The Solid Cabinet Corporation

A Supply Chain Network Configuration Project
IEM 5633 - Advanced Production and Inventory Control

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Executive Summary

The given business problem is about Solid Cabinet Inc., a company that produces and distributes file cabinets. In the current scenario, the company has two manufacturing facilities located in Des Moines and Dover who serve a number of retailer all over USA and small part of Canada. Both the facilities have their own warehouses for storage and supply of products. The newly appointed CEO had voiced his concerns about inefficiency of current distribution network and company Advanced Logistics Consulting was hired to re-engineer the entire distribution network.

The overall network optimization was done in Llamsoft Supply Chain Guru where. There was various data provided such as product details (price of the product was provided $55-$105) where for the calculation, price was assumed to be $105 alongside adjusted weight as 1. Furthermore, there were 313 customer demand sites in 2015 but since the software can only provide analysis for 100 sites, different customer sites were clustered to 82 sites based on the demand and distance profile. This 82 sites including 15 potential distribution centers and 3 manufacturing facilities account for total 100 sites. Demands of 2015 was taken into consideration for analysis and size of the facilities was determined by analyzing demand for 2016 and 2017 (3% growth of demand each year). Transportation rates were provided for FTL (Full truck load) and LTL (Less than truck load). Sourcing policies were added such that goods move from MFGs to potential facilities and from potential facilities to customers.

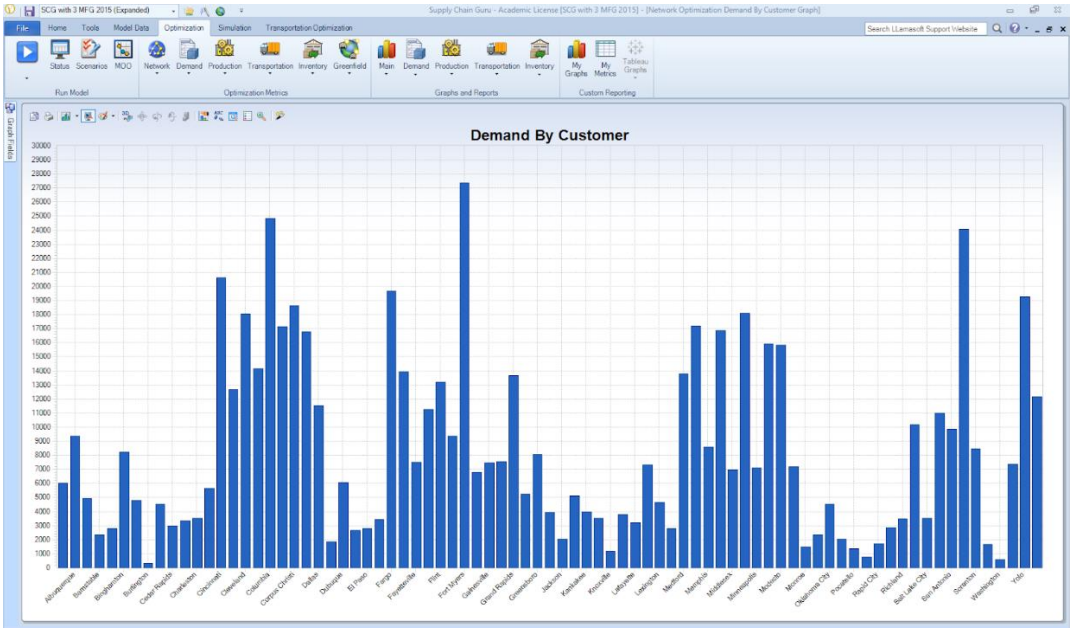
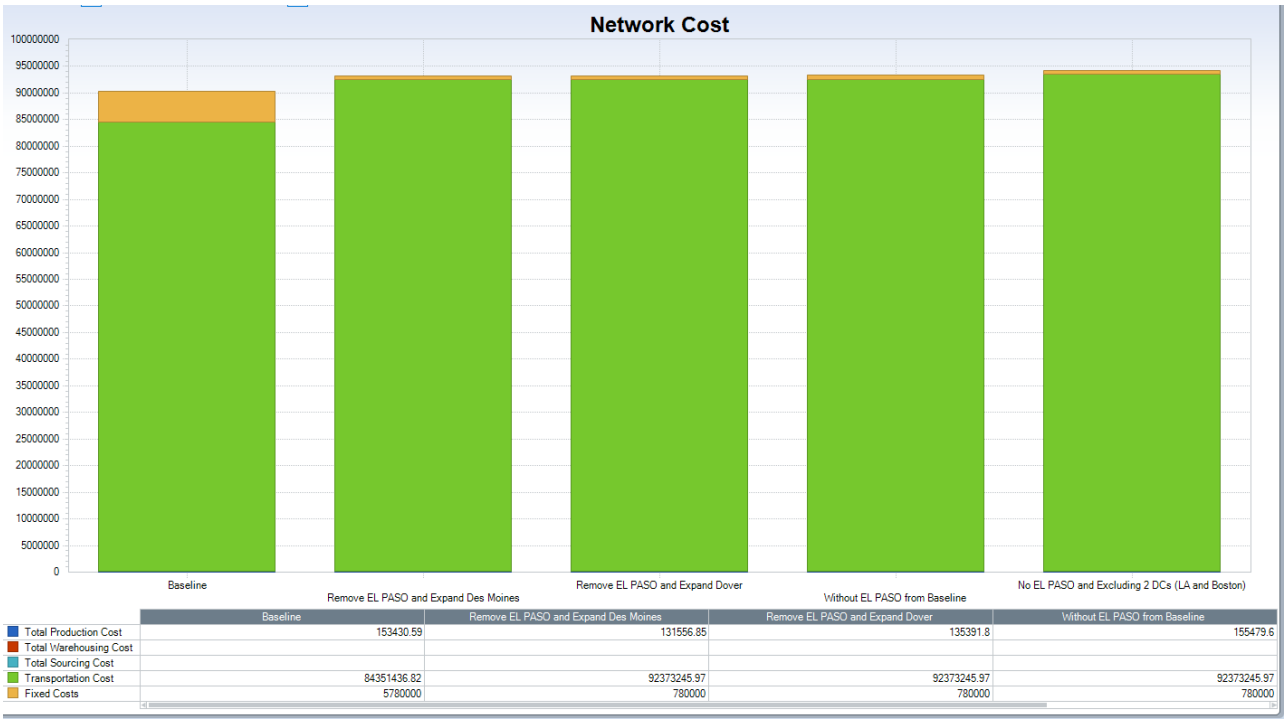


Fig 1: Demand of customer for different potential sites

Among the three scenarios provided which includes expanding MFG Des Moines, MFG Dover or establishing a new facility in El Paso, the third option establishing a new facility in El Paso resulted in the best solution. By building this new facility, the demand of customers in west was fulfilled sooner and this acquired less transportation cost. This significant decrease in transportation cost more than makes up for the building the facility which is 5 million. Apart from that, we would also recommend the corporation to consider opening all the potential facilities as that would also reduce transportation cost and the cost of opening a facility of size 600,000 is just $10,000.



	Baseline	Remove EL PASO and Expand Des Moines	Remove EL PASO and Expand Dover	Without EL PASO from Baseline
Total Production Cost	153430.59	131556.85	135391.8	155479.6
Total Warehousing Cost				
Total Sourcing Cost				
Transportation Cost	84351436.82	92373245.97	92373245.97	92373245.97
Fixed Costs	5780000	780000	780000	780000

Fig 2: Network cost of baseline with El Paso, expanding Des Moines, expanding Dover, baseline without El Paso and removing DCs respectively

Analysis

To approach the problem, we created different scenarios in which we created a baseline scenario, baseline including El Paso and all potential DCs, removing two DCs. Different scenarios provided varying results which can all be seen for the supply chain .sgpx file.

New Distribution Facilities

From the network optimization in supply Chain guru, it can be concluded that new distribution centers which are as of now potential facilities needs to be established. The transportation cost provided in the network optimization analysis was 0.31 for LTL(Less than truck load) which is used to ship products from the distribution centers to the customers and for transporting products from manufacturing sites to distribution centers, the cost used was 0.1 for FTL (Full Truck Load). The transportation cost used was weight basis (adjusted weight of the product taken to be 1). From the result, we can conclude that all the 15 potential distribution centers would be required to minimize the transportation cost. Below are the two results shown where we have compared a baseline (15 potential facilities and excluding El Paso as manufacturing facility) with scenario in which we removed distribution centers (Los Angeles and Boston).

Scenario	Without EL PASO from Baseline
Time of Run	10/12/2019 01:51:26
Type	Solve Optimally(MinCosts)
Optimization period	365 days
Total Cost	$96,711,686.34
Fixed Startup	$150,000.00
Fixed Operating	$630,000.00
Production	$155,479.60
Transportation	$92,373,245.97
Inventory Holding	$3,402,960.77
Total Revenue	$71,329,965.00
Profit	$-25,381,721.34

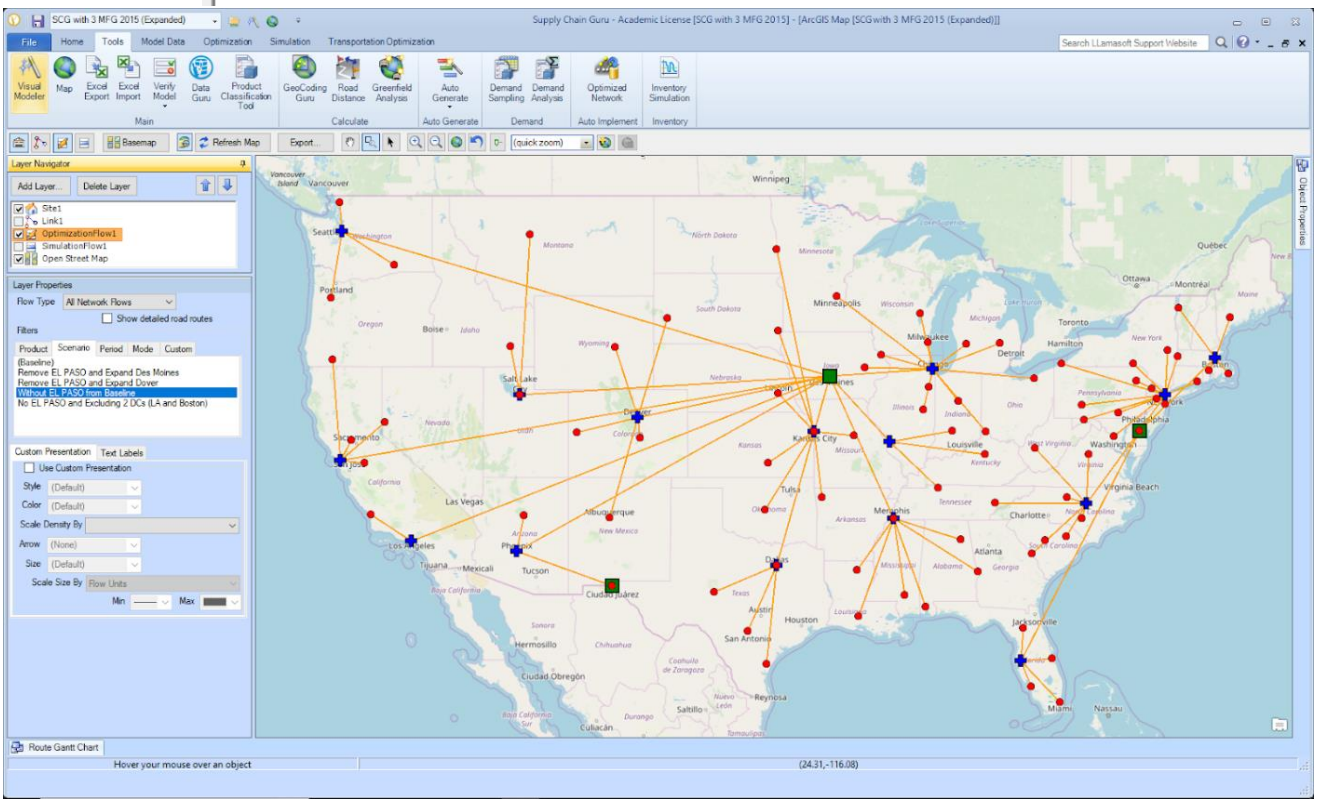
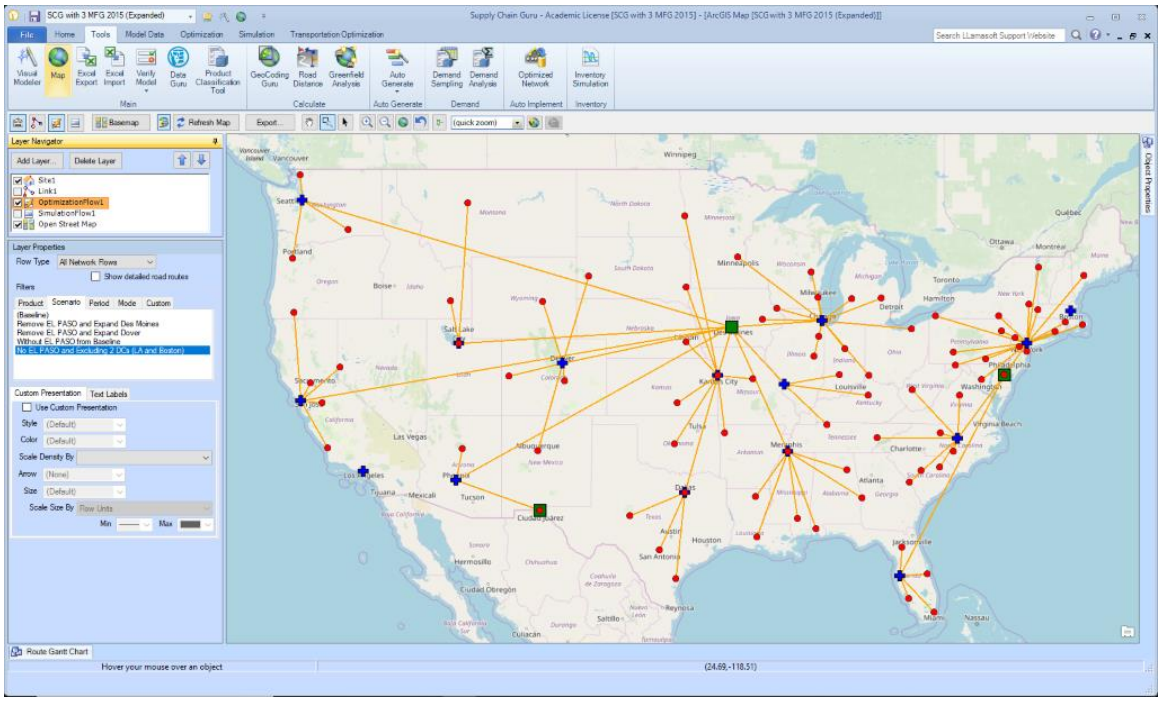


Fig 3: Network Cost for baseline (all potential DCs included without El Paso as manufacturing site)



Scenario	No EL PASO and Excluding 2 DCs (LA and Boston)
Time of Run	10/12/2019 01:51:51
Type	Solve Optimally(MinCosts)
Optimization period	365 days
Total Cost	$97,627,058.43
Fixed Startup	$130,000.00
Fixed Operating	$546,000.00
Production	$155,479.60
Transportation	$93,392,578.88
Inventory Holding	$3,402,999.95
Total Revenue	$71,329,965.00
Profit	$-26,297,093.43

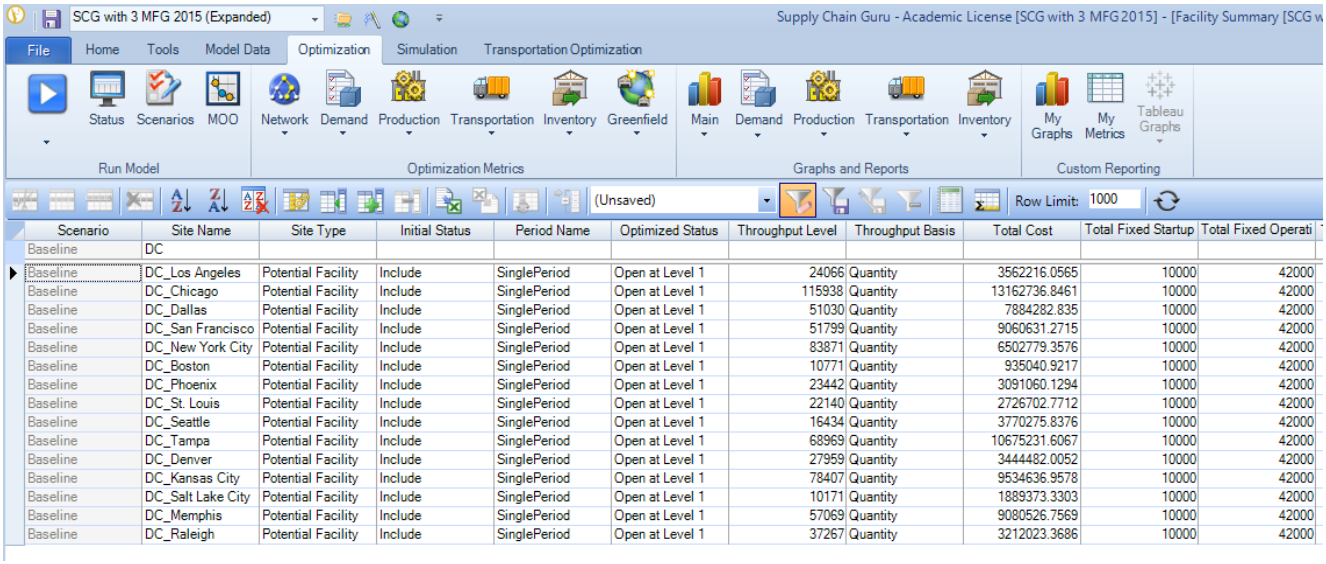
Fig 4: Network Cost for scenario excluding two DCs (Los Angeles and Boston)

From the above results we can clearly see that the transportation cost when removing the two facilities are overwhelming large ($93,392,578.88) that does not provide a tradeoff for opening cost ($10,000 for 600,000 capacity) for the distribution centers. Hence, we suggest to establish all 15 of the distribution centers.

Location of new warehouses

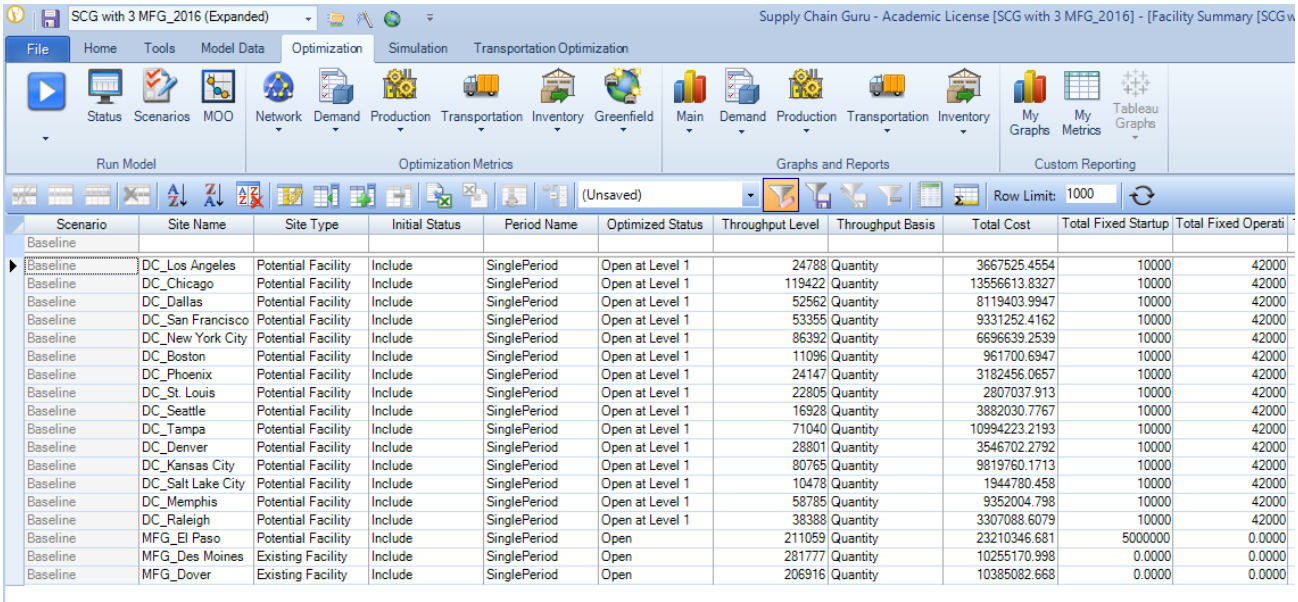
The new warehouses can be located in the suggested potential facility location for the distribution centers. The potential facility looks to connect all the customer cluster zones and establishing all 15 is

necessary to reduce the transportation costs. The option provided for the warehouses are default option of size 600,000 (opening cost $10,000), option 2 (size= 4,000,000; cost $69,000), option 3 (size 20,000,000; cost $170,000) and option 4 (size 50,000,000; cost $200,000). We have calculated the throughput level for years 2015, 2016 and 2017). From the throughput results we can conclude that the size of 600,000 ($10,000) will be reasonable for all the potential facilities. This is considered because of the fact that the warehouses would not have much throughput level and smaller capacity will cost only $10,000 to build.



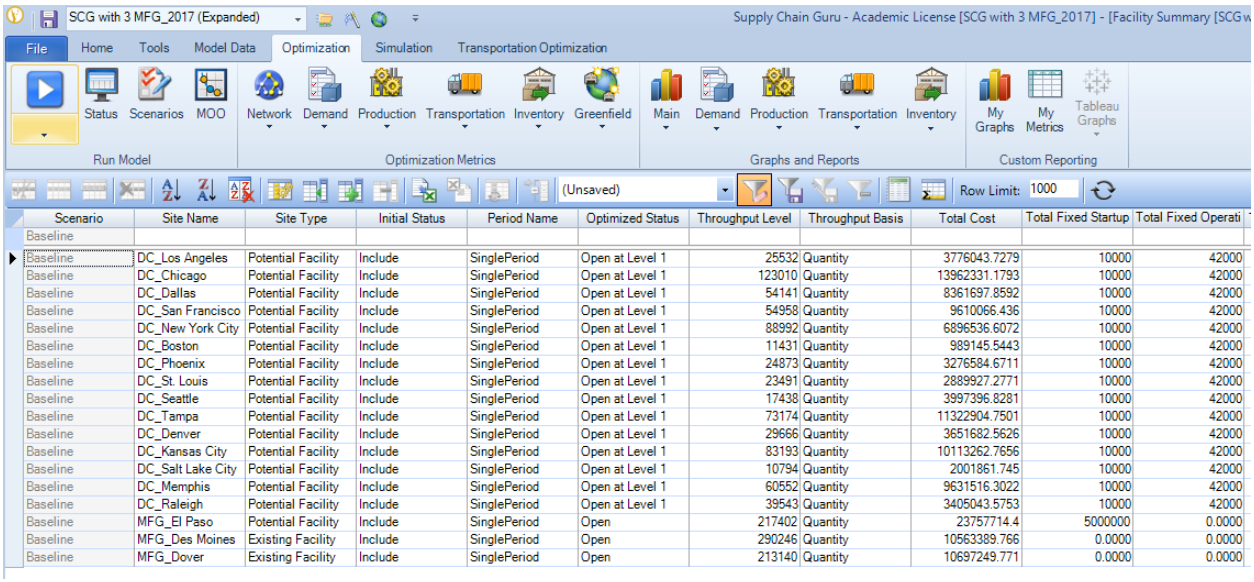
Scenario	Site Name	Site Type	Initial Status	Period Name	Optimized Status	Throughput Level	Throughput Basis	Total Cost	Total Fixed Startup	Total Fixed Operati
Baseline	DC									
Baseline	DC_Los Angeles	Potential Facility	Include	SinglePeriod	Open at Level 1	24066	Quantity	3562216.0565	10000	42000
Baseline	DC_Chicago	Potential Facility	Include	SinglePeriod	Open at Level 1	115938	Quantity	13162736.8461	10000	42000
Baseline	DC_Dallas	Potential Facility	Include	SinglePeriod	Open at Level 1	51030	Quantity	7884282.835	10000	42000
Baseline	DC_San Francisco	Potential Facility	Include	SinglePeriod	Open at Level 1	51799	Quantity	9060631.2715	10000	42000
Baseline	DC_New York City	Potential Facility	Include	SinglePeriod	Open at Level 1	83871	Quantity	6502779.3576	10000	42000
Baseline	DC_Boston	Potential Facility	Include	SinglePeriod	Open at Level 1	10771	Quantity	935040.9217	10000	42000
Baseline	DC_Phoenix	Potential Facility	Include	SinglePeriod	Open at Level 1	23442	Quantity	3091060.1294	10000	42000
Baseline	DC_St. Louis	Potential Facility	Include	SinglePeriod	Open at Level 1	22140	Quantity	2726702.7712	10000	42000
Baseline	DC_Seattle	Potential Facility	Include	SinglePeriod	Open at Level 1	16434	Quantity	3770275.8376	10000	42000
Baseline	DC_Tampa	Potential Facility	Include	SinglePeriod	Open at Level 1	68969	Quantity	10675231.6067	10000	42000
Baseline	DC_Denver	Potential Facility	Include	SinglePeriod	Open at Level 1	27959	Quantity	3444482.0052	10000	42000
Baseline	DC_Kansas City	Potential Facility	Include	SinglePeriod	Open at Level 1	78407	Quantity	9534636.9578	10000	42000
Baseline	DC_Salt Lake City	Potential Facility	Include	SinglePeriod	Open at Level 1	10171	Quantity	1889373.3303	10000	42000
Baseline	DC_Memphis	Potential Facility	Include	SinglePeriod	Open at Level 1	57069	Quantity	9080526.7569	10000	42000
Baseline	DC_Raleigh	Potential Facility	Include	SinglePeriod	Open at Level 1	37267	Quantity	3212023.3686	10000	42000

Fig 5: Throughput level for all potential DCs in 2015



Scenario	Site Name	Site Type	Initial Status	Period Name	Optimized Status	Throughput Level	Throughput Basis	Total Cost	Total Fixed Startup	Total Fixed Operati
Baseline										
Baseline	DC_Los Angeles	Potential Facility	Include	SinglePeriod	Open at Level 1	24788	Quantity	3667525.4554	10000	42000
Baseline	DC_Chicago	Potential Facility	Include	SinglePeriod	Open at Level 1	119422	Quantity	13556613.8327	10000	42000
Baseline	DC_Dallas	Potential Facility	Include	SinglePeriod	Open at Level 1	52562	Quantity	8119403.9947	10000	42000
Baseline	DC_San Francisco	Potential Facility	Include	SinglePeriod	Open at Level 1	53355	Quantity	9331252.4162	10000	42000
Baseline	DC_New York City	Potential Facility	Include	SinglePeriod	Open at Level 1	86392	Quantity	6696639.2539	10000	42000
Baseline	DC_Boston	Potential Facility	Include	SinglePeriod	Open at Level 1	11096	Quantity	961700.6947	10000	42000
Baseline	DC_Phoenix	Potential Facility	Include	SinglePeriod	Open at Level 1	24147	Quantity	3182456.0657	10000	42000
Baseline	DC_St. Louis	Potential Facility	Include	SinglePeriod	Open at Level 1	22805	Quantity	2807037.913	10000	42000
Baseline	DC_Seattle	Potential Facility	Include	SinglePeriod	Open at Level 1	16928	Quantity	3882030.7767	10000	42000
Baseline	DC_Tampa	Potential Facility	Include	SinglePeriod	Open at Level 1	71040	Quantity	10994223.2193	10000	42000
Baseline	DC_Denver	Potential Facility	Include	SinglePeriod	Open at Level 1	28801	Quantity	3546702.2792	10000	42000
Baseline	DC_Kansas City	Potential Facility	Include	SinglePeriod	Open at Level 1	80765	Quantity	9819760.1713	10000	42000
Baseline	DC_Salt Lake City	Potential Facility	Include	SinglePeriod	Open at Level 1	10478	Quantity	1944780.458	10000	42000
Baseline	DC_Memphis	Potential Facility	Include	SinglePeriod	Open at Level 1	58785	Quantity	9352004.798	10000	42000
Baseline	DC_Raleigh	Potential Facility	Include	SinglePeriod	Open at Level 1	38388	Quantity	3307088.6079	10000	42000
Baseline	MFG_El Paso	Potential Facility	Include	SinglePeriod	Open	211059	Quantity	23210346.681	5000000	0.0000
Baseline	MFG_Des Moines	Existing Facility	Include	SinglePeriod	Open	281777	Quantity	10255170.998	0.0000	0.0000
Baseline	MFG_Dover	Existing Facility	Include	SinglePeriod	Open	206916	Quantity	10385082.668	0.0000	0.0000

Fig 6: Throughput level for all potential DCs in 2016

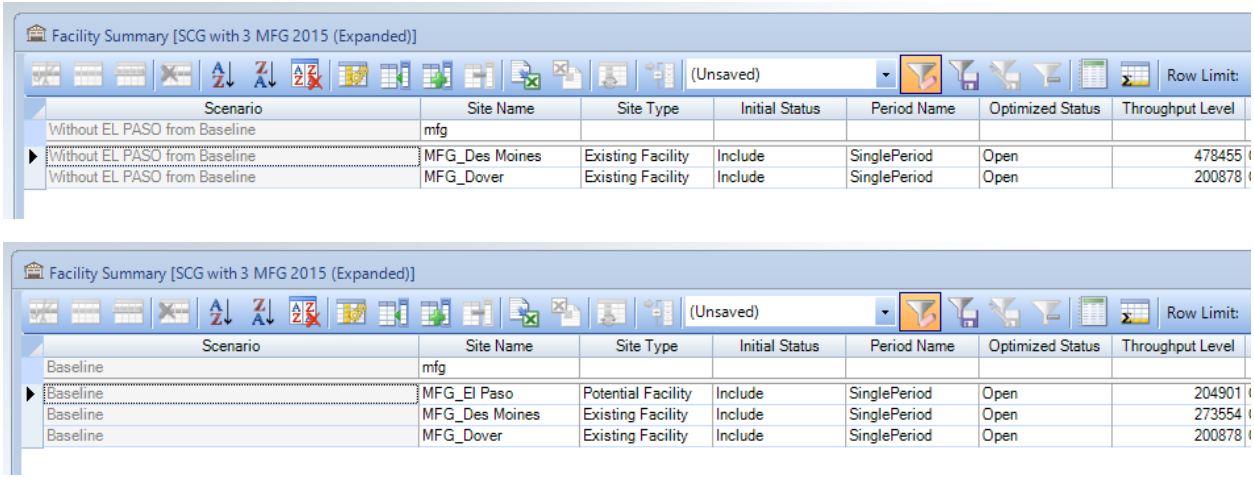


Scenario	Site Name	Site Type	Initial Status	Period Name	Optimized Status	Throughput Level	Throughput Basis	Total Cost	Total Fixed Startup	Total Fixed Operati
Baseline										
Baseline	DC_Los Angeles	Potential Facility	Include	SinglePeriod	Open at Level 1	25532	Quantity	3776043.7279	10000	42000
Baseline	DC_Chicago	Potential Facility	Include	SinglePeriod	Open at Level 1	123010	Quantity	13962331.1793	10000	42000
Baseline	DC_Dallas	Potential Facility	Include	SinglePeriod	Open at Level 1	54141	Quantity	8361697.8592	10000	42000
Baseline	DC_San Francisco	Potential Facility	Include	SinglePeriod	Open at Level 1	54958	Quantity	9610066.436	10000	42000
Baseline	DC_New York City	Potential Facility	Include	SinglePeriod	Open at Level 1	88992	Quantity	6896536.6072	10000	42000
Baseline	DC_Boston	Potential Facility	Include	SinglePeriod	Open at Level 1	11431	Quantity	989145.5443	10000	42000
Baseline	DC_Phoenix	Potential Facility	Include	SinglePeriod	Open at Level 1	24873	Quantity	3276584.6711	10000	42000
Baseline	DC_St. Louis	Potential Facility	Include	SinglePeriod	Open at Level 1	23491	Quantity	2889927.2771	10000	42000
Baseline	DC_Seattle	Potential Facility	Include	SinglePeriod	Open at Level 1	17438	Quantity	3997396.8281	10000	42000
Baseline	DC_Tampa	Potential Facility	Include	SinglePeriod	Open at Level 1	73174	Quantity	11322904.7501	10000	42000
Baseline	DC_Denver	Potential Facility	Include	SinglePeriod	Open at Level 1	29666	Quantity	3651682.5626	10000	42000
Baseline	DC_Kansas City	Potential Facility	Include	SinglePeriod	Open at Level 1	83193	Quantity	10113262.7656	10000	42000
Baseline	DC_Salt Lake City	Potential Facility	Include	SinglePeriod	Open at Level 1	10794	Quantity	2001861.745	10000	42000
Baseline	DC_Memphis	Potential Facility	Include	SinglePeriod	Open at Level 1	60552	Quantity	9631516.3022	10000	42000
Baseline	DC_Raleigh	Potential Facility	Include	SinglePeriod	Open at Level 1	39543	Quantity	3405043.5753	10000	42000
Baseline	MFG_El Paso	Potential Facility	Include	SinglePeriod	Open	217402	Quantity	23757714.4	5000000	0.0000
Baseline	MFG_Des Moines	Existing Facility	Include	SinglePeriod	Open	290246	Quantity	10563389.766	0.0000	0.0000
Baseline	MFG_Dover	Existing Facility	Include	SinglePeriod	Open	213140	Quantity	10697249.771	0.0000	0.0000

Fig 7: Throughput level for all potential DCs in 2017

Plant's Output Allocation to warehouses

After looking into the throughput level of present two MFGs, it can be observed that there is high variation in supply of the products to the customer zones. This high variation is not desired as there is a current difference of over 27000 in throughput level. Hence, it is desirable to level out the throughput such that each facilities have equal amount to serve. The recommendation for this scenario could be establishing a new MFG in El Paso which is one of the future scenario of the company.



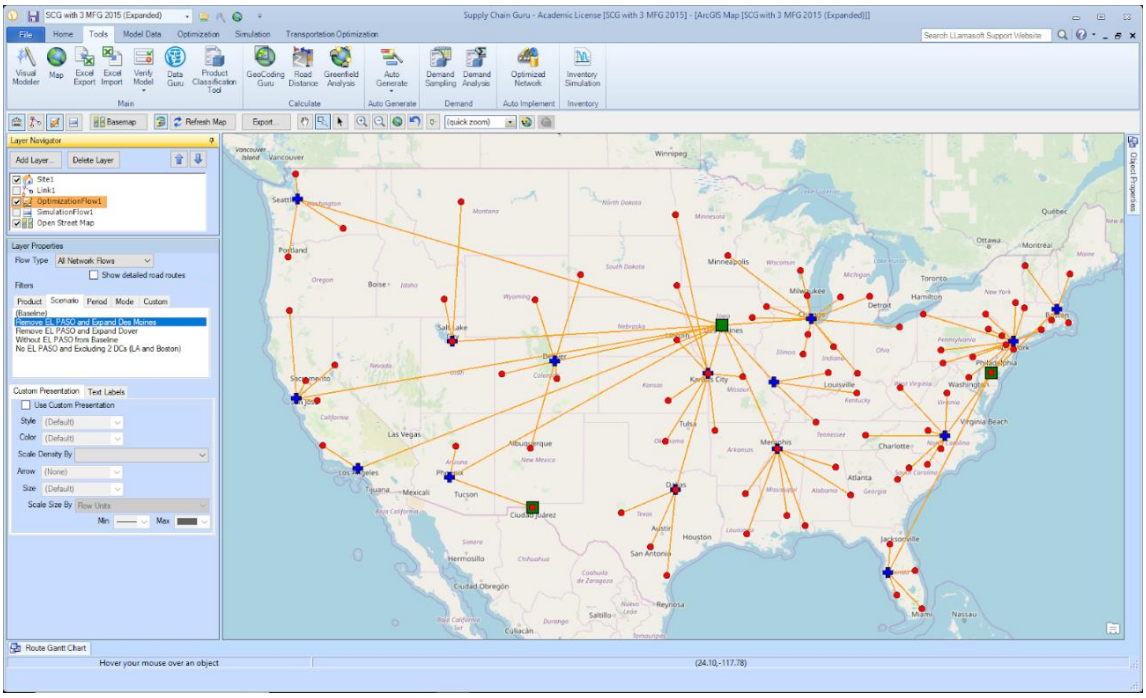
Scenario	Site Name	Site Type	Initial Status	Period Name	Optimized Status	Throughput Level
Without EL PASO from Baseline	mfg					
Without EL PASO from Baseline	MFG_Des Moines	Existing Facility	Include	SinglePeriod	Open	478455
Without EL PASO from Baseline	MFG_Dover	Existing Facility	Include	SinglePeriod	Open	200878

Scenario	Site Name	Site Type	Initial Status	Period Name	Optimized Status	Throughput Level
Baseline	mfg					
Baseline	MFG_El Paso	Potential Facility	Include	SinglePeriod	Open	204901
Baseline	MFG_Des Moines	Existing Facility	Include	SinglePeriod	Open	273554
Baseline	MFG_Dover	Existing Facility	Include	SinglePeriod	Open	200878

Fig 8: Throughput level of two MFGs and three MFGs (including El Paso) respectively

Expansion of Des Moines plant

When it comes to expanding the plant in either De Moines or Dover, we need to also consider the fact that we are accounting El Paso as new facility or not. For the first scenario, we compared without accounting new facility in El Paso, the cost of baseline model (when it is not expanded) is $96,711,686 and when it is expanded the cost is $96,687,764. Hence, it is beneficial to expand De Moines plant from the cost perspective. But this analysis ignores the comparison of opening new facility in El Paso.



Scenario	Remove EL PASO and Expand Des Moines	
Time of Run	10/12/2019 01:50:36	
Type	Solve Optimally(MinCosts)	
Optimization period	365 days	
Total Cost	$96,687,763.59	
Fixed Startup		$150,000.00
Fixed Operating		$630,000.00
Production		$131,556.85
Transportation		$92,373,245.97
Inventory Holding		$3,402,960.77
Total Revenue	$71,329,965.00	
Profit	$-25,357,798.59	

Fig 9: Expanding manufacturing plant De Moines excluding El Paso as manufacturing plant

Scenario	Without EL PASO from Baseline
Time of Run	10/12/2019 01:51:26
Type	Solve Optimally(MinCosts)
Optimization period	365 days
Total Cost	$96,711,686.34
Fixed Startup	$150,000.00
Fixed Operating	$630,000.00
Production	$155,479.60
Transportation	$92,373,245.97
Inventory Holding	$3,402,960.77
Total Revenue	$71,329,965.00
Profit	$-25,381,721.34

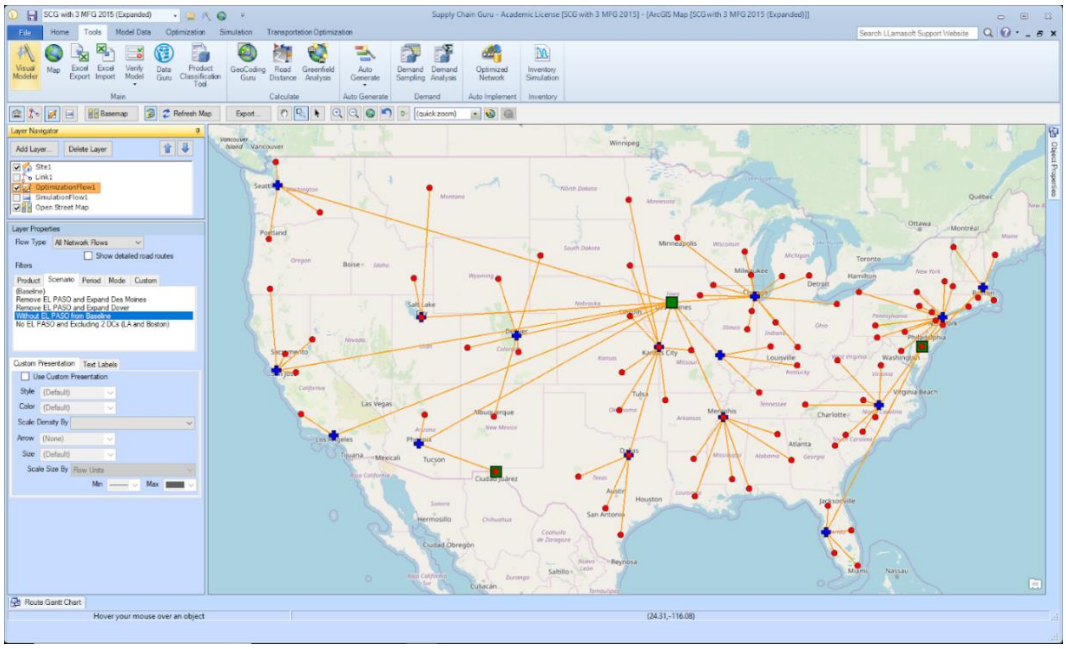


Fig 10: Baseline model (no expansion of De Moines and no El Paso)

But if we consider, opening a new facility that will be a better option because that will help to fulfill the current and future demand reducing the transportation cost.

Establishing new manufacturing plant in El Paso

The company is looking forward to establish a new manufacturing facility at El Paso. The two scenarios were run to observe the total cost difference. Also, the same kind of scenarios were run for the demand corresponding to the year 2016 and 2017 respectively. Fig 12 shows the Total cost structure of all the scenarios related to establishing new manufacturing facility at El Paso. It can be observed that there is significant total cost savings by establishing the new manufacturing facility at El Paso. The difference in total cost is also increasing with increasing year from 2016 to 2017 respectively. Considering the significant total cost savings in the first year itself i.e. year 2015 of over $3 Million, It is recommended that the new manufacturing facility should opened in the year 2015.

2015		Total Cost ($)
	Baseline - with EL PASO	93,686,996.77
	Without EL PASO from Baseline	96,711,686.34
	Difference	**3,024,689.57**
2016		Total Cost ($)
	Baseline - with EL PASO	96,328,875.46
	Without EL PASO from Baseline	99,594,637.67
	Difference	**3,265,762.21**
2017		Total Cost ($)
	Baseline - with EL PASO	99,050,457.05
	Without EL PASO from Baseline	102,564,588.79
	Difference	**3,514,131.74**

Fig 12: Total Cost of different scenarios

Year 2015

Network Optimization Output Summary

Scenario	Baseline
Time of Run	10/12/2019 01:50:12
Type	Solve Optimally(MinCosts)
Optimization period	365 days
Total Cost	$93,686,996.77
Fixed Startup	$5,150,000.00
Fixed Operating	$630,000.00
Production	$153,430.59
Transportation	$84,351,436.82
Inventory Holding	$3,402,129.36
Total Revenue	$71,329,965.00
Profit	$-22,357,031.77

Scenario	Without EL PASO from Baseline
Time of Run	10/12/2019 01:51:26
Type	Solve Optimally(MinCosts)
Optimization period	365 days
Total Cost	$96,711,686.34
Fixed Startup	$150,000.00
Fixed Operating	$630,000.00
Production	$155,479.60
Transportation	$92,373,245.97
Inventory Holding	$3,402,960.77
Total Revenue	$71,329,965.00
Profit	$-25,381,721.34

Year 2016

Network Optimization Output Summary

Scenario	Baseline
Time of Run	10/12/2019 01:57:44
Type	Solve Optimally(MinCosts)
Optimization period	365 days
Total Cost	$96,328,875.46
Fixed Startup	$5,150,000.00
Fixed Operating	$630,000.00
Production	$158,042.33
Transportation	$86,886,444.56
Inventory Holding	$3,504,388.58
Total Revenue	$73,473,960.00
Profit	$-22,854,915.46

Scenario	Without EL PASO from Baseline
Time of Run	10/12/2019 01:58:59
Type	Solve Optimally(MinCosts)
Optimization period	365 days
Total Cost	$99,594,637.67
Fixed Startup	$150,000.00
Fixed Operating	$630,000.00
Production	$160,152.92
Transportation	$95,149,239.79
Inventory Holding	$3,505,244.96
Total Revenue	$73,473,960.00
Profit	$-26,120,677.67

Year 2017

Network Optimization Output Summary

Scenario	Baseline
Time of Run	10/12/2019 01:57:44
Type	Solve Optimally(MinCosts)
Optimization period	365 days
Total Cost	$96,328,875.46
Fixed Startup	$5,150,000.00
Fixed Operating	$630,000.00
Production	$158,042.33
Transportation	$86,886,444.56
Inventory Holding	$3,504,388.58
Total Revenue	$73,473,960.00
Profit	$-22,854,915.46

Scenario	Without EL PASO from Baseline
Time of Run	10/12/2019 01:58:59
Type	Solve Optimally(MinCosts)
Optimization period	365 days
Total Cost	$99,594,637.67
Fixed Startup	$150,000.00
Fixed Operating	$630,000.00
Production	$160,152.92
Transportation	$95,149,239.79
Inventory Holding	$3,505,244.96
Total Revenue	$73,473,960.00
Profit	$-26,120,677.67

Issues Encountered and Future Opportunities

At present the company has 313 customer zones. These customers are very widely spread throughout the country. To satisfy the demand of all these customers there must be a good number of DCs which can serve these customer locations. To deal with the issue the company is looking forward to have 15 potential DCs through the country. Another issue regarding very high customer zones and their nature of being widely spread, the student version of software is only able to process 100 sites. In order to deal with this problem the clustering technique has been used to make the problem simpler. The only issue with this is that the optimization result may vary in real life situation when each customer has to deal individually.

Furthermore, the transportation cost provided to us is very high (0.31 for LTL and 0.1 FTL). This cost is based on distance weight system but is too high. Due to this numbers, the transportation cost accumulated is really high. To solve this problem, we used adjusted weight of 1 (Cubic Adjusted Weight). Furthermore, to address the future problem when the demand will increase and need for DC expansion arises, transportation cost needs to be considered as well. It means that the company should concentrate more on their partners dealing with transportation system. Also, there were 15 potential DC to satisfy the customers but it was observed that even removing one DC from the list, the total cost was increased. Thus, the company should also concentrate on establishing more DC in order to deal with high number of customer zones. For the long-term future, the demand increment of 3% per year was taken into account and for this the default warehouse option of size 600,000 was enough.

Conclusion

Our recommendation for the issue of number of potential DC to be established is 15 out of 15. This also implies that the company should look forward to open new DC in the near future to deal with an increase in the demand rate of customers which are widely spread. Also, our recommendation for establishing new manufacturing location was able to save over $3 Million cost. This implies that the company should also concentrate on increasing the capacity of their manufacturing sites or establish new manufacturing locations to satisfy the increasing demand of customers at the rate of 3% in the near future i.e. beyond 2017.