Marine Terminal Facilities Planning Through Simulation

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Abstract

This paper reviews the development of an inter-
active vessel scheduling and crude oil monitoring
system for crude shipments from Alaska to the West
Coast ports. The prime consideration in developing
a computerized model was to provide an operational
tool for scheduling the movements of a fleet of
ARCO owned and chartered vessels. Utilizing the
operating characteristics and design criteria
obtained from the various operating groups, a model
was developed to simulate the activities of the
tanker fleet, the supply sources in Alaska, and the
demand centers on the West Coast. For a given set
of starting conditions, the model generates manage-
ment reports that summarize crude inventory statis-
tics at Alaska and West Coast ports, tanker lifting
and delivery timings, refinery runouts at the
demand centers and penalty situations at the supply
sources.

INTRODUCTION

This paper describes the development of an inter-
active computerized vessel scheduling and crude oil
monitoring system for crude shipments from the
supply sources in Alaska to the demand centers on
the West Coast.

This model is an operational tool that allows the
Supply & Coordination function of the company to
automatically develop a scheduling plan for the
movement of Alaskan crude to the West Coast. Its
capabilities include: inventory tracking of crude
levels at the supply sources and demand centers;
tanker lifting and delivery timings and volumes;
spot charters; exchange deliveries/liftings; and
drydocking. Further, the model has the flexibility
to vary refinery crude runs and to vary tank
capacities.

The model generates management reports that monitor
the crude inventories and vessel movements. The
detailed lifting/delivery schedule reflects the day-
to-day vessel activity and inventories at the
supply sources and destinations. Itinery reports
for each of the vessels indicate lift and delivery
dates, source and destinations, waiting time and
volume by destinations. Several other reports are
generated that capture key statistics on vessel
waiting times, charter requirements and refinery
runouts.

SIMULATION MODEL

The Vessel Scheduling Model was developed in
Simscript II.5 to simulate the Alaskan and West
Coast crude shipping operations over a predeter-
mined time frame. The model monitors the crude oil
inventories at the various locations on a daily
basis, develops lifting and delivery schedules for
the tanker fleet; and generates statistical reports
on: vessel waiting times at the unloading ports,
chartering requirements for Valdez and Drift River,
and refinery runouts. The major objectives in
developing a simulation model were to provide
Supply & Coordination with a tool that would
quickly develop a scheduling plan for the movement
of Alaskan crude to the West Coast demand centers.
Furthermore, this model will then be used to gener-
ate a number of alternative schedules by varying
the chartering activities, hardwiring certain
voyages, etc. By comparing the key statistical
reports, the user then selects the "best schedule"
for implementation.

The events of interest that are incorporated in the
simulation model are:

> Tanker arrivals in Alaska or West Coast
>   demand centers
> Tanker docks
> Tanker starts loading/unloading operation
> Tanker completes loading/unloading operation
> Tanker undocks
> Tanker selects the next destination (source)
> Crude is pumped from vessel into the appro-
>   priate storage tank
> When tank is full, stop pumping
> Resume pumping from vessel when tank levels
>   drop to 90% of its working capacity
> Crude is withdrawn from storage tank into the
>   Refinery

If storage tank is empty, stop refinery run
for given crude type
Resume refinery runs when tank levels increase
to 10% of its working capacity

The above events are used to replicate the vessel
movements between Alaska and the West Coast des-
tinations and also duplicate the marine terminal
operations at the various locations. For simula-
tion control, daily reports are generated on inven-
tory levels and vessel locations and the simulation
is stopped at the end of a predetermined time span.

OPERATING RULES

The operating rules for the system were developed
with the various functions. This section of the
report contains the operating conditions at the
source and supply locations as well as the criteria
used in selecting the destination of the vessels.
The simulation model has been designed to allow
for changes in terminal facilities and may be
incorporated by changing the input data. A summary
of the operating facilities as they are modeled and
the vessel destination selection criteria follow:

o Sources

The crude oil supply sources in Valdez will be
referred to as V1 and V2. There is no upper limit
on the crude inventory levels at both V1 and V2;
however, we monitor the number of days the crude
levels at these locations exceed the working tank-
age. There are no restrictions on the size of
tankers docking at V1, whereas at V2, the largest
tanker that can dock is a 70 MDWT. The docking,
deballasting, and undocking times are known and the
loading times are a function of the tanker size.
We also assume that tankers do not wait for a berth
at V1. At V2, there is a single berth available
and tankers queue up for service if the berth is
occupied.

o Destinations

The destinations of all tankers lifting crude from
Valdez and Drift River are D1, D2 or D3. The char-
acteristics of each of the destinations as they are
represented in model are presented below.

- D1:

The dock capacity of the D1 berth is assumed
to be 120 MDWT. Tankers that arrive at D1 are
allowed to dock if the berth is empty, other-
wise they queue for service. The docking and
undocking time is known and the unloading rate
at D1 varies with vessel size. Once the

tanker is empty, it returns to either V1 or
V2. In case the tanker is also carrying cargo
for another customer, we delay its return
trip.

The tank farm at D1 has segregated tankage
for sweet and sour crudes. The working tank-
ages and refinery runs for each of the crude
types is provided. The model has the flexi-
bility to change refinery tankage and refin-
ery crude runs within each simulation run.

- D2:

Tankers arriving at D2 queue up for service.
A tanker proceeds to dock only if dock space
is available and if sufficient tankage for a
given crude type is available at the terminal
to unload the tanker. In order to determine
whether sufficient tankage is available at the
dock for a given crude type, the existing
terminal inventory is added to the tankage at
the dock, and this sum is subtracted from the
dedicated working tankage for the given crude
type. Sufficient tankage for the given crude
type is deemed available at the terminal if
the tanker cargo size is less than this avail-
able tankage at the refinery. Also, the dock-
ing and undocking time is known. Priority is
given to unloading ARCO-owned fleet vessels
over charter vessels. This will enable the
scheduler to adjust the schedules for charter
vessels.

Once the tanker is empty, it returns to V1 or
to V2. However, if the tanker is also carry-
ing crude for other customers, its return trip
is delayed.

At D2 there is segregated tankage for sweet
and sour crudes. The appropriate pumping
capacities from the berths at D2 to the
refinery are known. The model has the flexi-
bility to allow the user to change the refin-
ery crude runs at Watson and tankage available
within each simulation run.

- D3

The details on the unloading dock at D3 have
not been included in the model. For the pur-
poses of our model we have assumed that all
tankers delivering crude at D3 take a prede-
termined amount of time to dock, unload and
dock. Tankers from the supply sources may go
to D3 directly or in split loads with crudes
also delivered to D1 or D2.

o Vessels

The vessels lifting crude from Valdez may be cate-
gorized into vessels owned and operated by ARCO
and charter vessels. The charter vessels may be
used for liftings only, deliveries only or a com-
bination of liftings and deliveries from V1 and V2
to D1 and D2.

For ARCO's fleet, the vessel capacities vary with
the time of the year. The model automatically
adjusts the vessel capacity to the winter marks
for November through April and to the summer marks
from May through October.

The model allows the user to drydock ARCO's vessel
for a period of time, and the charter in or charter
out of ARCO vessels for a known time frame thereby
varying the fleet size during the length of the
simulation run.

o Source/Destination Selection Criteria

The rules incorporated in the model for selecting
the next source (destination) for the vessel were
developed in conjunction with Supply and Coordina-
tion. At V1 and V2, when a vessel has lifted the
crude, we use rules to select the destination for
this vessel. Likewise, at D1 and D2, we pick the
next source for the vessel when it has completely
unloaded its cargo. If any special voyage is
entered by the user, then this voyage will override
the source/destination selection rules and force
the vessel to move between predetermined source and
destinations. After this particular voyage, the
model will then take over and schedule the subse-
quent voyages of this vessel based upon selection
rules. The user may specify one or more voyages of
the vessels belonging to the ARCO fleet.

In Alaska, when a ship has completed the loading
operation, we evaluate the projected inventory for
the appropriate crude type at D1 and D2. This is
done by adding to the terminal inventory at each
location, the vessel inventories of the vessels
that are enroute to this location or currently in
dock and subtracting the refinery crude runs for
the number of days until the ship that we are
currently looking at gets there. If the projected
inventory at either of the two locations is below
the safety stock (safety stock X days demand), the
destination of the vessel is determined to be the
location at which the projected inventory falls
below the safety stock level. If no destination is
selected, we check to see at which destination this
vessel can be turned around the fastest and assign
that destination to this vessel.

When a ship has unloaded its cargo at one of the
three destinations, we must then select a source in
Alaska. The projected inventories at V1 and V2 are
evaluated. The appropriate source is assigned to
this vessel based on where it is needed the most.

REPORT INFORMATION

The simulation model generates reports on daily
crude inventories in Alaska and West Coast destina-
tions, vessel movement schedules, lifting schedules
for V1 and V2 and statistical reports on vessel
waiting times, chartering requirements and refinery
runouts.

In the report that contains the activities at the
supply sources and demand centers, the crude inven-
tories for each location by crude type are dis-
played at the beginning of each day. In addition,
refinery crude runs by crude type are also listed.
Vessel names as well as quantities of crude lifted
or delivered are displayed on the day the activity
occurs.

For each of the ARCO vessels, a report reflecting
its itinerary is produced. The information con-
tained in this report includes: lift date, voyage
number, crude source (V1 or V2), drop date, waiting
time the vessel incurs at the delivery port and
destination. A single report for all charter
vessels is produced and contains the identical
information that the ARCO itinerary reports
contain.

Separate lifting schedule reports for V1 and V2
are generated by the model. These reports reflect
the activity on a daily basis of ARCO, and ARCO
chartered vessels for both V1 and V2. These
reports contain: The name of the vessel lifting
crude, the date the vessel is ready for departure,
the volume of crude on board, crude ownerships and
destinations.

Two statistical reports, Vessel Movement Statistics
and Charter Requirements, are generated by the
model. The first report depicts waiting time
statistics for both D1 and D2 as a function of
vessel capacity (50, 70, 120 MDWT). This report
also contains average number of barrels lifted per
day for each of the vessels in the ARCO fleet. The
Charter Requirements Report for Alaskan Crude
depicts the need for any additional tonnage for
each month of the simulation run.

The report on Periods of Zero Production captures
the days of zero refinery runs due to runouts from
the lifting/delivery activity report. The days of
zero refinery runs are reported for both D1 and D2
by each crude type.

The model is now being used as an operational tool
on an ongoing basis by Supply and Coordination for
scheduling vessel movements and maintaining optimal
inventory levels at the supply source and demand
centers. Further enhancements of the model are
also in progress and will be used for improving
port efficiencies at the demand centers.