

# CONTAINERS MOVEMENTS COST ANALYSIS IN A MARINE TERMINAL

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# Introduction

*In a marine terminal, logistics of container movements and arrangement can certainly affect the benefit*

*Container logistics management understood from the time that a container is discharged at a port, can be defined as a set of financial transactions, and based on the logistic principle that every movement generates a cost*

*Can cost of passage and stay of a container at a terminal be reduced ?*

*Given the land cost, the machinery, the labour...*

# Formulation of the problem

20 and 40 foot containers. The TEU.

20-foot-long (6.1 m) and 8 feet (2.44 m) wide  
(exact length is 19 feet 10.5 inches (6.058 m) )

Height: between 4 feet 3 inches (1.30 m) and 9 feet 6 inches (2.90 m)  
The most common height is 8 feet 6 inches (2.59 m)

20 foot: 24000 kilograms max.

40 foot: 30480 kilograms max.

90% of containers in ships are 40 foot units

Some 80% of the world's freight moves via 40 foot containers

Heavy loads (twenty foot units) with a maximum mass of 30500 kg

# Formulation of the problem

Transport at sea by containers: different phases, summarized as:

- Filling of the container (packaging of goods in the containers)
- Arrival at a terminal (concentration of containers by road / train)
- Handling in the terminal** (at the yard) -> modern machinery
- It is **rarely known** where inside a ship (bay, row, and tier) a given container would be transported, at the moment of arrival at the terminal.
- Management of **knowledge might imply reduction in shifting/reordering** containers to be loaded in a ship, information could be used to reduce cost.
- Restrictions**: location of reefers, hazardous and over sized containers.
- Nowadays technology comprises Gantry cranes at port (sea-side), straddle carriers (SCs), forklifts top loaders, rubber-tyre and rail-mounted gantries (RTG and RMG), and tractor-trailers for movements and stacking at the terminal yard.

# Formulation of the problem

- Loading ship: the master bay plan problem (stability/safety of ship)  
Information processing and computation technology (stability), use of modern machinery to move the containers, from the yard terminal.
  - Ship routes and alterations to avoid bad weather important, but are not considered here.
- Unloading of a ship uses modern machinery, the same as the loading process, and is strongly conditioned by the previous loading process.
- Handling in the terminal** (at the yard), uses modern machinery and related to the **intermodality** (out of the port terminal, train and trucks)
  - Distribution on land side (done with road and train)
- Distribution of goods from the container (emptying the containers)

# Formulation of the problem

**Location of a container:**

In the ship:

Bay, row, tier

In the Terminal (at the yard):

the block, the bay, the row and the tier.

Maximum tier: 5-6

Reshuffles (or re-handles)

# Formulation of the problem

**The average daily yard utilization of large container terminals in Europe is about 10.000–20.000 containers resulting in about 15.000 movements per day.**

**The time of containers in the yard is in the range of 3–7 days at an average.**

**Barcelona: near 1.8 MTEU/year  
-> near 5000 TEU/day average**

# Formulation of the problem

## Operations:

(1) Cost of land;

(2) Cost of equipment; and

(3) Cost of labour.

(4) Also, machinery working  
-> fuel, maintenance

Other (not considered): customs, inspection, damage by  
accident

Decomposition: **Land + Machinery + Labour**



# Formulation of the problem

## Variables:

- Cost of loader for stacking the containers: CT
- Loader maintenance and operation, including energy/fuel: MTL
- Cost of chassis for containers, if wheeled: CC
  - Chassis maintenance: MCC
- Depreciation of machinery =  $1/15$  of their purchase value. (This assumes average 15 years of useful life)
  - Cost of labour for operating the loader: CW
  - Area required per container parked: AC
- Area required per container stacked: AS. Depends on tier number
  - Average stay of the containers in the terminal: AD
- Interest rates: RI (in %) (Applied for buying the machinery)
  - Cost of Land: CL (per unit area per year)
- The terminal's daily volume: DV (containers a day)
  - The loader's efficiency: LM

# Formulation of the problem

Data for the model. Area in m<sup>2</sup>, costs in Euro

AC = AREA PER CONTAINER REQUIRED FOR PARKING;	87
AD = average delay of a container in the terminal (number of days in the terminal);	5 (variable)
CC = chassis cost (purchase price);	7500
CL = cost of land, per square meter per year;	30-60
CT = cost of a loader	3E5-1E6
CT/15 = straight line depreciation over 15 yr;	20000-66700
CW = cost of personnel required for the operation of the loader, per year	60000
DV = daily container volume in the terminal;	5000
LM = number of containers a loader can handle in a day	50-150
MCC = cost of chassis maintenance;	750
MTL = maintenance cost of a top loader;	30000-100000
RI = interest rate in %;	6-12

# Formulation of the problem

## Equations:

The total cost for stacking operations (TCS) and the total cost for wheeled operations (TCC) were calculated according to the equations (quantities for a year):

$$TCS = AD \cdot DV \cdot AS \cdot CL + (DV/LM) * (CT*RI + CT/15 + MTL + CW)$$

$$TCC = AD \cdot DV \cdot AC \cdot CL + AD \cdot DV \cdot (CC \cdot RI + CC/15 + MCC)$$

The ratio  $R = TCS/TCC$  was also calculated

# Formulation of the problem

$$TCS = AD \cdot DV \cdot AS \cdot CL + (DV/LM) * (CT * RI + CT/15 + MTL + CW)$$

Note that if CT is higher, but LM is proportionally higher,  
Then CW effect is reduced (DV/LM means number of devices)

# Formulation of the problem

Area per container occupied for stacking

LEVELS (TIER NUMBER)	2	3	4	5	6
AS = area per container required for stacking, in square meter	43,7	29,3	22	17,6	14,5

1 level means 87 m<sup>2</sup> per container

# Formulation of the problem

**The reshuffling problem:**

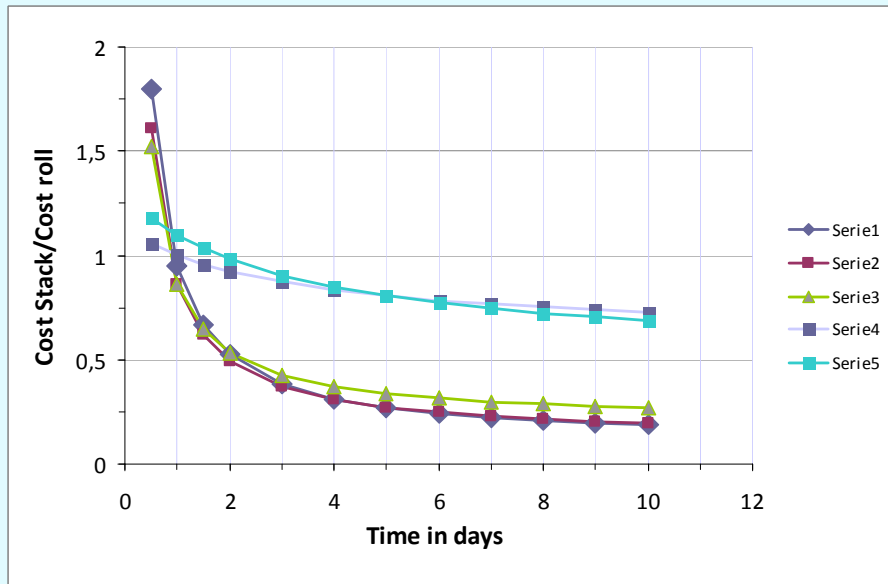
**LM depends on tier number**

**(say, near 70% at 5 tier)**

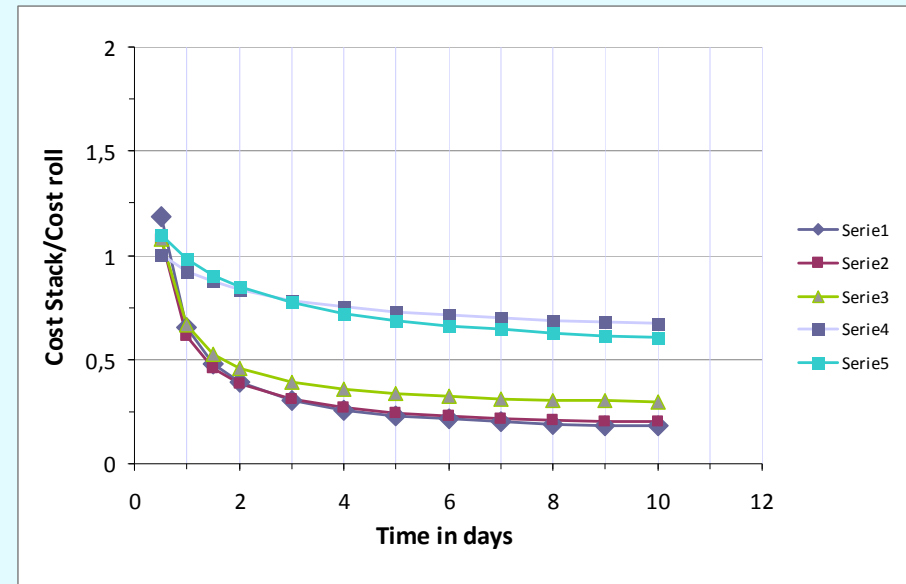
**Cost of machinery: at higher performance, cost increases,  
but doubling cost and doubling performance implies a  
benefit: Interaction among loaders, salaries**

**Interest rates affect to Machinery costs (no CW)**

# Results

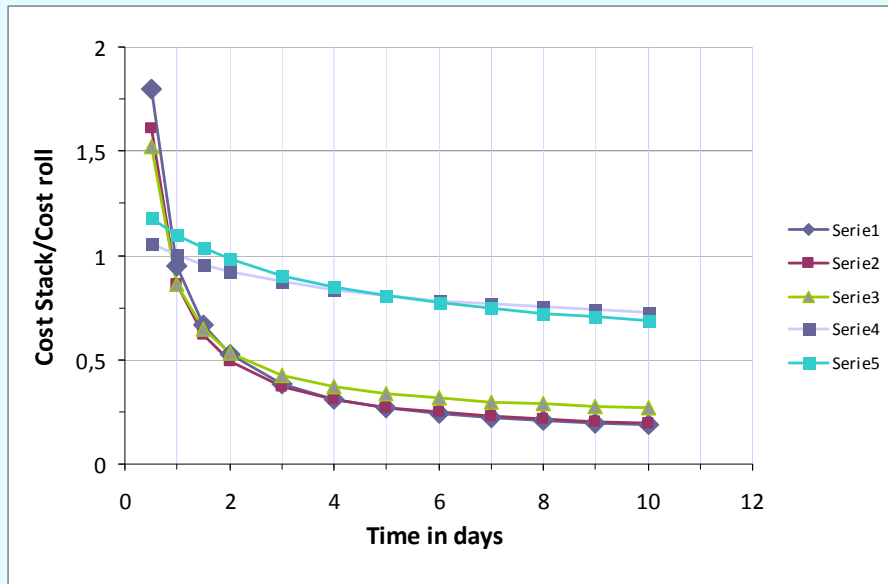


**Left:** Series 1: Cost stack to 6 tier divided by cost to wheel the containers (values under 1 favour the stacking). Series 2: Cost of stack to 5 tier divided by cost of wheel the containers. Series 3: Cost of stack to 3 tier divided by cost to wheel. Series 4: Cost of stack to 6 tier divided by cost to stack to 3 tier. Series 5: Cost to stack to 5 tier divided by cost to stack to 3 tier. Computations with 6% interest rate. The ratio Cost Stack/Cost roll goes to low values after 1 day (near zero with longer time) because of the high cost of land use (6% interest rate, loader 0.3E6, 30Euro/m2/year for land).

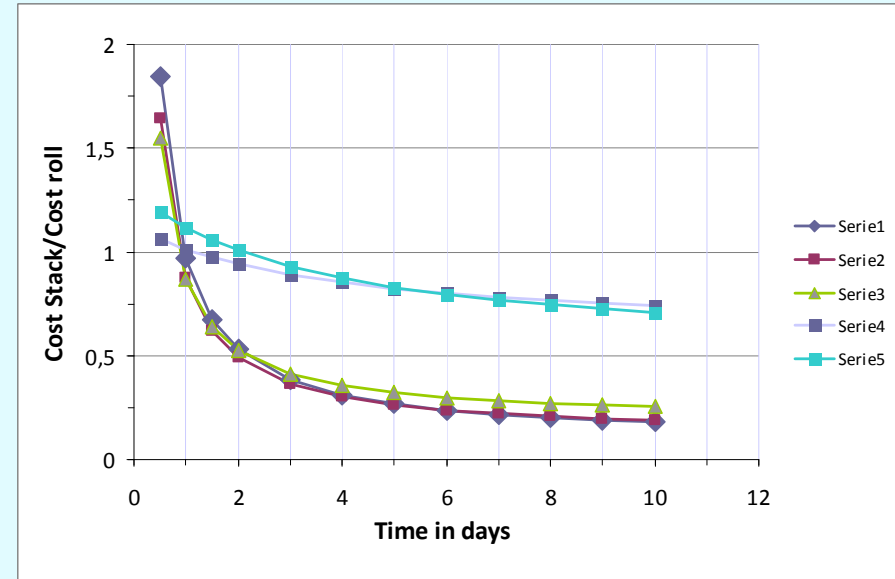


**Right:** Series 1: Cost stack to 6 tier divided by cost to wheel the containers (values under 1 favour the stacking). Series 2: Cost of stack to 5 tier divided by cost of wheel the containers. Series 3: Cost of stack to 3 tier divided by cost to wheel. Series 4: Cost of stack to 6 tier divided by cost to stack to 3 tier. Series 5: Cost to stack to 5 tier divided by cost to stack to 3 tier. The ratio Cost Stack/Cost roll goes to low values after 1 day (near zero with longer time) because of the high cost of land use (60 Euro/m2/year).

# Results



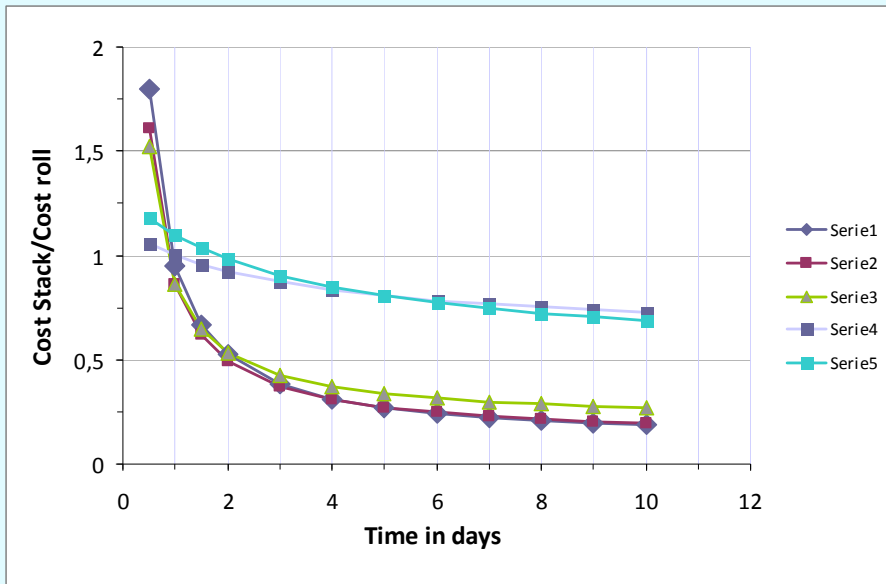
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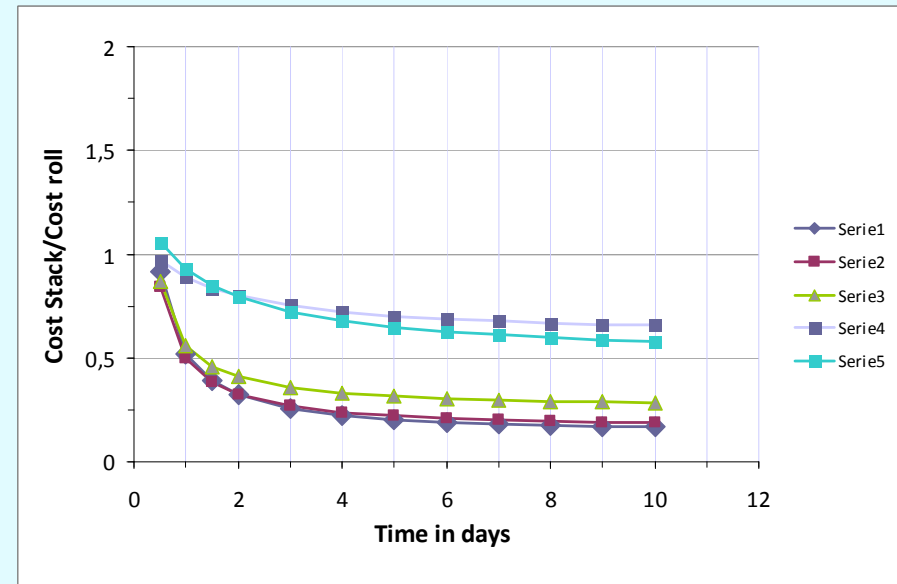
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# Results



**Left:** Series 1: Cost stack to 6 tier divided by cost to wheel the containers (values under 1 favour the stacking). Series 2: Cost of stack to 5 tier divided by cost of wheel the containers. Series 3: Cost of stack to 3 tier divided by cost to wheel. Series 4: Cost of stack to 6 tier divided by cost to stack to 3 tier. Series 5: Cost to stack to 5 tier divided by cost to stack to 3 tier. Computations with 6% interest rate. The ratio Cost Stack/Cost roll goes to low values after 1 day (near zero with longer time) because of the high cost of land use (30 Euro/m<sup>2</sup>year, loader 0.3e6 cost).



**Right:** Series 1: Cost stack to 6 tier divided by cost to wheel the containers (values under 1 favour the stacking). Series 2: Cost of stack to 5 tier divided by cost of wheel the containers. Series 3: Cost of stack to 3 tier divided by cost to wheel. Series 4: Cost of stack to 6 tier divided by cost to stack to 3 tier. Series 5: Cost to stack to 5 tier divided by cost to stack to 3 tier. The ratio Cost Stack/Cost roll goes to low values after 0.5 days (near zero with longer time) because of the high cost of land use (6% interest rate, cost loader 1E6).

# Conclusions

To achieve low cost in container handling, it is needed to **balance** land use and machinery (energy-intensive) use.

The high land cost and **the available space** force the stacking of containers.

The model allows computation of preferred stacking conditions, the high land cost suggests the use of a high stacking ratio (i.e., to use a high tier number), but safety reasons **limit** the tier number to 5 or 6.

# Conclusions

**In the real world: it would be better to use all the available land, for instance in the case of Barcelona or other ports, and by means of logistics and conditions assumed by the clients, force a relatively short stay of containers at the terminal, to keep the stacking relatively low and uniform.**

**Using all the available space to stock the containers might allow a non-maximum stacking height, and a reduced tier number would mean less reshufflings and less time and energy spent to stack the containers**

# Thanks for your attention!

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# Introduction

*Given the extension of a terminal,  
the costs of port land,  
the costs that placements and movements of containers,  
as well as their horizontal and vertical positioning,*

*this work seeks to make an analytical study to check  
whether the assumption of an efficient allocation is  
fulfilled*

*-There is a limit of practical resistance and safety*