Understanding the Needs, Requirements, and Definition of the Problem

Large capacity freight shipping by rail, ground, sea, and air has caused major concerns with NOx emissions and air pollution. These transportation methods are mainly powered by diesel. Diesel engines undergo a combustion process which results in large amounts of NOx. This process releases large amounts of harmful chemicals to both the environment and people. The polluted air contains components causing cancer, heart and lung damage, and other life-threatening diseases. Companies, including GE, are currently working to solve this major issue of NOx emissions. To understand the best way to fix this problem, it is important to learn about each type of large capacity freight shipping and the current issues each one brings to the table.

Locomotives:
Shipping by trains is one of the oldest way of transporting a large amount of goods from one place to another. It all goes back to the 19th century when the locomotive was invented. Since then, trains have improved exponentially. Unfortunately, they started emitting high doses of NOx which led to the start of the EPA emission standards. Nowadays, EPA’s tier 4 is in effect which forces locomotives to emit a limited amount to reduce pollution. This has led to ground-breaking changes in our ecosystem, but it has increased the price of shipping significantly. Rail rates have increased by 76% from 2001 to 2011 due to the increase in cost of maintenance. Making the new technology more efficient has created a price floor for the money used to improve it which affects the customers. As the EPA creates more restrictions, it will be more costly to keep up economically.

On the other hand, the rail system is really effective when it comes to transporting goods on a small time frame. One can take a train from New York to Los Angeles and arrive in less than two days and nineteen hours. Also, there is a rail system that expands to almost every major city in the United States. It may not be as fast as traveling by air, but it will get one to its destination in an insignificant amount of extra time. In addition, the capacity of trains depends on its power
capabilities, and as technology improves, more and more storage it will be able to carry. Trains nowadays can carry around 56 cars maximum depending on the weight of each cargo, but the weight of the cargo varies from 30 to 130 tons.

Locomotive engines also use a large amount of fuel. Trains can move a ton of freight for 480 miles/gallon. But, adding up all the tons and freights, the amount of gallons end up being a significant amount. Most engines use diesel fuel which causes more NOx than others, but it is the fuel that produces enough power for a small amount of money. Other types of fuel are either too expensive or are not efficient enough yet for them to be mass produced. One example of a cleaner fuel is biodiesel. It is made out of renewable resources like recycled cooking oil and animal fats. It is a clean-burning diesel replacement, but it is more expensive. The mpg difference between the two is almost insignificant when all else held constant.

Trains have been used for the past century for a reason. They have been effective for it’s ability to transport large amounts of cargo and because of an acceptable cost. The EPA has increased the standards and therefore increased the cost of maintenance. The money spent on trains will keep increasing, but for now it is a reliable source of transportation.

Upgrading engines through the tiers can be very expensive, but it is necessary to keep up to date with the EPA emission standards. The newly released Tier-4 standards make it a requirement for shipping companies to upgrade their engines, or else the public view of the company may drop due to the lack of environmental respect. The 2015 Tier-4 standards are a fraction of Tier-2 and Tier-3 (2011 Tier-4i) standards which makes them a more more environmentally and politically friendly option, but the high cost still pose an issue. The cost of upgrading can reach and even exceed $3 million for each locomotive, but this does not count the return money for selling old locomotives. There are even options in states like California that are offering the “Carl Moyer Emissions Grant Program” that provides grants up to 85% of the locomotive’s cost, providing that the previous locomotive is traded in. This gives a way for companies to more easily obtain new train engines, especially larger transportation based companies that require many locomotives.

Locomotives can also be outfitted with a mixture of liquid natural gas and diesel (about a 4:1 ratio respectively). This type of gas has not yet been tested or run to its fullest extent, but it would be a much cleaner alternative once engines could be manufactured to store and burn such a combination.
Water:

Freight services international companies are shipping companies that use waterways to transport cargo. There have been many recent changes in regulation in the past year. The International Maritime Organization (IMO) Maritime Safety Committee (MSC) approved changes to the Safety of Life at Sea (SOLAS) convention regarding mandatory container weight verification requirement on shippers in May of 2014 and it will be implemented Nov of 2015. Nov 21, 2014 SOLAS approved a requirement that the shipper has to use one of the permissible methods must verify the weight of a package export container. Denmark, The Netherlands, and the United States co-sponsored a formal proposal that would require the weight of all packed containers be verified prior to loading on board a vessel for export.

There are two types of shipping when you ship things by waterways. LCL and FCL. LCL stands for Less than Container Load and you aren’t limited by volume but there is a minimum charge. Also in LCL shipping your good are put into a container along other others goods. In FCL which stands for Full Container Load, you are charged for the entire ocean freight and your goods aren’t put in with others goods. The average cost of shipping overseas is about $1100 because there are many fees involved. Some of the fees include: entry filing for international ocean freight Commercial ($125), entry filing for international ocean freight Personal Shipment ($195-350), Customs Bond ($75-$7 per$1,000 value of an item, filing additional tariffs ($7), merchandise processing ($25-485), and harbor maintenance fee (0.125% of the value of the shipment).

There are five types of cargo ships: general cargo vessels, tankers, dry bulk carriers, multipurpose vessels, and reefer ships. General cargo vessels carry packaged items like chemicals, food, furniture, machinery, motor and military vehicles, footwear, garments, and other similar items. Tankers carry petroleum products and liquid cargo. Tankers are classified by size by calculating the deadweight (DWT). Small tankers are 10,000-24,999 DWT. Medium is 25,000-54,999. Long Range 1 and 2 is 55,000-159,999 DWT. Very large is 160,000-319,999 DWT and Ultra Large is 320,000-549,999 DWT. Dry bulk carries coal, grain, ore, and other loose form items. Bulk carriers size breakdown is Handysize is 10,000-35,000 DWT. Handymax is 35,000-59,000 DWT. Panamax is 60,000-80,000 DWT. And the Largest is Capesize 80,000 and over in DWT. Multipurpose vessels carry liquid and general cargo at the same time. There are four types MPV which are vessels with or without cargo gear, coastal trade liners, and sea-river vessels. Reefer ships are specially designed to carry items that need to be refrigerated. It has a temperature control component to it. There are three types of Reefers ships. Side door vessels have water-tight ports on the ship’s hull which opens into a cargo hold. This ship is well suited for inclement weather. Conventional vessels have a traditional cargo operation with top opening
hatches and cranes. This is also well suited for inclement weather. Container ships are designed to carry container units where each container has its own refrigerated unit.

Maritime shipping is very unpredictable because the weather on the open oceans is irregular. Because of this, many people do not trust using maritime shipping methods. Also, it is very impractical to use maritime shipping methods if one is shipping something domestically because there are not many ports in the United States. Also, there are many fees along with paying for your package to be shipped. If you are shipping personal items overseas, there are two types of companies you can use. One is a general shipping company and the other is an international moving shipping company. The general shipping company will require you the package your own cargo. But a moving company will charge you a extra fee to package your cargo. Also there are restrictions in what personal items you can ship. You cannot ship food, wine or drugs. With all of these restrictions and limitations when it comes to shipping via water many people don’t use it because it is not efficient.

**Air:**

Freight shipping by air is one of several ways of transporting tons of goods every day. Accounting for regulatory requirements, costs, capacity, public opinion, and on-time delivery are key components to consider when determining whether this shipping method is efficient or not.

To get these goods to their destination efficiently and safely, many airlines have requirements they must meet. The Transportation Security Administration (TSA), the U.S. Department of Transportation (DOT), and the Federal Aviation Administration (FAA) all work together to regulate air transportation services. These departments work with the regulation of safety, fares, hazardous wastes, and overall efficiency to meet their customer’s needs. Safety includes ensuring that aircraft standards are okay and that maintenance of the aircrafts are up to par. Large aircrafts undergo several inspections annually. At about 500 flight hours, airplanes go through a routine checkup. At about 12-18 months, the aircraft goes through detailed inspections. After 4-5 years of flight, the aircraft has each and every mechanism/component inspected, repaired, replaced, or maintained.

Fuel costs for freight shipping is one main factor that makes this method perhaps less efficient that other methods, such as rail. For example, UPS Freight shipping, depending on destination, averages around $11 per pound with a minimum charge of about $1,000.00. Compared to freight shipping by other methods, such as rail, this is quite costly. Although it is costly, it is arguably the fastest. Goods can be delivered very quickly, especially through some of the airlines “express” options. These goods can arrive overnight!
In summary, shipping by air is definitely a great way of transporting goods, however there are high costs involved. Aircrafts use a large amount of fuel; for example, an aircraft can easily burn over 35,000 gallons of fuel in a ten hour flight. It is hurtful to both the wallet and the environment. Perhaps there is a more economically/environmentally friendly way to ship freight in the future.

**Ground:**

Shipping via ground is perhaps the most common form of transporting goods. It is nearly impossible to drive from one place to another without passing several trucks. The US Department of Transportation is in charge of regulating the trucking industry. many of these rules and regulations are aimed to insure the safety of the driver, the package, and the environment. For example drivers are not allowed to drive over 11 hours after driving 10 consecutive hours off duty. The cost of the CAB usually ranges from $80,000-140,000 and the trailers are usually $30,000-70,000. The CAB is where the driver seats and where the engine lays. The trailer is where the cargo is placed and it is hooked up to the CAB. The trailer is usually 53 feet long and about 70 to 80 feet long including the CAB. 18 wheelers can haul 80,000 pounds

Shipping by ground has some problems. First, large trucks are involved in thousands of accidents every year. In fact, more people will be killed in accidents involving large trucks this year than have died in all airplane crashes in the last 45 years. This statistic is quite troubling, considering there are other ways to transport goods. In addition, trucks are a major source of toxic chemical pollution and smog. About one large truck emits as much pollution as 150 total cars.
Compare...
Cargo Capacity

One barge: 1,500 ton, 52,500 bushels, 483,600 gallons
One barging tow: 2,500 ton, 787,500 bushels, 6,804,000 gallons
Jumbo hopper cars: 100 ton, 3,500 bushels, 30,240 gallons
100 car train unit: 10,500 ton, 350,000 bushels, 3,024,000 gallons
Large semi: 26 ton, 910 bushels, 7,865 gallons

Equivalent Units

One barge: 15 jumbo hopper cars
One barging tow: 225 100 car unit trains
50 large semis

Equivalent Lengths

One barge tow: .25 miles
2.25 100 car train unit: 2.75 miles
970 large semis: 11.5 miles (bumper to bumper)
Citations:

Locomotives:
http://kentuckyriverports.com/water_transport_benefits/
http://papers.sae.org/2011-01-1195/
https://www.fra.dot.gov/Page/P0362
http://personal.psu.edu/jtg5343/blogs/frames%20intro2.html
http://www.gettransportation.com/locomotives/locomotives/evolution
http://www3.epa.gov/otaq/standards/nonroad/locomotives.htm
http://www.arb.ca.gov/msprog/tech/presentation/rail.pdf:
http://biodiesel.org/
https://webmail.psu.edu/webmail/get_file.cgi?dir=attach&fname=110085800%2epdf

Air:
http://www.wikinvest.com/stock/United_Parcel_Service_(UPS)/Government%20Regulation
http://science.howstuffworks.com/transport/flight/modern/question192.htm

Ground:
http://www.nytimes.com/2015/08/22/opinion/the-trucks-are-killing-us.html?_r=0
http://www.cleanairtrust.org/trucks.dirtytruth.html