Intermodal Container System Solutions for the Chicago Area -- Joliet Freight City

An IIT Interprofessional Project

Prepared by:
Fall 2009 IPRO 307 Project Team
The Interprofessional Projects Program
Illinois Institute of Technology

Konstantin Balakirev
Ryan Beau-Luby
John Bouikidis
Matthew Cargill
David Dziuba
Matthew Kehoe
Bryan Slonski
Melat Tesfaye
Matthew Wiese
Christopher Wiseman
Joel Zook

Lawrence Rohter, IPRO Instructor

Prepared for:
Mi-Jack Products Inc.
Peter Mirabella

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Acknowledgements

Thanks to our sponsors for their help and guidance throughout the semester.

Peter Mirabella
Mi-Jack Products Inc.

Jack Lanigan Sr.
Mi-Jack Products Inc.

Antonio Callado, M.Sc.
Technical Director
AnimaGraph Arte Digital Ltd.

1. Executive Summary

> "**Intermodal freight transport** involves the transportation of freight in an intermodal container or vehicle, using multiple **modes** of transportation (rail, ship, and truck), without any handling of the freight itself when changing modes. The method reduces cargo handling, and so improves security, reduces damages and losses, and allows freight to be transported faster." (Wikipedia)

Chicago is the largest hub and intermodal freight market in the United States (www.fhwa.dot.gov/). Joliet a good location for a depot because it is close enough to intercept much of Chicago's goods, while far enough away to avoid further congestion within the city. One hub currently exists near Joliet (Elwood BNSF), while another is being developed (Centerpoint), and a third is being proposed off of Lorenzo road. Our team will look at the logistics surrounding large intermodal facilities and their operations.

A large portion of cost, in all forms of shipping, is the price of fuel. Our group examined the implications of peak oil and alternatives to current fuel practices that will be necessary to cope with declining oil reserves and increasing energy costs.

The Pathfinder System is an exciting new proposition for intermodal yards developed by our sponsor, Mi-Jack, Inc. The system allows for faster, more efficient yard operations and less waiting time for trucks and trains. Our team has scripted a simulator using the Java programming language to demonstrate its effectiveness.

Many intermodal facilities are part of a larger "freight city." The idea of a "freight city" includes amenities for truckers and workers of a large intermodal facility. These typically include chassis pools and fueling stations, as well as hotels and restaurants to service drivers. Our team has included plans for a Gas C***iit***y fueling station near the facility, adjacent to the interstate.

2. Purpose & Objectives

Intermodal freight is the movement of containers and trailers by rail, truck or water carriers is the fastest growing segment of the US freight rail industry. It stands as one of the most utilized ways to transport large shipments of cargo across the country. The movement of goods plays a crucial role in the US economy; $29 billion worth of goods travel on the nation's transportation network on an average day. Moreover, freight shipments are growing, as domestic freight movement is expected to increase 90% by 2020. Studies have shown that national infrastructure has not kept up pace with the growing freight demand. Urban freight is a particular concern, as the high population density of cities creates high demand for goods in a confined space to deliver them. (Miodonski, Daniel)

Most of this intermodal traffic is moved in containers. As mentioned above, Chicago is nation's largest intermodal hub and as a result, there are currently 19 intermodal yards in the Chicago region. These 19 intermodal yards allow for approximately 700 miles of loading and unloading tracks over 2200 acres of land. Unfortunately, these intermodal yards often waste space and provide an influx of traffic to the surrounding area. As a result, intermodal yards can be inefficient, costing money to both rail road and trucking companies. Instead of trying to expand the intermodal yards to allow for the increased amount of freight, the current approach is to make improvements to the intermodal yards that can optimize performance with low cost and positive environmental benefits.

IPRO 307 is sponsored by Mi-Jack Products based in Hazel Crest, IL (http://www.mi-jack.com). Mi-Jack Products is the largest manufacturer and operator of intermodal equipment and produces products that increase the efficiency of intermodal yards around the country. Because of the interest Mi-Jack Products have in the efficiency of intermodal yards, the company could benefit from proposals provided by IPRO 307 on improving the movement of containers within an intermodal freight facility. Ideally, our solutions will reduce both business and societal costs; as being more efficient generally reduces consumption, therefore reducing costs.

3. Organization & Approach

This section of the report explains in task orientated terms how the research activities of the project were conducted. List which research methods were used to achieve results and why they were chosen by the team.

We are all in this together.

4. Analysis& Findings

4.1 Chapter Summary

This chapter catalogs all of the work we have done over the semester.

4.2 Peak Oil

Peak oil is the point in time when the maximum rate of global petroleum extraction is reached, after which the rate of production will decline and naturally prices will become higher and more volatile. Since fuel cost is a large part of any type of transportation, alternatives fuels will have to be used in the intermodal system if it is going to continue to be effective in the future.

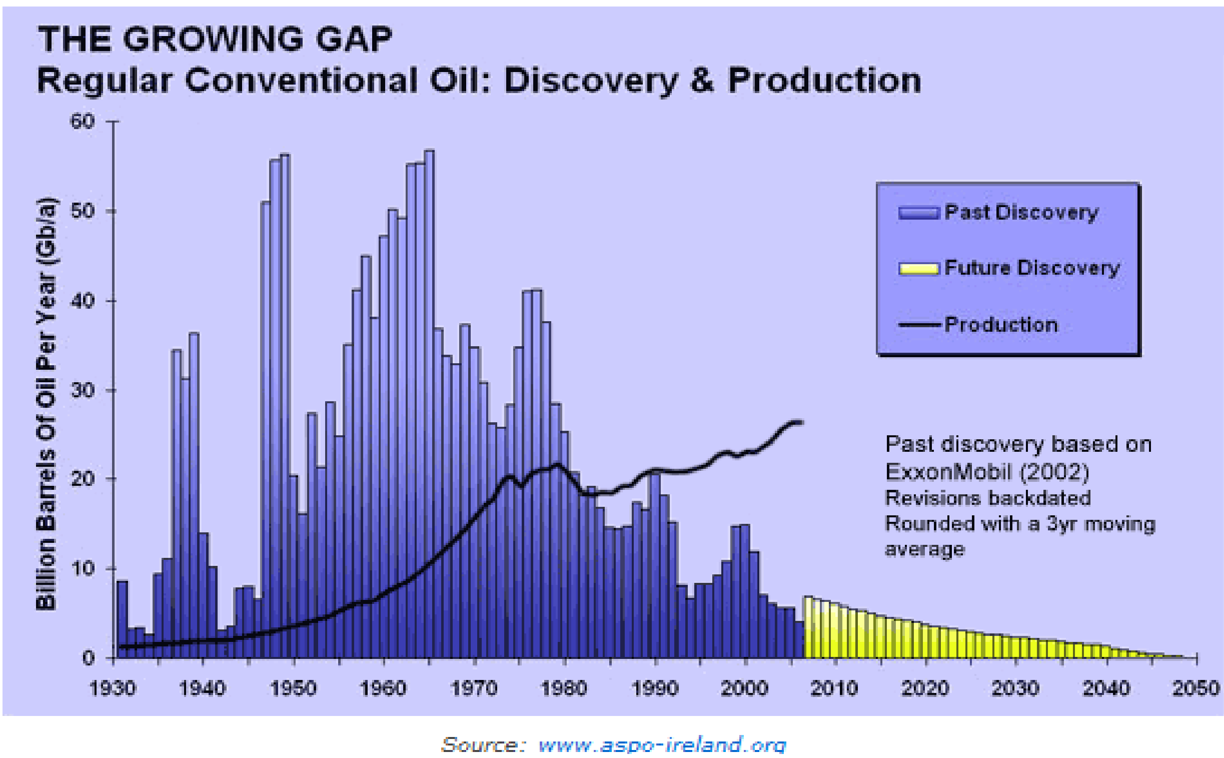


Fig. 4-1. A graph of the global past and future oil discovery verses production. The global oil discovery peaked in the late 1960s (1970s for the USA). Since the mid-1980s, oil companies have been discovering less oil than we have been consuming, and the production rate have been increasing each year.

4.3 Alternative Fuels Attributes Chart

With oil running out and greenhouse gas emissions rising, we *need* practical alternative fuels to keep our economy running and also keep the earth as an inhabitable environment. The alternative fuel chart (located in the appendix) was created to decide which was the most appropriate fuel to offset oil in the Joliet area. Other reasons to select the fuels were proximity of production and other stations (more information in section 4.5).

The cells are filled with different colors to help distinguish which fuels are appropriate (green), could be a potential fuel (yellow), or are inappropriate (red). Listed are the reasons why these colors were chosen for specific fuels.

Vegetable Oil (red)
-Not much better emissions, SVO (straight vegetable) oil is expensive, only 1% of oil could be displaced from current production

Biodiesel (green)
-Runs in most diesel engines, reactors available for purchase, infrastructure already ready to go.

CNG (green)
-Domestically available in large amounts, inexpensive, pipelines already exist, refuel stations available for in home installation, and is pretty good on emissions.

Hydrogen fuel (yellow)
- Currently difficult to aquire, store, and transport, with renewable energy it has the potential could be near zero emissions.

Propane LPG (yellow)
- already a fuel source commonly used for other uses (grills, heating homes, etc)

Ethanol (yellow)
-Vehicles in production already come equipped with flex fuel engines, can be made from agricultural waste, unfortunately takes a good amount of energy to produce.

Algae fuel (red)
- Appealing concept but requires expensive equipment, very sustainable (could recycle coal CO2 power plant emissions and be grown in small areas with high yields) but not practical at this moment in time.

LNG (red)
-High density makes good use for larger vehicles (semi-trucks, buses, etc.), but requires extensive processing, and needs to be kept cold (256 F) during transportation.

Vegetable Oil (red)
-Not much better emissions, SVO (straight vegetable) oil is expensive, only 1% of oil could be displaced from current production.

4.4 Biodiesel Movie

Our group made a movie of one of our team members van that runs on Straight Vegetable Oil (SVO). He acquires the oil from restaurants and filters and cleans it in his backyard. The only modification that his conventional diesel van required was a non-reactive fuel tank and a system that preheats the vegetable oil on its way to the engine.

4.5 Alternative Fuels Locations

Our group researched the existing infrastructure of alternative fuels within one hundred miles of Joliet.

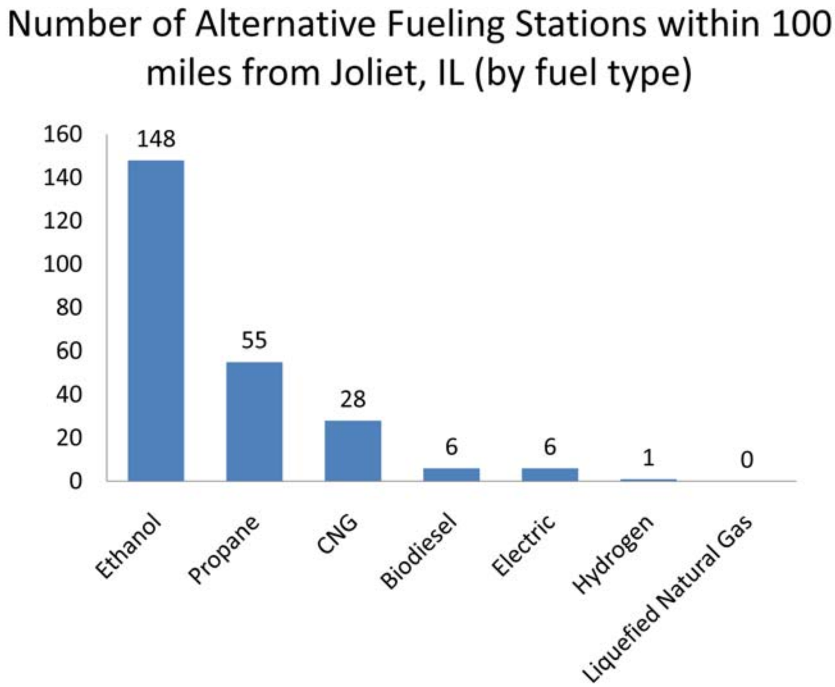


Fig. 4-x.

Fig. 4-x. Ethanol Stations within 100 mi of Joliet (148 Stations)

Fig. 4-x. Propane Stations within 100 mi of Joliet (55 Stations)

Fig. 4-x. CNG (Compressed Natural Gas) Stations within 100 mi of Joliet (28 Stations)

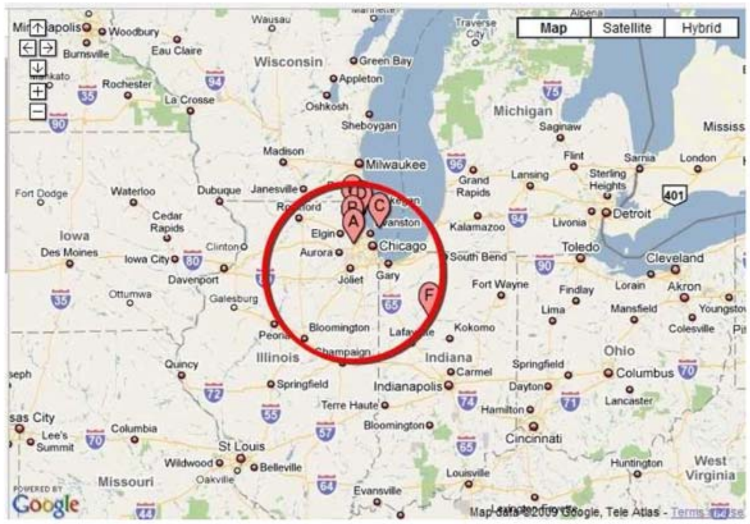


Fig. 4-x. Biodiesel Stations within 100 mi of Joliet (6 Stations)

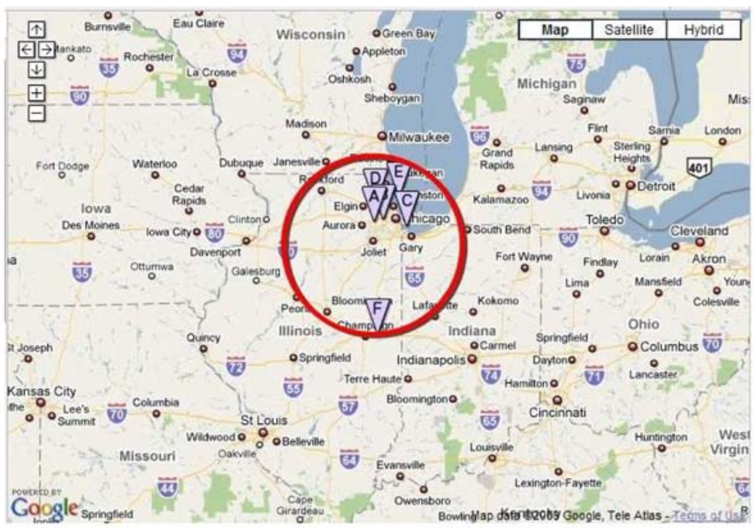


Fig. 4-x. Electric Stations within 100 mi of Joliet (6 Stations)

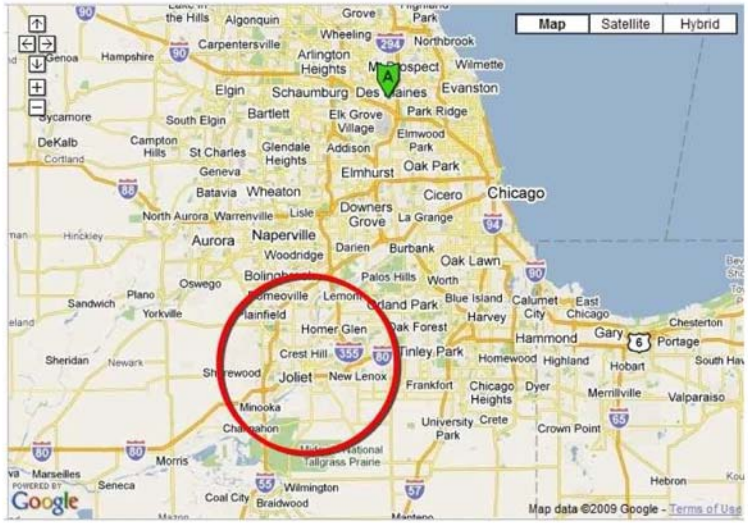


Fig. 4-x. Hydrogen Station within 100 mi of Joliet (1 Station)

4.6 Alternative Fuel Calculations

Demand Calculation

Purpose: To determine the energy needed to replace the existing dependence on fossil fuels by the year 2036 given the current production rates.
****Note:** Each biofuel was examined individually in order to determine the development required to replace fossil fuels with that single biofuel.

Assumptions:

- Biodiesel is reacted using a batch reactor and carried out at 70 degrees Celsius
- All of the biofuels (biodiesel and ethanol) are processed exactly the same and the rate of production remains constant
- In order to increase production more plants must be built
- The total energy of the world is modeled from a hyperbolic-tangent function fit
- The population of the earth in 2036 is 8.3×10^9
- There are 27 years until 2036
- The best way to increase production is to increase the number of biofuel plants

The basic concept behind my calculations is the same as that of the previous calculations. It seems though that there was some misunderstanding so I will go into more depth on theory.

Key Points:

The only reason why fuels are important is because they contain a large amount of energy that can be utilized by an engine. The total amount of fossil fuels used is the same thing as the amount of energy used. Energy is given out when the fuel burns and this energy is specific for each fuel.

Simplified Calculation:
(energy from biofuel)*(x)= (total energy used by fossil fuels)
(x is a number that determines how much of the fuel needs to be present to give the same amount of energy as that of fossil fuels)
For this calculation set once x is found the answer is in units of gallons (volume). In order to determine number of years that this amount of energy would need to be made by 2036 the rate at which the fuel is made must be estimated. The estimation of this rate was to find the total amount of fuel produced in the U.S. and divide that by the number of fuel production plants. The result of this give the units yrs*plant.
In order to determine the number of plants needed to produce this much fuel by 2036 the following equation was determined:
(years until 2036)*(x)=(total number of plants for years until 2036)
This formula says that if there are 27 years until 2036 I need to have x number of plants in order to reach my expected goal.
When the total number of plants by 2036 was calculated this resulted in two data points. These two points were plotted and the slope between them shows the rate at which the plants must be produced.

Results:

In conclusion the estimation calculated appears to be in serious error. The overall number of plants that need to be constructed in order to meet the approaching energy gap is vastly overestimated.

Reviewing the calculations performed the assumption/method that brought on the most error dealt with the rate of production of the biofuels. In order to determine rate in which the biofuels were produced from each plant, the total volume of biofuel produced for the U.S. was obtained and divided by the corresponding total number of plants for that year. This results gave an average rate of production with units of volume/(year*plant), in other words the amount of fuel produced in one year for one plant.

This method assumes that all plants process the fuels exactly the same, which would mean they produce at the same rate. If this is taken to be true then the only way to increase the amount of fuel made is to increase the number of plants or build larger plants. In addition this assumption means there would be no significant technological advancements within the 27 years of processing.

There are a variety of methods that can be used to produce the same biofuel. In terms of production time by far the fastest method is a continuous reactor which processes chemicals without stopping similar to an assembly line. The second method is the batch reactor which combines the reactants in a large vessel and the reaction is allowed to take place. Once a specific amount of time has passed the final product is removed, this is the slower method.

In determining the rate for biodiesel production the only data found was that of a commercial batch reactor. In addition the temperature at which the reaction occurred was assumed to be 70 degrees Celsius. Both of these assumptions result in a much larger time required to produce biodiesel when compared to a continuous reactor.

Once the total number of plants was determined the data was plotted for each individual fuel. Given the lack of data points the behavior was assumed to be linear. The assumption for linear behavior is in error because this would mean that every year a large number of plants would come online. This is not physically possible given the complexity of these plants and the need for proper location. Currently the number of biofuel plants produce a very small fraction of energy required to offset fossil fuels. If the world is to indeed avoid the projected energy gap the growth will most likely be an exponential or polynomial function. This means that construction on a large number of plants begins at the same time, and when completed the production of biofuels skyrockets.

Calculations for the production of alternative fuel needed in order to replace the existing dependence on fossil fuels by the year 2036.

<u>Calculations</u>

Units:
J = joule (unit of energy)
Gal= gallon (unit of volume)

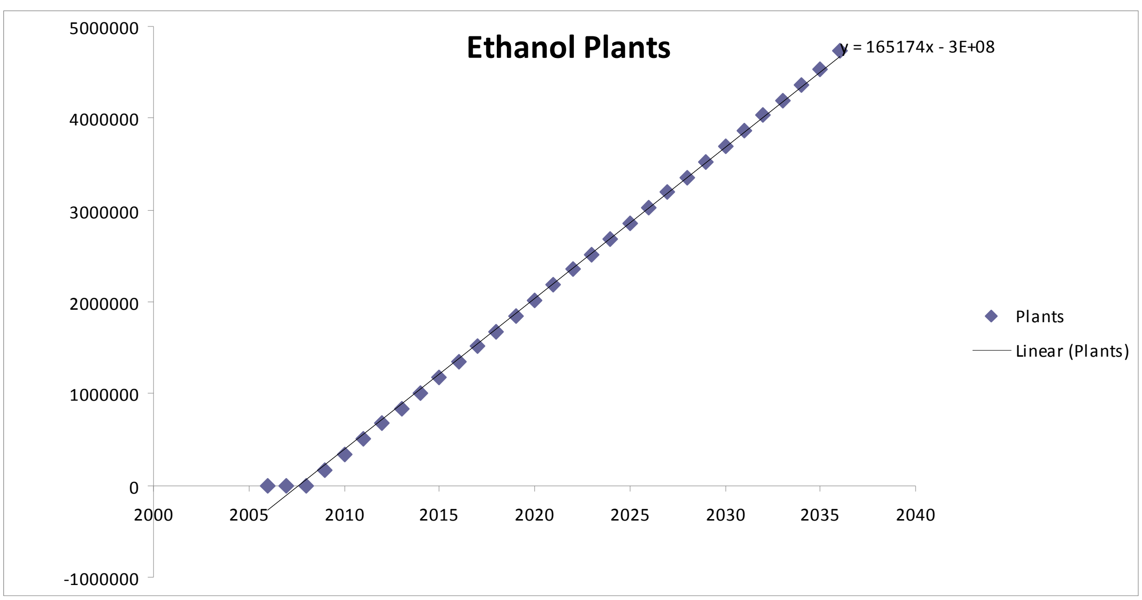
Ethanol

$$\left(\frac{1300x10^3 J}{mol}\right)\left(\frac{1mol}{46g}\right)\left(\frac{786kg}{m^3}\right)\left(\frac{m^3}{264gal}\right)X = 6.225x10^{20} J$$

$$\left(\frac{7.40x10^{15} gal}{1}\right)\left(\frac{57.38x10^6 gal}{year}\right) = 1.28x10^8 (years * plants)$$

$$27(years)X = 1.28x10^{14}(years * plants)$$

$$X = 185185\,\frac{plants}{year}$$



Hydrogen

$$\left(\frac{286x10^3 J}{mol}\right)\left(\frac{1mol}{2g}\right)\left(\frac{1000g}{kg}\right)\left(\frac{0.0899kg}{m^3}\right)\left(\frac{m^3}{264gal}\right)X = 6.225x10^{20} J$$

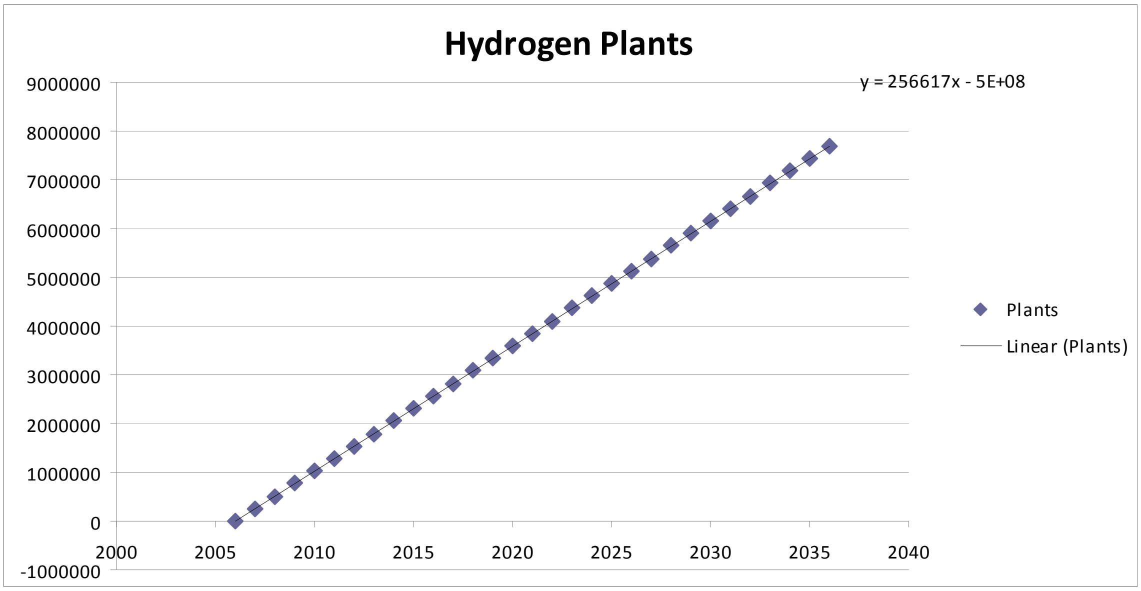
$$X = 1.27x10^{16} gallons$$

$$\left(\frac{1.27x10^{16} gal}{1}\right)\left(\frac{2.31x10^7 m^3}{year}\right)\left(\frac{m^3}{264gal}\right) = 2.08x10^6 (years * plants)$$

$$27(years)X = 2.08x10^6 (years * plants)$$

$$X = 7.70x10^4 plants$$

$$X = 2852 \frac{plants}{year}$$



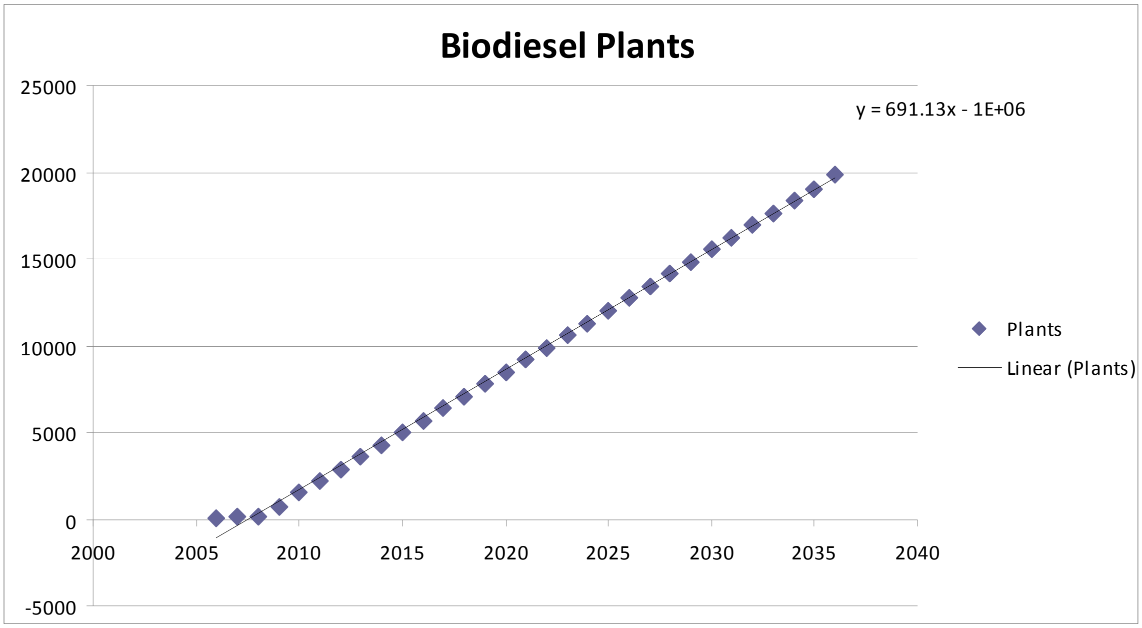
Biodiesel

(volume calculated similar to previous calculations)

$$X = 4.41x10^{12} gallons$$

$$\left(\frac{4.41x10^{12} gal}{1}\right)\left(\frac{8228571 gal}{year}\right) = 535937 (years * plants)$$

$$X = 1.98x10^4 plants => 735\ \frac{plants}{year}$$



4.7 Current Intermodal Setup

Summary… [Ryan]

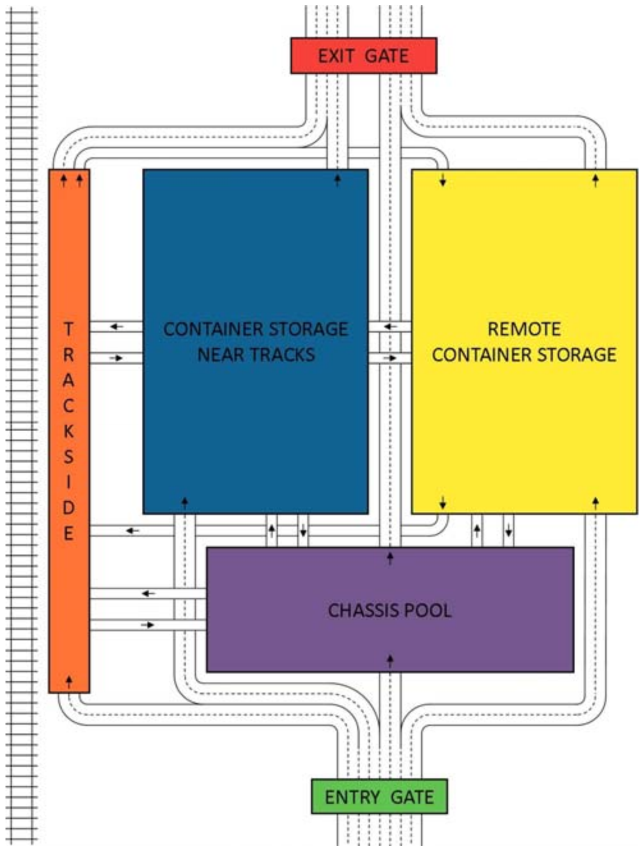


Fig. 4-x. Conventional Terminal Diagram

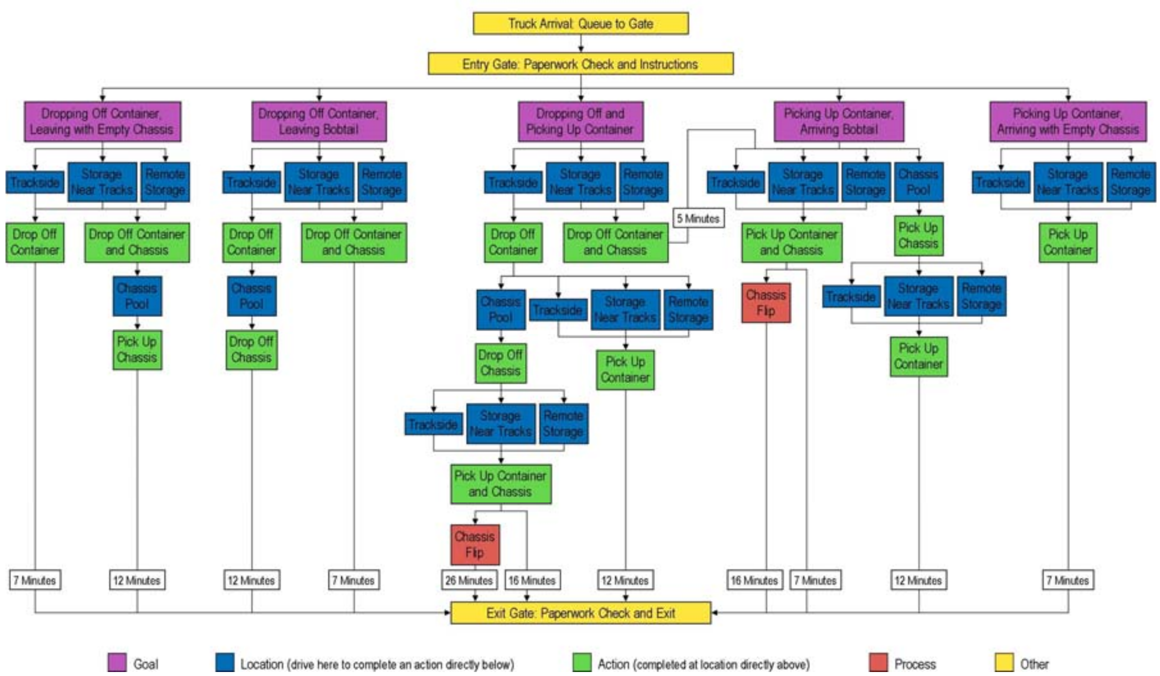


Fig. 4-x. Conventional Terminal Flowchart, with timings

4.8 New Pathfinder System

Summary… [Ryan]

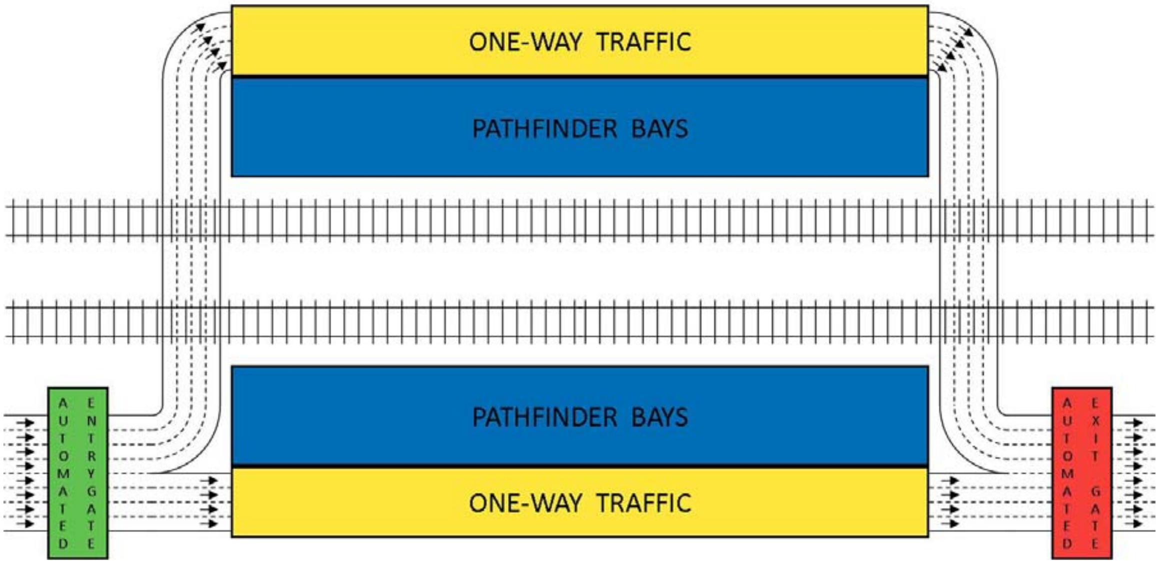


Fig. 4-x. Terminal with Pathfinder Diagram

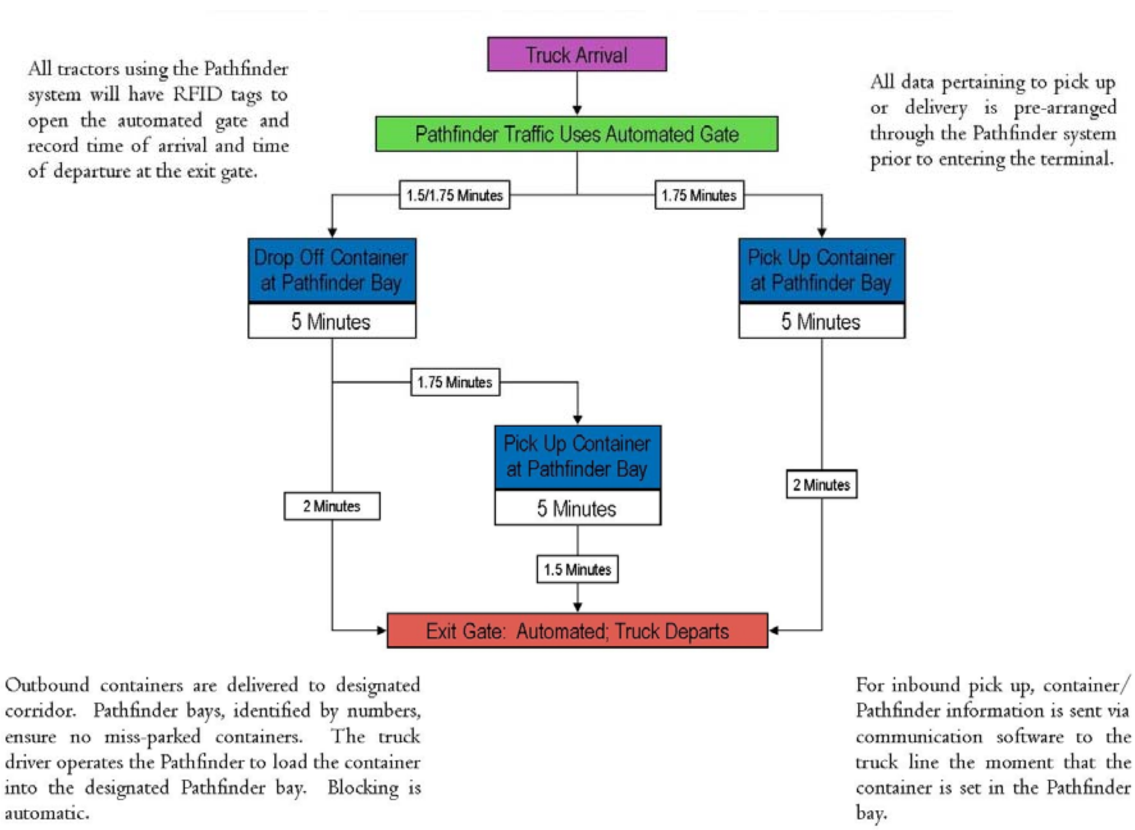


Fig. 4-x. Terminal with Pathfinder Flowchart, with timings

4.9 Team Created Movie

The Fall semester IPRO-307 team was new to the ideas of intermodal freight transportation and facilities. Research of their equipment, concepts and layouts was completed to educate the group so that further research and tasks would be completed with an understanding of how facilities operate. Information was gathered from previous IPRO-307 semesters as well as from hofstra.edu. A lot of information and pictures were found, but it could have been overwhelming for people and pictures were limited to a person's imagination.

The team created a simplified movie showing how the conventional facility works. The movie was designed to use the fewest different types of models and simple directing to reduce the strain on older computers and to decrease render time and the number of key-frames. The file also has the ability to be expanded on next semester.

The truck used in the film completes its role as a 3rd party owned truck as well as also taking the role of a hostler and receives a container from a train. This action is not typical, since hostlers move containers to and from the remote storage area from trains and move to another area where a 3rd party truck can pick up the container and deliver it. The movie instead has the truck also take the role of holster so the viewers can also see the crane loading in action and to have a better view of the facility as a whole.

Fig. 4-x. Truck Entering Intermodal Freight Facility Queue.

Fig. 4-x. Mi-jack Gantry Crane Lifts Container Off Train And Prepares To Load Truck.

Fig. 4-x. Mi-jack Pathdfinder concept with truck dropping off container.

<u>4.10 Simulation output (Summary)</u>

Simulation Details

The Simulation takes in the type of terminal, the number of railways, the percent of trucks arriving with a container, and the percent of those trucks that also leave with a conainer.

The simulations are a very rough estimate. There are a number of assumptions and choices that were made that cause the differences from what the actual statistics are.

Example Pathfinder(Future) Solution Simulation

```
~/simulation> java Simulator Pathfinder 3 80 30

****************************************************************

*                      Pathfinder Solution                     *

****************************************************************

* Settings: Railroads = 3

* Settings: Cranes Per Railroad = 1

****************************************************************

* Lifts Per Hour = 104.33

* Trucks Per Hour = 172.00

* Trains Per Hour = 0.73

* Average Truck Duration Within Terminal = 5.10 minutes

* Average Train Duration Within Terminal = 161.02 minutes

****************************************************************
```

Example Current Solution Simulation

```
~/simulation> java Simulator Pathfinder 3 80 30

****************************************************************

*                       Classic Solution                       *

****************************************************************

* Settings: Railroads = 3

* Settings: Cranes Per Railroad = 1
```

```
****************************************************************

* Lifts Per Hour = 68.75

* Trucks Per Hour = 40.75

* Trains Per Hour = 0.20

* Average Truck Duration Within Terminal = 5.77 minutes

* Average Train Duration Within Terminal = 450.93 minutes

****************************************************************
```

Actual Pathfinder Statistics

Time to Drop Off or Pick Up a Container: 5 minutes

Time to Unload and Load a Train: 3 hours

Lifts per Crane per Hour: 40

Actual Conventional Statistics

Time to Drop Off or Pick Up a Container: 5 minutes

Time to Unload and Load a Train: 13 hours

Lifts per Crane per Hour: 40

Simulation Information

A portion of our project was devoted towards simulating both the conventional terminal and the future (Pathfinder) terminal. The first obstacle encountered was to determine how the simulation was going to be constructed. After investigating two of the more robust simulation designing applications, it was decided that using a pre-built system would not be practical. The only other viable choice was to write the simulations from scratch. The complexity of the terminals made for a tough problem, but with a few generalizations the simulators became a possible task. The simulators were written in Java, at first using a set of complex and complete classes. As the difficulty in scheduling became more apparent this system was pared down and rewritten to be more focused on the timings for trucks and trains rather than the containers. Over the following semesters of IPRO 307 the simulators could be upgraded to become both more accurate and robust.

4.11 Definition of a Freight City

Many intermodal facilities are part of a larger "freight city." The idea of a "freight city" includes amenities for truckers and workers of a large intermodal facility. These typically include chassis pools and fueling stations, as well as hotels and restaurants to service drivers. Our team has included plans for a Gas C***iit***y fueling station near the facility, adjacent to the interstate.

4.12 Google Earth Files

Summary… talk about how this is an active file, ready to be changed by future groups [John]

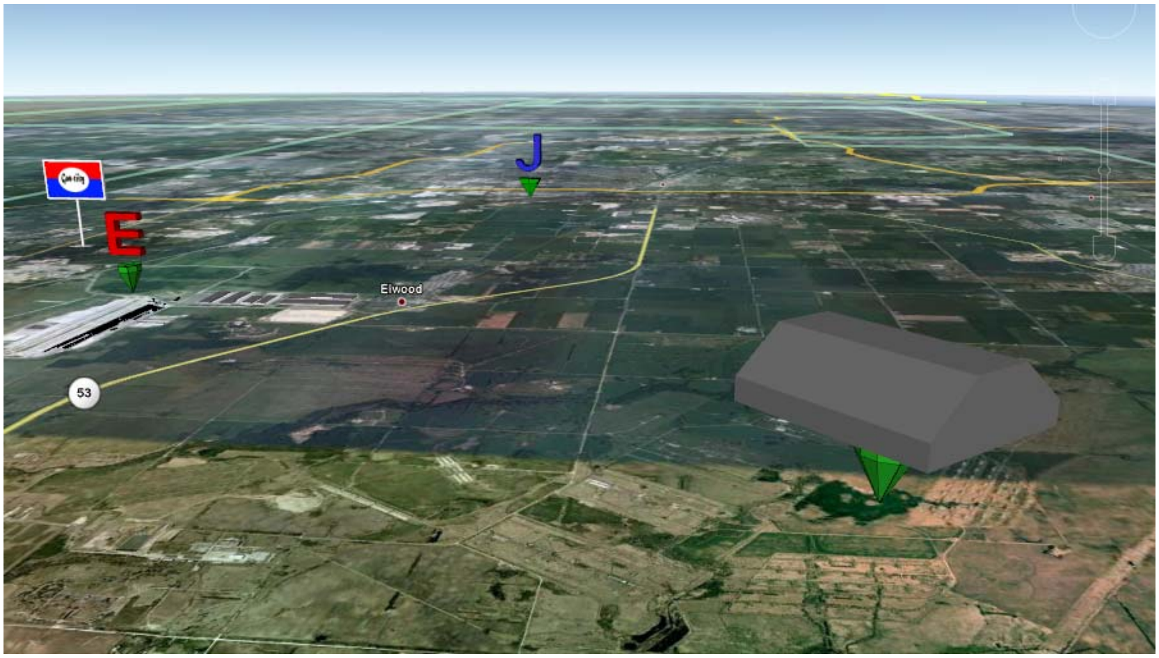


Fig. 4-x. Site Picture

Fig. 4-x. Location Overview

4.13 Gas Station Precedent Analysis

Summary… [John, Konstantin]

		Gas Ciity	O'Hare	Russel Rd		
Trucks	Traffic Overall	14250	10900	11500		
	Traffic to Station (4% of overall)	570	436	460		
	Parking area (ft^2)	133803.4	72000	140000		
	Parking area/traffic (ft^2/truck)		165.1	304.3	Ave. parking area/truck (ft^2/truck)	234.7
	Pumps	6	4	6		
	Pumps/truck		0.009174	0.013043	Ave. pumps/truck	0.0111
Cars	Traffic Overall	55300	161000	89000		
	Traffic (4% of overall)	2212	6500	3560		
	Parking area	16342.61	50400	25000		
	Parking area/traffic (ft^2/car)		7.8	7.0	Ave. parking area/car (ft^2/car)	7.4
	Pumps	6	12	12		
	Pumps/car		0.001846	0.003371	Ave. pumps/car	0.0026
	Building area		3500	8100		

Fig. 4-x. Gas Stations Comparison/Analysis Chart

Trucks	Daily Traffic (trucks/day)	10900
	Traffic to Station (trucks/day)	436
	Parking area (ft^2)	72000
	Pumps	4
Cars	Traffic Overall (cars/day)	161000
	Traffic to Station (cars/day)	6500
	Parking area (ft^2)	50400
	Pumps	12
	Building area	3500

Fig. 4-x. O’Hare Oasis Gas Station

Trucks	Daily Traffic (trucks/day)	11500
	Traffic to Station (trucks/day)	460
	Parking area (ft^2)	140000
	Pumps	6
Cars	Traffic Overall (cars/day)	89000
	Traffic to Station (cars/day)	3560
	Parking area (ft^2)	25000
	Pumps	12
	Building area	8100

Fig. 4-x. Russell Rd. Truck Stop

<u>4.14 Gas-Ciity Location Analysis – including traffic counts</u>

The location for our proposed Gas-Ciity alternative fuel station had to be determined. Following requirements had to be met: station has to be feasible, function efficiently and not be a discomfort to a local population.

Four sites (A, B, C, and D) in the proximity to the intermodal facility were chosen. These locations were analyzed by the means of the Measures of Effectiveness analysis (MOE). Three major criteria were stated: Average daily traffic count, proximity to the residential area, and proximity to the intermodal facility. Location C – at the intersection of I-55 highway and Bluff Rd. - came first as the option with the most balanced results in for all the criteria. Needed data was obtained from the IDOT website, area dimensions were determined using Google Earth software.

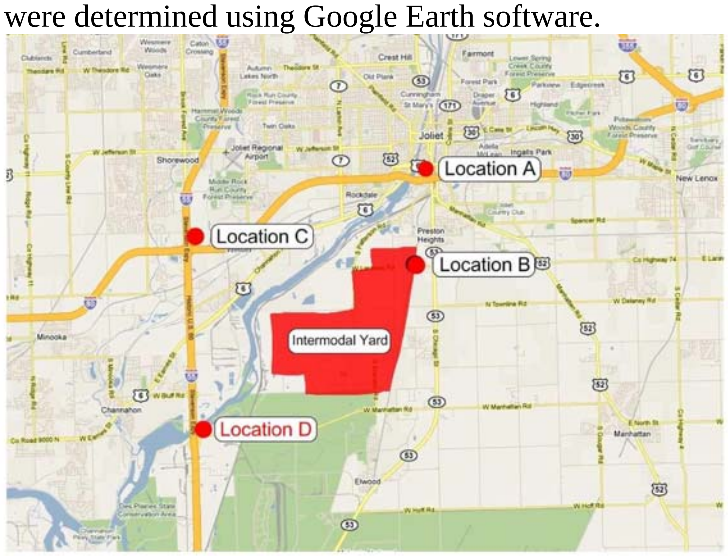
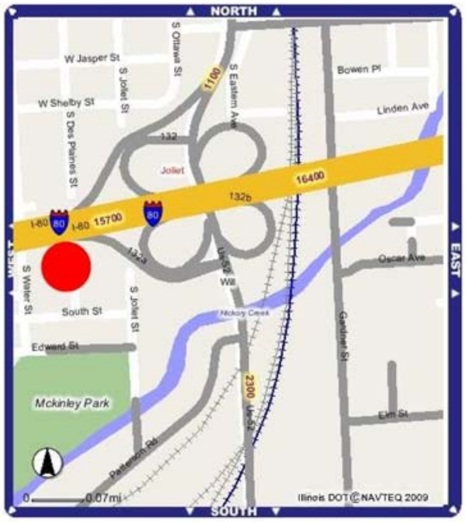
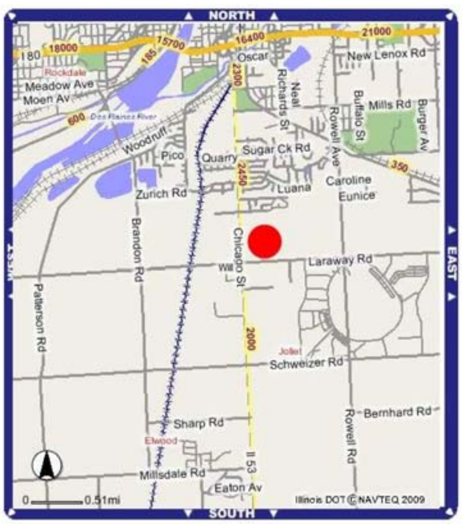


Fig. 4-x. Area Overview



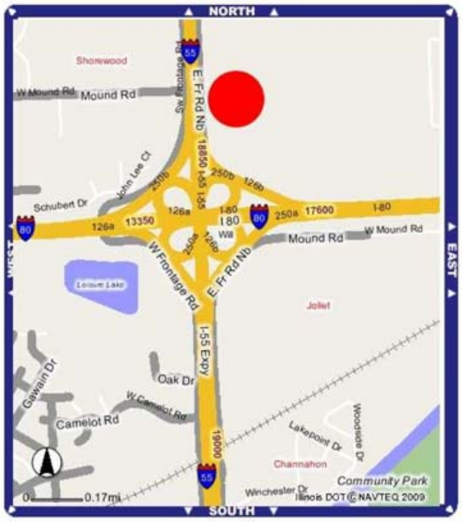
Truck Count: 15700 trucks/day
Proximity to the Facility: ~3 miles
Proximity to residential area: 5 pt.

Fig. 4-x. Location A – near I-80 and IL-53



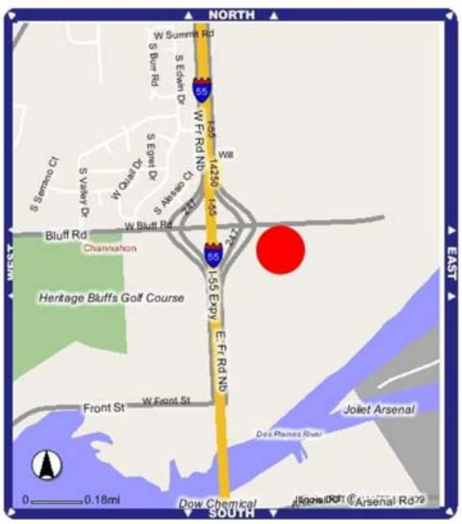
Truck Count: 15700 trucks/day
Proximity to the Facility: on site
Proximity to residential area: 2 pt.

Fig. 4-x. Location B – On site



Truck Count: 18850 trucks/day
Proximity to the Facility: ~8 miles
Proximity to residential area: 3 pt.

Fig. 4-x. Location C – near I-80 and I-55



Truck Count: 14250 trucks/day
Proximity to the Facility: ~6 miles
Proximity to residential area: 1 pt.

Fig. 4-x. Location D – near I-55 and Bluff Rd.

	1 (traffic)	2 (impact on population)	3 (proximity to facility)	Total Effectiveness (lower score – better effectiveness)
On Site	7.7 (2450 trucks/day)	2 pt.	1 (on site)	3.6
I-80/IL-53	1.2 (15700 trucks/day)	5 pt.	4 (~3 miles)	3.4
I-55/Bluff Rd.	1.3 (14250 trucks/day)	1 pt.	7 (~6 miles)	3.1
I-80/I-55	1 (18850 trucks/day)	3 pt.	9 (~7 miles)	4.3

Fig. 4-x. Location Analysis Matrix

<u>4.15 Gas C*iity*</u>

After the location for the Gas-Ciity was chosen – dimensions of the station and a number of pumps had to be determined. Since the average daily traffic is the main factor affecting the size of the proposed fuel station - we looked at two stations in Illinois: O'Hare Oasis and the Truck Stop off the I-94 by the IL-WI border. Number of pumps and dimensions of each of the station was compared to the average daily traffic to the station. Then based on the numbers obtained – dimensions and number of pumps for Gas-Ciity was determined to furnish the traffic to the Gas-Ciity location.

Trucks	Daily Traffic (trucks/day)	14250
	Daily Traffic to Station (trucks/day)	570
	Parking area (ft^2)	133803.4
	Pumps	6
Cars	Daily Traffic (cars/day)	55300
	Daily Traffic to Station (cars/day)	2212
	Parking area (ft^2)	16342.61
	Pumps	6

Fig. 4-x. Gas C***iit***y Alternative Fuel Site

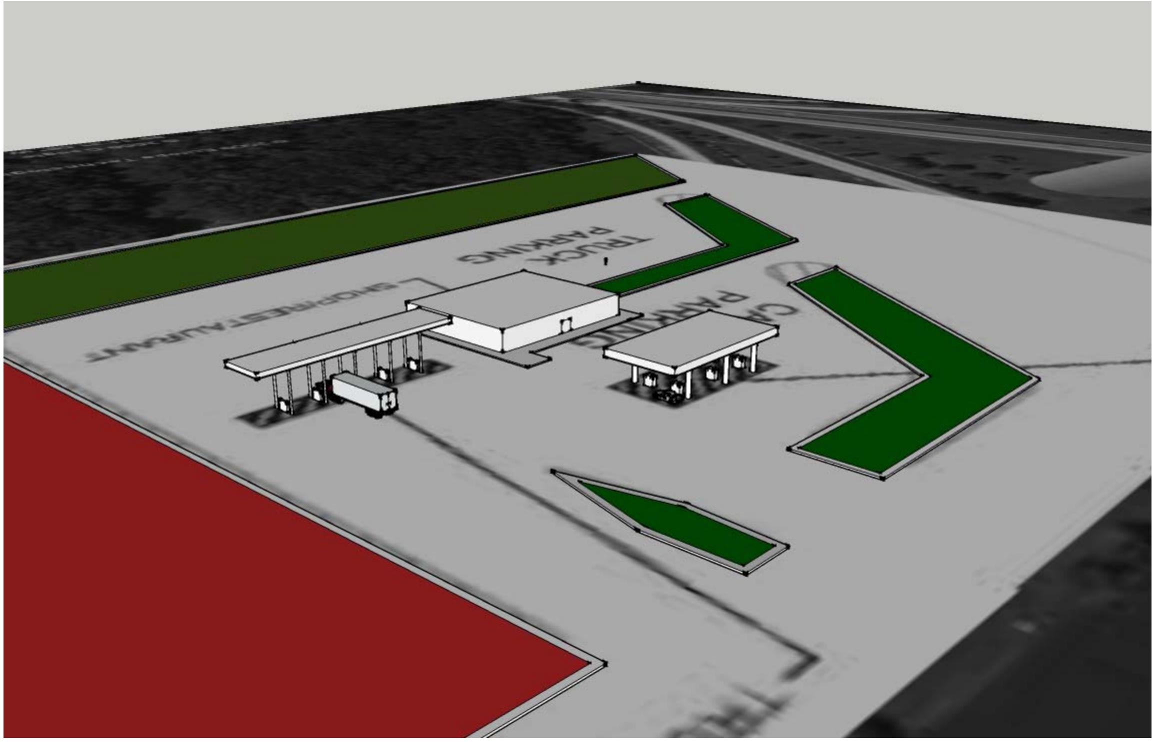


Fig. 4-x. Gas C***iit***y Rendering

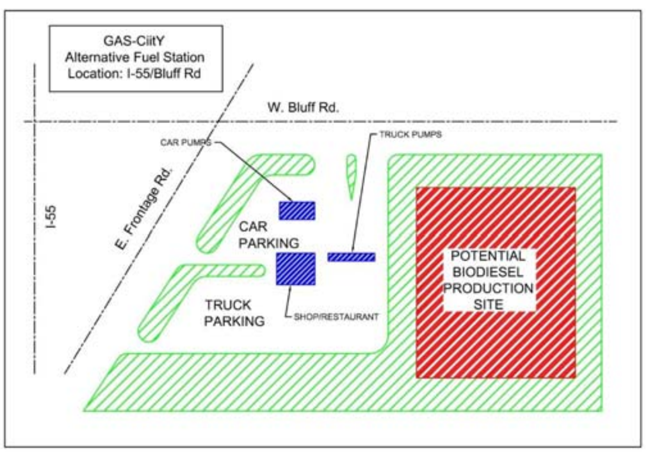


Fig. 4-x. Gas C***iit***y Site Plan

<u>4.16 Cost Analysis For Biodiesel Production On Site</u>

Purpose: To determine the price of onsite production of biodiesel based on the traffic statistics calculated.

Assumptions:

- The overall traffic consists only of medium sized cars
- The cars fill up an entire gas tank

- The cars will run entirely only biodiesel
- The biodiesel reactor has a batch size of 300 gallons
- The reactor is capable of making 3 batches a day
- The overall traffic is per month
- The price of biodiesel production remains constant
- The hourly wage of a part-time worker is $9.00/hr and works 4hrs
- The cost for transportation of the reactants is neglected

Approach:

The approach to this problem starts with obtaining correct traffic data. The total traffic per month has been estimated and all that is left is to determine how much energy (biodiesel) these cars need. This approach is the same one used in my other calculations and is basically an energy balance.

Results:

In conclusion the initial start up fee for the first month will be $36905. This includes the cost of fuel, the worker's wage, and the initial purchase of the reactor. After the initial purchase the monthly cost will drop to $30305 and is expected to stay constant or decrease slightly. The reactor will occupy 32 square feet and is 11 feet tall. The reactor can be operated outside but special precautions much be taken to avoid weather damage. As long as there is sufficient space to store excess biodiesel produced there will not be any shortages of biodiesel given the reactor can produce 900 gallons a day. Lastly the price for production of biodiesel does not take into account any additional increases to ensure a profit.

5. Conclusions and Recommendations

Some issues involved in having another freight terminal in Joliet may include;

- Neighboring area will be burdened with increased traffic and noise
- Possible pollution from vehicles and ice salt may contaminate surrounding area
- Would increase volume of water that needs to be treated

After running the simulation we understand how much faster and efficient a Pathfinder system is compared to a conventional system. A more efficient intermodal freight terminal allows for less materials, less time required for drivers, and less room for error. It could also possibly reduce the number of freight yards needed in the Joliet (as well as Chicago) area minimizing the issues previously stated.

Some issues that may be involved with this new system may include;

- Capital development and installation
- Faster more efficient yards will displace jobs, which might not be that much of an issue considering a job in the yard gets more dangerous the closer you get to moving containers.

Oil plays an important role in transportation of goods. With oil running out and greenhouse gas emissions rising, we *need* alternatives to keep our economy running and also keep the earth as an inhabitable environment. Our problem may not just lie in alternative fuels, but how we transport our goods along with our selves.

The next IPRO will have their site located in Harvey, Illinois. Some recommendations for them may be to investigate how one of these Pathfinder systems would displace other terminals in the city and also what steps could be taken to lessen traffic, noise, and pollution in the area. They may also want to investigate a way to persuade society to use more local goods to help reduce the need for these large yards, thus reducing traffic, thus reducing pollution, noise, congestion etc.

Appendix

Fuel Type	Availability	Cost of fuel (gal)	Vehicle Alterations Required
Vegetable Oil (WVO, SVO)	Local greasy food restaurants and factories. As of 2000 the United States was producing in excess of 2.9 billion gallons of waste vegetable oil annually. WVO, SVO, PPO.	Free other than initial cost for filtration system	Diesel car with separate tank for vegetable oil containing heating element and a three way valve.
Biodiesel	Same as vegetable oil; Fats and oils from sources such as soy beans, waste cooking oil, animal fats, and rapeseed	Initial investment in reactor required. Costs are dependent on cost of methanol and catalyst used to create fuel	None for newer cars. Older cars require replacing rubber fuel lines with biodiesel compatible lines.
Algae Fuel (biodiesel/biobutanol)	Can be grown on ocean or wastewater. Yields claims cover a vast range from 5,000 to 150,000 US gallons of oil per acre per year. Algae can produce 15-300 times more oil per acre than conventional crops.	Expensive processing plants.	Biodiesel (B100) can be run in any newer diesel engine. In most gasoline engines, biobutanol can be used in place of gasoline with no modifications.
Hydrogen fuel cell	Hard to acquire. Moving and storing mass quantities is unpractical and costly. Non-existent infrastructure.	With renewable energy produced on site, gas only costs initial instalation of equipment + maintanence.	Basically an electric car with hydrogen tank, a fuel cell stack, and an air compressor.

Propane/LPG	A by-product of petroleum refining or natural gas processing. Approximately half of the LPG in the U.S. is derived from oil, but no oil is imported specifically for LPG production.	World prices of LPG in general move in line with crude oil prices, although as with most commodities it does have its own supply and demand parameters, which is a critical determinant of price.	Gasoline and diesel vehicles can be retrofitted to run on LPG in addition to conventional fuel. The LPG is stored in high-pressure fuel tanks, so separate fuel systems are needed in vehicles powered by both LPG and a conventional fuel such as gasoline.
Ethanol	Abundant in Midwest. Comes from corn, grains, or agricultural waste (cellulose).	It is cheaper than gasoline in some areas, such as the Midwest, and more expensive in others.	Flex fuel vehicles are commercially produced and already retrofitted for ethanol fuel blends.
CNG	Domestic, available around the world. Underground reserves.	Less expensive than oil. Anywhere from $0.95 to $2.50 in the midwest. Usually just over $1.	CNG is stored on board vehicles in (3,000-3,600 psi) tube-shaped puncture -safe cylinders that are installed in the trunk, roof, bed or undercarriage of the vehicle. CNG travels from tank through high pressure fuel line with a filter and a pressure regulator. Then it travels through a low pressure line to the fuel injectors. Roughly $4,000 for parts, excluding tools required.
LNG	Domestic, available around the world. Underground reserves.	Less expensive than oil.	LNG is stored in special cryogenic cylinders resembling a vacuum flask to retain the cold temperature. LNG can be used for all classes of vehicle but is generally used in heavy vehicles which are used frequently.

Fuel Type	Processing	Efficiency	Emmisions
Vegetable Oil (WVO, SVO)	Settling tanks with series of filters.	85-95% efficient compared with petroleum based diesel.	Less carbon dioxide and sulfur. More nitrous oxides
Biodiesel	React vegetable oils or animal fats catalytically with a short-chain aliphatic alcohols (typically methanol or ethanol).	90-95% efficient compared with petroleum based diesel fuel. B100 has 103% the energy of gasoline or 93% of diesel. B20 has 109% of gasoline or 99% of diesel.	Biodiesel is domestically produced, renewable, and reduces petroleum use 95% throughout its lifecycle.
Algae Fuel (biodiesel/biobutanol)	Expensive process of converting algae to biodiesel or biobutanol. PhotoBioreactors, Closed loop system, Open pond, Fermentation tanks.	Biobutanol has an energy density 10% less than gasoline, and greater than that of either ethanol or methanol.	Depends on the production process. Systems have been made to recycle CO2 emissions from power plants.
Hydrogen fuel cell	Production on site makes for less distribution costs, but higher production costs.	The energy in 2.2 lb (1 kg) of hydrogen gas is about the same as the energy in 1 gallon of gasoline. 1lb H2 has 44.4% the energy in 1 gal gasoline.	Depends on type of production of hydrogen and oxygen (renewable energy?)
Propane/LPG	LPG can occur naturally with other hydrocarbons such as wet natural gas in oil and gasfields, or it can be extracted at oil refineries during the production of other petroleum products.	73% compared to gasoline.	Fewer toxic and smog-forming air pollutants.
Ethanol	Starch of the corn is acidified into sugar then fermented into CO2 and ethanol. Wastes are distilled out and the ethanol gets shipped to E85	Lower energy content, resulting in fewer miles per gallon (20-30% drop in miles per gallon). E100 contains 66%, E85 contains 72% to	Ethanol is produced domestically. E85 reduces lifecycle petroleum use by 70% and E10 reduces petroleum use by 6.3%.

	stations where it is blended with gasoline.	77%.	
CNG	Extensive processing. Remove biproducts; ethane, propane, butanes, pentanes and higher molecular weight hydrocarbons, elemental sulfur, and sometimes helium and nitrogen.	1 lb CNG has 17.5% the energy of 1 gal gasoline.	60-90% less smog-producing pollutants. 30-40% less greenhouse gas emissions.
LNG	Remove hydrocarbons, sulfur compounds and water. Then cool to -256F. Then ship by insulated LNG tankers. While LNG can be produced on-site from available natural gas, it is typically delivered to the station via tanker truck.	Same horsepower and performance as diesel counterparts. 64% compared to gasoline.	Cleaner for the environment than diesel.

Fuel Type	Pros	Cons	Infrastructure
Vegetable Oil (WVO, SVO)	From current production 1% of US oil consumption could be offset. Not very difficult or costly.	The EPA clearly states it is illegal to burn SVO (straight vegetable oil).	Viable as a fuel today. Small systems with a centrifuge can handle 5-7 gallons per hour. Larger systems are feasible.
Biodiesel	Could offset 1% of US oil consumption. No vehicle modification necessary. Lubricity is improved over that of conventional diesel fuel.	Needs at least a B20 mix to be used in freezing winter climates. Hoses and seals may be affected by higher-percent blends.	Viable as a fuel today. 100 gallon per day reactors can be acquired easily.
Algae Fuel (biodiesel/biobutanol)	The United States Department of Energy estimates that if algae fuel	Energy losses due to converting the algae lipids into fuels.	Only a few plants exist, however bio-fuel infrastructure is fairly abundant.

	replaced all the petroleum fuel in the United States, it would require 15,000 square miles.		
Hydrogen fuel cell	Potential for near-zero greenhouse gas. Doesn't need to be imported. Low noise. When hydrogen is used in fuel cell applications, maintenance should be very minimal.	low volumetric energy density calls for a large tank. Moving and storing mass quantities is unpractical. Lack of infrastructure. Cost.	Fueling stations already exist in southern California. Fuel cost is comparable to gasoline.
Propane/LPG	85% of LPG used in U.S. comes from domestic sources. Less expensive than gasoline. The gaseous nature of the fuel / air mixture in an LPG vehicle's combustion chambers eliminates the cold-start problems associated with liquid fuels.	Extremely explosive. Fewer miles on a tank of fuel. No new passenger cars or trucks commercially available (2004 only1).	There are over 3,000 publicly accessible fueling stations nationwide.
Ethanol	Domestically produced, reducing use of imported petroleum. Practices are very similar, if not identical, to those for conventionally fueled operations. Byproducts in production can be used in other applications.	In the US, takes 1 gallon of fossil fuel to produce 1.3 gallons of ethanol. Less efficient than gasoline. Can only be used in flex-fuel vehicles. Currently expensive to produce. Fuel ethanol content is lowered to 70% in the winter in cold climates to facilitate cold starts. Special lubricants may be required.	Already avaiable at many gas stations around the country. Most popular in the midwest.
CNG	Most abundant natural resource in the US(could lessen	Only slightly "greener" than petroleum based	Vehicles already on the road. Ford, Honda, Mercedes… Stations exist in many

	dependence on foreign countries). Nearly 87% of U.S. natural gas used is domestically produced. Less expensive than gasoline. Very safe.	fuels. Fewer miles on a tank of fuel. High-pressure tanks require periodic inspection and certification.	locations, many of which are private. The Clean Air Act approves EPA certified conversions for vehicles as a clean fuel. Pipelines already exist around the country.
LNG	Liqufication reduces volume about 600x. Same horsepower. Very safe.	Need to put through a refridgeration process and kept cold during transport. High-pressure tanks require periodic inspection and certification.	Popular in austrailia, Lacks infrastructure in US.

Specific Fuels
Biodiesel
http://www.biodiesel.org/

Propane/LPG
http://www.aph.gov.au/library/INTGUIDE/sci/petrol.htm

Ethanol
http://www.cleanairtrust.org/E85-Chemical-Properties-Production.html

CNG
http://www.cngnow.com/EN-US/Pages/default.aspx

LNG
http://www.geoilandgas.com/businesses/ge_oilandgas/en/applications/lng_prodplant.htm

Multiple Fuels
http://www.fueleconomy.gov/FEG/current.shtml

http://www.afdc.energy.gov/afdc/fuels/properties.html

Alternative fuel prices
http://www.altfuelprices.com/

Alternative Fuel Station locations
http://www.afdc.energy.gov/afdc/locator/stations/

Gasoline Gallon Equivalent
http://alternativefuels.about.com/od/resources/a/gge.htm

Conversions and Regulations
http://www.transecoenergy.com/pages/CNG_Conversions.htm

Alternative Fuel Station locations
http://www.afdc.energy.gov/afdc/locator/stations/