TRANS WORLD OIL COMPANY

The Trans World Oil Company is an international producer, refiner, transporter, and distributor of oil, gasoline, and petrochemicals. Trans World is a holding company with subsidiary operating companies that are wholly or partially owned. A major problem for Trans Oil is to coordinate the actions of these various subsidiaries into an overall corporate plan, while at the same time maintaining a reasonable amount of operating autonomy for the subsidiary companies.

To deal with this dilemma, an annual corporate-wide plan that detailed the pattern of shipments among the various subsidiaries was developed. This plan was not rigid, but provided general guidelines, and the plan was revised periodically to reflect changing conditions. Within the framework of this plan, the operating companies could make their own decisions and plans.

This corporate plan was originally done on a trial and error basis. There were two problems with this approach. First, the management of the subsidiaries complained that the planners did not take into account the operating conditions under which the subsidiary had to operate. The plan might call for operations or distribution plans that were impossible to accomplish. Second, the corporate management was concerned that the plan did not optimize for the total company.

The technique of linear programming seemed a possible approach to aid in the annual planning process. It would be able to answer, at least in part, the two objections above. In addition, the building of such a model would make it possible to make changes in plans quickly when the need arose.

Far Eastern Operations

The details of the 1996 planning model for the Far Eastern Operations are now described.

There were two sources of crude oil, Iran and Borneo. The Iranian crude was relatively heavier (24 API), and the Far Eastern sector could obtain as much as 60 000 barrels per day (bbl/d) at a cost of $18.50 per barrel at Abadan during 1996. A second source of crude was from the Brunei fields in Borneo. This was a lighter crude oil (36 API). Under the terms of an agreement with Netherlands Petroleum Company in Borneo, a fixed quantity of 40 000 bbl/d of Brunei crude, at a cost of $20.50 per barrel was to be supplied during 1996.

There were two subsidiaries that had refining operations. The first was in Australia, operating a refinery in Sydney with a capacity of 50 000 bbl/d throughout. The company also marketed its products throughout Australia, as well as having a surplus of refined products available for shipment to other Far Eastern subsidiaries.

The second subsidiary was in Japan, which operated a 30 000 bbl/d capacity refinery. Marketing operations were conducted in Japan, and excess production was available for shipment to other Far Eastern subsidiaries.

In addition, there were two marketing subsidiaries without refining capacity of their own. One of these was in New Zealand and the other in the Philippines. Their needs could be supplied by shipments from Australia, Japan, or the Trans World Oil subsidiary in the United States. The latter was not a regular part of the Far Eastern Operations, but might be used as a source of refined products.

Finally, the company had a fleet of tankers that moved the crude oil and refined products among the subsidiaries.

Refinery Operations

The operation of a refinery is a complex process. The characteristics of the crudes available, the desired output, the specific technology of the refinery, etc. make it difficult to use a simple model to describe the process. In fact, management at both Australia and Japan had complex linear programming models involving approximately 300 variables and 100 constraints for making detailed decisions on a daily or weekly basis.

For annual planning purposes, the refinery model was greatly simplified. The two crudes (Iranian and Brunei) are input. Two general products are output: (a) gasoline products; and (b) other products other products known collectively as distillate. In addition, although the refinery had processing flexibility that permitted a wide range of yields, for planning purposes it was decided to include only the use of the values at highest and lowest conversion rates (process intensity). Each refinery could use any combination of the two extreme intensities. These yields are shown in Table 1.

The incremental costs of operating the refinery depended somewhat upon the type of crude and process intensity. These costs are shown in Table 1. Also shown are the incremental transportation costs from either Borneo or Iran.

Table 1: Refinery Costs and Yields

Location, Crude, Process Intensity	Cost of Crude $/bbl	Incremental Shipping Costs $/bbl	Incremental Refining Costs $/bbl	Total Costs $/bbl	Yields (bbl Output Per bbl Crude Input)	
					Gasoline	Distillate
Australia:						
Brunei Crude Low	20.50	0.78	0.36	21.64	0.259	0.688
Brunei Crude High	20.50	0.78	0.84	22.12	0.365	0.573
Iran Crude Low	18.50	1.86	0.45	20.81	0.186	0.732
Iran Crude High	18.50	1.86	0.90	21.26	0.312	0.608
Japan:						
Brunei Crude Low	20.50	0.72	0.48	21.70	0.259	0.688
Brunei Crude High	20.50	0.72	1.02	22.24	0.350	0.588
Iran Crude Low	18.50	1.77	0.60	20.87	0.186	0.732
Iran Crude High	18.50	1.77	1.17	21.44	0.300	0.620

Marketing Operations

Marketing was conducted in two home areas (Australia and Japan) as well as in the Philippines and New Zealand. Demand for gasoline and distillate in all areas had been estimated for 1996 and is shown in table 2.

Table 2: Demand (Thousands Of bbl/d)

Area	Gasoline	Distillate
Australia	9.0	21.0
Japan	3.0	12.0
Philippines	5.0	8.0
New Zealand	5.4	8.7
Total	22.4	49.7

Variable costs of supplying gasoline or distillate to New Zealand and the Philippines are shown in table 3.

Table 3: Variable Costs Of Shipment Of Gasoline/Distillate In $/bbl

From/To	New Zealand	Philippines
Australia	0.30	0.45
Japan	0.30	0.60

Tanker Operations

Tankers were used to bring crude from Iran and Borneo to Australia and Japan and to transport refined products from Australia and Japan to the Philippines and New Zealand. The variable costs of these operations are included in the previous shipment table 3. However, there was a limited capacity of tankers available. The fleet had a capacity of 6.9 equivalent (standard-sized) tankers.

The amount of capacity needed to deliver one barrel from one destination to another depends upon the distance traveled, port time, and other factors. The table below lists the fraction of one standard-sized tanker needed to deliver 1000 bbl/d over the indicated routes. It was also possible to charter independent tankers. The rate for this was $8 600 per day for a standard tanker.

Table 4: Tanker Usage Factors (Fraction of Standard-Sized Tanker Needed To Deliver 1000 bbl/d)

Between	Australia	Japan
Iran	0.12	0.11
Borneo	0.05	0.045
Philippines	0.02	0.01
New Zealand	0.01	0.06

United States Supply

United States operations on the West Coast expected a surplus of 12 000 bbl/d of distillate during 1996. The cost of distillate at the loading port of Los Angeles was $19.80 per barrel. There was no excess gasoline capacity. The estimated variable shipping costs and tanker requirements of distillate shipments from the Unites States are in Table 5.

Table 5: Shipping Costs And Tanker Requirements From the US

	Variable Cost Of Shipments	Tanker Requirements (Fraction Of Standard-Sized Tanker Needed To Deliver 1000 bbl/d)
New Zealand	2.10	0.18
Philippines	1.65	0.15

Formulate an LP model that could be used to generate a comprehensible plan for Far East Operations of the Trans World Oil Company. Solve the problem with Matlab.