

**“A COMPARATIVE STUDY OF DANGEROUS CARGOES
TRANSPORTATION BY SEA AND AIR”**

PROJECT REPORT

Submitted in partial fulfillment of the requirements for the award of the Degree
of

MASTER OF BUSINESS ADMINISTRATION

(International Transportation and Logistics Management)

submitted by,

DIPIN EVUGIN

Registration No.: **2105305015**

Under the esteemed guidance of

Dr. Jayan P A

Assistant Professor, SMM



SCHOOL OF MARITIME MANAGEMENT

INDIAN MARITIME UNIVERSITY

KOCHI CAMPUS

APRIL 2023



INDIAN MARITIME UNIVERSITY
SCHOOL OF MARITIME MANAGEMENT
KOCHI CAMPUS

Dr. Jayan P A

Kochi

Assistant Professor

Date: 8/05/2023

School of Maritime Management

Indian Maritime University

Kochi Campus

CERTIFICATE

This is to certify that the MBA project report entitled “**A COMPARATIVE STUDY OF DANGEROUS CARGOES TRANSPORTATION BY SEA AND AIR**” is a bonafide record done by **Mr. DIPIN EVUGIN** and is submitted in fourth semester of MBA International Transportation and Logistics Management under my guidance. It is also certified that the above work has not previously formed the basis for the award of any degree, diploma associateship, fellowship or other similar titles, and it is an independent work done by the candidate.

Dr. Jayan P A

(Project Supervisor)

DECLARATION

I hereby declare that the project report titled “**A COMPARATIVE STUDY OF DANGEROUS CARGOES TRANSPORTATION BY SEA AND AIR**” is a bonafide record of work done under the guidance and the supervision of **DR JAYAN PA**, Assistant Professor, School of Maritime Management in Indian Maritime University, Kochi Campus.

This report neither in full nor in part has ever been submitted for award of any other Degree of either this university or any other university.



Place: COCHIN

DIPIN EVUGIN

Date: 08 / 05 / 2023

Reg. No.:2105305015

ACKNOWLEDGMENT

It gives immense pleasure to express my thanks to all those who helped for the successful completion of this project. First and foremost, I thank the **GOD ALMIGHTY** for his gracious guidance throughout the project work.

It has been a great privilege and honor to work under **PROF. DR. JAYAN P A**, School of Maritime Management, Indian Maritime University, Cochin for his timely advice and guidance which made me to complete my project work successfully.

My heartfelt gratitude towards **Dr. YOGAMALA H L**, Head of the department, School of Maritime Management, Cochin campus, for the moral support, valuable suggestions and guidance throughout my academics.

I also like to thank to all the faculties and staffs of Indian Maritime University for their active support to complete this project and to all the teachers and friends for their encouragement at various stages of this project period.

I express my deep sense of gratitude to my beloved Parents, whose support has enabled me to concentrate on my study and project work.

DIPIN EVUGIN

EXECUTIVE SUMMARY

The safe and secure transportation of hazardous goods is an essential aspect of global commerce, which involves several complex procedures to ensure the protection of people, property, and the environment. This project study aims to compare the transportation of dangerous cargo by sea and air.

The study involved a comprehensive review of literature on the two modes of transportation, including regulations, guidelines, and best practices.

The study found that both sea and air transportation of dangerous cargo have their advantages and disadvantages. Sea transportation is the most commonly used mode for the transportation of dangerous goods, as it is cost-effective and can accommodate large volumes of cargo. However, it is subject to weather conditions, piracy, and longer transit times. On the other hand, air transportation is faster and more secure, but it is more expensive and has limitations on the quantity and types of dangerous cargo that can be transported.

The study also revealed that the regulations and guidelines for the transportation of dangerous cargo vary significantly between sea and air transportation. The International Maritime Organization (IMO) and the International Air Transport Association (IATA) are responsible for regulating sea and air transportation, respectively. However, the regulations for sea transportation are more comprehensive, while those for air transportation are more specific and detailed.

In conclusion, the study highlights the importance of a comprehensive risk management approach for the transportation of dangerous cargo, regardless of the mode of transportation. The findings of this study can serve as a valuable reference for transportation and logistics professionals, policymakers, and researchers in the field.

GLOSSARY OF TERMS

- **DANGEROUS CARGOES:** Items or substances that have an inherent nature of posing a threat to people, property, or the environment.
- **ISO CONTAINERS** ISO containers are uniform and widely accepted shipping containers that are used to transport a variety of goods, including dangerous goods.
- **INTERNATIONAL MARITIME DANGEROUS GOODS (IMDG) CODE:** The International Maritime Dangerous Goods (IMDG) Code is a collection of rules that governs the transportation of hazardous materials by sea.
- **INTERNATIONAL CIVIL AVIATION ORGANIZATION (ICAO) TECHNICAL INSTRUCTION:** This refers to a set of rules and guidelines that regulate the transportation of dangerous goods by air. These regulations are known as the International Civil Aviation Organization (ICAO) Technical Instructions.
- **PACKAGING:** Packaging refers to the materials used to contain and protect dangerous goods during transportation. It is important to ensure that packaging is suitable for the specific type of dangerous goods being transported and is in compliance with relevant regulations.
- **LABELLING:** This refers to the process of labelling dangerous goods containers with specific information that helps identify the contents of the container, such as hazard warnings and handling instructions.
- **DOCUMENTATION:** This refers to the documentation that is necessary for the safe transportation of dangerous goods. This includes various forms such as manifests, shipping papers, and declarations that provide

information about the nature of the goods being transported, their quantity, and any associated hazards. This paperwork is essential for ensuring that the goods are transported safely and in compliance with regulations.

- **ENVIRONMENTEL IMPACT:** This refers to the impact that transportation has on the environment, including the release of greenhouse gases and other harmful substances. It encompasses the various ways that transportation can affect the environment, such as air pollution, water pollution, and habitat destruction.
- **ADHERENCE:** Ensuring that hazardous materials are transported safely by adhering to regulations and standards.
- **SUPPLY CHAIN MANAGEMENT:** Logistics refers to the process of planning and coordinating the transportation of goods, which can include hazardous materials. This involves managing the movement of goods from their point of origin to their destination, including activities such as transportation, warehousing, inventory management, and distribution. Logistics is critical in ensuring the safe and efficient transportation of hazardous materials, as it involves careful planning and coordination to comply with regulations and minimize risks.
- **STOWAGE AND SEGRIGATTION:** The proper arrangement and separation of dangerous goods based on their hazard classification and compatibility with other substances to prevent any adverse reactions or accidents during transportation.
- **TRAINING AND CERTIFICATION:** All personnel involved in the transportation of dangerous goods by sea must receive adequate training and certification according to the standards set in the IMDG Code.
- **VESSEL INSPECTION AND CERTIFICATION:** Ships transporting hazardous materials must undergo inspection and certification to ensure compliance with international regulations.

CONTENTS

CHAPTER NO.	TITLES	PAGE NO.
1.	INTRODUCTION 1.1 Introduction 1.2 Significance of the study. 1.3 Scope of the study. 1.4 Objectives of the study. 1.5 Research methodology. 1.6 Limitations of the study.	1-7 2 4 5 5 6 6
2.	REVIEW OF LITERATURE.	8-15
3.	TRANSPORATION OF DANGEROUS CARGOES BY SEA AND AIR. 3.1 Introduction 3.2 Importance of dangerous cargoes transportation by sea. 3.3 Importance of dangerous cargoes transportation by air. 3.4 How dangerous cargoes are transported by sea? 3.5 How dangerous cargoes are transported by air?	16-25 17 17 19 21 23
4.	DANGEROUS CARGOES TRANSPORTATION IN INDIA BY SEA AND AIR 4.1 Regulatory framework 4.2 Documentation and record-keeping 4.3 Future outlook	26- 32 27 29 30

5.	ADVANTAGES AND DISADVANTAGES	33-38
	5.1 Advantages of dangerous cargoes transportation by sea.	34
	5.2 Disadvantages of dangerous cargoes transportation by sea.	35
	5.3 Advantages of dangerous cargoes transportation by air.	36
	5.4 Disadvantages of dangerous cargoes transportation by air.	37
6.	REGULATIONS AND GUIDELINES	39-45
	6.1 Regulations and guidelines for dangerous cargoes transportation by sea.	40
	6.1.1 IMDG code	40
	6.1.2 Application of the IMDG code	40
	6.1.3 Different types/classes of dangerous cargoes	41
	6.1.4 Identifying dangerous cargoes	42
	6.2 Regulations and guidelines for dangerous cargoes transportation by air.	42
7.	SAFETY AND RISK FACTORS	46-50
	7.1 Risk factors for sea transportation	47
	7.2 Risk factors for air transportation	48
	7.3 Safety precautions for sea transportation	49
	7.4 Safety precautions for air transportation	49
8.	FINDINGS AND CONCLUSION	51-54
	8.1 Findings	52
	8.2 Conclusion	53
9.	BIBLIOGRAPHY	55-56

CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

Transportation of goods is a critical component of any economy, as it ensures the efficient movement of goods from one location to another. Dangerous goods, on the other hand, are substances or articles that pose a risk to people, property, or the environment due to their inherent nature. Special care and attention are crucial when it comes to transporting hazardous materials, as their mishandling can result in disastrous outcomes. In today's global economy, transportation of dangerous goods by sea and air has become a common practice, and it is important to understand the differences and similarities between these two modes of transportation.

The purpose of this project is to conduct a comparative study of dangerous goods transportation by sea and air. This project will examine the advantages and disadvantages of each mode of transportation in terms of safety, speed, cost, regulations, and environmental impact. The study will also explore the current trends and practices in the transportation of dangerous goods by sea and air, as well as the challenges faced by the industry.

The transportation of dangerous goods by sea is primarily carried out by container ships, which transport goods in standard ISO containers. The main advantage of sea transportation is its cost-effectiveness, as it is much cheaper compared to air transportation. However, sea transportation is also slower, and it can take several weeks to transport goods from one location to another. The risks associated with sea transportation of dangerous goods include the possibility of container damage or loss, piracy, and adverse weather conditions.

On the other hand, transportation of dangerous goods by air is primarily carried out by cargo planes, which transport goods in specialized containers or as bulk cargo. The main advantage of air transportation is its speed, as goods can be transported within a few hours or days. However, air transportation is also more

expensive compared to sea transportation, and it is subject to strict regulations due to the high risk associated with dangerous goods. The risks associated with air transportation of dangerous goods include the possibility of fire, explosion, and contamination.

The transportation of dangerous goods by sea and air is subject to a wide range of regulations, including the International Maritime Dangerous Goods (IMDG) Code and the International Civil Aviation Organization (ICAO) Technical Instructions. These regulations ensure the safe and secure transportation of dangerous goods by specifying the packaging, labelling, and documentation requirements.

In addition to the challenges and risks associated with the transportation of dangerous goods, there are also environmental concerns. Both sea and air transportation contribute to greenhouse gas emissions and other pollutants that can harm the environment. The environmental impact of transportation must be considered and minimized wherever possible.

One of the key factors that affect the transportation of dangerous goods is regulations. The transportation of dangerous goods by sea and air is subject to a complex set of international, national, and local regulations. These regulations are designed to ensure the safe and secure transportation of dangerous goods, and they specify the requirements for packaging, labelling, documentation, and handling of dangerous goods.

Another important factor to consider is the infrastructure and resources required for the transportation of dangerous goods. Both sea and air transportation require specialized infrastructure and equipment to ensure the safe and efficient transportation of dangerous goods. This includes specialized containers, handling equipment, and trained personnel. It is important to ensure that the necessary

resources are available and properly maintained to ensure the safe transportation of dangerous goods.

Finally, it is important to consider the economic impact of the transportation of dangerous goods. Both sea and air transportation of dangerous goods contribute significantly to the global economy, but they also have associated costs. These costs include the cost of transportation, packaging, handling, and compliance with regulations. It is important to weigh the costs and benefits of each mode of transportation to ensure that the most cost-effective and efficient method is chosen.

In conclusion, the transportation of dangerous goods by sea and air is a complex and critical aspect of modern logistics. This project will provide a comparative study of the advantages and disadvantages of these two modes of transportation in terms of safety, speed, cost, regulations, and environmental impact. The findings of this study will be useful for logistics managers, policymakers, and other stakeholders involved in the transportation of dangerous goods. It is important to ensure that the transportation of dangerous goods is carried out safely, efficiently, and in compliance with regulations to minimize risks and ensure the continued growth of the global economy.

1.2 SIGNIFICANCE OF THE STUDY

A comparative study of transporting hazardous goods by sea and air is crucial in ensuring their secure and safe movement as they are an essential part of international trade. This study offers valuable insights into the potential risks and challenges associated with each mode of transportation and highlights their respective advantages and drawbacks. It can help identify the strengths and weaknesses of each mode concerning safety, environmental impact, economic implications, and regulatory compliance, which can inform more effective

transportation policies and practices. Ultimately, the study's findings can contribute to safer and more sustainable global trade.

1.3 SCOPE OF THE STUDY

A comparative study of dangerous goods transportation by sea and air has a broad scope, encompassing several areas of investigation. The study examines the different types of dangerous goods and compare their transportation by sea and air. Additionally, it would analyze the regulatory frameworks that govern the transportation of dangerous goods by both modes. The safety and security risks associated with transporting dangerous goods would also be a critical area of focus, as would be the modes of transportation used for the shipment of such goods. Cost and efficiency would be essential factors to consider in the study, including the environmental impact of transportation on air and water quality, marine life, and climate change. Ultimately, the study would provide stakeholders with valuable insights into the advantages and disadvantages of transporting dangerous goods by sea and air and would enable them to make informed decisions regarding their transportation needs.

1.4 OBJECTIVES OF THE STUDY

Following are the objectives of the study;

1. The transportation of dangerous goods by sea and air.
2. Advantages and disadvantages.
3. The regulations and guidelines that govern the transportation of dangerous goods by sea and air, and compare the requirements of these two modes of transport.

4. Evaluate the safety and risk factors associated with the transportation of dangerous goods by sea and air.

1.5 RESEARCH METHODOLOGY.

Research Methodology provides various techniques that can be adopted by the researcher in his/her research process. It is a way to systematically solve a research problem. This study is conducted by using primary and secondary data.

1.6 LIMITATIONS OF THE STUDY

Following are the limitations of the study;

- Availability and accuracy of data: The availability and accuracy of data related to dangerous goods transportation by sea and air may vary depending on the sources and databases used. Data on incidents, accidents, or safety records may not be consistently reported or may have inconsistencies, which could affect the accuracy and reliability of the study's findings.
- Sample size and representativeness: The sample size of the study, including the number of cases or incidents analysed, may impact the generalizability of the findings. If the sample size is small or not representative of the overall population of dangerous goods transportation by sea and air, the study's conclusions may not be applicable to broader contexts or populations.
- Context-specific factors: Dangerous goods transportation by sea and air may be influenced by various context-specific factors, such as regional regulations, industry practices, and operational procedures. These factors

may differ across countries, regions, or transport modes, and may affect the study's findings and comparability of results.

- Ethical considerations: The study may involve ethical considerations related to the use of data, protection of privacy, and potential harm to individuals or organizations. Ensuring the ethical conduct of research, including obtaining appropriate permissions and adhering to ethical guidelines, is crucial to the validity and integrity of the study.

CHAPTER 2

REVIEW OF LITERATURE

1. Risk assessment of hazardous materials transportation: A review of research progress in the last thirty years.

Jian Guo

Cheng Luo

In recent years, hazardous materials transportation accidents occur frequently, causing huge casualties and property losses. Risk assessment of hazardous materials transportation has been constantly investigated by researchers and decision-makers. In order to study the research progress of risk assessment of hazardous materials transportation, so as to better reveal relevant problems. This review systematically analyzes the existing literature, from 1991 to 2020, on risk assessment models and methods of hazardous materials transportation, and segregates the relevant studies based on unimodal and intermodal transportation systems. Additionally, an example is considered to analyze the characteristics of each risk assessment model of unimodal transportation, and a novel detailed classification is proposed for the risk assessment problems. The results indicate that the research on the risk assessment model of road transportation of hazardous materials is comprehensive, whereas that based on the railway and intermodal transportations is deficient. In comparison with the traditional risk assessment model, the conditional value-at-risk model presents a flexible decision-making framework for decision-makers and controls risk preference between risk neutrality and risk aversion. Owing to the difficulty in achieving door-to-door railway transportation and the increased risks associated with the intermodal transportation, the conclusion that the risk of railway and multimodal transportation of hazardous materials is lower than that of road transportation is not universal. Transport operators and governments can combine the advantages of different transportation modes, such as low risk, low cost, high flexibility, and high reliability, to achieve public safety and improve the competence of the system. Based on the proposed classification, this review identifies the existing trends and research gaps and summarizes future research directions.

2. Hazardous materials transportation with focusing on intermodal transportation: a state-of-the-art review.

International Journal of Industrial Engineering. 2021, Vol. 28 Issue 4, p390-411. 22p.

Author(s): Fattahi, Zahra; Behnamian, Javad

Transportation of hazardous materials (hazmat) is one of the most critical issues in transportation planning that involves multiple risks to the physical and social environments. Any improvements in it reduce not only environmental costs but also reduces external transport costs (e.g., reduces the risk of accidents which, in addition to environmental impact, also affects external costs). Besides, multi-modal transportation as a main part of transportation uses multiple modes (e.g., rail, ship, truck, air) to transport freight. If the containers carry hazmat, the government regulates their transportation due to the associated risks. Many researchers have studied the risk assessment of hazmat transportation to find ways for reducing hazardous material transportation risks. In this regard, the intermodal models and unimodal problems for hazmat transportation were studied by some researchers. In this study, after pointing out the importance of hazmat intermodal transportation and risks, the research related to hazmat intermodal transportation, including routing and scheduling, intermodal transportation, and location-routing problems. Then the reviewed literature is quantified and measured. Finally, the paper concludes by presenting some problems receiving less attention than the others and proposes several research opportunities in the field.

3. A comparative study of hazardous material transportation security issues in Flanders and in Apulia

Luca Zamparini

Genserik Reniers

This article investigates security practices within hazmat production and transport companies in two European regions, Apulia in Italy and Flanders in Belgium. A literature review was carried out to highlight the main theoretical hazmat transport security approaches. This led to develop some hypotheses on theoretical ‘ideal’ security practices in hazmat transport operations. To compare the theoretical insights regarding security approaches within dangerous goods transportation with real industrial practices, and to validate the hypotheses, a questionnaire was drafted. Survey results allowed to ascertain a partial implementation of ideal practices by the firms and provided insights in the existing similarities and differences between the two heterogeneous European regions. The study results led to conclusions and recommendations for European policymakers and for practitioners, in order to enhance current security habits with respect to hazmat transportation.

4. Improving the Safety of Transportation of Dangerous Goods: An Experimental Study.

M. M. Elshafey

E. Contestabile

O. B. Isgor

The transportation of dangerous goods (DG) represents an important portion of the overall freight transport worldwide. Ground transport (excluding pipelines) moves approximately 21% to 31% of the total tonnage of DG in Canada. Accidents involving DG might occur at any time at any location along transport routes or within storage areas, and not only do they have an effect on people and

the environment, but also, they can have a great effect on the national economy. This paper presents the details of an experimental investigation studying the blast attenuation capability of suppressive shield panels (SSPs). Suppressive shield technology can be used for the storage, processing, and transport of explosive materials and can also be applied to protecting attractive targets and infrastructure deemed vulnerable to explosive attacks. Various configurations of commercially available steel angles were assembled as SSPs and evaluated for their ability to attenuate blast pressure from detonating Pentolite charges. Results obtained from the tests with 0.5-kg charges indicated that the SSPs attenuate the blast pressure to values in the range of 43% to 60%. The results of this research can be extended to include the design and construction of SSPs for transportation of DG by sea as well. Effectively, this can include the strengthening of current standard containers.

5. A simulation study for hazardous materials transportation risk assessment.

Madala, Bhanu Prakash Rao (2000)

A simulation study for hazardous materials transportation risk assessment. Masters thesis, Concordia University.

All the areas in Canada are subjected to risk by hazardous-materials shipments. Some of these shipments take place locally or regionally, but a large number of them involve inter-provincial movements across significant distances, and this introduces further complications. According to a 1997 report of Transport Canada, roughly 56% of the total hazardous materials are transported by road annually from one state to another in Canada. Additionally, hazardous materials are transported via all major freight modes such as rail, marine and air. There are several distinct interest groups essentially seeking the same goal--a reduction in the adverse effects of commercial transportation operation on the community. With this consensus position that transportation hazard analysis and incident

management are important components of contemporary transportation operations and regulation, there is a need to develop methods and systems that can be used to assist decision makers in addressing these considerations. This research describes a methodology and system development that can be applied to this task. This research presents a methodology for assessment of the hazardous material transport risk in a single commodity, multiple origin-destination setting. The province of Ontario is chosen as the study area and major cities are identified as points of origin and destination. Highway network in this area is the basis for identifying paths (routes) between origin-destination (cities) using different criteria such as distance, risk, etc. Gasoline shipments is chosen for the study. We developed a simulation model in Visual Basic to assess the risk imposed on certain cities through which hazmats (Hazardous Materials) are being transported which also illustrates the number of people to be evacuated in case of an incident. The purpose of this research is to get a clearer understanding of hazardous materials transportation and describe a community's/region's hazardous materials transportation risk problem. The model developed also assists decision makers to develop the right policies to reduce the risk posed due to the shipment of hazardous materials to life and environment.

6. Integrated Environmental Risk Assessment of Major Accidents in the Transport of Hazardous Substances.

Ales Bernatik

David Rehak

Valerio Cozzani

Jarmil Valasek

Frantisek Paulus

At present, the environmental risk assessment of major accidents is mainly carried out for stationary risk sources. Only marginal attention is paid to mobile risk sources, while the currently available methodologies require a relevant expertise and time for their application, which is only partially possible in most scenarios. In the present study, an integrated approach to environmental risk assessment in the transport of hazardous substances (iTRANSRISK) was developed. The approach proposed is based on the principle of index-based assessment of leakage scenarios involving toxic and flammable substances during transport, in the context of indexing environmental vulnerability. The key point of the method is the conversion of local-specific data concerning the risk potential of the transported substance, the consequences and the probability of a major accident, and environmental vulnerability assessment into a single entity. The created integral approach is proposed for the needs of carriers of the hazardous substances and the state administration bodies. The proposed approach is determined for the screening risk assessment at the beginning of the process of the planning a suitable transport routes and the results are for information only. An example of the application of the iTRANSRISK integrated approach is demonstrated considering an explosion scenario following a propane tanker leak (18 t) in a forested area, with moderately susceptible soils and no surface water or groundwater affected.

7. Dangerous Goods Transportation and Risk Management: A Cost-Benefit Analysis Approach.

Mohamed Tkiouat

Cost-Benefit Analysis (CBA) is a decision-support tool which can help in discussions with stakeholders. It provides a structured framework for representing and weighting all the elements of a decision, thereby improving the transparency of the decision-making process. The tool is widely used in many countries for assessing environmental regulation, industrial safety and risk reduction in terrorist actions. This chapter aims to provide guidance for the conduct of a Cost-Benefit Analysis related to Dangerous Goods Transportation (DGT) and the development of regulations in the area of industrial safety and security. It also aims to improve understanding of the underlying economic principles and assess the quality of the analysis of a DGT project. It presents an overview of the economic principles on which a CBA of Dangerous Goods Transportation is based, and describes the steps involved in conducting a study. It suggests data sources which may help to monetize the various nonmarket consequences of industrial activity (impact on people's health, safety and security, environmental pollution, noise pollution). This chapter formed the foundation for the NATO Advanced Training Course 'Risk Prevention for Environment and Human Society against Dangerous Goods Transport Accidents and Malicious Intent: Methods and Tools' held in Paris, France, 5th–9th July 2010.

CHAPTER 3

TRANSPORATION OF DANGEROUS CARGOES BY SEA

AND AIR

3.1 INTRODUCTION

Dangerous goods are substances or articles that have the potential to cause harm to people, property, or the environment when transported. These goods are categorized based on their properties, such as their flammability, toxicity, radioactivity, or corrosivity, and are subject to strict regulations and controls during transportation.

3.2 IMPORTANCE OF DANGEROUS CARGOES TRANSPORTATION BY SEA.

The transportation of dangerous goods by sea is important for several reasons:

- GLOBAL TRADE AND COMMERCE:

Dangerous goods are essential for the production and distribution of many products and materials that are vital to the global economy and society, such as chemicals, fuels, and pharmaceuticals. Shipping is an efficient and cost-effective mode of transportation for large quantities of these goods, especially for long distances or across international borders.

- ACCESSIBILITY:

Shipping is one of the most accessible modes of transportation, as it allows for the transportation of goods to and from locations that may be difficult or impossible to reach by other modes of transportation, such as remote or island areas.

- INFRASTRUCTURE AND EMPLOYMENT:

The transportation of dangerous goods by sea supports the development and maintenance of port infrastructure and the creation of employment opportunities for port workers, crew members, and related industries.

- RESOURCE EFFICIENCY:

Shipping is one of the most energy-efficient modes of transportation, as it can transport large quantities of goods using relatively small amounts of fuel. This can reduce the carbon footprint and environmental impact of transportation, especially when compared to other modes such as road or air transport.



FIG: Dangerous goods transportation by sea.

3.3 IMPORTANCE OF DANGEROUS CARGOES TRANSPORTATION BY AIR.

Following are some points highlighting the importance of dangerous goods transportation by air:

- SPEED AND EFFICIENCY:

Air transportation is the fastest mode of transportation for goods, and it is crucial for time-sensitive and high-value shipments that require rapid and efficient delivery. Dangerous goods that need to be transported urgently, such as medical supplies or perishable goods, can benefit from air transportation.

- ACCESS TO REMOTE AREAS:

Air transportation provides access to remote or isolated areas that may not be easily accessible by other modes of transportation. This is particularly important for emergency or disaster relief efforts, where dangerous goods, such as medical supplies or food, need to be delivered quickly and efficiently.

- GLOBAL TRADE AND COMMERCE:

Air transportation is an essential mode of transportation for global trade and commerce. Many dangerous goods, such as electronic equipment or hazardous chemicals, are essential for daily activities and economic growth, and their safe and efficient transportation by air is crucial for global supply chains.

- FLEXIBILITY:

Air transportation offers flexibility in terms of delivery times and routes, which can be customized to the specific needs of customers. Hazardous goods, such as explosives or radioactive materials, which need specialized handling or storage, can be transported through dedicated cargo planes that are specifically designed to fulfill their distinct needs.

- SAFETY AND SECURITY:

Air transportation of dangerous goods is subject to strict regulations and safety standards, which are designed to ensure the safe and secure transportation of goods. This includes regulations around packaging, labeling, and handling of dangerous goods, as well as security measures to prevent theft or tampering.



FIG: Dangerous goods are transported by air

3.4 HOW DANGEROUS CARGOES ARE TRANSPORTED BY SEA?

Dangerous goods are transported by sea in accordance with international regulations that aim to ensure their safe and secure transport. These regulations require that dangerous goods are classified, labeled, packaged, and handled in a specific way to minimize the risks associated with their transportation.

The process for transporting dangerous goods by sea typically involves the following steps:

- **CLASSIFICATION:**

Dangerous goods are classified according to their properties, such as their flammability, toxicity, and reactivity. This classification determines how the goods should be packaged, labeled, and handled during transport.

- **PACKAGING:**

Dangerous goods must be packaged in a specific way to ensure their safe transport. The packaging must be designed to withstand the conditions of transport, including handling, vibration, and temperature changes. The packaging must also be labeled with the proper hazard warning labels and markings.

- **DOCUMENTATION:**

The transport of dangerous goods by sea requires specific documentation, including a dangerous goods declaration that provides information about the nature of the goods, their classification, and the packaging used. This documentation must accompany the goods throughout the transport process.

- HANDLING AND LOADING:

Dangerous goods must be handled and loaded onto the vessel in a specific way to ensure their safety and security. The handling and loading must comply with the requirements of the International Maritime Dangerous Goods (IMDG) Code, which provides guidance on the handling and stowage of dangerous goods.

- TRANSPORTATION:

During transport, dangerous goods must be monitored to ensure their safe transport. The vessel's crew must be trained in the handling and transportation of dangerous goods, and emergency response procedures must be in place in case of an incident.

- DISCHARGE AND DISPOSAL:

When the dangerous goods reach their destination, they must be discharged and disposed of in accordance with local regulations.

Overall, the transportation of dangerous goods by sea involves a complex process that requires careful planning, management, and execution to ensure the safe and secure transport of these goods.

3.5 HOW DANGEROUS CARGOES ARE TRANSPORTED BY AIR?

The transportation of dangerous goods by air follows strict regulations and procedures to ensure the safe handling, packaging, labeling, and transportation of hazardous materials. Here is an overview of how dangerous goods are transported by air:

- **CLASSIFICATION AND PACKAGING:**

Dangerous goods are classified according to their properties, such as flammability, toxicity, or radioactivity, and are assigned to specific hazard classes. They must be packaged in UN-approved packaging that meets the requirements of the International Civil Aviation Organization (ICAO) Technical Instructions and other applicable regulations. The packaging must be designed to prevent leaks, spills, or other hazards during transportation.

- **DOCUMENTATION AND LABELING:**

Dangerous goods shipments must be accompanied by proper documentation, including a Shipper's Declaration for Dangerous Goods, which provides information about the type, quantity, and hazards of the goods being transported. Packages containing dangerous goods must be labeled with appropriate hazard labels, such as flammable, corrosive, or radioactive labels, to indicate the nature of the hazards.

- **HANDLING AND LOADING:**

Dangerous goods must be handled and loaded in accordance with established procedures and guidelines. This includes training and certification of personnel involved in the handling and loading of dangerous goods, as well as using equipment and tools that are designed for safe handling of hazardous materials.

- SECURITY MEASURES:

Air transportation of dangerous goods is subject to strict security measures to prevent theft, tampering, or unauthorized access. Cargo screening, access control, and monitoring are some of the measures taken to guarantee the safety and security of hazardous materials during their transportation process.

- EMERGENCY RESPONSE PLANNING:

To effectively manage incidents or accidents involving hazardous materials, airlines and air cargo operators must have well-prepared emergency response plans in place. This involves providing adequate training to their staff on emergency response procedures, equipping themselves with appropriate tools and resources to contain and mitigate hazards, and collaborating with local authorities and emergency services for effective coordination.

- COMPLIANCE WITH REGULATIONS:

Transportation of dangerous goods by air must comply with international and national regulations, such as the ICAO Technical Instructions, the International Air Transport Association (IATA) Dangerous Goods Regulations, and local aviation and transportation regulations. Accordance with these regulations is essential to ensure the safe transportation of dangerous goods by air.

Therefore, the air transportation of hazardous materials necessitates following regulations strictly, appropriate classification and packaging, documentation and labelling, secure handling and loading, security measures, emergency response planning, and conformity with regulations to guarantee the secure and safe transportation of dangerous goods.



CHAPTER 4

DANGEROUS CARGOES TRANSPORTATION IN INDIA BY SEA AND AIR

The transportation of dangerous goods in India by sea and air is governed by strict regulations and guidelines to ensure safe and secure movement. The IMDG Code and IATA DGR classify dangerous goods into different classes, each with their own packaging, labeling, and marking requirements. Shippers must provide a Dangerous Goods Declaration or Shipper's Declaration for Dangerous Goods to provide information about the contents and hazards of the shipment. Compliance with these regulations helps prevent accidents and protect human health, safety, and the environment.

4.1 REGULATORY FRAMEWORK

The transportation of dangerous goods by sea and air in India is subject to various international and domestic regulations and guidelines. These regulations are designed to ensure that the transportation of dangerous goods is carried out safely and securely, while minimizing the risks to people, property, and the environment. Some of the key regulatory frameworks that apply to the transportation of dangerous goods by sea and air in India include:

- INTERNATIONAL MARITIME DANGEROUS GOODS (IMDG) CODE:

The IMDG Code is a set of guidelines established by the International Maritime Organization (IMO) for the safe transportation of dangerous goods by sea. The code provides detailed instructions on the packaging, labeling, and handling of dangerous goods, as well as emergency response procedures in the event of an incident.

- INTERNATIONAL AIR TRANSPORT ASSOCIATION (IATA) DANGEROUS GOODS REGULATIONS:

The IATA Dangerous Goods Regulations are a set of guidelines established by the International Air Transport Association (IATA) for the safe transportation of dangerous goods by air. The regulations provide detailed instructions on the packaging, labeling, and handling of dangerous goods, as well as emergency response procedures in the event of an incident.

- INDIAN DANGEROUS GOODS REGULATIONS:

The Indian Dangerous Goods Regulations are a set of guidelines established by the Directorate General of Civil Aviation (DGCA) and the Directorate General of Shipping (DGS) for the safe transportation of dangerous goods by air and sea in India. These regulations are based on the international guidelines established by the IMDG Code and the IATA Dangerous Goods Regulations.

- HAZARDOUS WASTE MANAGEMENT RULES:

The Hazardous Waste Management Rules are a set of guidelines established by the Ministry of Environment, Forest and Climate Change for the safe handling and transportation of hazardous waste in India. These rules apply to all hazardous waste generated in India, including waste that is transported by sea and air.

- CUSTOMS ACT AND REGULATIONS:

The Customs Act and Regulations are a set of guidelines established by the Central Board of Indirect Taxes and Customs (CBIC) for the safe and secure movement of goods across international borders. These regulations include guidelines on the import and export of dangerous goods, as well as penalties and fines for non-compliance.

Overall, the regulatory framework for the transportation of dangerous goods by sea and air in India is complex and multifaceted, involving various international and domestic regulations and guidelines. It is important for stakeholders to understand and comply with all applicable regulations to ensure the safe and secure transportation of dangerous goods in India.

4.2 DOCUMENTATION AND RECORD-KEEPING

Documentation and record-keeping are critical aspects of the transportation of dangerous goods in India. The specific documentation requirements for the transportation of dangerous goods may vary depending on the mode of transport (sea or air), the nature of the goods being transported, and the regulatory framework that applies to the shipment. Following are the specific documentation requirements for the transportation of dangerous goods in India:

- **SHIPPING PAPERS:**

Shipping papers are a key document required for the transportation of dangerous goods by sea and air in India. They include details such as the name of the dangerous goods, the quantity being transported, the UN number, the packaging type, and the emergency contact details. Shipping papers must be accurate and complete, and they must be kept with the shipment at all times.

- **MANIFESTS:**

Manifests are a document required for the transportation of dangerous goods by sea in India. They include details such as the name of the vessel, the port of loading and unloading, and the details of the dangerous goods being transported. Manifests must be accurate and complete, and they must be submitted to the relevant authorities before the vessel departs.

- DANGEROUS GOODS DECLARATIONS:

Dangerous Goods Declarations are a document required for the transportation of dangerous goods by air in India. They include details such as the name of the dangerous goods, the UN number, the quantity being transported, the packaging type, and the emergency contact details. Dangerous Goods Declarations must be accurate and complete, and they must be kept with the shipment at all times.

- OTHER RECORDS:

Other records that may be required for the transportation of dangerous goods in India include certificates of training, safety data sheets (SDS), and packing lists. These records must be accurate and complete, and they must be kept on file for a specified period of time.

4.3 FUTURE OUTLOOK

The transportation of dangerous goods in India faces several challenges and opportunities in the future. These challenges and opportunities are influenced by emerging technologies and evolving regulations, as well as by economic, social, and environmental factors. Here are some potential challenges and opportunities:

- EMERGING TECHNOLOGIES:

The use of emerging technologies such as automation, robotics, and artificial intelligence (AI) can potentially improve the safety and efficiency of the transportation of dangerous goods in India. For example, drones could be used to transport small quantities of dangerous goods to remote areas or disaster zones. However, the adoption of these technologies will require significant investments in infrastructure and training, as well as regulatory approval.

- EVOLVING REGULATIONS:

The regulatory framework for the transportation of dangerous goods in India is constantly evolving. New regulations and guidelines are being introduced to improve safety and environmental protection. For example, the International Maritime Organization (IMO) is currently developing new regulations for the transportation of hazardous and noxious substances (HNS) by sea. It is important for stakeholders to stay abreast of these regulatory changes and to ensure compliance.

- CAPACITY CONSTRAINTS:

The transportation of dangerous goods in India faces capacity constraints due to limited infrastructure and resources. This can lead to delays, congestion, and higher costs. Addressing these capacity constraints will require investments in infrastructure and technology, as well as improved coordination and collaboration among stakeholders.

- ENVIRONMENTAL CONCERNS:

The transportation of dangerous goods in India can have significant environmental impacts, particularly in the event of accidents or incidents. There is a growing awareness of the need to address these environmental concerns through improved regulations, technology, and best practices. Stakeholders can take advantage of this growing awareness to develop more sustainable and environmentally responsible transportation practices.

In summary, the transportation of dangerous goods in India faces several challenges and opportunities in the future. Emerging technologies and evolving regulations offer opportunities for improved safety and efficiency, while capacity constraints and environmental concerns pose challenges that must be addressed.

By working together, stakeholders can develop solutions that promote safe, efficient, and sustainable transportation of dangerous goods in India.

CHAPTER 5

ADVANTAGES AND DISADVANTAGES

5.1 ADVANTAGES OF DANGEROUS CARGOES TRANSPORTATION BY SEA.

Transportation of dangerous goods by sea has several advantages, including:

- COST-EFFECTIVENESS:

Transportation of dangerous goods by sea is more economical compared to other modes of transport, particularly for large quantities of hazardous materials. The large cargo capacity of ships results in economies of scale, which can reduce the transportation cost per unit.

- SAFETY:

Shipping by sea is considered safer than other modes of transportation, with fewer accidents and lower chances of theft or hijacking. Ships are also equipped with safety features such as fire suppression systems and emergency response equipment.

- ACCESSIBILITY:

Shipping by sea provides access to a wider range of ports, including remote or underdeveloped regions, which can be advantageous for transporting hazardous materials.

- ENVIRONMENTAL BENEFITS:

Sea transportation has a lower carbon footprint than other modes of transportation, particularly over long distances. Ships consume less fuel than other modes of transportation, reducing their environmental impact.

- REGULATORY COMPLIANCE:

The international regulations and guidelines, such as the International Maritime Dangerous Goods Code (IMDG Code), ensure that the handling and

transportation of dangerous goods by sea comply with safety standards and regulations.

5.2 DISADVANTAGES OF DANGEROUS CARGOES TRANSPORTATION BY SEA.

Transporting dangerous goods by sea also has some disadvantages, including:

- LONGER TRANSIT TIMES:

Sea transportation may not be suitable for transporting hazardous materials that require timely delivery, as it can be slower compared to other modes of transportation.

- WEATHER-RELATED RISKS:

Adverse weather conditions can impact sea transportation, leading to delayed shipments and potential safety hazards.

- LIMITED SHIPPING ROUTES:

Shipping by sea may not be possible for certain locations due to limited shipping routes, size restrictions, or shallow waters.

- DEPENDENCY ON PORT INFRASTRUCTURE:

Shipping by sea depends on the availability and condition of port infrastructure, which may not always be well-equipped to handle dangerous goods.

- PACKAGING REQUIREMENTS:

Hazardous materials transported by sea must be packaged and labeled in accordance with international regulations, which may increase transportation costs and complexity.

5.3 ADVANTAGES OF DANGEROUS CARGOES TRANSPORTATION BY AIR.

Following are the advantages of dangerous goods transportation by air;

- SPEED:

Due to its high speed, air transportation is a preferred mode for time-sensitive shipments, including hazardous materials where quick delivery is crucial. Air transport can guarantee timely delivery of dangerous goods to their intended destination.

- ACCESSIBILITY:

Air transportation allows for easy access to almost any location in the world, regardless of how remote or difficult it may be to reach by other means. This is particularly important when transporting dangerous goods, as they often need to be delivered to remote areas where other modes of transportation may not be available.

- SAFETY:

Air transportation is generally considered one of the safest modes of transportation available, with strict safety regulations and procedures in place to ensure that dangerous goods are handled and transported safely.

- COST-EFFECTIVENESS:

While air transportation may be more expensive than other modes of transportation, it can often be more cost-effective for certain types of dangerous goods, especially when time is of the essence. For example, when transporting perishable or time-sensitive dangerous goods, the cost of air transportation may be justified by the potential cost of spoilage or loss if the goods are not delivered quickly.

- FLEXIBILITY:

Air transportation offers a high degree of flexibility, with the ability to quickly adapt to changing circumstances or unexpected delays. This can be particularly important when transporting dangerous goods, as any delays or disruptions can have serious consequences.

5.4 DISADVANTAGES OF DANGEROUS CARGOES TRANSPORTATION BY AIR.

While there are many advantages to transporting dangerous goods by air, there are also some disadvantages to consider. Here are some of them:

- COST:

Air transportation can be more expensive than other modes of transportation, especially for large or heavy shipments of dangerous goods. This can make it difficult for some businesses to justify the expense of air transport, especially if there are cheaper alternatives available.

- CAPACITY:

Airplanes have limited cargo capacity compared to other modes of transportation, which can make it difficult to transport large volumes of dangerous goods by air. This can be a particular challenge for businesses that need to transport hazardous materials in large quantities.

- REGULATIONS:

Transporting dangerous goods by air requires strict adherence to a range of regulations and guidelines, which can be complex and time-consuming to navigate. This can be a challenge for businesses that are not familiar with these regulations, or that lack the resources to ensure compliance.

- SECURITY:

To prevent the transport of hazardous materials by criminals or terrorists, airports have strict security protocols in place. While these measures are essential for public safety, they can make the transportation process more complex and challenging.

ENVIRONMENTAL IMPACT:

Air transportation is one of the most carbon-intensive modes of transportation available, with significant environmental impacts. While efforts are being made to reduce these impacts, it's important to consider the environmental costs of transporting dangerous goods by air.



CHAPTER 6

REGULATIONS AND GUIDELINES

6.1 REGULATIONS AND GUIDELINES FOR DANGEROUS CARGOES TRANSPORTATION BY SEA

The International Maritime Dangerous Goods (IMDG) Code, administered by the International Maritime Organization (IMO), governs the shipping of hazardous materials by sea. The IMDG Code offers detailed instructions on how to classify, package, mark, label, and document dangerous products for shipping by sea.

6.1.1 IMDG CODE

The International Maritime Dangerous Goods (IMDG) Code contains provisions for the safe carriage of dangerous goods by sea.

- The key objectives are to:
 - Protect human life
 - Prevent marine pollution
 - Facilitate the free movement of dangerous goods.

6.1.2 APPLICATION OF THE IMDG CODE

- All ships covered by the following two conventions must adhere to the IMDG Code's requirements
- SOLAS 1974, the International Convention for the Safety of Life at Sea, which addresses the dangers posed by the presence of dangerous products on board ships.
- MARPOL, the International Convention for the Prevention of Pollution from Ships, which addresses the pollution issues for ships transporting hazardous materials.

6.1.3 DIFFERENT TYPES/CLASSES OF DANGEROUS CARGOES

Class 1 - Explosives

Class 2 - Gases

Class 3 - Flammable liquids

Class 4 - Flammable solids and other flammable substances

Class 5 - Oxidizing substances and organic peroxides

Class 6 - Toxic and infectious substances

Class 7 - Radioactive material

Class 8 - Corrosive substances

Class 9 - Miscellaneous dangerous substances and articles



6.1.4 IDENTIFYING DANGEROUS CARGOES

- Each class has a distinctive diamond label that is used to indicate transportation danger.
- The United Nations has assigned each dangerous good a unique identification number and name, known as the "Proper Shipping Name" or PSN. For instance, paraffin is designated as a flammable liquid (class 3), is a recognized PSN, and has the UN number 1223.
- To ensure proper handling, stowage, segregation, etc., as well as the right steps in an emergency, the UN number and PSN permit swift and accurate identification during transport.

6.2 REGULATIONS AND GUIDELINES FOR DANGEROUS CARGOES TRANSPORTATION BY AIR

To protect the safety of passengers, crew, and aircraft, strict adherence to rules and guidelines is required while transporting dangerous items by air. The primary rules and recommendations for sending risky items by air are as follows:

- INTERNATIONAL CIVIL AVIATION ORGANIZATION (ICAO) TECHNICAL INSTRUCTIONS:

The ICAO Technical Instructions provide guidelines for the safe transportation of hazardous materials by air transport. These instructions cover various aspects, such as classification, packaging, labelling, marking, and documentation standards for shipments of dangerous goods.

- INTERNATIONAL AIR TRANSPORT ASSOCIATION (IATA) DANGEROUS GOODS REGULATIONS:

The IATA Dangerous Goods Regulations build upon the guidelines provided by the ICAO Technical Instructions for the air transportation of hazardous materials. Updated annually, these regulations provide additional instructions for the transport of dangerous goods by air, including comprehensive details on packing guidelines, exclusions, and special rules for specific categories of hazardous items.

- NATIONAL REGULATIONS:

Each country has its own national regulations for the transport of dangerous goods by air. These regulations may be more restrictive than the ICAO Technical Instructions and the IATA Dangerous Goods Regulations, and shippers must comply with both sets of regulations.

- PROPER CLASSIFICATION:

According to their hazard class, packaging group, and quantity, dangerous commodities must be categorised. The classification establishes the proper standards for the shipment's packaging, labelling, and documentation.

- PROPER PACKAGING:

Hazardous materials need to be packed in strong containers that can withstand the demands of air transportation and prevent any leaks or spills. The containers used must be approved for the particular substance being shipped and comply with the guidelines provided by the ICAO Technical Instructions and the IATA Dangerous Goods Regulations.

- MARKING AND LABELLING:

Dangerous goods packages must be marked and labelled in accordance with the ICAO Technical Instructions and the IATA Dangerous Goods Regulations. The markings and labels must identify the substance being shipped, its hazard class, and other relevant information.

- DOCUMENTATION:

When transporting hazardous materials, appropriate documentation is necessary, including a declaration of dangerous goods by the shipper, a safety data sheet, and any other mandatory documents. The documentation must be accurate and complete, and the responsibility of providing it lies with the shipper.

- STOWAGE AND SEGREGATION:

Dangerous goods must be stowed and segregated according to the requirements of the ICAO Technical Instructions and the IATA Dangerous Goods Regulations. This includes identifying which classes of dangerous goods can be stowed together and which must be kept apart, as well as proper stowage location on the aircraft.

- EMERGENCY RESPONSE:

It is essential to have a well-developed emergency response plan in case of an accident or incident involving dangerous goods. The plan should include procedures for dealing with spills, fires, and other emergencies, as well as the availability of appropriate equipment and personnel trained in emergency response procedures.

Compliance with these regulations and guidelines is essential for the safe and efficient transportation of dangerous goods by air. The ICAO Technical Instructions and the IATA Dangerous Goods Regulations provide comprehensive

guidance on the transport of dangerous goods by air and are essential resources for shippers, carriers, and airport operators.

CHAPTER 7

SAFETY AND RISK FACTORS

The transportation of hazardous materials via air and sea involves significant safety and risk factors that require careful management to avoid accidents and safeguard public safety. The following are some of the key safety and risk factors associated with the transportation of dangerous goods by sea and air:

7.1 RISK FACTORS FOR SEA TRANSPORTATION:

- Fire and Explosion:

Dangerous goods transported by sea can present a risk of fire and explosion if they are not properly packaged, labelled, and stowed. This risk is particularly high for substances like flammable liquids and gases.

- Water Contamination:

Dangerous goods that leak or spill during transportation by sea can cause water contamination, which can harm marine life and ecosystems. This risk is particularly high for substances like toxic chemicals and pesticides.

- Stability and Trim:

If hazardous materials are not loaded or stowed correctly on a ship, it can lead to instability or changes in trim, which can compromise the vessel's safety and heighten the chances of it capsizing or sinking.

- Human Error:

Human error, such as incorrect documentation, mislabelling, or inadequate training, can result in accidents or incidents involving dangerous goods during sea transportation.

7.2 RISK FACTORS FOR AIR TRANSPORTATION:

- Fire and Explosion:

Dangerous goods transported by air can pose a risk of fire and explosion if they are not properly packaged, labelled, and stowed. This risk is particularly high for substances like flammable liquids and gases.

- Toxic Fumes:

Some dangerous goods, such as certain chemicals and gases, can emit toxic fumes if they are not properly packaged, labelled, and stowed, which can pose a risk to passengers and crew.

- Pressure Changes:

Changes in pressure and temperature during air transportation can cause dangerous goods to leak or spill, which can pose a risk to passengers, crew, and aircraft.

- Human Error:

Human error, such as incorrect documentation, mislabelling, or inadequate training, can result in accidents or incidents involving dangerous goods during air transportation.

7.3 SAFETY PRECAUTIONS FOR SEA TRANSPORTATION:

- Stowage and Segregation:

Dangerous goods must be stowed and segregated according to their hazard class and compatibility with other substances to prevent any adverse reactions or accidents.

- Training and Certification:

All personnel involved in the transportation of dangerous goods by sea must be properly trained and certified in accordance with the IMDG Code.

- Vessel Inspection and Certification:

Vessels transporting dangerous goods must be inspected and certified to ensure compliance with international regulations.

- Proper Packaging and Labelling:

Dangerous goods must be packaged and labelled in accordance with the IMDG Code to prevent leaks, spills, or other incidents during transportation.

7.4 SAFETY PRECAUTIONS FOR AIR TRANSPORTATION:

- Proper Packaging and Labelling:

Dangerous goods must be packaged and labelled in accordance with the ICAO Technical Instructions to prevent leaks, spills, or other incidents during transportation.

- Cargo Compatibility:

Dangerous goods must be loaded in accordance with the aircraft's cargo compatibility manual to prevent any adverse reactions or accidents.

- Training and Certification:

All personnel involved in the transportation of dangerous goods by air must be properly trained and certified in accordance with the ICAO Technical Instructions.

- Aircraft Inspection and Certification:

Aircraft used to transport dangerous goods must be inspected and certified to ensure compliance with international regulations.

- Air Cargo Security:

Measures must be taken to ensure the security of air cargo, including dangerous goods, during transportation.

By following these safety precautions, the risk of incidents or accidents during the transportation of dangerous goods can be minimized, ensuring the safety of the public, transportation personnel, and the environment.

CHAPTER 8
FINDINGS AND CONCLUSION

8.1 FINDINGS:

After conducting a comparative study of dangerous goods transportation by sea and air, the following findings were observed:

1. COST:

The cost of transportation is a significant consideration when transporting dangerous goods. The study found that sea transportation is generally more cost-effective compared to air transportation, especially for bulky and heavy cargoes. This is due to the higher cost of air freight and the limited capacity of cargo that can be transported by air.

2. SAFETY:

Safety is a primary concern when transporting dangerous goods, and both modes of transportation have essential risks. However, the study found that air transportation is considered to be safer than sea transportation due to the strict regulations and guidelines imposed by regulatory authorities, such as the International Civil Aviation Organization (ICAO) and the International Air Transport Association (IATA).

3. SPEED:

The speed of transportation is another crucial factor, particularly for time-sensitive cargo. The study found that air transportation is significantly faster than sea transportation, which makes it more suitable for transporting dangerous goods that require quick delivery.

4. ACCESSIBILITY:

The accessibility of transportation is also a critical consideration, particularly when transporting dangerous goods to remote locations. The study found that sea transportation is more accessible as it covers more destinations globally, while air transportation is limited to areas with airports.

5. ENVIRONMENTAL IMPACT:

The study found that both modes of transportation have an environmental impact, but sea transportation is considered to have a higher impact due to the emission of greenhouse gases and the potential for oil spills. In contrast, air transportation has a lower environmental impact due to its more efficient use of fuel and reduced emissions.

8.2 CONCLUSION

The comparative study of dangerous goods transportation by sea and air has provided valuable insights into the advantages and disadvantages of each mode of transportation. The study found that sea transportation is generally more cost-effective and accessible, while air transportation is faster and considered safer. However, both modes of transportation have inherent risks, and strict adherence to regulatory guidelines is necessary to ensure the safe and efficient transportation of dangerous goods.

Factors such as cost, safety, speed, accessibility, and environmental impact must be carefully considered when deciding on the mode of transportation for dangerous goods. It is essential to balance these factors to ensure that the cargo is delivered safely, timely, and efficiently while minimizing environmental impact.

The study highlights the need for continued research and development in both modes of transportation to improve their safety, efficiency, and environmental impact. Future studies may focus on the development of new technologies and regulatory frameworks to further improve the transportation of dangerous goods by sea and air.

In conclusion, the comparative study of dangerous goods transportation by sea and air provides a comprehensive understanding of the opportunities and challenges associated with these modes of transportation. The findings of this study can be used to inform the decision-making process for the safe and efficient transportation of dangerous goods in the future.

CHAPTER 9

BIBLIOGRAPHY

➤ BOOKS

- Dangerous Goods Regulations (DGR) by International Air Transport Association (IATA).
- Dangerous Goods Transportation Regulations by the United Nations (UN).
- Air Cargo Management: Air Freight and the Global Supply Chain by Michael Sales.
- Logistics and Supply Chain Management by Martin Christopher
- Multimodal Transport Law: The Law Applicable to Multimodal Contract for the Carriage of Goods" by Baris Soyer and Andrew Tettenborn.

➤ WEBSITES

- International Maritime Organization:
<https://www.imo.org/en/OurWork/Safety/Cargoes/DangerousGoods/Pages/Default.aspx>
- International Air Transport Association:
<https://www.iata.org/en/publications/dgr/>
- International Civil Aviation Organization:
<https://www.icao.int/safety/DangerousGoods/Pages/default.aspx>
- UNCTAD: <https://unctad.org/topic/transport-and-trade-facilitation/review-maritime-transport>
- IATA: <https://www.iata.org/en/publications/economics/economic-briefings/air-cargo-overview/>