Platform Supply Vessel Logistics

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ESI6520 Digital Simulation Techniques

April 25, 2022

Executive Summary:

Simio Supply Logistics (SSL) is an organization that charters offshore vessels to and from various offshore drilling locations. SSL can choose from a variety of watercraft to rent monthly. The collection of platform supply vessels (PSVs) is selected and dispatched out of ports. These vessels service four deep-water rigs. The system is presently under scrutiny due to high costs, unmet demand, and excessive standby time. Our objective for this project is to find an optimal combination of vessels that they require at both their port and what type of vessel (Out of three models) will serve the purpose of minimizing the penalties they have to pay because of the late deliveries.

Due to the complexity involving varying weather conditions across the locations that they operate and its effects on vessel speeds,varying load in and load out conditions based on the material that they are carrying, traditional analytical methods are not good enough in solving this problem.Hence, we went ahead with Discrete event simulation using Simio.

To minimize the cost function which includes two components i.e Vessel cost (Capital+Usage cost) and Penalty due to order delay, Cost function is our primary response that we would comparing the end alternatives based on and properties defined in simio like the 'Vessel type' and 'Number of Vessels at Rotterdam Port' and 'Number of Vessels at Hamburg Port' are the decision variables that would be altered in design for varying scenarios. Upon running the simulation for 108 altering scenarios, we recommend to use vessel type '9000' at both the locations,have 30 at Hamburg port and 40 at Rotterdam port for minimizing the total cost that they are incurring.

Assumptions and Problem Scope:

We made following assumptions from the given initial problem:

- All the rigs follow same discrete distribution in the quantities of each material
- Only one kind of vessel type is used at any given time in the system (Combination of multiple vessel types not studied)

- Bundles are considered to be 1 unit for certain material types like Pipes and Casing which will affect the Load in,Load out periods.
- Alpha and Beta Rigs served by Rotterdam and Charlie and Delta Rigs served by Hamburg port

Current Scope:

- Considered 2 ports,3 vessel types to serve 4 rigs orders
- Vessel Speed variations based on weather conditions
- Loading and unloading times of orders based on material type
- Ships carrying only one order at a time - Capacity for loading in multiple orders together into one vessel is not done.
- Cost calculations - Ship daily costs, Usage Costs,Penalty Costs

Excluded scope from original problem description:

- Usage of combination of vessel types.
- Impact of third port on the service levels,penalties and cost.
- Dwell times in case of fueling conditions. (Was able to include in the model but its impact on costs should be studied further)
- Clubbing multiple orders into single vessel was not studied
- Cost calculations for Slip usage at each port.

Input Data:

A log of Demand and Fulfillment is provided with the problem statement. We analyzed a total of 5078 entries of Orders from all the rigs combined.As Statfit has a limit of 50 entries, we analyzed this data in excel.Upon analysis, we noticed these and Order Counts from Each Rig:

Orders from	**Count over a year**	**Interarrival (hours)**
AlphaRig	934	Random.exponential(9.37)
BetaRig	1492	Random.exponential(5.87)

CharlieRig	1403	Random.exponential(6.24)
DeltaRig	1249	Random.exponential(7.01)

We assumed the distribution to be exponential.

Material mix at each rigs are as follows:

Alpha Rig:

Material	**Mix**	**Cumulative Distribution**
DeckCargo	100	0.107066381
Casing	188	0.308351178
DryBulk	152	0.471092077
Fuel	123	0.602783726
Liquid Bulk	173	0.788008565
Pipe	198	1

Beta Rig:

Material	**Mix**	**Cumulative Distribution**
DeckCargo	249	0.16689008
Casing	211	0.308310992
DryBulk	299	0.508713137
Fuel	236	0.66689008
Liquid Bulk	248	0.83310992

Pipe	249	1

Charlie Rig:

Material	**Mix**	**Cumulative Distribution**
DeckCargo	284	0.202423378
Casing	237	0.371347113
DryBulk	236	0.53955809
Fuel	187	0.672843906
Liquid Bulk	248	0.849607983
Pipe	211	1

Delta Rig:

Material	**Mix**	**Cumulative Distribution**
DeckCargo	225	0.180144115
Casing	201	0.341072858
DryBulk	213	0.511609287
Fuel	187	0.661329063
Liquid Bulk	213	0.831865492
Pipe	210	1

Order quantity,Load Unload sizes based on materials following these discrete distributions:

Calculations were done in attached Excel Sheet

Unit Sizes for Casing and Pipes are assumed to be 1.

Alpha Seq | Beta Seq | Charlie Seq | Delta Seq | Veh Prop | Material Prop

	Material Types	Load_Unload Timeper Unit	Unit Size	Order Quant
1	DeckCargo	10	1	Random.Discrete(5,0.32,7,0.75,32,0.843,68,0.92,57,0.98,9,1)
2	Casing	13	1	Random.Discrete(9,0.34,20,0.74,12,1)
3	DryBulk	60	2500	Random.Discrete(1600,0.01,1700,0.0244444444444444,1800,0.0577777777777778,1900,0.1088888
4	Fuel	60	2000	Random.Discrete(1000,0.00136425648021828,1100,0.00272851296043656,1200,0.0109140518417
5	LiquidBulk	60	3000	Random.Discrete(1000,0.00453514739229025,1100,0.0328798185941043,1200,0.0770975056689
6	Pipe	15	1	Random.Discrete(5,0.237,18,0.585,40,0.631,12,0.900,50,0.95,60,1)
*				

Model Conceptualization:

Components:

- 4 Model entities

  AlphaRigOrders,BetaRigOrders,CharlieRigOrders and DeltaRigOrders
- 4 Sources

  Each one for the above with arrival rates from previous tables
- 2 Servers Representing Ports RotterDam and Hamburg.
- 4 Sinks

  Alpha,Beta,Charlie and Delta Rigs
- 8 Servers for waypoints with 0 service times
- 1 Entity,1 Source and 1 sink for Weather calculations

State Variables at Model Entity level:

Model Entity State variables	**Usage**
ModelEntity.OrderDate	To store the order creation date, state assignment at Entity creation on all 4 sources

ModelEntity.Material	To allocate type of material at each source based on the distribution explained above in table 1
ModelEntity.Quantity	To allocate the quantity of material based on the previous assignment using distributions from table 3
ModelEntity.Load_UnloadTimes	Calculated based on the formula : (Quantity/Unit Size) * Load unload times per unit from table 3
ModelEntity.TotalDeliveryTime	To store the total delivery time,assigned at rigs

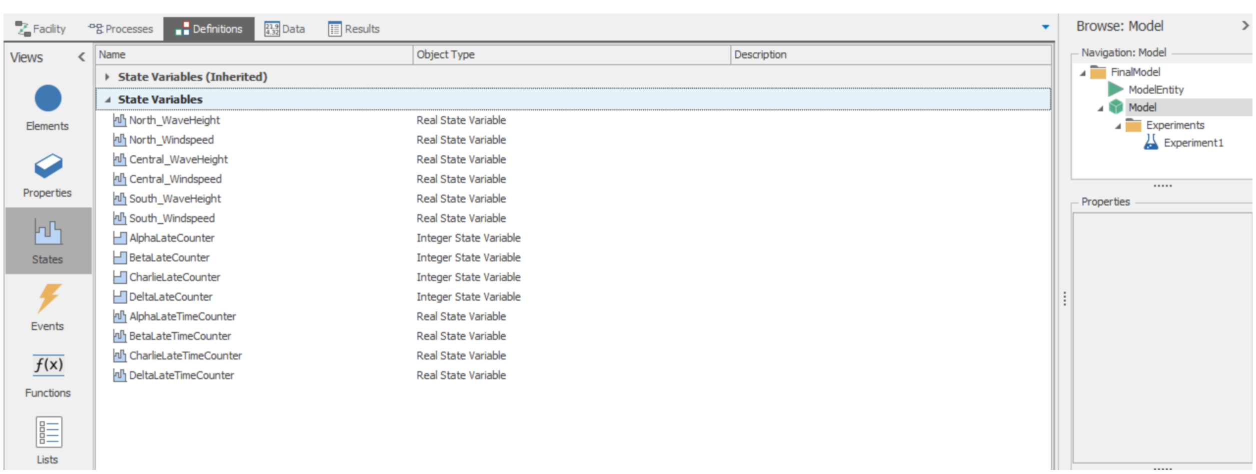
Tally Stats:

{Rig}LateDeliveries,{Rig}LateTimes

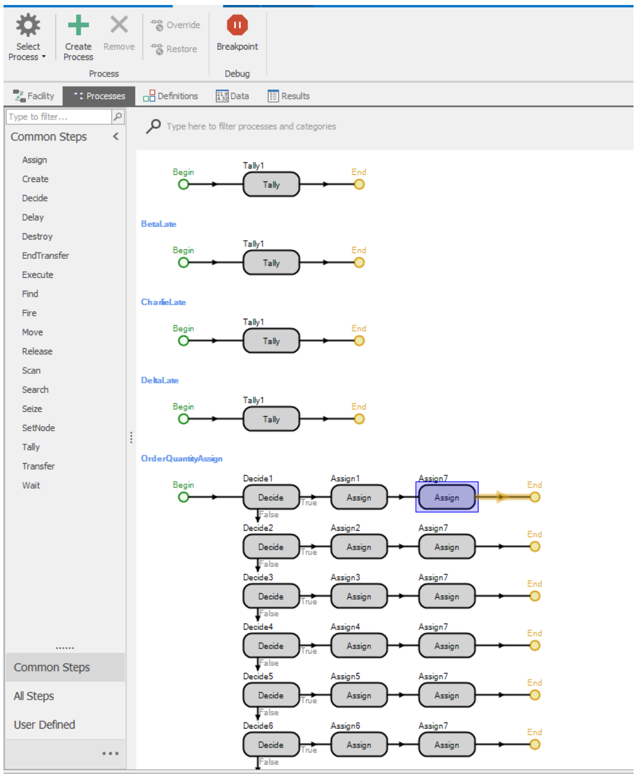
{Rig}LateDeliveries to count number of late deliveries (i.e. If ModelEntity.TotalDeliveryTime is greater than 5)
{Rig}LateTimes to calculate how delayed the delivery is (i.e if {Rig}LateDeliveries>0 then {Rig}LateTimes = ModelEntity.TotalDeliveryTime-5)

{Rig} indicates any of the four rigs.

State variables at Model level:

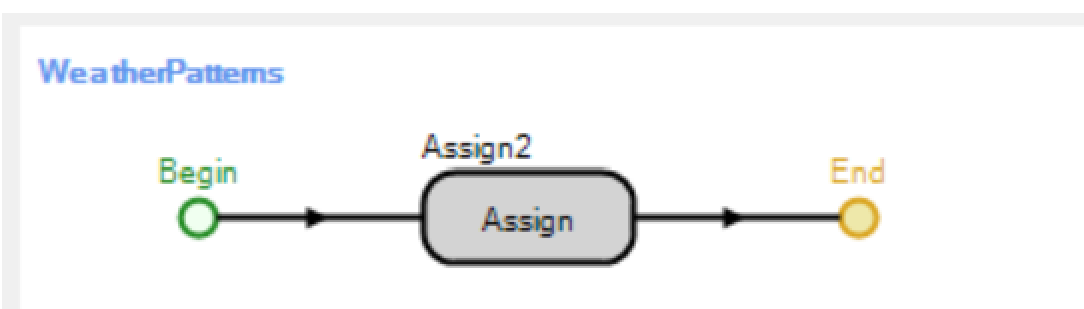


Add on Process:



From the above screenshot, first four add on processes with tally process are to count the number of late deliveries and how delayed each delivery is.

The add on process 'Order Quantity Assign' is to assign the order quantity and thus load in and load out times for each entity.



Another add on process that triggers the weather pattern changes and thus the vehicle speeds at all the exit nodes of servers.

Model Animation:

- For animation, we applied models ‘oil rig’,’sea port’, ‘buoy’,’Cargo+Ship (1)’,’container’ for the components Rigs,Ports,Waypoints,Vessels and entities respectively in the model.
- We added a status label to the vessels to print the current speed of the vessel at given time with expression as ‘Desired Speed’
- We added a floor label to showcase Wind speeds and wave heights and vessel speeds in all three zones (i.e, Central,North,South) by following expressions:
  North Wave Height: {North_WaveHeight}
  South Wave Height: {South_WaveHeight}
  Central Wave Height: {Central_WaveHeight}
  North Wind Speed: {North_Windspeed}
  South Wind Speed: {South_Windspeed}
  Central Wind Speed: {Central_Windspeed}
  South_Speed: {VehProp[VesselType].MaxSpeed - 1.9 * ((South_Windspeed + South_WaveHeight) / (VehProp[VesselType].WaveHeightResistance + VehProp[VesselType].WindResistance))}
  North_Speed: {VehProp[VesselType].MaxSpeed - 1.9 * ((North_Windspeed + North_WaveHeight) / (VehProp[VesselType].WaveHeightResistance + VehProp[VesselType].WindResistance))}
  Central_Speed: {VehProp[VesselType].MaxSpeed - 1.9 * ((Central_Windspeed + Central_WaveHeight) / (VehProp[VesselType].WaveHeightResistance + VehProp[VesselType].WindResistance))}

  Max Speed: {VehProp[VesselType].MaxSpeed}
  Weather Factor: {(South_Windspeed + South_WaveHeight) / (VehProp[VesselType].WaveHeightResistance + VehProp[VesselType].WindResistance)}

- We added a status label at each rig showcasing the number of delays at that particular rig with expression as ‘{Rig}LateCounter’.
- We added 4 status pie labels with 2 rows in each to represent ‘Number of orders created’ and ‘Number of late deliveries’ to understand the percentage of late deliveries at each rig.

Experimentation and results:

Primary responses:

Count of Late Deliveries at each rig and how delayed each late delivery is?

Penalty = 240000*DelayedTime in Days

Total Cost=Penalty+Ship expenses

OptQuest parameters and alternatives analyzed:

- Objective = Max(TotalCostFunc)
- Variables: Vessel Type (1,2&3)
- Vessel Counts at each port: [20,70] increments of 10
- Warm up period: 30 days
- Run Time: 365 days
- Confidence level: 95%
- Min and max replicas: 10,20
- Max scenarios: 300

Optquest ran a total of 108 scenarios with 10 replications in each scenario.

Final Recommendations:

A minimal cost is obtained by employing vessel type 9000 by having 30 at Hamburg port and 40 at Rotterdam Port