Maritime Transportation
An Overview and research directions

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https://unctad.org/publication/review-maritime-transport-2022

Objective

- Understand basics of maritime transport
- Basic research directions

Maritime transportation

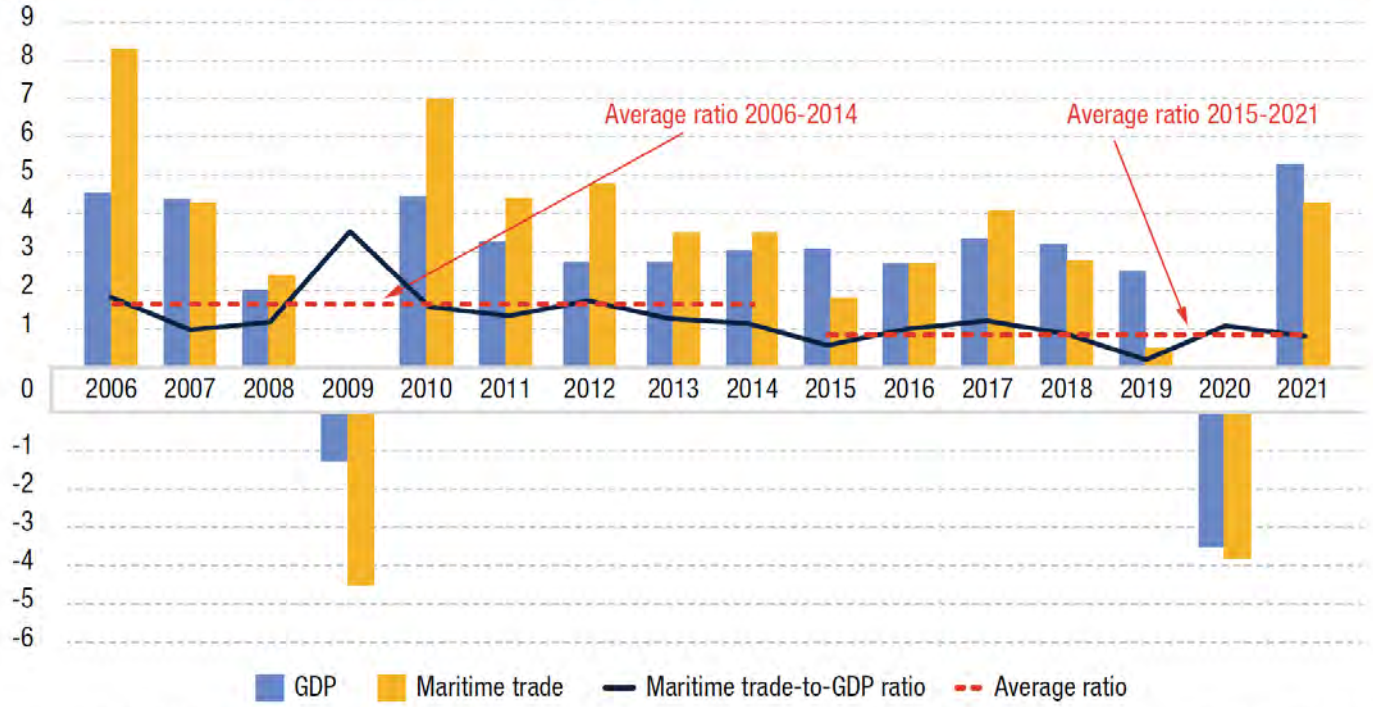
- Almost 90% of the global trade transported by sea
- Most of the general cargo and consumption goods are transported in containerized form
- Tremendous increase in container shipping during the last four years (mainly due to East Asia countries)
- Trade imbalances
- The security issue
- The environment
- Reshoring, onshoring, nearshoring, offshoring: where is the balance
- National security

SOME DATA

World gross domestic product and seaborne trade 2006-2021

Review of Maritime Transport by UNCTAD

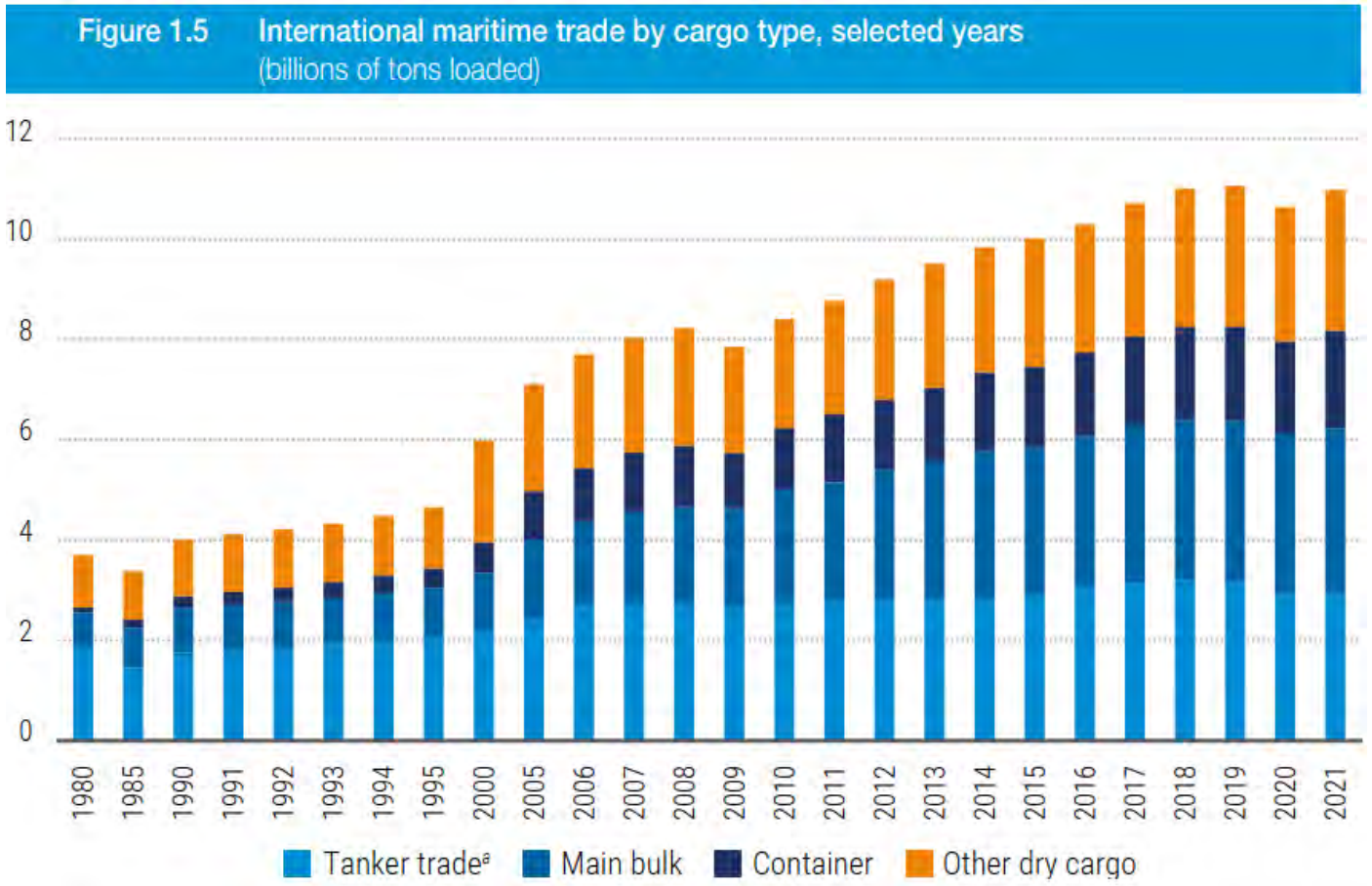
Figure 1 International maritime trade, world gross domestic product (GDP) and maritime trade-to-GDP ratio, 2006 to 2021
(percentage annual change and ratio)



Source: UNCTAD calculations, based on the *Review of Maritime Transport*, various issues, data from UNCTADstat and table 1.1 of the UNCTAD *Trade and Development Report 2021. From recovery to resilience: The development dimension.*

International seaborne trade, selected years (Millions of tons loaded)

- Major Commodities
  - Energy
  - Metal
  - Agricultural
  - Other



MARITIME TRANSPORT MARKETS

The Three Transport Markets

Tramp

- Few transactions per year per vessel (e.g., 6)
- Single cargo
- Operators do not become involved in terminal operations

Liner

- Mostly containers
- Small quantities of bulk
- Very organizational intensive business
- Some operators become involved in terminal operations

Specialized Cargo

- Difficult cargoes (cars, forest products, refrigerated cargo, chemicals, liquefied gas)
- They fall in-between bulk and liner
- Some operators become involved in terminal operations

Difficult entry

Market Characteristics

Tramp market (also known as charter market)

- Perfect competition
- Relatively low value
- Relatively slow speed
- Ship full – empty

Liner market

- Conference/Alliance/Consortia
- Relatively high value
- Relatively high speed
- Ship (partially) full

MAIN DIFFERENCE

Perfect Competition VS Conference/Alliances/Consortia

Tramp vs Liner: type of service

TRAMP

- Service: rental of ship
- Ship can go anywhere- there is no schedule
- Ship is typically full in one direction, empty in ballast
- Most costs are variable

LINER

- Service: get a box from A to B
- Scheduled services
- Thousands of different consignments
- Ship is rarely 100% full or empty
- Most costs are fixed

Difference in cargo type

TRAMP

- Bulk cargo
- Dry or liquid
- Relative value: low

LINER

- General cargo
- Packaged cargo
- Relative value: high

Tanker size classes

- Product tanker 10,000-60,000 DWT
- Panamax 60,000-80,000 DWT
- Aframax 80,000-120,000 DWT
- Suezmax 120,000-200,000 DWT
- VLCC 200,000-320,000 DWT
- ULCC 320,000-550,000 DWT

Bulk carrier size classes

- Coastal <10,000 DWT
- Handysize 10,000-35,000 DWT
- Handymax 35,000-60,000 DWT
- Panamax 60,000-80,000 DWT
- Capesize >80,000 DWT

Liner operators

Some of their ships are owned, some are chartered

This means that many containership owners are not operators

NVOCC (non-vessel operating common carrier): Sell cargo or container space onboard mainline transport vessels

Container Routes

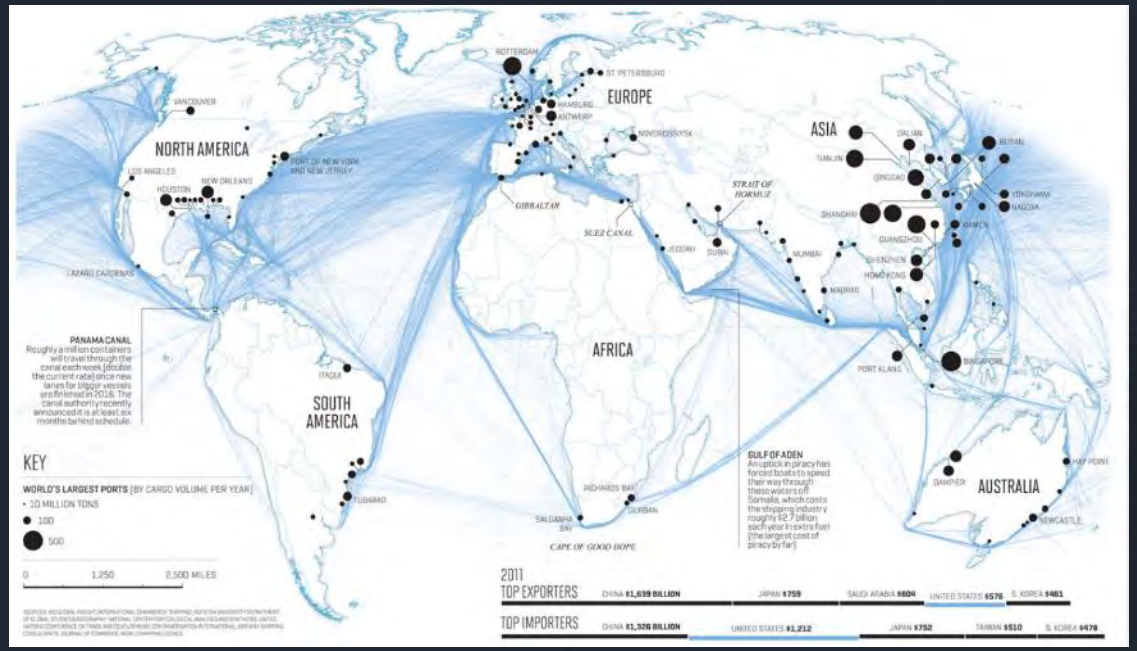
- http://www.worldshipping.org/about-the-industry/global-trade/trade-routes
- http://www.gatewaycontainersales.com.au/how-shipping-containers-changed-the-world/

Trade between an origin group of countries and a destination group of countries is referred to as a **trade route**.

Top Trade Routes (TEU shipped) 2013

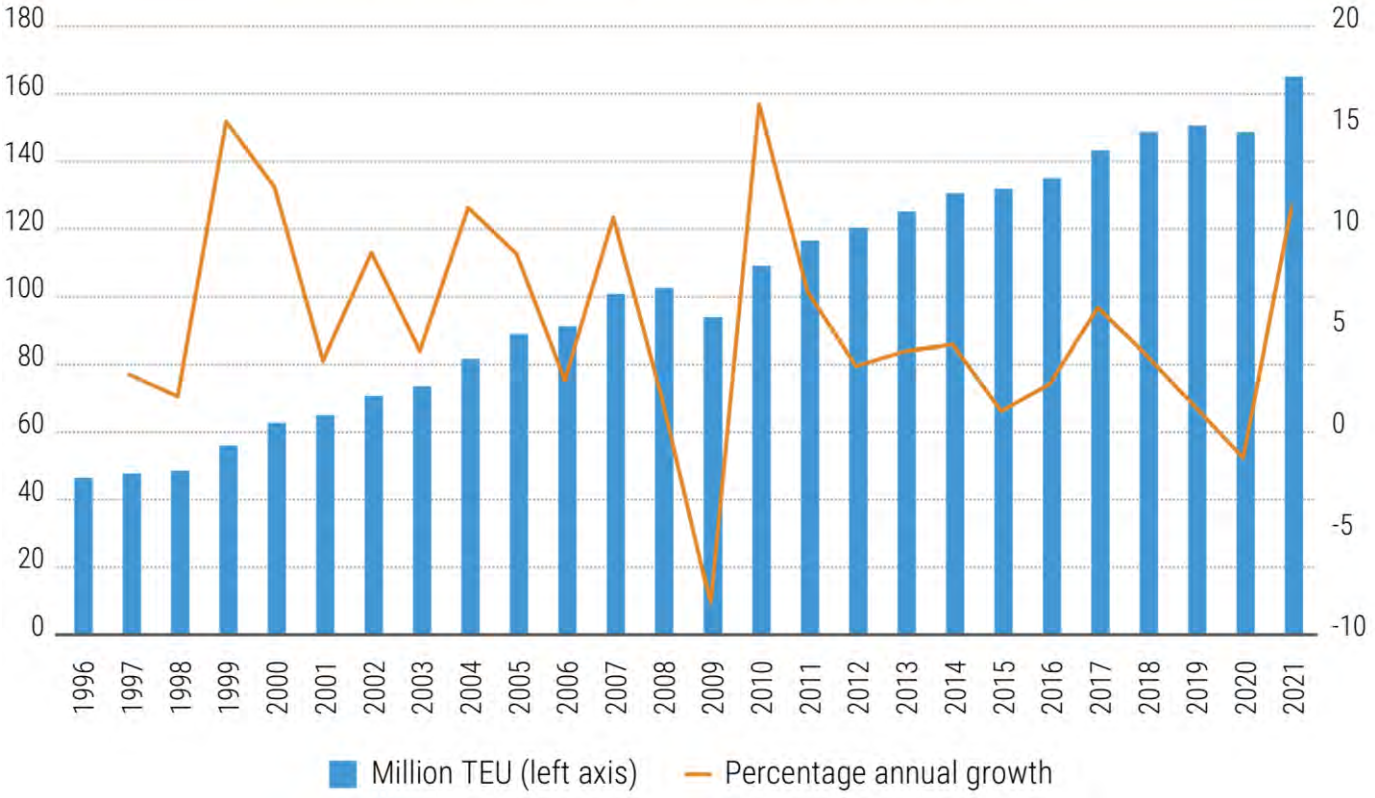
Route	West Bound	East Bound	North Bound	South Bound	Total
Asia-North America	7,739,000	15,386,000			23,125,000
Asia-North Europe	9,187,000	4,519,000			13,706,000
Asia-Mediterranean	4,678,000	2,061,000			6,739,000
Asia-Middle East	3,700,000	1,314,000			5,014,000
North Europe-North America	2,636,000	2,074,000			4,710,000
Australia-Far East *			1,072,016	1,851,263	2,923,279
Asia-East Coast South America			621,000	1,510,000	2,131,000
North Europe/Mediterranean-East Coast South America			795,000	885,000	1,680,000
North America-East Coast South America			656,000	650,000	1,306,000

* : 2012 data



Global containerized trade

Figure 1.6 Global containerized trade, 1996–2021
(million 20-foot equivalent units and percentage annual change)



Top 15 liner shipping companies by number of ships and total shipboard capacity deployed in TEUs

https://www.marineinsight.com/know-more/10-largest-container-shipping-companies-in-the-world/

Table 2.5. World's top 50 liner shipping companies, 2017

Rank	Company	End-2015		End-2016		May 2017			
		Number of ships	Capacity	Number of ships	Capacity	Number or ships	Capacity	Market share (percentage)	Average vessel size
1	Maersk	629	3 103 266	655	3 323 064	621	3 201 871	16.0	5 156
2	Mediterranean Shipping Company	487	2 734 409	458	2 802 830	469	2 935 464	14.6	6 259
3	CMA-CGM	553	2 449 350	460	2 227 600	441	2 220 474	11.1	5 035
4	China Ocean Shipping (Group) Company	285	1 616 462	254	1 508 207	277	1 603 341	8.0	5 788
5	Hapag-Lloyd	187	999 950	171	987 892	180	1 038 483	5.2	5 769
6	Evergreen	197	955 108	188	990 792	186	995 147	5.0	5 350
7	Orient Overseas Container Line	111	583 969	101	594 550	107	666 558	3.3	6 230
8	Hamburg-Süd	138	670 029	127	638 906	116	594 008	3.0	5 121
9	Yang Ming	101	543 772	101	584 839	100	588 389	2.9	5 884
10	United Arab Shipping Company	51	452 510	59	565 433	56	546 220	2.7	9 754
11	Nippon Yusen Kaisha	101	493 443	95	498 076	97	538 754	2.7	5 554
12	Mitsui Osaka Shosen Kaisha Lines	99	549 987	78	467 389	82	515 880	2.6	6 291
13	Hundai Merchant Marine	56	384 403	67	455 841	69	458 247	2.3	6 641
14	Kawasaki Kisen Kaisha Limited – K Line	71	397 557	63	351 890	64	363 019	1.8	5 672
15	Pacific International Lines	134	336 327	132	360 939	132	361 752	1.8	2 741

Source: UNCTAD secretariat calculations, based on data from Clarksons Research.

Size

1) **Feeders** – with a carrying capacity ranging from 1,000 to 3,000 TEUs, further segmented into Small feeders and Large feeders.

2) Classic Panamax – nominal capacity of 5,300 TEUs, so named because they approached the maximum limit of the Panama Canal before its expansion.

3) Neo Panamax – vessels with a nominal capacity of 14,500 TEUs, the maximum permissible limit for the expanded Panama Canal. Sub-divisions include the Small Neo Panamax (10,000 TEUs), Large Neo Panamax (12,500 TEUs) and Maxi Neo Panamax (14,500 TEUs – the largest vessel size that the Panama Canal can cater to)

4) Very Large Container Vessel / Neo post-Panamax – vessels exceeding the Panama Canal limits. The nominal capacity of 18,000 TEUs

5) Ultra Large Container Vessels (ULCVs) – the very largest container vessels, capable of carrying almost 24,000 TEUs.

Source: https://www.marineinsight.com/maritime-law/evolution-and-upsizing-of-container-vessels/

Source: http://www.worldslargestship.com

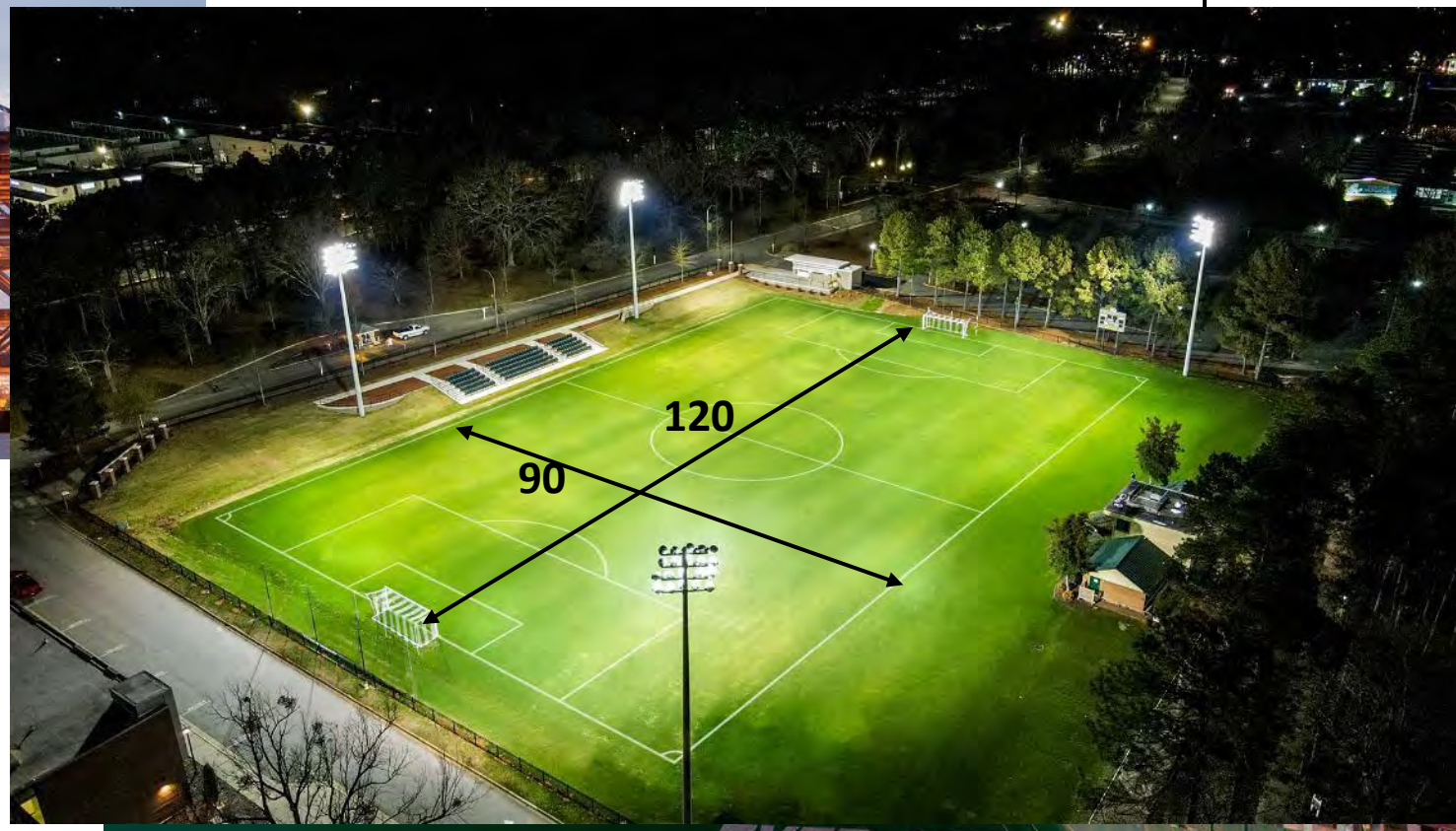
- 20% less CO_2 per container moved compared to Emma Maersk
  - 50% less CO_2 than the industry average
- 35% less fuel per container than the 13,100 TEU

OOCL Hong Kong (2017)

- Ultra Large Container Vessel (ULCV)
- Carrying capacity at 21,413 TEU

Ever Ace: 24,000 TEU

8 ft wide container.
How wide is the ship?



Her length overall (LOA) is 400 m, and her width is 61 m.

A football field is 120m long and 90 m wide!!!!!!!!!

Evergreen has 6 of these things!!!!!!

Is Bigger Better?

- **Who's the boss**
  - Liner shipping companies
  - Big shippers (e.g., Wal-Mart, Target)
  - Savannah port can surpass New York (ajot.com)
- **Cons**
  - Deeper navigational channels, larger turning circles

And who pays for the additional infrastructure ?!!!!!!!!!

  - Bigger cranes (72m outreach, 52m lift height, 8-10 million, 10-12 cranes/vessel)
  - More equipment, Better technology
  - What is one 24,000 TEU vessel sinks or get delayed?
- **Pros**
  - Easier loading/unloading (stowage plan)
  - Greater productivity (double/triple trolley cranes)
  - Economies of scale (????)

Liner market

Something completely different!

Consortia

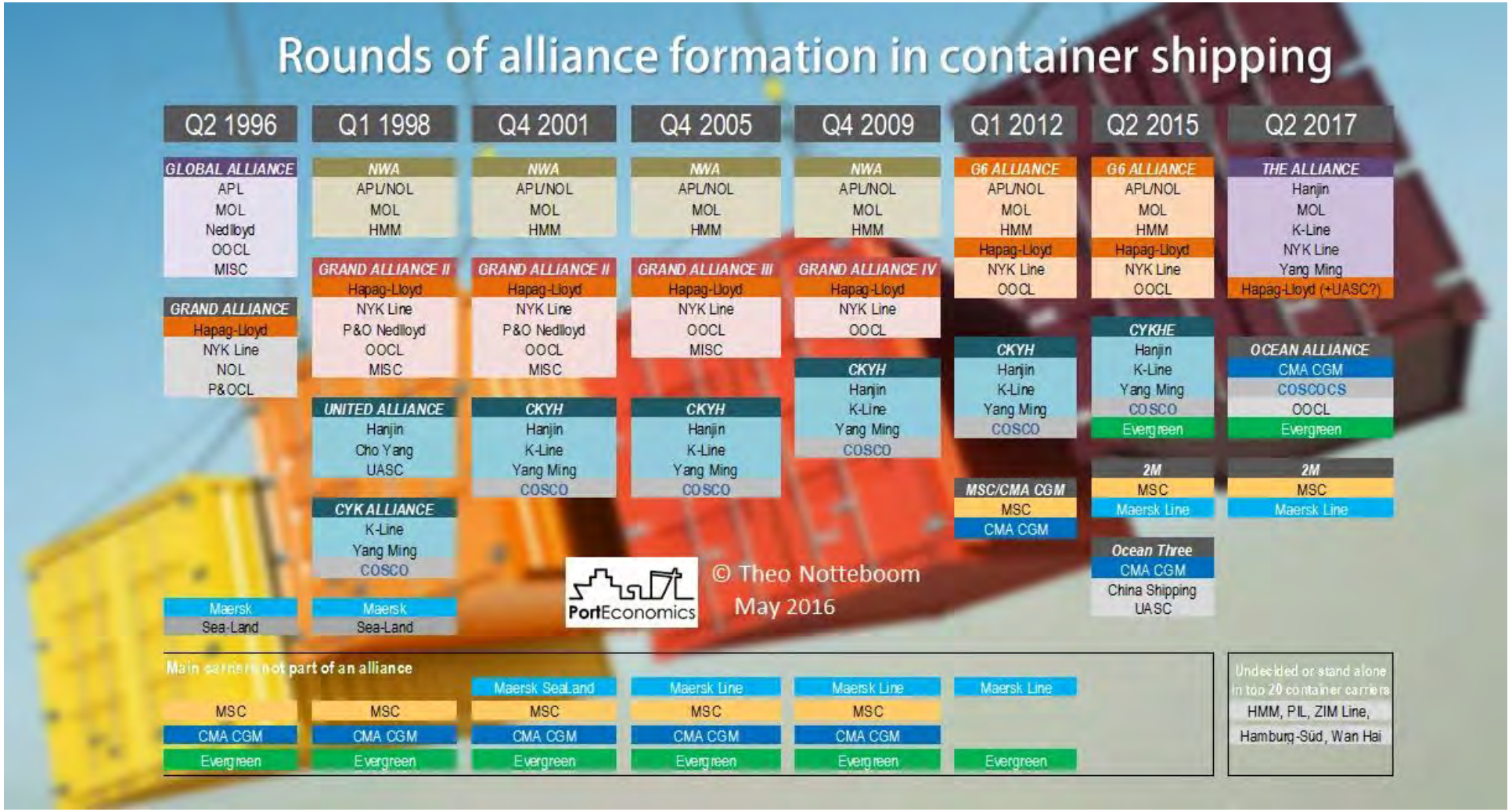
Conferences

Alliances

Alliances

- Started in the 1990’s
- Substantial asset sharing and operational cooperation
- Maintain individual marketing and commercial identities
- Global vessel sharing agreements
- In many jurisdictions they are treated as a consortium

Alliances 1996-2015



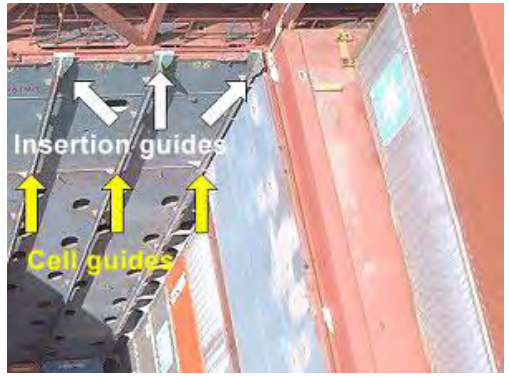
Source: https://porteconomicsmanagement.org/pemp/contents/part1/ports-and-container-shipping/alliances-container-shipping/

Ocean Carrier Alliances

Ocean Carrier	Ships	Total TEU	Ships	Owned TEU	Ships	Chartered TEU	Ships	Orderbook TEU
2M Alliance								
1 Maersk	710	4,122,702	298	2,280,090	412	1,842,612	17	44,036
2 Mediterranean Shipping Co.	591	3,902,661	157	1,047,070	434	2,855,591	22	451,544
Total	*1,301*	*8,025,363*	*455*	*3,327,160*	*846*	*4,698,203*	*39*	*495,580*
THE Alliance								
5 Hapag-Lloyd	255	1,774,132	112	1,052,321	143	721,811	6	141,600
6 ONE (Ocean Network Express)	223	1,612,250	69	500,971	154	1,111,279	15	266,152
8 Hyundai Merchant Marine	74	750,872	28	449,074	46	301,798	6	96,060
9 Yang Ming Marine Transport Corp.	89	628,467	46	193,813	43	434,654	12	125,598
Total	*641*	*4,765,721*	*255*	*2,196,179*	*386*	*2,569,542*	*39*	*629,410*
Ocean Alliance								
3 COSCO Group (includes OOCL)	501	3,022,125	177	1,567,423	324	1,454,702	12	276,000
4 CMA CGM Group	558	3,019,469	118	1,030,328	440	1,989,141	23	354,024
7 Evergreen Line	199	1,327,918	111	639,764	88	688,154	74	703,573
Total	*1,258*	*7,369,512*	*406*	*3,237,515*	*852*	*4,131,997*	*109*	*1,333,597*
Alliances Total	*3,200*	*20,160,596*	*1,116*	*8,760,854*	*2,084*	*11,399,742*	*187*	*2,458,587*

Source: Alphaliner 02/04/21

Ports



"Intermodal freight terminals are not the weakest link…… They are the weakest node in the supply chain"

Directorate –General for Energy and Transport (2006). Intermodal Freight Terminals: In Search of Efficiency to Support Intermodality Growth. European Commission Report

You only make money when you are moving!!!!

Port Importance

Main transport link (focal point for motorways and railway system)

Major economic multiplier for nation's prosperity

Location of shipping services and industries

Maritime accidents

Cargo damage/theft

Additional costs (delays)

Main Functions and Features-1

- **Administrative functions**
  - Control of vehicles (all modes entering/leaving port)
  - Environmental control
  - Dangerous cargo control
  - Safety and security
  - Immigration, health, customs, commercial documentation control

Main Functions and Features-2

Engineering

- Sea and land access
- Infrastructure for berthing
- Road and rail network
- Industrial area management

Operational functions

- Pilotage, tugging, mooring
- Use of berths
- (Un)loading, storage and distribution of cargo

Types of ports

Hub (i.e. mega-port)> 4million TEUs/year

- Initially import/export ports
- Nowadays intermediate points along a pendulum (and mainly trans-shipment – i.e. Algeciras 90%)

Superhub: >1million TEUs/year

Feeder port: feed and distribute cargo from Hubs and Super hubs

Domestic port i.e. outlet for surrounding hinterland

Large industrial zone (with its own marine terminal)

Customs free port (a.k.a foreign trade zone)

Oil port

Naval port

Fishing port

Specific cargo port (mainly bulk - coal and iron ore)

Decisions

Strategic-level

- process flow design
- equipment selection

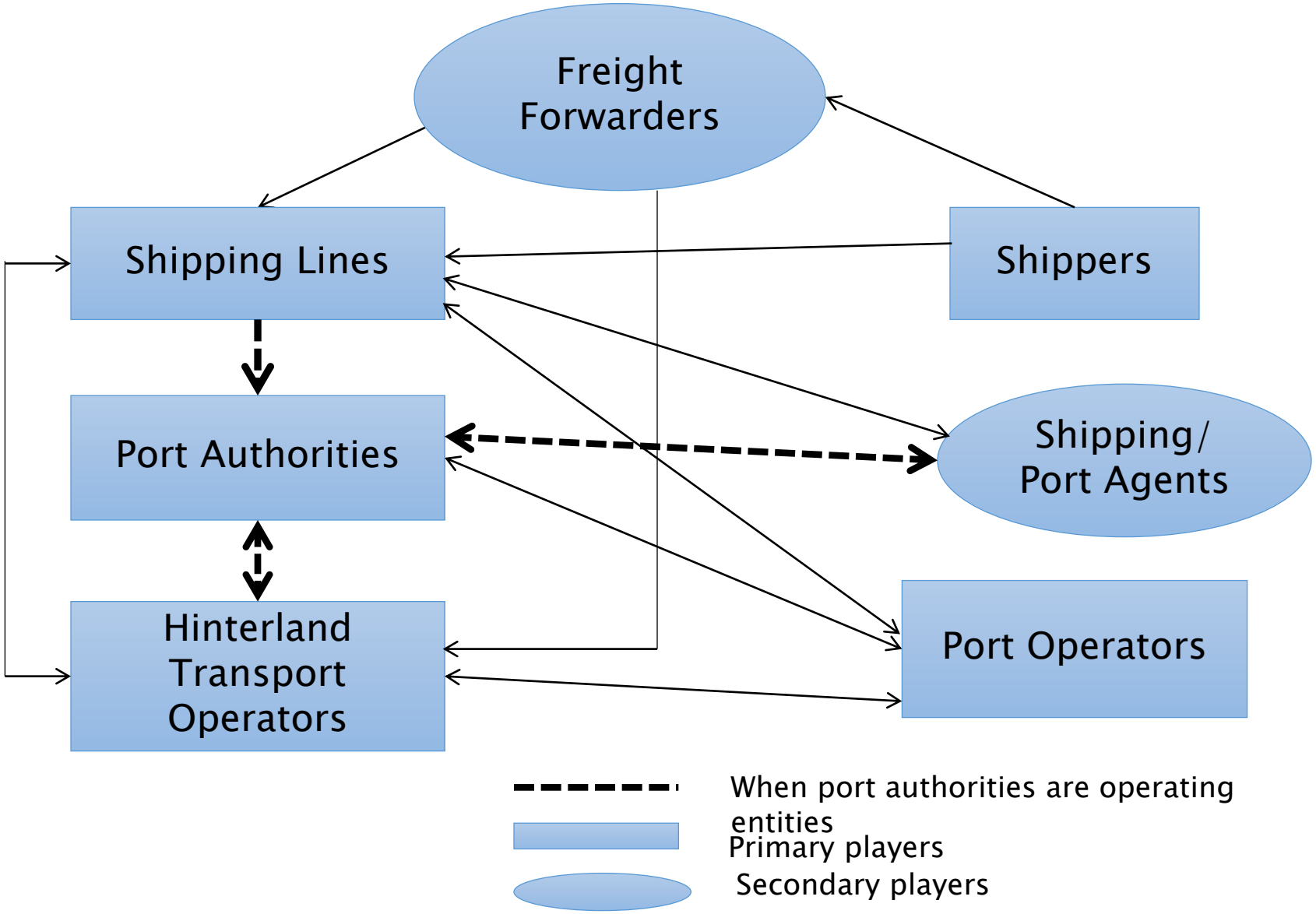
Tactical-level decisions

- sizing of the facility areas and its equipment
- storage layout
- resolution of organizational issues like the storage and replenishment schemes, and batch sizing

Operational-level decisions

- assignment and control problems of people and equipment

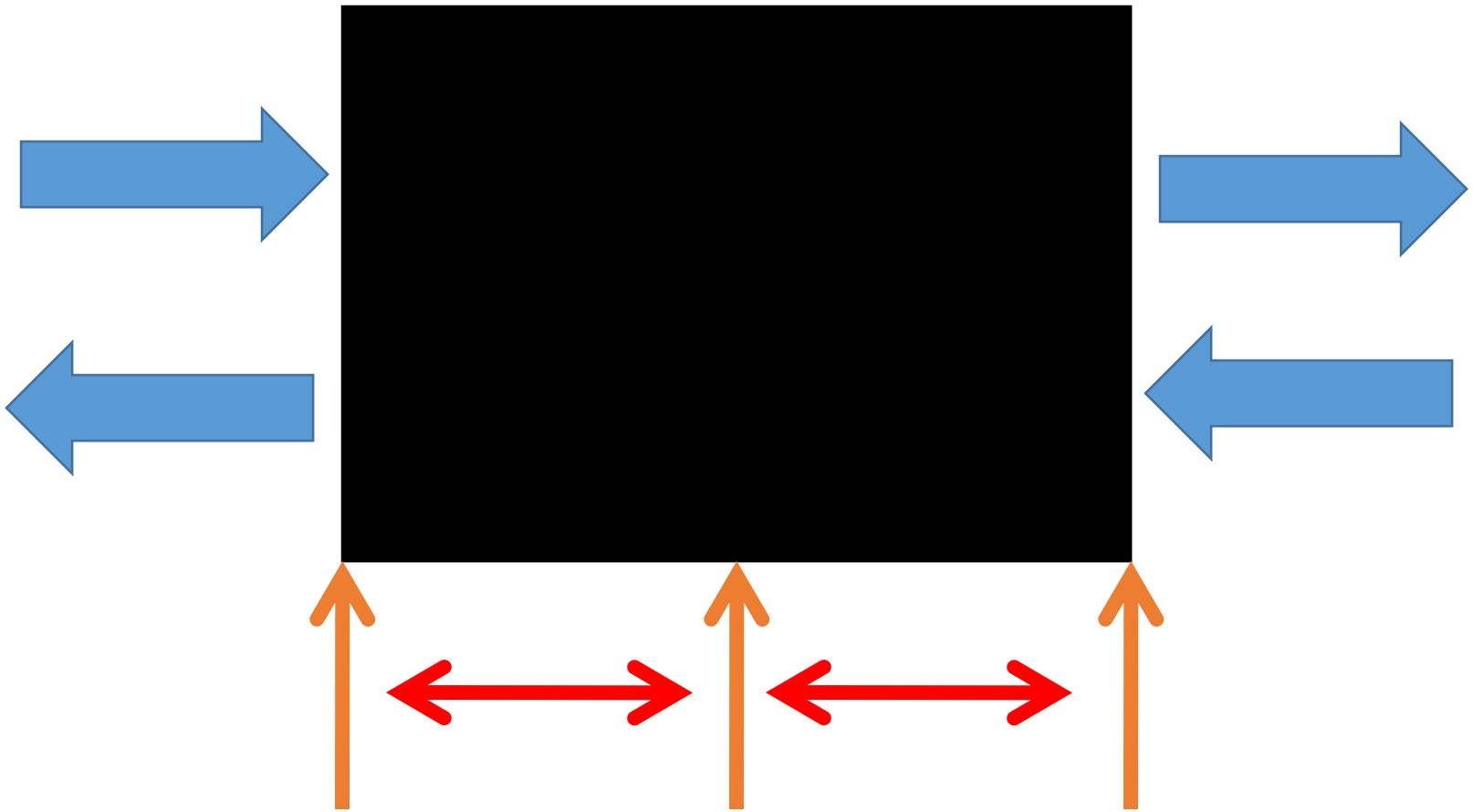
Port Community

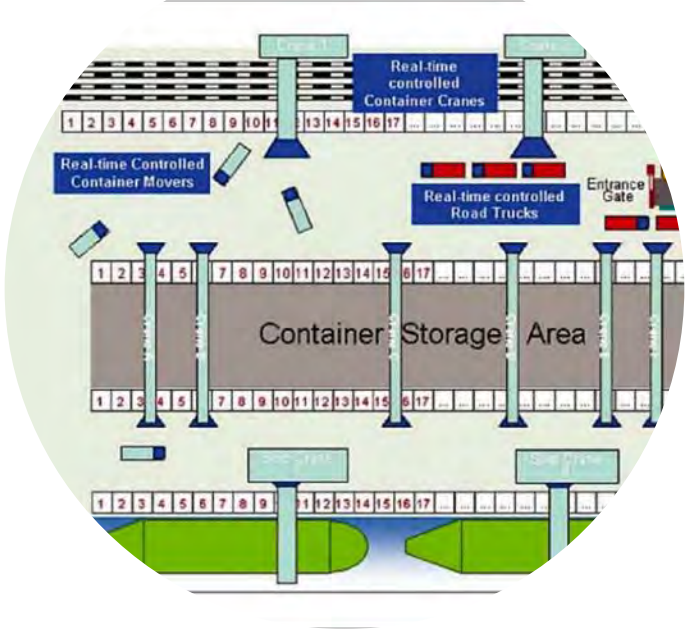


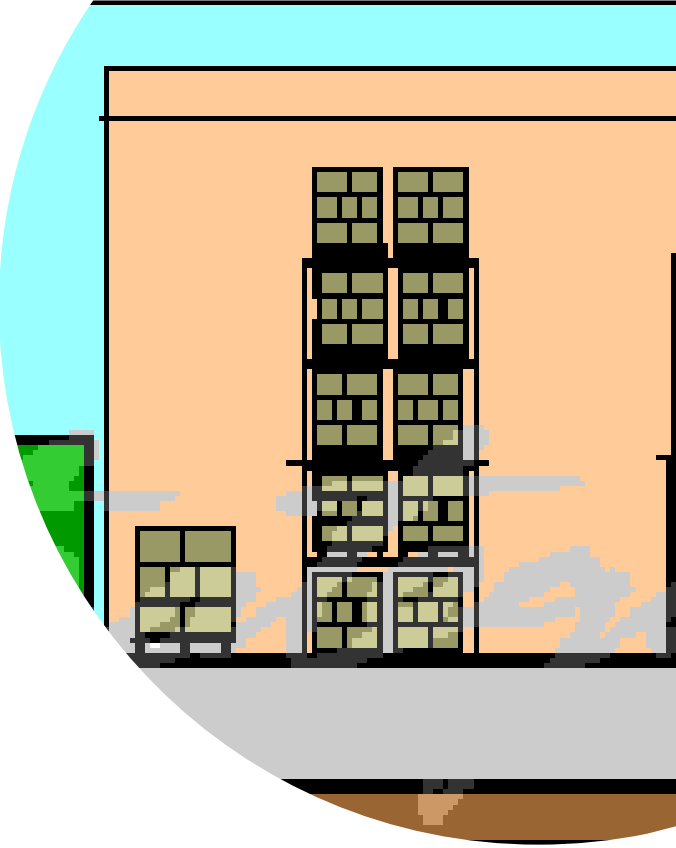
Port Management Models and Ownership

BASIC MODEL	INFRA-STRUCTURE	SUPER-STRUCTURE	CARGO HANDLING	LABOR	OTHER FUNCTIONS
Public Service Port	Public	Public	Public	Public	Majority Public
Tool Port	Public	Public	Private	Private	Public/ Private
Landlord Port	Public	Private	Private	Private	Public/ Private
Private Service Port	Private	Private	Private	Private	Majority Private

The Black Box







What's in the box?

Container Terminal System

SEASIDE OPERATIONS

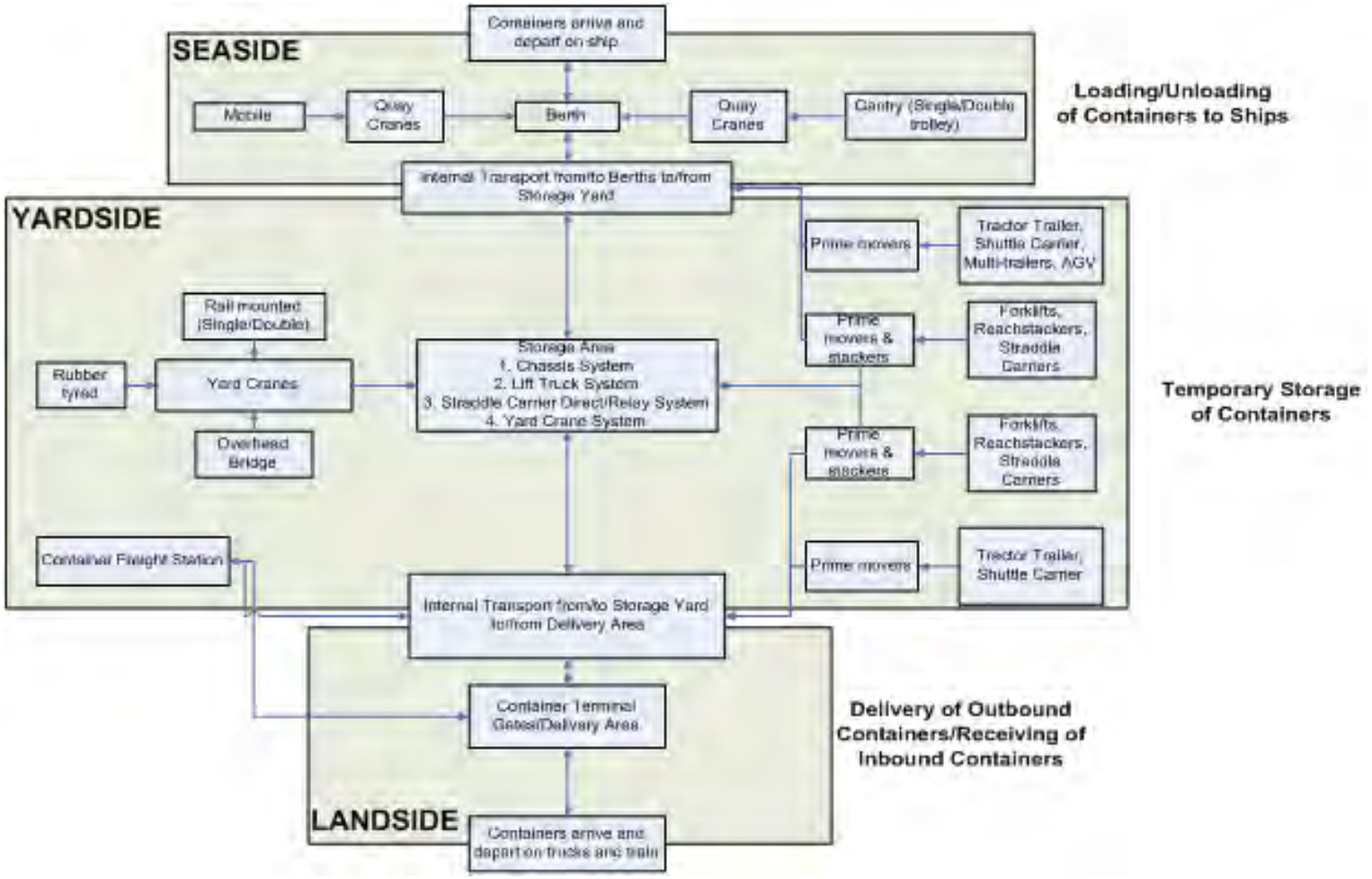
LANDSIDE OPERATIONS

YARD OPERATIONS

INTRA-TERMINAL TRANSFER (BINDING OPERATION)

CONTAINER FREIGHT STATION MAY OR MAY NOT BE A PART OF TERMINAL OPERATIONS

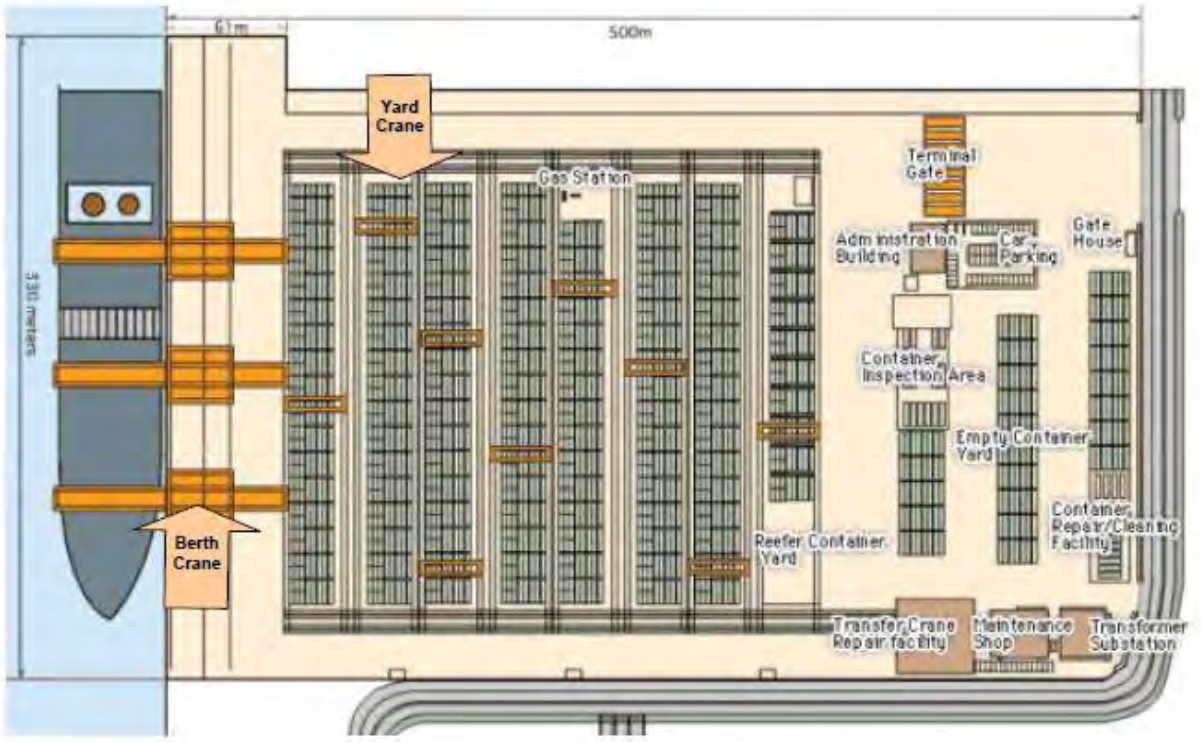
Modules and Flows



Golias, 2007

Container Terminal Layout

- Source: http://www.maine.gov/doc/initiatives/SearsIsland/ContainerTerminal.pdf



What type of problems

- Scheduling
  - Machine scheduling
  - Job-Shop scheduling
- Queuing
- Transportation
  - Transshipment
  - Min/Max cost

Major Categories

- Berth scheduling
- Quay crane scheduling
- ITV routing and scheduling
- Yard crane scheduling
- Gate truck queuing models
- Liner shipping scheduling

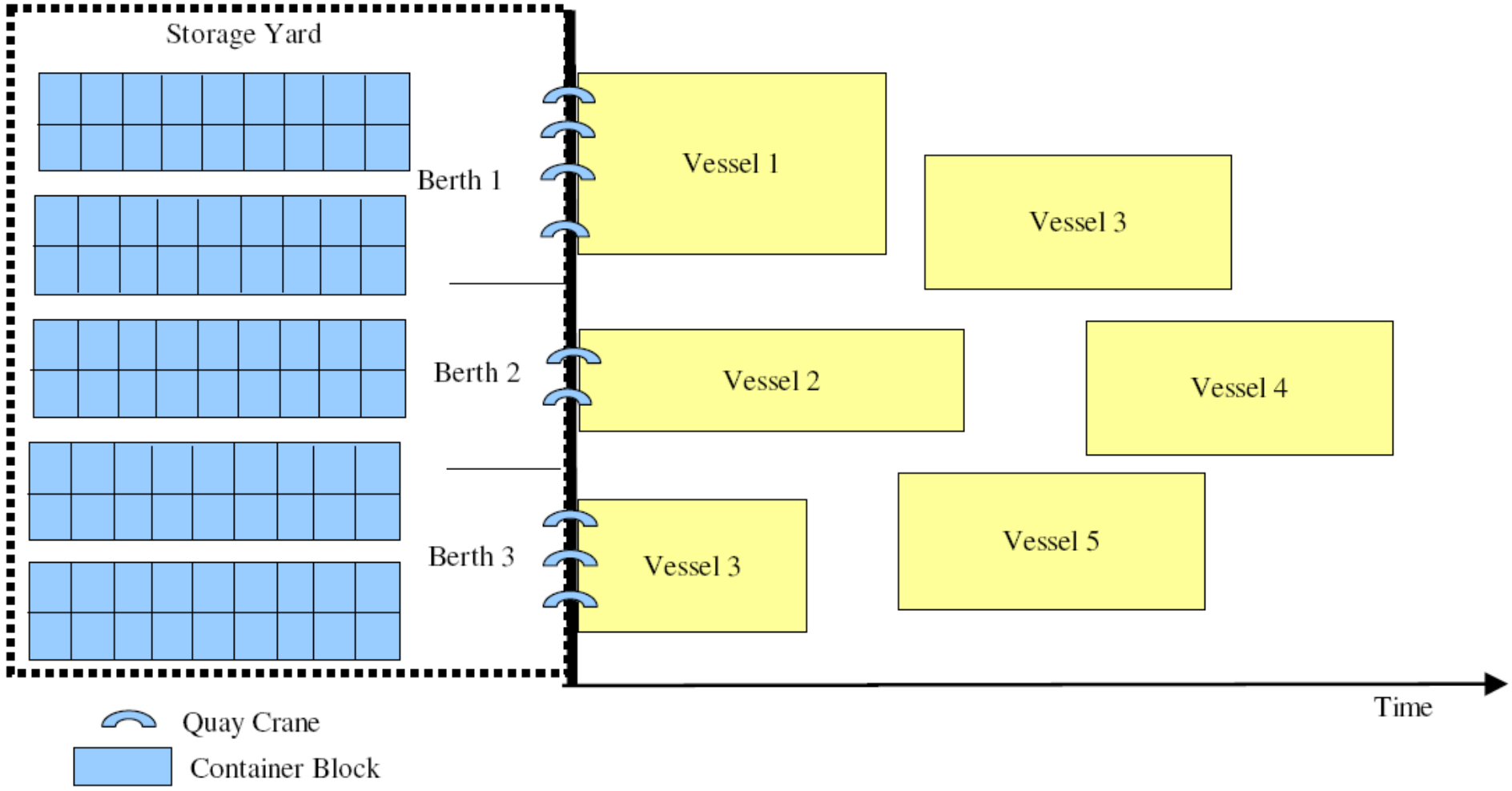
Optimization/Simulation

- Majority of problems are formulated as mathematical optimization problems or simulation
- Good knowledge of algebra, calculus, statistics
- Mathematical programing and simulation analysis a must
- Metaheuristics and Hybrid (sometime called memetic algorithms)

Let’s see an example

How do we assign berth space/time to container terminals to maximize efficiency/profits/……..

Berth Allocation



The Unrelated Machine Scheduling Problem

- A number of machines
- A number of jobs
- Each job may be served in any machine
- Each job has a different handling time at each machine
- Each job has a release time
- NP-Hard (see M-TSP)

Discrete and Dynamic BAP

Variables

i = $(1,\ldots\ldots,I) \in B$ set of berths,

j = $(1,\ldots..,T) \in V$ set of vessels,

k = $(1,\ldots..,T) \in O$ set of service orders,

S_i = Time when berth i becomes available for the first time in the current planning horizon,

A_j = Arrival time of vessel j,

C_{ij} = Handling time of vessel j at berth i,

y_{ijk} = Idle time of berth i before vessel j is serviced as the k^{th} vessel,

X_{ijk1} = 1 if vessel j serviced at berth i as the k^{th} vessel and departs or berths before the requested time window and zero otherwise,

X_{ijk2} = 1 if vessel j serviced at berth i as the k^{th} vessel and departs or berths after the requested time window and zero otherwise,

X_{ijk3} = 1 if if vessel j serviced at berth i as the k^{th} vessel and departs or berths within the requested time window and zero otherwise,

a_{j1} = Hourly earliness departure premium for vessel j,

a_{j2} = Hourly earliness berthing premium for vessel j,

a_{j3} = Hourly cost of wait time of vessel j,

b_{j1} = Hourly lateness departure penalty for vessel j,

b_{j2} = Hourly lateness berthing penalty for vessel j,

γ_{j1} = Hourly timely departure premium for vessel j,

γ_{j2} = Hourly timely berthing premium for vessel j,

t_{j1} = Requested early departure/berthing time of vessel j,

t_{j2} = Requested late departure/berthing time of vessel j,

WST_j = 1 if vessel j sets a request for early, timely and late departure 0 otherwise,

HC_j = 1 if handling cost is considered and 0 otherwise,

CC_{ij} = Handling cost of vessel j serviced at berth i,

DT_{ijk} = Difference of early/late actual and requested finish/start time of vessel j serviced at berth i as the k^{th} vessel,

DT^{+}_{ijk} = $\max(0, DT_{ijk})$,

DT^{-}_{ijk} = $\min(0, DT_{ijk})$,

DTT_{ijk} = Difference of early timely requested and actual timely finish/start time of vessel j serviced at berth i as the k^{th} vessel.

R_{ij} = 0 if vessel j cannot be serviced at berth i due to physical or technical restrictions and 1 otherwise

Discrete and Dynamic BAP : Objective Function

$$\min -\sum_i \sum_j \sum_k \left\langle \begin{array}{l} \{a_{j1}WST_j + a_{j2}(1-WST_j)\}DT^+_{ijk} + \{b_{j1}WST_j + b_{j2}(1-WST_j)\}DT^-_{ijk} \\ -\{\gamma_{j1}WST_j + \gamma_{j2}(1-WST_j)\}DTT_{ijk} - HC_jCC_{ij}(\sum_{r=1}^{3} X_{ijkr}) \\ -a_{j3}WST_j\{(t_{j1} - A_j - C_{ij})X_{ijk1} - DT^+_{ijk} + (t_{j2} - A_j - C_{ij})X_{ijk2} - DT^-_{ijk} \\ +(t_{j1} - A_j - C_{ij})X_{ijk3} - DTT_{ijk}\} \end{array} \right\rangle,$$

Premium for Early Berth/Departure: $\{a_{j1}WST_j + a_{j2}(1-WST_j)\}DT^+_{ijk}$

Cost for Late Berth/Departure: $\{b_{j1}WST_j + b_{j2}(1-WST_j)\}DT^-_{ijk}$

Premium for Timely Berth/Departure: $\{\gamma_{j1}WST_j + \gamma_{j2}(1-WST_j)\}DTT_{ijk}$

Handling Cost: $HC_jCC_{ij}(\sum_{r=1}^{3} X_{ijkr})$

Waiting Time Cost: $-a_{j3}WST_j\{(t_{j1} - A_j - C_{ij})X_{ijk1} - DT^+_{ijk} + (t_{j2} - A_j - C_{ij})X_{ijk2} - DT^-_{ijk} + (t_{j1} - A_j - C_{ij})X_{ijk3} - DTT_{ijk}\}$

Discrete and Dynamic BAP : Constraints

Every Vessels Serviced Once

$$\sum_{i}\sum_{j}\sum_{k}\sum_{r=1}^{3} X_{ijkr} = 1, \forall j,$$

Every Berth Services One Vessel at a time

$$\sum_{j\in V}\sum_{r=1}^{3} X_{ijkr} \le 1, \forall i \in B, k \in O$$

Idle Time Estimation

$$\sum_{m\neq j\in T}\sum_{h<k\in O}(C_{im}\sum_{r=1}^{3} X_{imhr} + y_{imh}) + y_{ijk} - (A_j - S_i)\sum_{r=1}^{3} X_{ijkr} \ge 0, \forall i \in B, j \in T, k \in O$$

$$y_{ijk} \le M\sum_{r=1}^{3} X_{ijkr}, \forall i \in B, j \in T, k \in O$$

Hours of Early Berth/Departure Estimation

$$DT_{ijk}^{+} \le (t_{j1} - WST_j C_{ij} - S_i)X_{ijk1} - y_{ijk} - \sum_{j\neq m\in T}\sum_{h<k\in O}(C_{im}\sum_{r=1}^{3} X_{imhr} + y_{imh}) + alpha_{ijk}, \forall i \in B, j \in T, k \in O$$

$$t_{j1}X_{ijk1} \ge \sum_{j\neq m\in T}\sum_{h<k\in O}(C_{im}\sum_{r=1}^{3} X_{ijkr} + y_{imh}) + y_{ijk} + (WST_j C_{ij} + S_i)X_{ijk1} - M(1 - X_{ijk1})\forall i \in B, j \in T, k \in O,$$

Hours of Late Berth/Departure Estimation

$$DT_{ijk}^{-} \le (t_{j2} - WST_j * C_{ij} - S_i)X_{ijk2} - y_{ijk} - \sum_{j\neq m\in T}\sum_{h<k\in O}(C_{im}\sum_{r=1}^{3} X_{imhr} + y_{imh}) + M(1 - X_{ijk2})\forall i \in B, j \in T, k \in O,$$

$$t_{j2}X_{ijk2} \le \sum_{j\neq m\in T}\sum_{h<k\in O}(C_{im}\sum_{r=1}^{3} X_{imhr} + y_{imh}) + y_{ijk} + (WST_j C_{ij} + S_i)X_{ijk2}, \forall i \in B, j \in T, k \in O$$

Discrete and Dynamic BAP: Constraints

Hours of Timely Berth/Departure Estimation

$$t_{j1}X_{ijk3} \le \sum_{j\neq m\in T}\sum_{h<k\in O}(C_{im}\sum_{r=1}^{3}X_{imhr}+y_{imh})+y_{ijk}+(WST_jC_{ij}+S_i)X_{ijk3}+M(1-X_{ijk3}),\forall i\in B, j\in T, k\in O,$$

$$t_{j2}X_{ijk3} \ge \sum_{j\neq m\in T}\sum_{h<k\in O}(C_{im}\sum_{r=1}^{3}X_{imhr}+y_{imh})+y_{ijk}+(WST_jC_{ij}+S_i)X_{ijk3}-M(1-X_{ijk3}),\forall i\in B, j\in T, k\in O,$$

$$DTT_{ijk} \le t_{j1}X_{ijk3}-\sum_{j\neq m\in T}\sum_{h<k\in O}(C_{im}\sum_{r=1}^{3}X_{imhr}+y_{imh})-y_{ijk}-(WST_jC_{ij}+S_i)X_{ijk3}+M(1-X_{ijk3}),\forall i\in B, j\in T, k\in O,$$

Berth Physical Constraints

$$\sum_k\sum_r X_{ijkr} \le MR_{ij},\forall i\in B, j\in T$$

Other Auxiliary Variable Estimation

$$alpha_{ijk} \le M(1-X_{ijk1}),\forall i\in B, j\in T, k\in O$$

$$alpha_{ijk} \le \sum_{j\neq m\in T}\sum_{h<k\in O}(C_{im}\sum_{r=1}^{3}X_{imhr}+y_{imh})+y_{ijk},\forall i\in B, j\in T, k\in O,$$

$$DT^{+}_{ijk} \le MX_{ijk1},\forall i\in B, j\in T, k\in O,$$

How did we solve it?

I. Genetic Algorithm (GA) for the BAP
II. Optimization Based GA
III. Rolling Time Window Heuristic
IV. 2-opt based Heuristic

Please remember: All solution algorithms are descent methods

1. Find the gradient (or the closest to a feasible direction)
2. Move for while
3. Change direction and continue until no improvement

Some are smart, some are random, and some are just ……..

Handling Equipment

Ship to/from shore (transfer only)

- Quayside gantry cranes
- Yard equipment (shore/storage yard/gate)
- Pure transporting (T)
- Tractors with trailers or multitrailers
- Shuttle carriers
- AGVs

Pure Stacking (S)

- Rail mounted gantry cranes (RMG) (Trastainers)
- Rubber tyred gantry cranes (RTG)
- Overhead bridge cranes (OBC)

Transfer & Stacking

- Straddle carriers (SC)
- Reach stackers (RSC)
- Front end (or side end) loaders

VESSEL LOADING/UNLOADING EQUIPMENT

http://en.wikipedia.org/wiki/File:Containerbücken_für_Eurogate_009.jpg

http://en.wikipedia.org/wiki/File:Portainer_(gantry_crane).jpg

Port of Shenzhen

Twin and Triple Quayside Container Cranes

Source: http://www.zpmc.com/product_detail.asp?Article_ID=40&Column_ID=54

Port of Dubai

INTRATERMINAL TRANSFER & STACKING EQUIPMENT

- Types of landside equipment
  - Prime movers
  - Stacking equipment
  - Combined prime mover & stacking equipment
  - Empty container handling equipment
  - Equipment for Ancillary moves (e.g., customs control / security control / veterinary control / CFS operation)

INTRATERMINAL Prime Movers

- Equipment to move containers between the apron and the storage yard
- Shuttle carriers
- Tractor / trailer
- Multitrailer
- Automated guided vehicles

INTRATERMINAL Prime Movers- Shuttle Carrier

http://www.kalmarind.com/source.php?id=43756

INTRATERMINAL Prime Movers- Tractor Trailer

http://www.evergreen-marine.com/tbi1/images/hubs2.jpg

http://www.nauticexpo.com/prod/kalmar-industries/container-straddle-carrier-30427-189085.html#

INTRATERMINAL Stacking

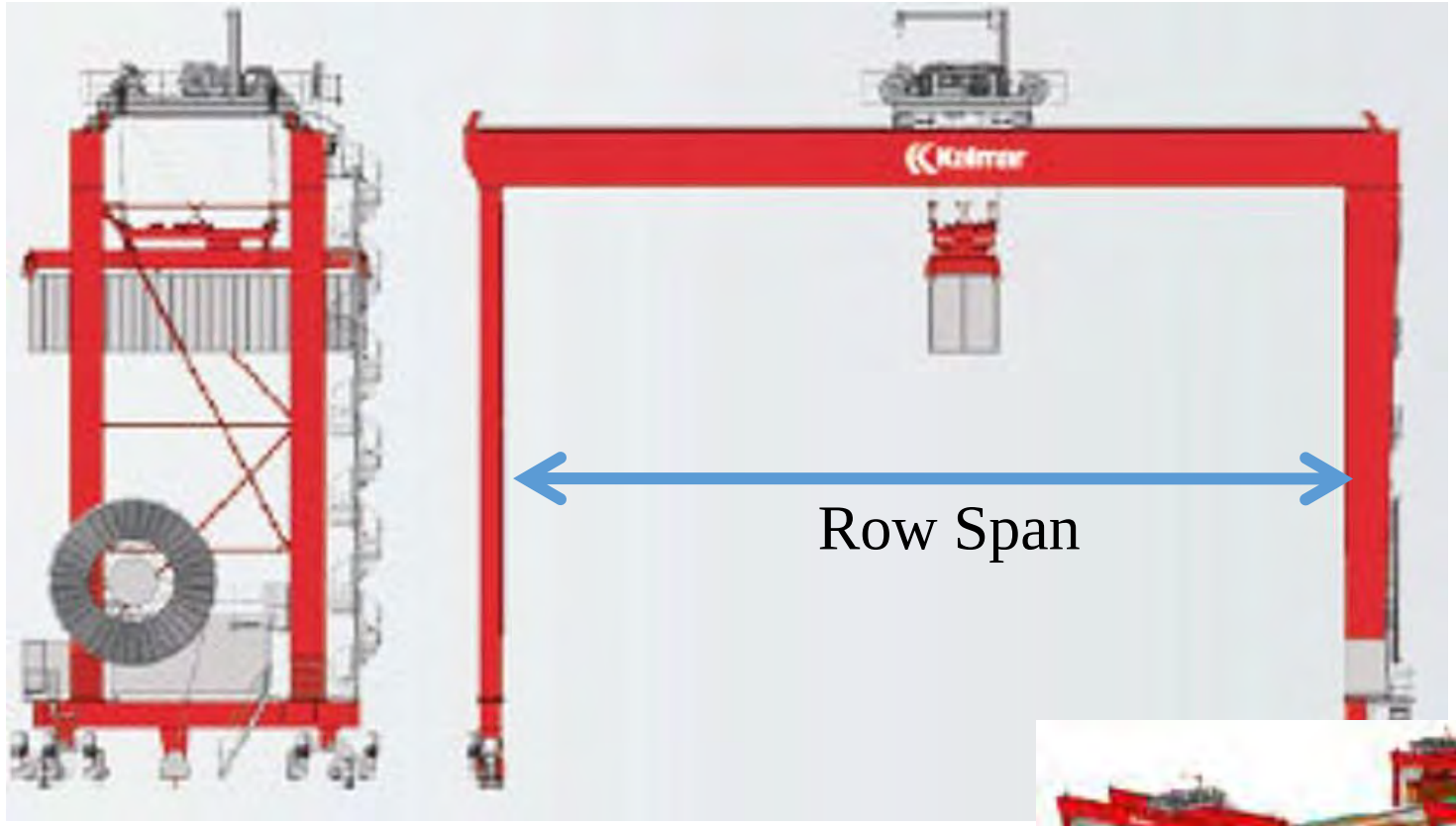
- Performs only stacking within the storage yard
- Rubber tyred gantry crane (RTG)
- Rail Mounted Gantry Crane (RMG) or Transtainer
- Overhead Bridge Crane (OBC) or Automated Stacking Crane (ASC)

INTRATERMINAL TRANSFER & STACKING EQUIPMENT: Stacking-RTG

http://www.fantuzzi.co.uk/images/cranes_rubber_tyred_1l.jpg

http://2.bp.blogspot.com/_b4PnJVb9cjQ/SM-0ogGK7KI/AAAAAAAAAQk/N_maazyQE94/s1600-h/rubbertyredgantrycrane.jpg

INTRATERMINAL TRANSFER & STACKING EQUIPMENT: Stacking-RMG-1



http://img.nauticexpo.com/images_ne/photo-p/container-stacking-crane-automatic-rail-mounted-189088.jpg

http://www.kalmarind.com/source.php?id=1083746

INTRATERMINAL Stacking-RMG-2

http://t3.gstatic.com/images?q=tbn:ql1jqSLBshlYLM:http://img.directindustry.com/images_di/photo-g/rail-mounted-gantry-crane-381071.jpg

http://www.muuga-ct.com/182ior.jpg

INTRATERMINAL Stacking-OBG

- http://www.naicranes.com/cranes/bridge_cranes.htm?gclid=CP61q6zm5Z8CFQoNDQodlnefgw

INTRATERMINAL Combined movers and stackers

Perform both intraterminal transportation and

Stacking

Straddle carriers

Reach stackers (for small size terminals)

INTRATERMINAL Combined movers and stackers- Straddles

http://mechanical.pnl.gov/images/straddle3.jpg

http://img.nauticexpo.com/images_ne/photo-g/container-straddle-carrier-189085.jpg

INTRATERMINAL Combined movers and stackers- reach stackers

- http://img.nauticexpo.com/images_ne/photo-p/empty-container-reach-stacker-with-side-lift-spreader-189084.jpg

INTRATERMINAL TRANSFER & STACKING EQUIPMENT: Empty Containers and Ancillary

- Front end loaders
- Top loaders
- Forklift

Interesting Research Directions

- **Holistic performance measurement** system/**New value-added services**/**Asset** management
- Going **green**
- Cyber/Technology/Workforce
- **Cooperation/Competition/Coopetition** models (strategic, tactical and operational) for the ***agents/players/actors*** (e.g., shippers, carriers, freight forwarders, state/local government)
- Port business models (public, private, mixed)

Where to look

The World Bank Group and port performance


UNCTAD and port performance


OECD ITF and port performance


The EU and port performance

Some links

- *Drewry Monthly,* Drewry Shipping Consultants Ltd www.drewry.co.uk
- *Lloyds List,* Informa plc. www.lloydslist.com
- *Lloyds Shipping Economist,* Informa plc. www.shipecon.com
- *IMO* www.imo.org
- *UNCTAD:* www.unctad.org
- *Clarksons* www.clarksons.net
- *Fearnleys* www.fearnleys.com
- *ShippingWatch* shippingwatch.com
- *ECSA* www.ecsa.be
- *Fairplay International Shipping Weekly,* Fairplay Publications www.fairplay.co.uk

Some websites to signup for newsletter

- https://www.seatrade-maritime.com/
- https://gcaptain.com/
- https://www.joc.com
- https://www.freightwaves.com/
- https://theloadstar.com/
- https://www.waterwaysjournal.net/