



## Discrete Event Simulation Helps to Improve Terminal Productivity for New Design Container Ships

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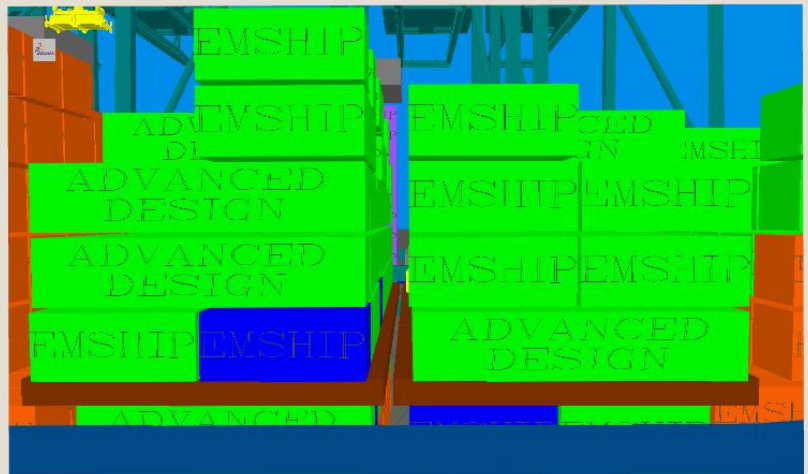
Professor Jean-David Caprace

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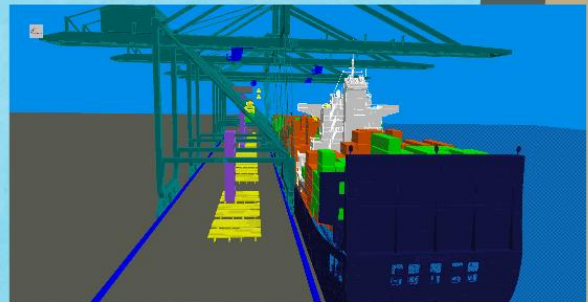
# Introduction

Efficiency improvement in container terminal operations:

- Lead to increase service capacity,
- Reduce berthing time
- Reduce operational expenses of ports.

Also

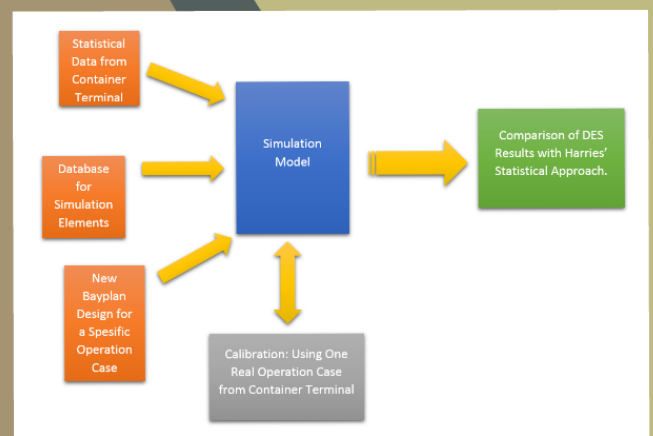
- Allow ships to sail in slower speeds and save petroleum. (Slow Steaming)



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# Objectives

- Examine the efficiency of a new bay plans design which aim to be faster to load and unload at container terminals
- Productivity assessment and validation of a specific container terminal.



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# Methodology

## Discrete Event Simulation:

Stochastic approach for combined probabilities of all individual event on the process flow.



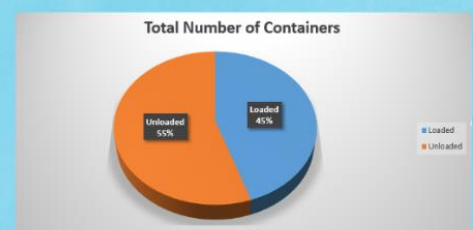
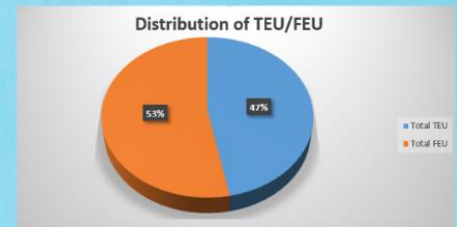
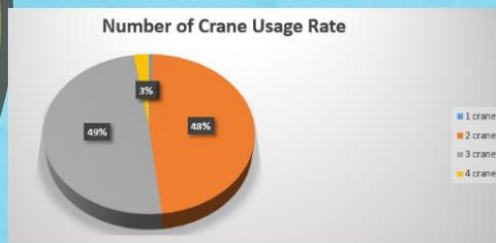
Realistic Prediction

“Each event occurs at a particular instant in time and marks a change of state in the system” Robinson (2004).



## Statistical Analyse of the Terminal

- Libra Container Terminal, Rio de Janeiro - Brazil
- 500 Crane operations in total of 197 ship berthing cases between January-July 2014
- Total number of 78180 containers handled



## Statistical Analysis of Delays

### Delays are examined under 3 main title:

- Delays Due to Waiting for Truck and Container (depending on yard interface efficiency)
- Delays due to Defect of Crane or Spreader
- Delays due to Other Reasons
  - Due to Lashing-Unlashing, Safety Inspections, Accidents, Put/Remove OOG adaptor, etc.)

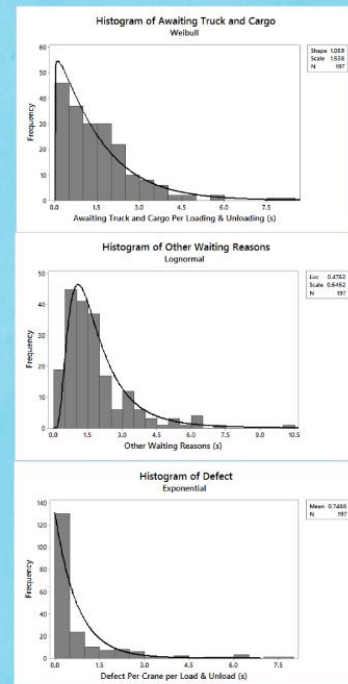


## Distributions of Delays

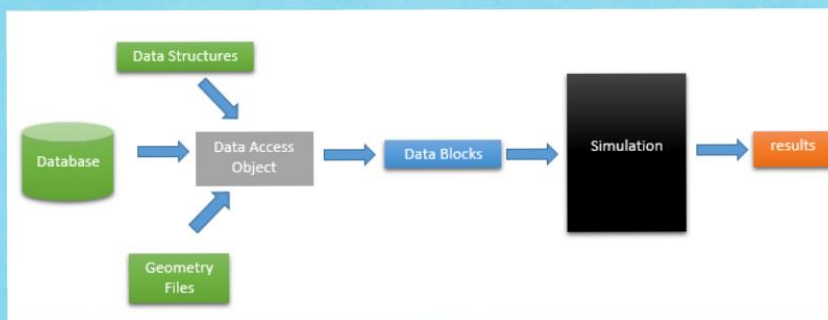
For each operation, container terminal data contains total duration of different delays.

In order to apply these delays in the simulation, they are calculated per engagement/disengagement to container for 3 main delay cases.

Distribution fitting test is made and the best fitting distributions are chosen and applied on simulation.



## Simulation Model Creation



All simulation model is created parametrically.

**Database:** Files which contains related data. Arrival condition, Bayplan, Containers, Stowing Schedule, objects, etc.

**Data Structures:** Includes the main variables used in each Data Access Objects. (For instance, for Container Structure file, to define container id, type, color, etc.)

**Data Access Objects:** Files used to implement Database files to be called in Data Blocks.

**Data Blocks:** Contains logics to control elements.

# Simulation Model Calibration

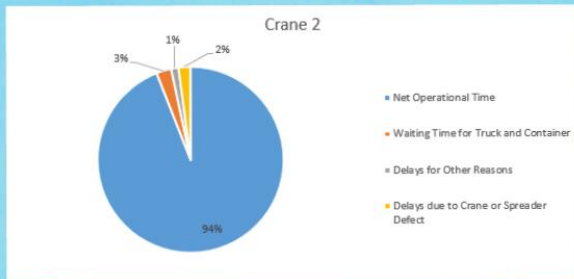
- One real operation report from container terminal belongs to most frequently seen ship on terminal is examined.

Vessel Name: Hyundai Platinum  
 Operation Date: 13.09.2014  
 Total Loaded: 126  
 Total Unloaded: 624  
 Total Crane Used: 3

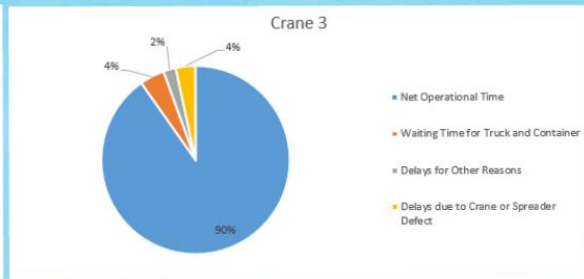
Calibration		Total Operational Time (hh:mm)	Net Operational Time (hh:mm)	Total Crane Moves	Gross Crane Productivity (Movement/hour)	Net Crane Productivity (Movement/hour)
From Operation Report of Libra	Crane 1	09:48	07:59	164	16.73	20.54
	Crane 2	09:11	08:42	305	33.21235	35.06
	Crane 3	08:01	07:32	305	38.05	40.49
	Crane 2&3 Average	08:36	08:07	305	35.63	37.78
From Simulation Calibration	Crane 1	04:23	04:13	164	37.44	38.96
	Crane 2	08:19	08:00	305	36.65	38.10
	Crane 3	08:34	08:14	305	35.59	37.06
	Crane 2&3 Average	08:27	08:07	305	36.12	37.58

\*Each simulation is run for 400 iteration.  
 \*\*Standard deviation for crane 1, 2, and 3 are \*\*Standard deviations for Crane 1, 2, and 3 are 20, 27 and 29 seconds, respectively.

# Simulation Model Calibration Results

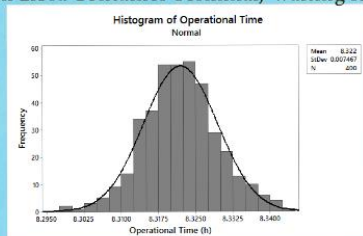


Operational Time & Delays Pie Chart for Crane 2



Operational Time & Delays Pie Chart for Crane 3

In Libra Container Terminal, waiting for truck and container takes 4% of total operational time.



Distribution of Total Operational Time - Crane 2



Convergence plot of Crane 2



## Simulation Cases

### 1st case:

One Crane Comparison

- +10% Speeds of Crane
- High Tide/Low Tide (Assumed to be  $\pm 0.5$ m tide amplitude.)
- 53% FEU (As the statistical analyse result of Libra Terminal)

### 2nd case:

TEU Multiple Crane Comparison

- Up to 5 cranes implemented (practical upper limit)

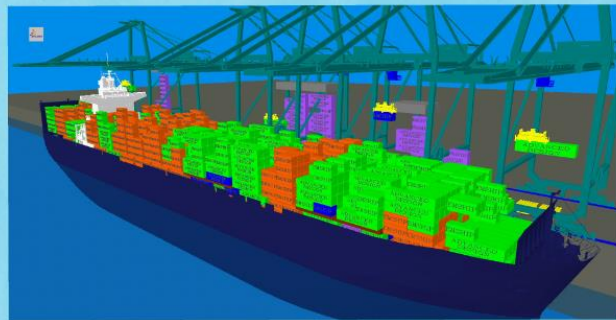
### 3rd case:

FEU Multiple Crane Comparison

- FEU Case is examined with up to 5 cranes.

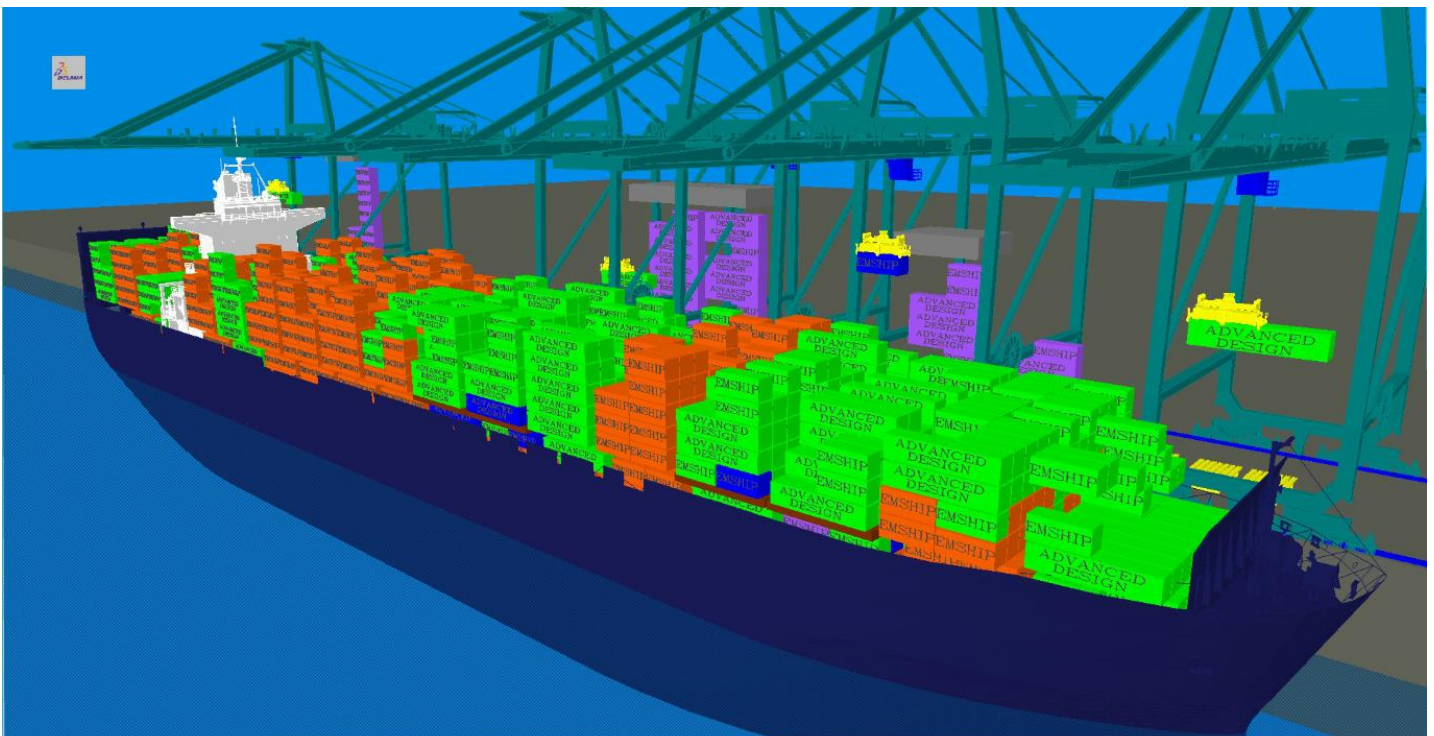
### Simulated Vessel

- 4250 TEU Panamax
- 1292 Container Unloaded
- 92 Containers Loaded
- 15 hatch covers unloaded&loaded back.



Each Other Stage - Discrete Event Simulation Helps to Improve Terminal Productivity for New Design Container Ships - EMSHIP 2013-2015

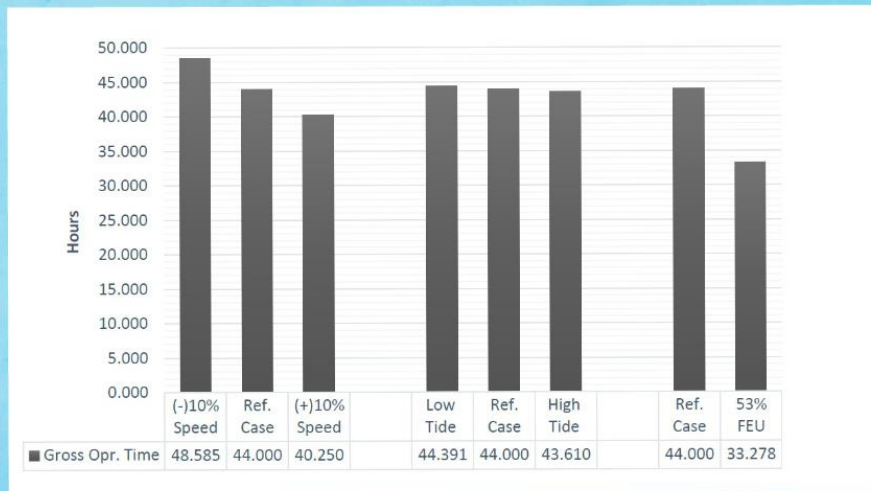
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## Simulation Results

### Case 1

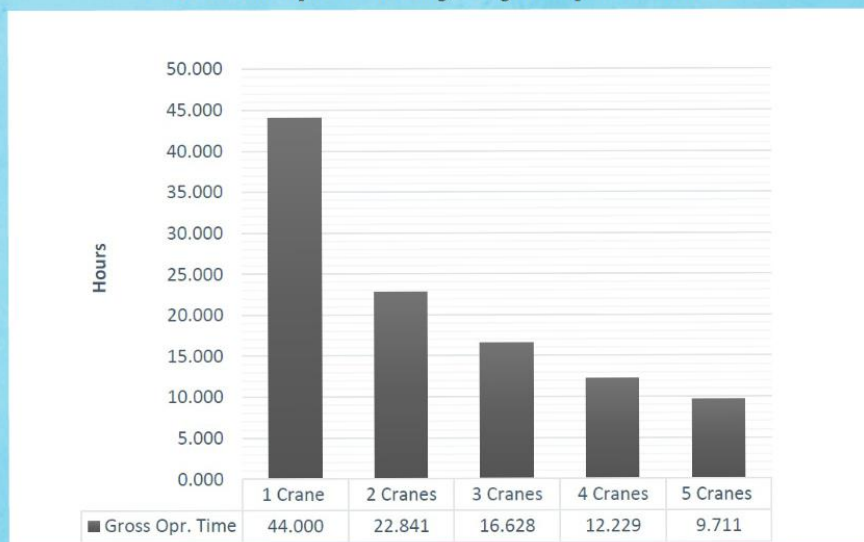
Gross Operational Times of Different Studies Comparison with Reference Case



## Simulation Results

### Case 2

Effect of multiple crane usage on gross operational time.

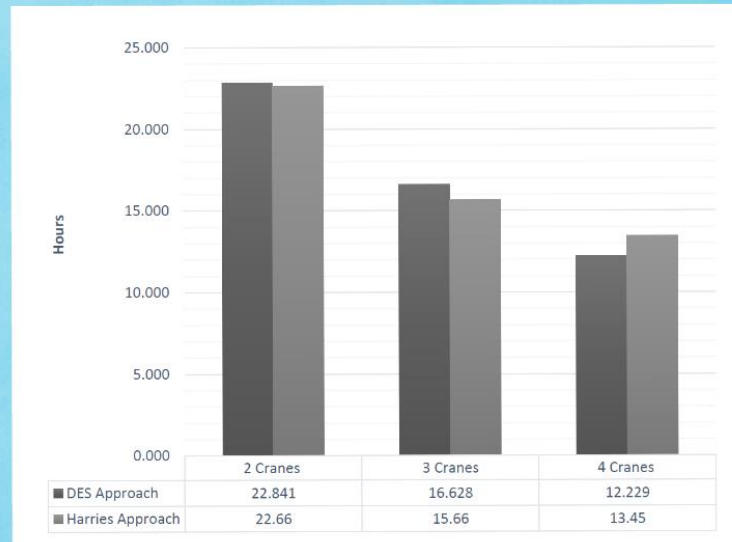




## Simulation Results

### DES & Statistical Approach Comparison

Comparison of DES & Statistical (Harries') Approaches on Gross Operational Times for multiple cranes.



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## Conclusions

- Container terminal simulation is created fully parametrically, calibrated with one specific ship operation and 7 months of operational data.
- The effect of various conditions on the total operational time of the new vessel is assessed stochastically.
- Effect of multiple crane usage on berthing time of a ship is observed.
- It is seen that tide does not have a big influence on total operational time, however changing the speeds of hoist and spreader affects productivity likewise.
- It is clarified that DES is a reliable tool to inspect the port efficiency of a new bay plan design for a container ship.

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**EMship**  
Advanced Design



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**Thank you for your attention.**