

Math 360 Final Project #1

THE TEXAGO CORPORATION SITE SELECTION PROBLEM (Part 1)

(from Hillier, Introduction to Operations Research)

The Texago Corporation is a large, fully integrated petroleum company based in the United States. The company produces most of its oil in its own oil fields and then imports the rest of what it needs from the Middle East. An extensive distribution network is used to transport the oil to the company's refineries and then to transport the petroleum products from the refineries to Texago's distribution centers. The locations of these various facilities are given in Table 1.

Table 1 Location of Texago's Current Facilities

Type of Facility	Locations
Oil fields	1. Several in Texas 2. Several in California 3. Several in Alaska
Refineries	1. Near New Orleans, Louisiana 2. Near Charleston, South Carolina 3. Near Seattle, Washington
Distribution Centers	1. Pittsburgh, Pennsylvania 2. Atlanta, Georgia 3. Kansas City, Missouri 4. San Francisco, California

Texago is continuing to increase its market share for several of its major products. Therefore, management has made the decision to expand its output by building an additional refinery and increasing its imports of crude oil from the Middle East. The crucial remaining decision is where to locate the new refinery.

The addition of the new refinery will have a great impact on the operation of the entire distribution system, including decisions on how much crude oil to transport from each of its sources to each refinery (including the new one) and how much finished product to ship from each refinery to each distribution center. Therefore, the three key factors for management's decision on the location of the new refinery are

1. The cost of transporting the oil from its sources to all the refineries, including the new one.
2. The cost of transporting finished product from all the refineries, including the new one, to the distribution centers.
3. Operating costs for the new refinery, including labor costs, taxes, the cost of needed supplies (other than crude oil), energy costs, the cost of insurance, and so on. (Capital costs are not a factor since they would be essentially the same at any of the potential sites.)

Management has set up a task force to study the issue of where to locate the new refinery. After considerable investigation, the task force has determined that there are three attractive potential sites. These sites and the main advantages of each are spelled out in Table 2.

Table 2 Potential Sites for Texago's New Refinery and Their Main Advantages

Potential Site	Main Advantages
Near Los Angeles, California	<ol style="list-style-type: none"> 1. Near California oil fields. 2. Ready access from Alaska oil fields. 3. Fairly near San Francisco distribution center.
Near Galveston, Texas	<ol style="list-style-type: none"> 1. Near Texas oil fields. 2. Ready access from Middle East imports. 3. Near corporate headquarters.
Near St. Louis, Missouri	<ol style="list-style-type: none"> 1. Low operating costs. 2. Centrally located for distribution centers. 3. Ready access to crude oil via the Mississippi River.

Gathering the Necessary Data

The task force needs to gather a large amount of data, some of which requires considerable digging, in order to perform the analysis requested by management.

Management wants all the refineries, including the new one, to operate at full capacity. Therefore, the task force begins by determining how much crude oil each refinery would need brought in annually under these conditions. Using units of 1 million barrels, these needed amounts are shown on the left side of Table 3. The right side of the table shows the current annual output of crude oil from the various oil fields. These quantities are expected to remain stable for some years to come. Since the refineries need a total of 360 million barrels of crude oil, and the oil fields will produce a total of 240 million barrels, the difference of 120 million barrels will need to be imported from the Middle East.

Table 3 Production Data for Texago Corp.

Refinery	Crude Oil Needed Annually (Million Barrels)	Oil Fields	Crude Oil Produced Annually (Million Barrels)
New Orleans	100	Texas	80
Charleston	60	California	60
Seattle	80	Alaska	100
New site	120	Total	240
Total	360	Needed imports = $360 - 240 = 120$	

Since the amounts of crude oil produced or purchased will be the same regardless of which location is chosen for the new refinery, the task force concludes that the associated production or purchase costs (exclusive of shipping costs) are not relevant to the site selection decision. On the other hand, the costs for

transporting the crude oil from its source to a refinery are very relevant. These costs are shown in Table 4 for both the three current refineries and the three potential sites for the new refinery.

Table 4 Cost Data for Shipping Crude Oil to a Texago Refinery

	Cost per Unit Shipped to Refinery or Potential Refinery (Millions of Dollars per Million Barrels)					
	New Orleans	Charleston	Seattle	Los Angeles	Galveston	St. Louis
Source						
Texas	2	4	5	3	1	1
California	5	5	3	1	3	4
Alaska	5	7	3	4	5	7
Middle East	2	3	5	4	3	4

Also very relevant are the costs of shipping the finished product from a refinery to a distribution center. Letting one unit of finished product correspond to a refinery's production from 1 million barrels of crude oil, these costs are given in Table 5. The bottom row of the table shows the number of units of finished product needed by each distribution center.

Table 5 Cost Data for Shipping Finished Product to a Distribution Center

	Cost per Unit Shipped to Distribution Center (Millions of Dollars)			
	Pittsburgh	Atlanta	Kansas City	San Francisco
Refinery				
New Orleans	6.5	5.5	6	8
Charleston	7	5	4	7
Seattle	7	8	4	3
Potential Refinery				
Los Angeles	8	6	3	2
Galveston	5	4	3	6
St. Louis	4	3	1	5
Number of units needed	100	80	80	100

The final key body of data involves the *operating costs* for a refinery at each potential site. Estimating these costs requires site visits by several members of the task force to collect detailed information about local labor costs, taxes, and so forth. Comparisons then are made with the operating costs of the current refineries to help refine these data. In addition, the task force gathers information on one-time

site costs for land, construction, and other expenses and amortizes these costs on an equivalent uniform annual cost basis. This process leads to the estimates shown in Table 6.

Table 6 Estimated Operating Costs for a Texago Refinery at Each Potential Site

Site	Annual Operating Cost (Millions of Dollars)
Los Angeles	620
Galveston	570
St. Louis	530

Armed with these data, the task force has appointed you to develop an optimal shipping plan for *each* potential refinery. Write an accompanying memorandum that presents your results and recommendations, also include your Excel document so your recommendations can be reviewed. Management needs to make their decisions by the end of this fiscal year and so has asked you to submit your report and spreadsheet no later than December 1st at midnight.

(Completely solve this problem before moving on to the next part.)

THE TEXAGO CORPORATION SITE SELECTION PROBLEM (Part 2)

After a relaxing and over-filling Thanksgiving, Texago management has had a revelation—BIGGER IS BETTER! To prepare for possible future increases in demand beyond the current forecasts, management now wants to also consider the option of enlarging the plans for the new refinery past the original yearly capacity of 120 million barrels. Although this would force the corporation's refineries collectively to operate below full capacity for a while, the extra capacity then would be available later if Texago were to continue to increase its market share. This might be well worthwhile since the capital and operating costs incurred by enlarging the plans for the new refinery would be far less (perhaps 40 percent less) than constructing and operating another refinery later. Furthermore, management feels that this extra capacity might be needed within a few years.

Enlarging the refinery would cost \$15 million for every increase in capacity of 10 million barrels. Note that a larger refinery would have a larger operating cost but decreasing the production rate by the same amount at another refinery would decrease the total operating cost by a comparable amount. Since the operating cost per million barrels of crude oil processed is roughly the same at all the refineries, including the new one, the total operating cost for processing 360 million barrels should not be substantially affected by the allocation of this work to the refineries. However, management feels that having some flexibility for where to allocate this work might permit a substantial reduction in the cost of shipping crude oil and finished product.

Unfortunately, Ebenezer Scrooge is the CFO (Chief Financial Operator) and he has suggested that if the capacity at the new plant could be increased enough, Texago could close down another refinery. Closing any refinery would save roughly \$30 million. However, management is unwilling to close more than one refinery, as this would lead to a precarious union relationship.

Management now is asking you to analyze the situation under the option of increasing the capacity of the new refinery. The task force has reappointed you to use your knowledge of sensitivity analysis to decide which of the new refineries should be considered for enlargement and to develop an optimal shipping plan accordingly. Add on to your memorandum and your Excel document so your updated recommendations can be reviewed. Management needs to make their decisions by the end of this fiscal year and so has asked you to submit your report and spreadsheet no later than December 1st at midnight.

Turn in a single Excel file with your analysis for both parts (labeled appropriately). Turn in two memos/reports, one for each part.