Container Terminal Simulation
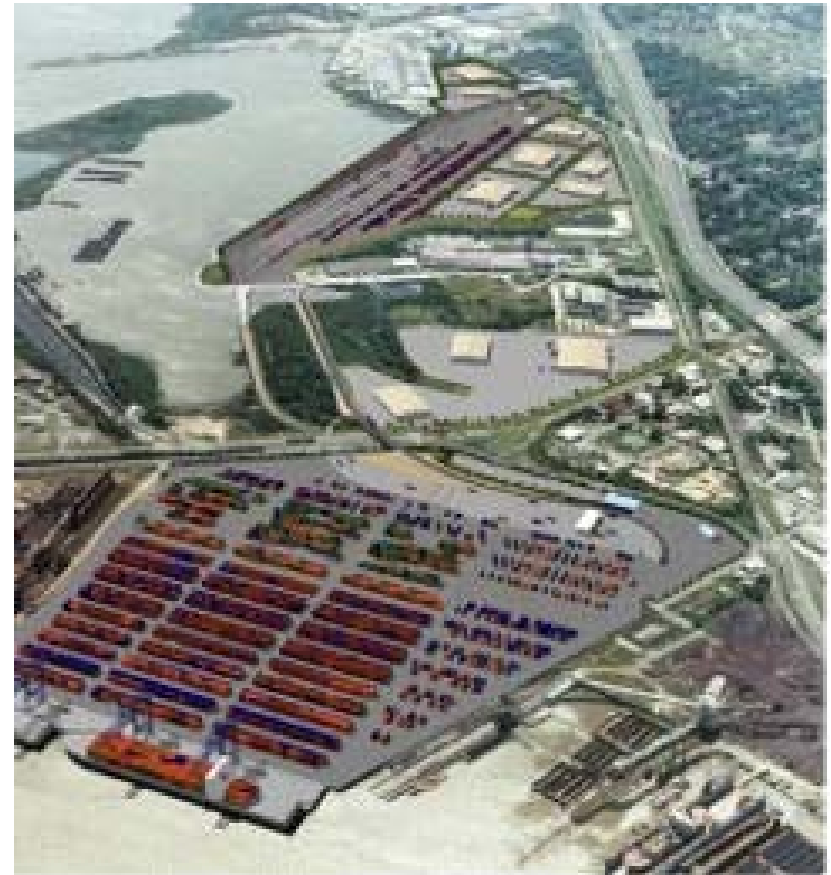
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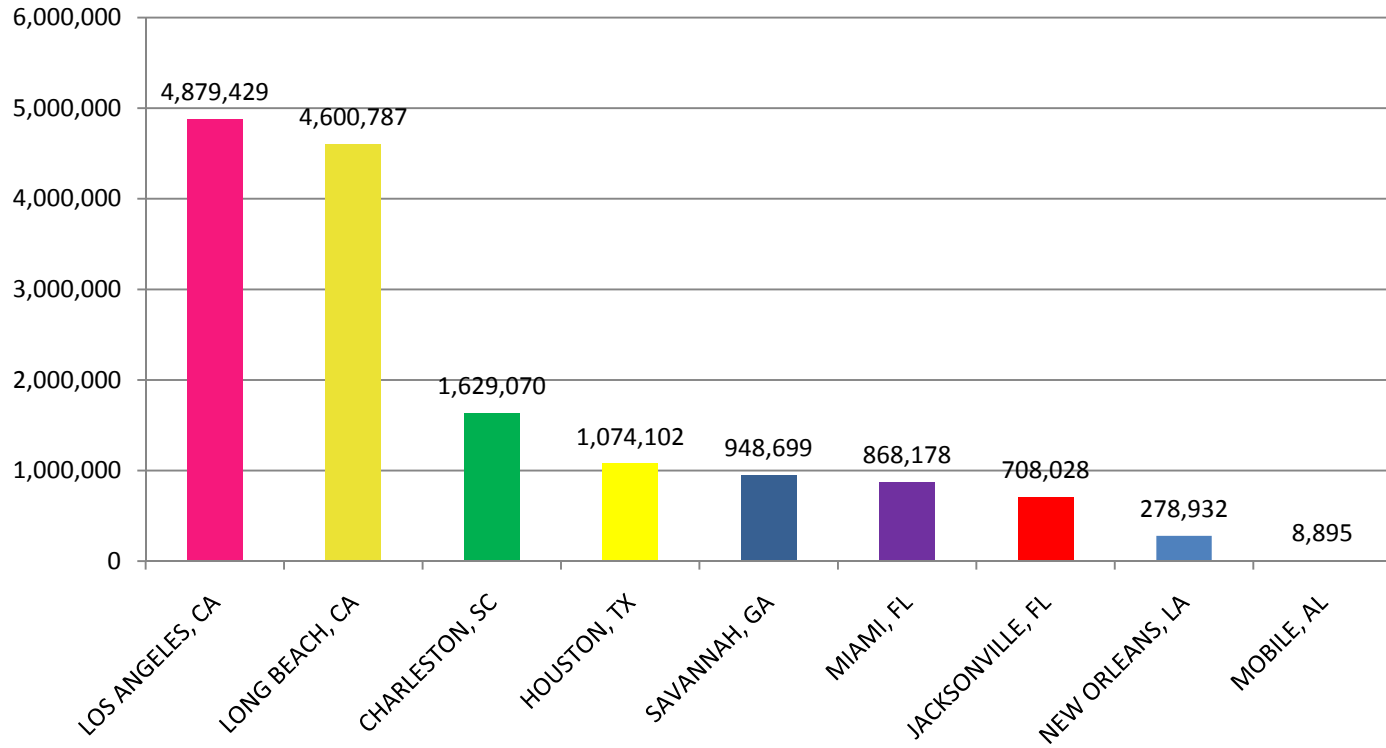
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Introduction
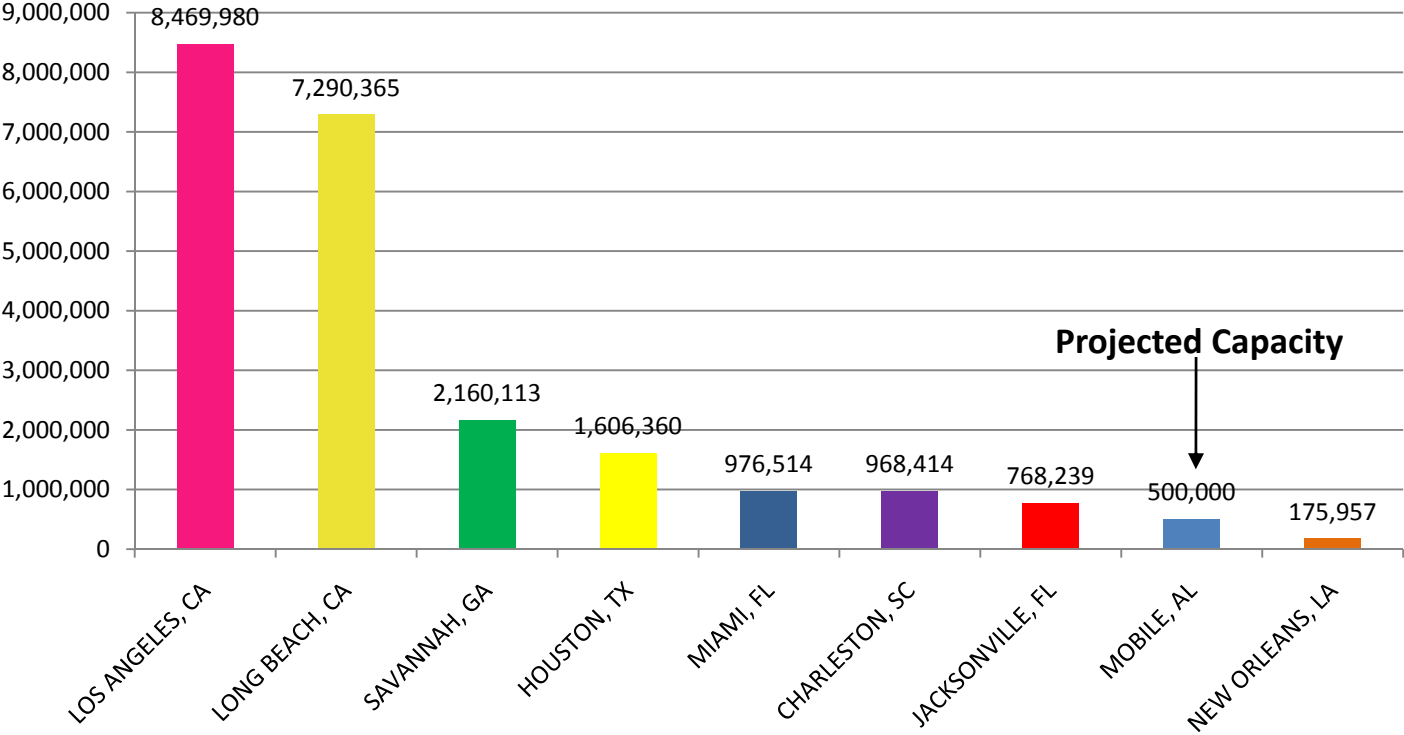
- Over 90% of cargo currently transported worldwide is shipped as containerized cargo. Supply chains are becoming more global, and containerized cargo is increasing.

- The Alabama State Port Authority is currently enhancing container and intermodal operations at the Alabama State Docks in Mobile.

- The project should be completed by the end of 2007(?) at an estimated cost of $240 million.

PORT STATISTICS - 2000 TEUs

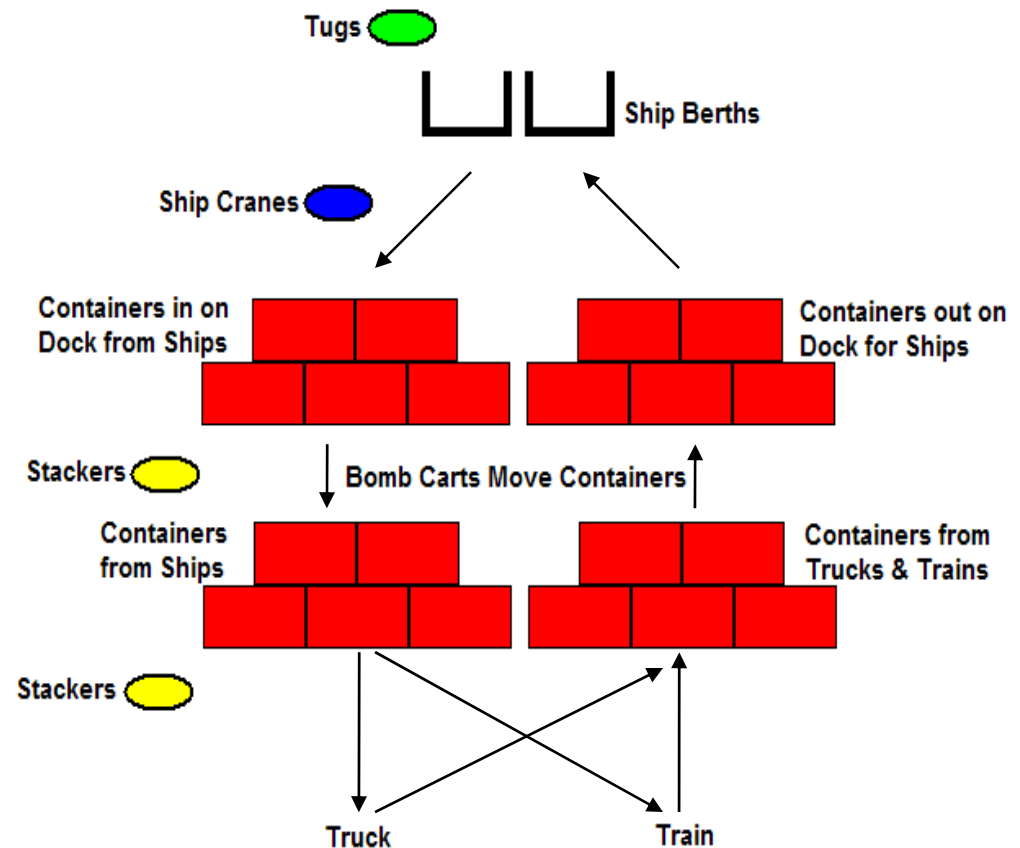| Port	TEUs
LOS ANGELES, CA	4,879,429
LONG BEACH, CA	4,600,787
CHARLESTON, SC	1,629,070
HOUSTON, TX	1,074,102
SAVANNAH, GA	948,699
MIAMI, FL	868,178
JACKSONVILLE, FL	708,028
NEW ORLEANS, LA	278,932
MOBILE, AL	8,895

Reason for Research

- Can a container terminal be simulated quickly to verify capacity?

- Interested in validation of the design capacities of the container terminal.

- Special Interest: utilization of the berths, cranes and stackers, and the maximum container throughput of the terminal.

Container Terminal Conceptual Framework

- Ship Unloading and Loading of Containers
- Train Unloading and Loading of Containers
- Truck Unloading and Loading of Containers
- Movement of Containers from Ship Dock to Container Yard
- Movement of Containers from Container Yard to Ship Dock
- 2 Container Inventory Locations

ProcessModel Sub-Model for Ships

Ship Crane

Ship

Tug

All Capacities = 2

Ship_Berth

Containers_In_Ship=500
Containers_Out_Ship=150
GET Tug
TIME (20min)
FREE Tug
GET Ship_Berth
GET Ship_Crane

Conditional
ContainerS<Containers_In_Ship

FREE Ship_Crane
Capacity=1

WAIT UNTIL Containers_On_Dock_Out>
Containers_Out_Ship
DEC Containers_On_Dock_Out, Containers_On_Ship
INC Total_Out_On_Ship, Containers_Out_Ship
GET Ship_Crane

FREE Ship_Crane
FREE Ship_Berth
GET Tug
Time (20min)
FREE Tug

| Ship Arrives at Terminal | Unload Ship | Dummy 1 | Process Paper to Load Ship | Wait for Containers at Ship | Load Ship | Dummy 3 | Tug Escorts Ship to Harbor | Ship Leaves Terminal |

Conditional
ContainerS>=Containers_In_Ship

Move t=10

Capacity=1

Crane Unloads 1 Container on Dock

Crane Loads 1 Container on Ship

Conditional
ContainersSL<Containers_Out_Ship
Conditional
ContainersSL>=Containers_Out_Ship

TIME (2min)
INC ContainerS, 1
INC Containers_On_Dock_In, 1
INC Total_From_Ship, 1

TIME (2min)
INC ContainerSL, 1

Verification & Validation

- Used a "label-block" option that displays data from the global variables during simulation.

- Reduced simulation speed makes it possible to observe and verify the values as entities move through.

- The TABLE shows values after running the model for 1,440 hours, or 60 days.

- Model validation was not possible because the Mobile Container Terminal is still under construction.

- Data from the existing facility was used for service times.

Containers Unloaded from Ships	10,000
Containers Unloaded from Trains	6,000
Containers Unloaded from Trucks	1,440
Containers Loaded onto Ships	3,000
Containers Loaded onto Trains	6,000
Containers Loaded onto Trucks	1,440
Containers on Dock Unloaded from Ships	0
Containers on Dock Waiting to be Loaded onto Ships	4,440
Containers in Container Yard from Ships	2,560
Containers in Container Yard from Trains and Trucks	0

Model Run Settings

	Time Between Arrivals			
	Ships	*Trains*		*Trucks*
Baseline	4,320 min	1,440 min		60 min
Run 1	2,880 min	960 min		40 min
Run 2	1,440 min	480 min		20 min
Run 3	720 min	240 min		10 min
	Ships	*Full*	*Empty**	*Trucks*
Run 4	1,440 min	1,440 min	720 min	20 min
Run 5	1,440 min	1,440 min	900 min	20 min
Run 6	1,440 min	1,440 min	1,080 min	20 min

* The results indicate that the addition of the logic for the arrival of empty trains greatly reduce the number of containers waiting in the terminal.

Utilization of Resources in Baseline Simulation

- Tugs (2)   1%
- Berths (2)   22%
- Cranes (2)   22%
- Bomb Carts (20) 11%
- Stackers (8)   18%

- 20 Ships through terminal
- 60 Trains through terminal
- 1,440 Trucks through terminal

Results

Container Activity	
	Run 5
Containers Unloaded	
Ship	29,973
Train	6,000
Truck	4,320
Containers Loaded	
Ship	8,850
Train	25,200
Truck	4,320
Containers in Yard	
From Ship	449
From Train & Truck	0
Containers on Dock	
In from Ship	0
Out from Train & Truck	1,470

Containers Unloaded =   40,293

Containers Loaded =   38,370

Containers in Yard =   449

Containers on Dock =   1,470

Total for 60 days =   80,582

x   6

Total for 12 Months =   483,492

Conclusions

- The authors were able to rapidly construct this simulation using ProcessModel.

- Model Verification was rather lengthy.

- The use of ProcessModel labels greatly improved the V&V process

- Containers were animated to show movement.

- The large container build-up in the terminal for runs 1-3 indicate a need to further balance the entity arrivals to give a more accurate estimate of container throughput.

Conclusions

- Runs 4-6 included logic for the arrival of empty trains.

- The terminal capacity was 240,000 containers for Run 5 with about 2,000 containers still in the terminal

- The simulation of a container facility can provide insight for the initiation of operational improvements needed to increase freight throughput and velocity.

Areas for Model Refinements

- Refinement to the model in the areas of train arrival and number of cars available would greatly increase accuracy.

- The constant data used in the model should be replaced with valid statistical distributions such as triangular distribution to more accurately replicate real world scenarios.

- Additional refinements to limit the time in which a rail car will wait for loading before leaving the resource pool are needed.