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INSIDE DEEP SPACE LOGISTICS

DEEPER LOOK INTO
SPACE EXPLORATION

FIRST LOOK:

EARTH TO
MOON TO MARS
SUPPLY CHAINS

GATEWAY LOGISTICS PROJECT

DS FALL
INTER

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EXPLORE

Presentation Outline

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ABOUT DEEP SPACE LOGISTICS

Part 1.A: Background

Recently, KSC was awarded the multi-billion dollar GLS contract to provide support for upcoming lunar missions for a 2024 launch date in mind. The Gateway is a spaceship that will orbit the Moon and enable the return of astronauts to the surface of the Moon by 2024 (Phase 1) as a first step toward crewed missions to Mars and to enable science activities and additional missions to the Moon beyond 2024. KSC's Gateway Logistics team leads the effort to develop the Logistics Element for the Gateway Program, NASA's commercial supply chain for deep space.

Part 1.B: Abstract

Through a technical review, historical context on the relationship between the subsets of the logistics industry and their associated evolutionary changes, this work develops a concept, and hence, a proposition of the current future of space logistics within the supply chain world.

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Part 1.C: Introduction

Historically, logistics refers to the movement of products or services to a designated location at an agreed upon time, cost, and condition. The earliest development of logistics reaches as far back as the war between Ancient Rome and Greece. During those historic time periods, the two civilization developed the basis for a highly efficient logistics system to advance their military efforts. In similar fashion, logistics advanced greatly during the Middle Ages, World War I, and World War II. Thus, the evolution of the supply chain system has been uniquely synchronous with the adaptation of civilization, war, and time.

As a result of these dramatic advances in transportation and communication, there were novel introductions of railway and ship transport to expand supply systems; and eventually bolster into business. These business practices developed into Freight Rail and Trucking logistics, Maritime transport logistics, Air and Express delivery logistics, and soon to be, Space logistics.

Part 2.A: Freight Rail and Trucking Logistics Market Overview

Ground transport relates directly to high-volumes of heavy cargo shipments delivered by train or truck. Typically, it is more affordable than air transport, but more expensive than maritime transport. In recent years, Freight rail moved more than 70 percent of the nation's coal and raw metal ores; and 1.6 million carloads of agriculture products. Additionally, Trucking transport moves almost 11 billion tons of freight year-over-year.

Between the periods of 2019-2024, the Freight transport market is expected to have a compound annual growth rate of 9.8%. Within the market, technological advances and operational improvements are key reasons for the expected advancement. Those include Telematics and GPS fleet tracking systems, self-driving trucks and platooning technology, Big Data and Analytics, and advanced fuel management systems. The emergence of new technology is resultantly driving the market and providing both shippers and buyers with reliable transport. Contradictorily, the biggest challenge that the industry faces is its inefficiencies of shipping and delivering goods with low cost. There are also negative implications on the freight industry due to trading across international borders and regulatory issues.

Market Trends

Rail and Trucking are leading in areas such as land use, energy consumption, and safety. Also, it has recently become the most cost-efficient shipping alternative. This is due to lower interest cost and an overall increase in payload per carry. COVID-19 caused restrictions on air and maritime transport in many international regions. For this reason rail and trucking logistics received a supply chain advantage in comparison to other transport methods.

Competitive Landscape

Most of the industry share is controlled by international companies who have invested heavily into ground logistics because of its economic efficiency. In particular, European countries are relying heavily on ground freight amid the current health pandemic. In terms of the American economy, the industry is dominated by both state-ran companies and a few large conglomerates who operate in all subsets of the logistics industry. But notably in the US, the trucking freight method dominates much of the industry's movement. This is evident in both Table 1.1 and Table 1.2.

Part 2.B: Industry Statistics

North American Cross-border Freight Movement, by Mode,
by Value (USD billion)

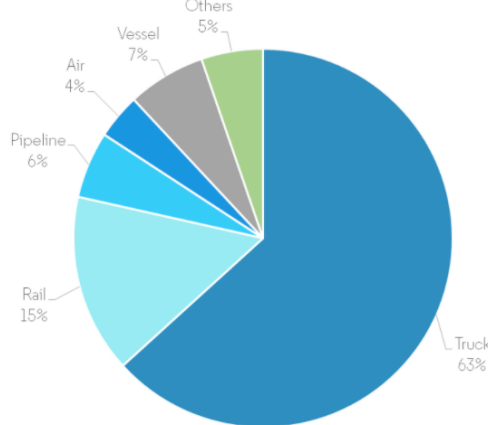


Table 1.1

2018 U.S. Freight Transportation by Mode (\$ in billions)

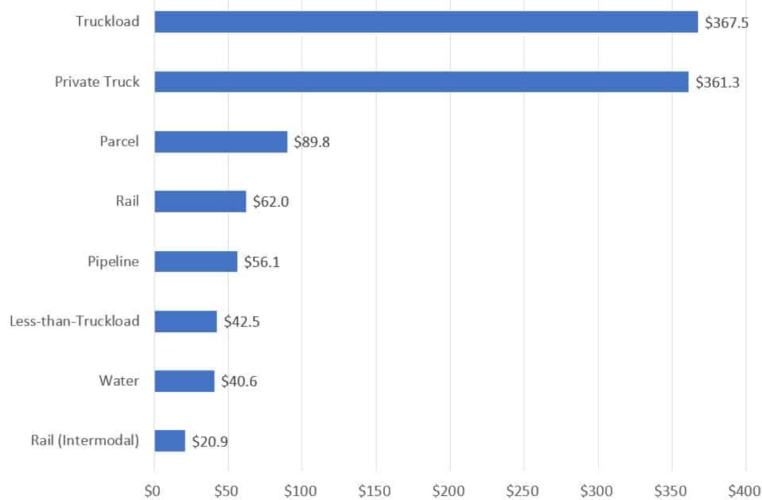


Table 1.2

2018 N.A. Net Revenue for Logistics Companies in U.S. (\$ in millions)



Table 1.3

Part 3.A: Maritime Logistics Market Overview

This subset of the logistics industry consist of moving freight transport of finished goods from one port to another by utilizing cargo ships. Maritime logistics has traditionally been the primary means of transporting freight globally. Resultantly, globalization and world trade have put immense pressure on the industry to expand and technologically advance.

Environmental sustainability has increasingly become a major policy concern that drive regulations. Notably, the International Maritime Organization confirmed a mandate that puts a cap on sulphur content to 0.5% in global Marine fuels. The hope is to reduce air pollution caused by the marine shipping industry. Other environmental policies are developing framework that will positively impact sustainability within the industry, but may have negative economic implications initially.

Digitalization is another key sector improvement. The shipping industry is adopting technologies like block chain to transform business and supply chain models. There are real chances of the utilization of autonomous ships in the near future that will help to push operational efforts further. Job requirements within the industry will also experience a drastic change.

Market Trends

The maritime industry is facing current economic growth decline accompanied with an expectation for a further downturn. Since 2017, Gross Domestic Product growth for several key countries have slowed or declined (Table 1.4). The greatest indicator for this trend is the Global Industrial Production rate which saw a reduction by 0.5 percentage points between year 2017 and 2018. Also, there were disappointing trends in international trade, global merchandise trade, and key market segments of maritime trade (i.e. oil and containerized dry cargo).

Competitive Landscape

There are a few opportunities that are at the forefront on the industry like improved technology and services, more regionalized trade flows and China's rebalanced role in the economy. All of which serve as unique possibilities for industry players to gain a greater share of the market. Regional carriers are also competing to adapt to changing conditions from new aforementioned environmental regulations and policies.

Part 3.B: Industry Statistics

World Economic Growth

Region or country	1994–2008	2017	2018 ^a	2019 ^b
World	3.3	3.1	3.0	2.3
Developed countries	2.6	2.3	2.2	1.6
<i>of which:</i>				
United States	3.2	2.2	2.9	2.2
European Union (28)	2.5	2.5	2.0	1.3
Japan	1.1	1.9	0.8	0.8
Developing countries	5.1	4.4	4.2	3.5
<i>of which:</i>				
Africa	4.6	2.6	2.8	2.8
East Asia	8.1	6.2	5.9	5.4
<i>of which:</i>				
China	9.7	6.9	6.6	6.1
South Asia	5.7	6.3	6.0	4.1
<i>of which:</i>				
India	6.6	6.9	7.4	6.0
South-East Asia	4.2	5.2	5.0	4.5
Western Asia	4.3	2.8	2.3	0.7
Latin American and the Caribbean	2.9	1.0	0.8	0.2
<i>of which:</i>				
Brazil	2.9	1.1	1.1	0.6
Transition economies	4.1	2.1	2.8	1.4
<i>of which:</i>				
Russian Federation	3.9	1.6	2.3	0.5
Least developed countries	6.0	4.3	4.4	4.6

Table 1.4

Part 4.A: Air and Express Delivery Logistics Market Overview

The fastest mode of shipment and transportation comes in the form of air logistics. It is widely considered one of the most efficient ways to move cargo and recently saw cargo volumes of 63.7 million metric tons in 2018. There are concerns and challenges that the industry faces, such as global economic activity, fallen consumer confidence, and declining global trade. But the projection is for the market to grow due to increased technological advances in the value chain.

Market Trends

E-commerce is the leading market trend for air logistics. Both B2B and B2C sales are evolving factors that put immense pressure on sales channels to produce cargo at a faster rate. This will especially be important as the international E-commerce demand increases and changes the way logistics service providers approach their methods of transport. North America shows positive trends as the fastest-growing region in the market. American companies are expanding their shipping services to offer air programs (i.e. Amazon Prime Air Program) and capitalize on international trade.

Competitive Landscape

As previously mentioned, the North American region is the fastest-growing in the market, but the Asia-Pacific region currently has the largest market share (Table 1.5). Freight tonne per kilometer (FTK/CTK) showed that both North America and Latin America grew substantially in 2018, well over the global average. FTK represents the measurement of how much freight business an airline gets. One FTK is one metric tonne of revenue load carried one kilometer. It is important to note that the North American airlines experienced tremendous downfall due to the COVID-19 pandemic which halted much of the industry (Table 1.6). Additionally, the market is fragmented, but uniquely there are industry leaders who dominate across multiple regions. There is an increased focus on integrating new technology and developing more storage facilities globally to meet the growing air cargo industry.

Part 4.B: Industry Statistics

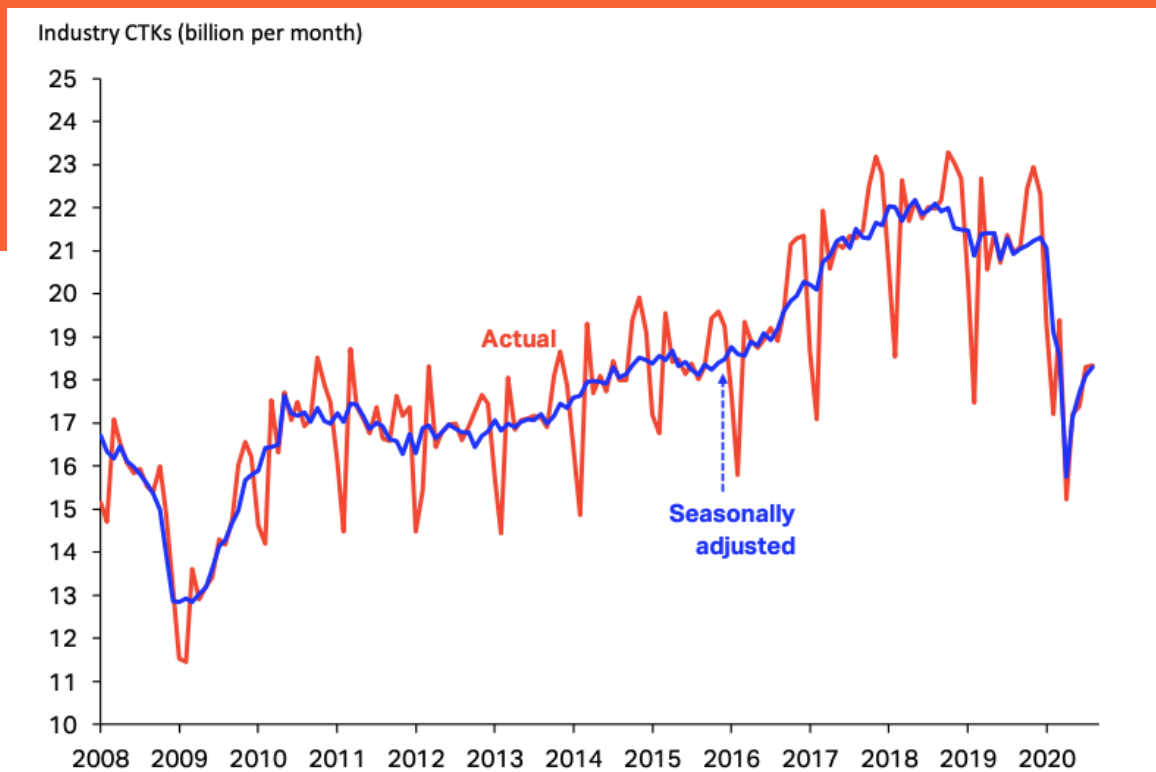
	<i>World share</i> ¹	August 2020 (% year-on-year)				% year-to-date			
		CTK	ACTK	CLF (%-pt) ²	CLF (level) ³	CTK	ACTK	CLF (%-pt) ²	CLF (level) ³
TOTAL MARKET	100.0%	-12.6%	-29.4%	10.6%	54.8%	-14.0%	-24.8%	6.7%	53.0%
Africa	1.8%	-0.2%	-37.9%	19.0%	50.2%	-3.3%	-16.5%	5.6%	41.2%
Asia Pacific	34.5%	-20.1%	-33.5%	10.3%	61.6%	-17.7%	-29.5%	8.7%	60.3%
Europe	23.6%	-18.9%	-32.1%	9.3%	56.8%	-20.2%	-30.0%	7.1%	57.9%
Latin America	2.8%	-27.3%	-43.5%	10.6%	47.8%	-23.2%	-36.7%	7.4%	42.4%
Middle East	13.0%	-6.9%	-24.3%	10.0%	53.5%	-14.4%	-19.9%	3.2%	49.3%
North America	24.3%	1.7%	-23.3%	12.0%	48.9%	-2.3%	-17.2%	7.1%	46.7%
International	86.8%	-14.0%	-31.6%	12.5%	61.3%	-15.2%	-25.0%	6.7%	57.9%
Africa	1.8%	1.0%	-36.9%	19.0%	50.8%	-2.5%	-14.8%	5.3%	41.7%
Asia Pacific	30.4%	-18.3%	-35.0%	14.8%	72.4%	-15.4%	-26.1%	8.4%	66.5%
Europe	23.3%	-19.3%	-33.5%	10.5%	59.7%	-20.4%	-29.8%	7.0%	59.7%
Latin America	2.3%	-26.1%	-38.5%	8.8%	52.8%	-21.6%	-33.1%	7.3%	49.7%
Middle East	13.0%	-6.8%	-24.2%	10.0%	53.8%	-14.3%	-19.5%	3.0%	49.5%
North America	16.0%	-4.0%	-28.2%	14.5%	57.6%	-8.6%	-22.0%	7.9%	54.0%

¹% of industry CTKs in 2019

²Year-on-year change in load factor

³Load factor level

Table 1.5



CTK = Cargo Ton Kilometers

Table 1.6

Part 5.A: Deep Space Logistics Market Overview and Analysis

NASA's Artemis program is currently at the forefront of space exploration. With a mission to land the next man and first woman on the Moon by 2024, Artemis looks to extend Lunar missions and prepare for future explorations to Mars. The Gateway program is a subset of the overarching Artemis program, and it provides critical support to science investigations and deep space transportation. Specifically, Gateway is an orbiting outpost that serves as a transit port. The Deep Space Logistics project has a further responsibility to lead the commercial supply chain in deep space. They are particularly focused on commercial acquisition and contract management; End-to-end commercial service mission management, insight, and approval; and Spaceport host for commercial, deep space logistics, payload processing and delivery services. (Heiney, 2020)

Government Initiatives

Artemis and the Gateway program will help guide the future of commercial space transportation and supply chain. With that said, the United States Government laid out clear initiatives to attempt to support mission goals. Those included:

- Promote a secure space environment for longterm sustainability.

- Support the development of commercial activity.
- Support research and development of space technology.
- Create infrastructure needed for space exploration with commercial and international partners.
- Support space research by private and public national

Competitive Landscape

Government-based space agencies and technology companies currently compete in an industry geared towards scientific space exploration. Arianespace, Orbital Sciences, Sierra Nevada, and SpaceX contribute to the manufacturing of interplanetary commercial launch systems. When SpaceX launched the Falcon Heavy rocket, there became a clear indication that logistics and supply chain management will become that much more important for the space industry... (KucuKcay, 2020) International government programs like the China Aerospace Industry Corporation and the Europeans Space Agency are also competing to deliver sustainable space exploration. This has resulted in a diverse network of players who each add innovative value to the improvements and development of the industry.

Spotlight on Key Commodities Transported by Space

NASA is awarding contracts for a fleet of space vehicles to deliver payloads – both active and passive – to the Lunar service. Each mission, vehicles will deliver thousands of kilograms of pressurized and unpressurized cargo to the Gateway.

Static Passive • remains attached to lander • does not perform mission tasks Example: memorabilia	Deployable Passive • detaches from lander • does not perform mission tasks Example: surface time capsule
Static Active • remains attached to lander • performs mission tasks Example: telescope	Deployable Active • detaches from lander • performs mission tasks Example: rover

Table 1.7 Passive v.
Active Payload

Figure 1. Gateway



Part 6.A: Future commercialization of Space Logistics

The question of "can space technology and rockets deliver cargo internationally?", has been posed for many years. The concept of space exploration becoming commercialized has caused the U.S. Transportation Command (TRANSCOM) to dedicate a lot of research & development to understanding if point-to-point space launches will ever exist. Research finds that a rocket would need an average speed of 9,000 miles per hour to travel anywhere across the globe in 60 minutes. (Tingley, 2020) Obviously, the concept faces many challenges that include how the cargo will be delivered, cost to launch and land vehicles, reusability of rocket and cargo ships, and facilities necessary to receive cargo. Conceptualizations of a C-17 flight; which is a rocket that has the ability to launch suborbital; calculated that the cost to launch would be around 1/100th the cost of a SpaceX flight.

Figure 2. Point-to-point Travel

Part 6.B: Conclusion

As the DSL team at KSC develops the capabilities necessary to lead the Deep Space commercial supply chain, we recognize that new and improved technologies in the logistics industry overall can enhance our work in space and their work on Earth. We are beginning to explore what new technologies various logistics organizations are working to advance. Our inquisitive journey to learn just how far away the reality of rocket powered logistics really is, began in January 2020 at the AirCargo 2020 conference in Nashville, TN. Mark Wiese, DSL Project Manager, gave the keynote address to an audience of logistics companies. Freight Waves is hosting a virtual event in early December 2020 called “Space Waves.” Mark has accepted the invitation to keynote the conference and we are also working to engage our GLS partner, SpaceX, at the event. This is an exciting time for our Project as we’re continuing to support initiatives that allow us to form collaborations with external partners. We believe our involvement with ground logistics commercial companies will help us to further our collaborations with the logistics industry and allow us to gain further insight that will posture DSL and the Gateway Program for future partnerships with the logistics industry.”

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