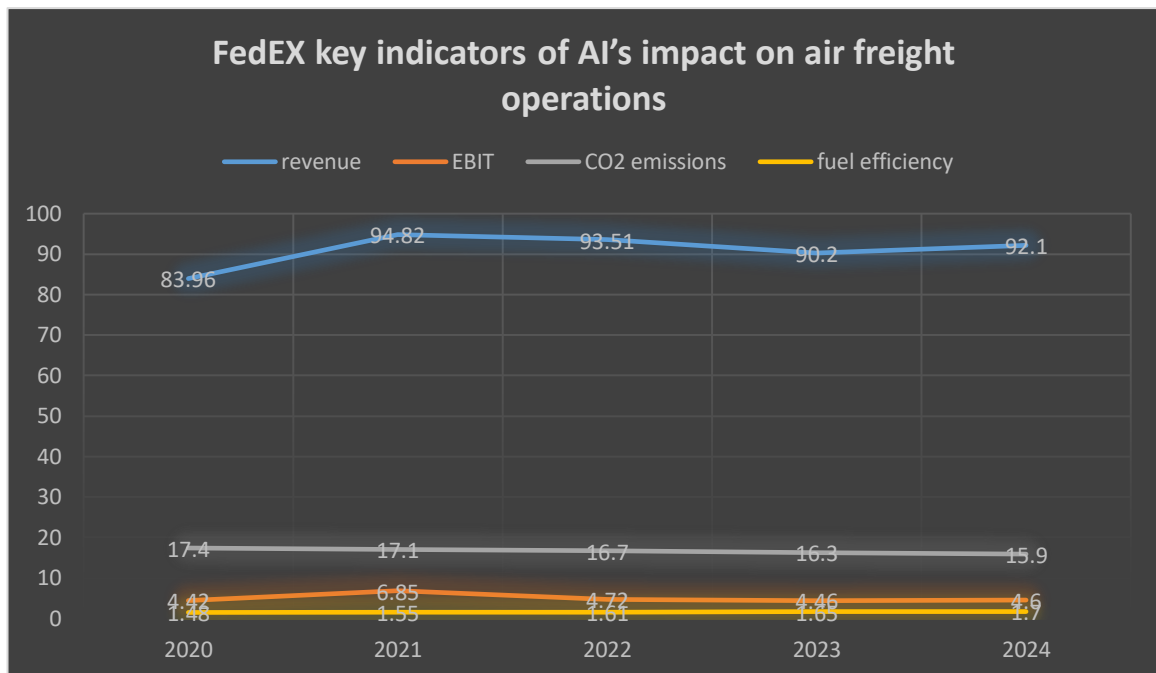


Figure (15): FedEx key indicators of AI's impact on air freight operations

Source: student's elaboration.

- **Analysis:**

The following analysis focuses on revenue, CO2 emissions, fuel efficiency and EBIT as key indicators of AI's impact on air freight operations between the years of 2020-2024:

- Revenue grew consistently, peaking in 2022 before dropping slightly in the following years. This trend reflects strong performance during the pandemic, with later adjustments in global freight demand.
- 2021 saw a notable rise in EBIT, driven by pandemic-related demand. In subsequent years, EBIT remained relatively stable, reflecting ongoing AI-driven efficiencies despite a market slowdown.

- CO2 emissions increased slightly at first but began to decline after 2022, likely due to AI tools like predictive analytics and robotic loading systems.
- Fuel efficiency also showed meaningful improvement, from 1,48 in 2020 to 1,7 in 2024, signaling enhanced energy efficiency in air operations.

FedEx adoption of AI in air freight improved both operational efficiency and environmental impact, particularly after 2022.

3.3.3 UPS:

After the adoption of AI, we can see that the company went through different financial and sustainability changes. We will address them in the following table:

Table (03): UPS Financial and Sustainability Key Figures.

Source: Student's Elaboration based on (UPS 2020 annual report), (UPS 2022 sustainability report) and (UPS 2024 SEC Filing)

Indicator	2020	2021	2022	2023	2024
Revenue (B USD)	84,63	97,29	100,30	91,00	92,50
Operating Income (EBIT) (B USD)	7,77	13,06	13,12	11,00	11,20
Net Income (B USD)	4,79	12,89	11,55	9,90	10,10
CapEx (B USD)	~ 5,6	~ 6,4	~ 6,2	~ 5,5	~ 5,8
FREE Cash Flow (B USD)	~ 4,0	~ 6,3	~ 5,2	~ 4,8	~ 5,0
CO2 Emissions (MMT)	14,6	14,4	14,1	13,7	13,4
Energy Use (GWh est.)	~ 28000	~ 28500	~ 29000	~ 28300	~ 28000
Fuel Efficiency (MPG)	1,42	1,50	1,58	1,62	1,68
Number of Employees	~ 540000	~ 543000	~ 500000	~ 480000	~ 470000

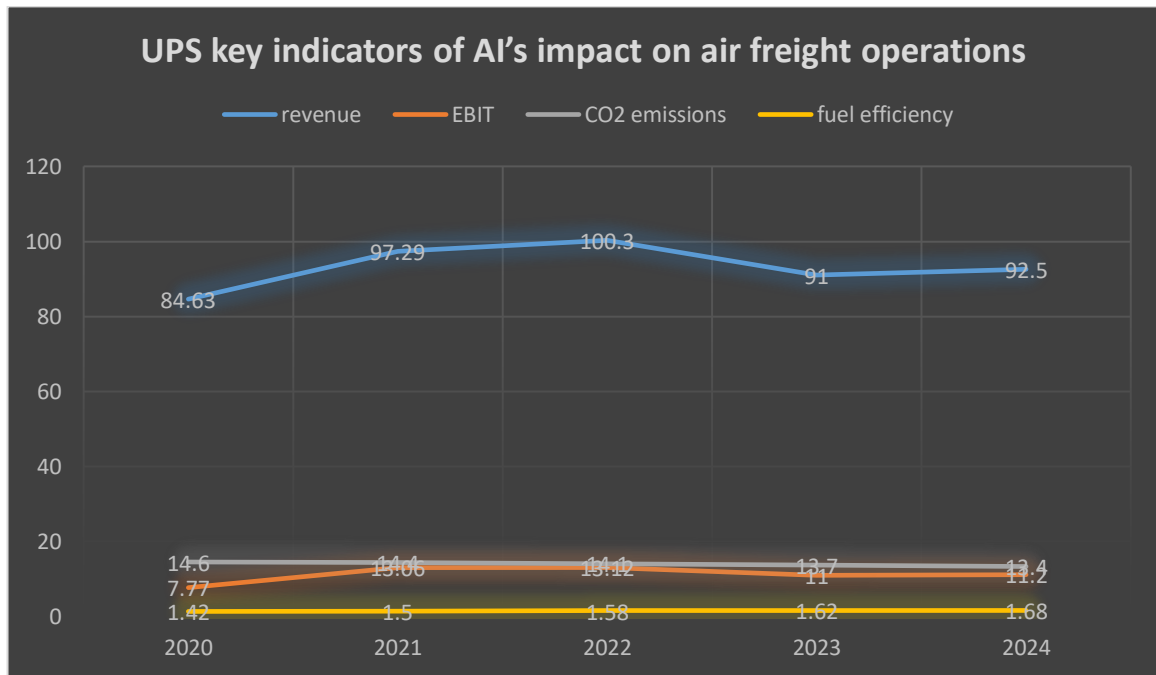


Figure (16): UPS key indicators of AI's impact on air freight operations.

Source: student's elaboration.

- **Analysis:**

The following analysis focuses on revenue, CO2 emissions, fuel efficiency and EBIT as key indicators of AI's impact on air freight operations between the years of 2020-2024:

- Revenue peaked in 2021 then declined slightly, following a trend similar to other logistics firms.
- EBIT surged in 2021 due to the pandemics impact, peaking at 13,12 billion. Afterwards, UPS saw a slight decline but maintained strong EBIT levels through 2024, supported by AI-driven operational efficiency.
- Emissions were relatively stable but began dropping in 2023 and 2024, showing the effects of AI in network capacity and sorting systems.
- Fuel efficiency improved from 1,42 to 1,68 across five years, reflecting better route management and vehicle utilization.

UPS's AI-driven logistics innovations helped reduce emissions while maintaining strong operational output, particularly in air freight efficiency.

Collectively, all three firms leveraged AI to navigate post-pandemic disruptions, streamline air freight operations, and move toward more sustainable and adaptive global logistics.

3.4 Points of Similarities:

3.4.1 Global Air Freight Network:

All three companies operate extensive and well-connected global air freight networks, enabling them to provide comprehensive international shipping services. These networks are supported by a fleet of cargo aircraft and partnerships with airlines, ensuring efficient delivery to virtually any destination worldwide.

3.4.2 Adoption of Advanced Technologies:

DHL, FedEx, and UPS utilize cutting-edge technologies, including AI, machine learning, and sensor-based logistics, to streamline their operations. These technologies enable predictive analytics, real-time shipment tracking, and proactive interventions, enhancing efficiency and improving the overall customer experience.

3.4.3 Commitment to Sustainability:

Each company demonstrates a strong commitment to green logistics by adopting measures to reduce their environmental footprint. This includes investing in energy-efficient aircraft, utilizing alternative fuels, and implementing sustainable practices throughout their supply chains to meet global sustainability goals.

3.4.4 Customer-Centric Services:

All three companies prioritize offering flexible and reliable services tailored to customer needs. This includes specialized solutions such as time-critical delivery, temperature-controlled transportation for sensitive goods, and value-added services like delivery scheduling and rerouting options.

3.4.5 Focus on Innovation:

DHL, FedEx, and UPS continuously invest in innovation to stay ahead of industry trends. This includes research and development in logistics technologies, the integration of automation in operations, and exploring new approaches to enhance air freight efficiency and reliability.

3.4.6 Extensive Market Presence:

Each company has established a significant footprint in key global markets, particularly in industries such as healthcare, e-commerce, and technology. Their broad market presence allows them to handle diverse customer requirements and adapt to evolving market demands effectively.

DHL, FedEx, and UPS share notable strengths, including expansive global air freight networks, the integration of advanced technologies, and strong commitments to sustainability initiatives. By leveraging these shared attributes, the companies can continue to drive innovation, enhance operational efficiency, and maintain their leadership positions in the highly competitive logistics sector.

3.5 Points of Differences:**3.5.1 Geographical Focus:**

- DHL has a stronger foothold in Europe and emerging markets, leveraging its extensive network and expertise in these regions.

- FedEx is heavily focused on North America, benefiting from its robust domestic network and strong market presence in the U.S.
- UPS also has a strong North American focus but places greater emphasis on balancing its operations across Europe, Asia, and other global markets.

3.5.2 Technological Emphasis:

- DHL prioritizes digitalization in its operations, using AI for shipment tracking, route optimization, and supply chain transparency.
- FedEx emphasizes sensor-based technologies, such as SenseAware ID, for precise, real-time shipment monitoring, especially for sensitive cargo.
- UPS is distinguished by its use of data analytics and AI-powered customer solutions, such as its chatbot integrated with UPS My Choice.

3.5.3 Sustainability Initiatives:

- DHL is deeply committed to green logistics and has implemented its 'GoGreen' program with ambitious carbon-neutral targets.
- FedEx focuses on fleet modernization and renewable energy solutions to reduce its carbon footprint.
- UPS combines green technologies with its 'Carbon Natural' program, which offers customers the option to offset emissions.

3.5.4 Market Positioning:

- DHL is recognized as a leader in international air freight, dominating cross-border markets.
- FedEx is a pioneer in time-sensitive deliveries and excels in high-value, critical shipments.
- UPS is known for its reliability in e-commerce logistics and last mile delivery services.

3.5.5 Service Specialization:

- DHL emphasizes flexibility with tailored solutions for diverse industries.
- FedEx focuses on premium services, such as temperature-controlled shipping for healthcare and aerospace.
- UPS stands out for its efficient network integration and cost-effective logistics solutions tailored to small and medium-sized business.

By leveraging their unique strengths, DHL, FedEx, and UPS have differentiated themselves in the air freight and logistics market. DHL excels in international operations and sustainability, FedEx stands out with advanced sensor-based technologies and time-sensitive solutions, and UPS thrives on customer-focused services and cost-efficient logistics. These differences highlight how each company addresses distinct market needs, creating specialized value propositions that cater to diverse industries and geographies. However, continued innovation and adaptation will be crucial for each to maintain their competitive edge in an evolving global market.

3.6 Conclusion:

In conclusion, this analysis of DHL, FedEx, and UPS has highlighted both their strengths and weaknesses, showing how each company uses its global networks and advanced technologies to maintain a competitive edge. While they share similarities in their focus on innovation and customer-centric services, their differences in strategy and specialized offerings set them apart in the air freight industry. Together, these insights provide a clearer understanding of how these leading companies navigate challenges, leverage opportunities, and contribute to shaping the future of air freight.

Summary of the Chapter:

In this chapter, we explored the development of three major logistics companies: DHL, FedEx, and UPS. And examined their integration of AI technologies into air freight operations. We concluded with a comparative analysis highlighting their strengths, weaknesses, and key outcomes of AI adoption.

Key results:

- DHL, FedEx, and UPS have strong global networks, with DHL having a wider international presence, FedEx excelling in express services, and UPS known for operational efficiency.
- Financially, AI adoption initially increased costs but later contributed to better operational margins and efficiency.
- Sustainability efforts were strengthened, particularly through improved fuel efficiency and lower CO2 emissions post-AI implementation.
- DHL showed faster progress in sustainability, while FedEx demonstrated stronger innovation in predictive analytics.
- UPS focused more operational optimization and steady AI integration.
- Despite their different strategies, all three companies share a common goal of leveraging AI to boost reliability, speed, and environmental performance on air freight.

General Conclusion

General Conclusion

Conclusion

In the theoretical part of this study, we delved into the foundational concepts and theoretical frameworks surrounding the integration of Artificial Intelligence (AI) in air freight. By exploring the motivation behind leveraging AI solutions in air freight operations, we have highlighted the significance of addressing operational inefficiencies, reliability risks, customer needs, and environmental impact to enhance global trade and connectivity. Through a comprehensive literature review and analysis of existing research, we have gained insights into the potential benefits and challenges associated with AI adoption in air freight and logistics.

Transitioning to the practical part, our focus shifted towards examining real-world implementations of AI solutions in three key leading companies: DHL, FedEx, and UPS. Through case studies and comparative analyses, we have evaluated the effectiveness of AI applications in optimizing logistics, improving reliability, customer satisfaction, and promoting sustainability within these companies. By drawing parallels and identifying best practices from leading companies, we have aimed to provide strategic recommendations for enhancing air freight operations on a global scale.

In conclusion, our study underscores the transformative potential of AI in revolutionizing air freight operations. By bridging theoretical insights with practical case studies, we contribute to advancing knowledge in air freight and logistics, ultimately aiming to foster more efficient, reliable, and sustainable air freight ecosystems worldwide.

Testing the Validity of Hypotheses

General Hypothesis

The general hypothesis of "the integration of AI in air freight operations significantly transforms the industry by driving exceptional improvements in reliability, customer service and sustainability." has been confirmed in this research. Furthermore, integrating AI in air freight operations yields significant improvements in reliability, customer service, and sustainability. In DHL, AI-driven route optimization has strengthened air freight reliability, by minimizing delivery delays and operational disruptions. FedEx has enhanced customer satisfaction and the quality of its services with AI-automated customer services (e.g.; FedEx surround), by enhancing communication and tracking solutions. UPS on the other hand, with AI-enabled optimization algorithms, has minimized energy consumptions and emissions, contributing to sustainability goals. These examples demonstrate the tangible benefits of AI integration in air freight operations.

Secondary Hypotheses

The first secondary hypothesis is AI-driven route optimization will strengthen the reliability of air freight by minimizing delays, operational disruptions, resulting in reduced delivery time. Our study confirms this hypothesis. To elaborate, DHL has implemented AI-driven route optimization in its air freight operations to strengthen its reliability and minimize delivery delays. By analyzing real-time data using machine learning algorithms and predicting any delivery changes. The company has been able to enhance reliability, leading to notable reduction in delivery times and minimized delays.

The second hypothesis is Customer service automation is one of AI-driven innovations that will enhance customer satisfaction and improve service quality by streamlining communication

General Conclusion

and order tracking. The findings of this research support this hypothesis. Further, FedEx surround have been deployed to enhance customer satisfaction and service quality by robusting its shipping and tracking solutions. Through real-time monitoring and analysis using advanced machine learning technologies such as Sense Aware ID that allow the company and its customers to make informed decisions and track shipments. The company has been able to improve its express services leading to significant improvement in its air freight services and customer satisfaction.

AI-enabled optimization algorithms will minimize energy consumptions and carbon emissions by optimizing resource allocation and routing within air freight operations is the third hypothesis. This hypothesis has been proved in this research. To elaborate, UPS has employed AI-enabled optimization algorithms to minimize fuel consumption and carbon emissions. By optimizing resource allocation and routing within airports. UPS has achieved notable reduction in energy consumption and emissions, contributing to its sustainability goals.

The fourth hypothesis is AI-driven innovations has enabled companies such as DHL, FedEx, and UPS to achieve significant advancements in operational reliability, customer service, and sustainability. Thereby, positioning them for sustained growth and enhanced competitiveness in the global market.

This research partially proves the hypothesis by emphasizing the importance of using modern technologies, specifically AI innovations to modernize air freight operations to meet the dynamic needs of global trade.

Findings

Accordingly, and in light of our study, we arrived to a set of results, which are as follows:

- The adoption of Artificial Intelligence (AI) in air freight has introduced transformative changes across logistics operations, reshaping traditional supply chain models.
- AI technologies such as predictive maintenance, automated sorting, intelligent scheduling, and real-time tracking have significantly improved operational efficiency and decision-making within the air cargo sector.
- the integration of AI has strengthened reliability by minimizing delays, improving cargo handling accuracy, and enabling proactive problem-solving for unforeseen disruptions.
- AI's role in enhancing customer satisfaction is evident through greater shipment visibility, faster delivery times, and more personalized service offerings tailored to customer needs.
- Sustainability goals in air freight have been further supported by AI applications that optimize flight routes, improve load planning, and reduce fuel consumption, thereby lowering emissions and environmental impact.
- Companies like DHL, FedEx, and UPS exemplify how AI integration has been effectively translated into real-world air freight operations, achieving measurable improvements across performance areas.
- DHL has leveraged AI for predictive analytics and dynamic routing, enabling improved reliability through better risk anticipation, maintenance scheduling, and route adjustments to avoid delays.
- FedEx has prioritized operational optimization through AI-driven automation, intelligent sorting, and chatbots, which collectively elevate service quality and responsiveness to customer demands.

General Conclusion

- UPS has leveraged AI through tools like ORION, automated sorting, and smart tracking to enhance sustainability by optimizing routes, reducing fuel consumption, minimizing emissions, and supporting more efficient, eco-friendly air freight operations.
- Across all three companies, AI has directly contributed to enhance reliability, improved customer satisfaction through high-quality service delivery, and strengthened sustainability practices, demonstrating its strategic value in modern air freight logistics.
- Despite its benefits, AI integration also presents challenges including high implementation costs, data management complexity, and the need for continuous technological updates to remain competitive.

As a final reflection, despite adopting diverse AI technologies and tailored strategies, DHL, FedEx, and UPS are unified by a shared commitment to leveraging AI as catalyst for continuous improvement, environmental responsibility, and maintaining competitive advantage in global air freight, all while enhancing reliability, delivering high-quality customer service, and achieving sustainability.

Recommendations

Based on the preceding findings and in order to implement key methods to facilitate transportation we propose the following recommendations:

DHL

- It is recommended to accelerate the integration of AI- powered predictive analytics to further optimize air cargo scheduling and reduce delays.
- It is proposed to expand AI applications in autonomous freight handling to improve operational efficiency at major air hubs.
- It is suggested to strengthen AI-driven sustainability initiatives by increasing investment in electric and alternative-fuel aircraft for air freight operations.

FedEx

- It is recommended to enhance the use of AI in real-time tracking systems to provide more transparent and reliable shipment visibility for customers.
- It is proposed to leverage AI and robotics for automated parcel sorting to increase throughput and reduce manual errors in air freight facilities.
- It is suggested to integrate AI solutions that support dynamic route optimization to lower fuel consumption and operational costs.

UPS

- It is recommended to expand AI adoption in predictive maintenance programs to improve aircraft reliability and minimize unplanned downtime.
- It is proposed to explore AI-driven drone delivery networks to complement traditional air freight services for time-sensitive shipments.
- It is suggested to invest in AI-based carbon tracking tools to monitor and report emissions reductions in line with sustainability targets.

Future research prospects

We suppose further exploration into the following research areas:

- ❖ Integration of AI and Blockchain for Secure Air Cargo Tracking Assessing the impact of carbon-neutral initiatives in global supply chains.
- ❖ Investigating the adoption of alternative fuels to reduce carbon emissions in shipping.

General Conclusion

- ❖ Assessing the role of blockchain and smart contracts in improving transparency and reducing paperwork in international shipping.
- ❖ Autonomous Drones for Last-Mile Air Cargo Delivery.

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Appendices

Appendix 01:

ملحق بالقرار رقم 10824... المؤرخ في 27 شهر 2020
الذي يحدد القواعد المتعلقة بالوقاية من السرقة العلمية ومكافحتها



الجمهورية الجزائرية الديمقراطية الشعبية وزارة التعليم العالي والبحث العلمي

مؤسسة التعليم العالي والبحث العلمي:

نموذج التصريح الشرفي
الخاص بالالتزام بقواعد النزاهة العلمية لإنجاز بحث

أنا الممضي أسفله،
السيد(ة): عامر لينة
الصفة: طالب، أستاذ، باحث طالبة
الحامل(ة) لبطاقة التعريف الوطنية رقم: 205903922. والصادرة بتاريخ: 24/06/2020
المسجل(ة) بكلية / معهد العلوم الاقتصادية والتجارية العلوم التجارية
والمكلف(ة) بإنجاز أعمال بحث (مذكرة التخرج، مذكرة ماستر، مذكرة ماجستير، أطروحة دكتوراه).
عنوانها: Exploring the Role of Artificial Intelligence in Enhancing Air Freight Efficiency. CASE STUDY: DHL EXPRESS, FedEx EXPRESS, UPS
أصرح بشرفي أنني ألتزم بمراعاة المعايير العلمية والمنهجية ومعايير الأخلاقيات المهنية والنزاهة الأكاديمية
المطلوبة في إنجاز البحث المذكور أعلاه .

التاريخ: 26/05/2025

توقيع المعني (ة)

Appendix 02:

الجمهورية الجزائرية الديمقراطية الشعبية
وزارة التعليم العالي والبحث العلمي

بسكرة في: 2025/05/26

جامعة محمد خيضر-بسكرة
كلية العلوم الاقتصادية والتجارية وعلوم التسيير
قسم العلوم التجارية

إِذْنٌ بِالْإِيْدَاعِ

أنا الممضي أسفله الأستاذ: بن عبيد فريد

الرتبة: أستاذ التعليم العالي

قسم الارتباط: قسم العلوم التجارية

أستاذ مشرف على مذكرة ماستر الطالبة: عامر لينة

الشعبة: العلوم التجارية

التخصص: مالية وتجارة دولية

بغـوان:

Exploring the Role of Artificial Intelligence in Enhancing Air Freight Efficiency

CASE STUDY: DHL EXPRESS, FedEx EXPRESS, UPS

أرخص بإيداع المذكرة المذكورة.

إمضاء الاستاذ المشرف