LogDynamics
International Graduate School

Industrial Engineering Applications to Optimize Container Terminal Operations

Asela K. Kulatunga* & D.H. Haasis+

*gLINK Postdoctoral researcher, University of Bremen Germany

Senior Lecturer, Faculty of Engineering, University of Peradeniya, Sri Lanka

+Chair, Maritime Logistcis, University of Bremen, Germany

Universität Bremen*

*EXZELLENT.

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What is Industrial Engineering?

- Generally known as
  - a branch of **engineering** which deals with the **optimization of complex processes**, **systems or organizations**.
  - **Industrial engineers** work to **eliminate waste of time, money, materials, man-hours, machine time, energy** and other resources that do not generate value.
- IISE Definition
  - Industrial and Systems Engineering is concerned with the **design, improvement and installation of integrated systems of people, materials, information, equipment and energy**. It draws upon specialized **knowledge and skill** in the **mathematical, physical, and social sciences** together with the principles and methods of **engineering analysis and design**, to **specify, predict, and evaluate the results** to be obtained from such systems.

Challenges of Maritime Logistics

- Cost vs. service levels
- Vessel capacity vs. utilization
- Ports Automation vs. Efficiencies
- ICT developments (Big Data, Data Analytics, cloud computing)
- Operational excellence & Green logistics / Sustainability

Sections of CT & its Operations

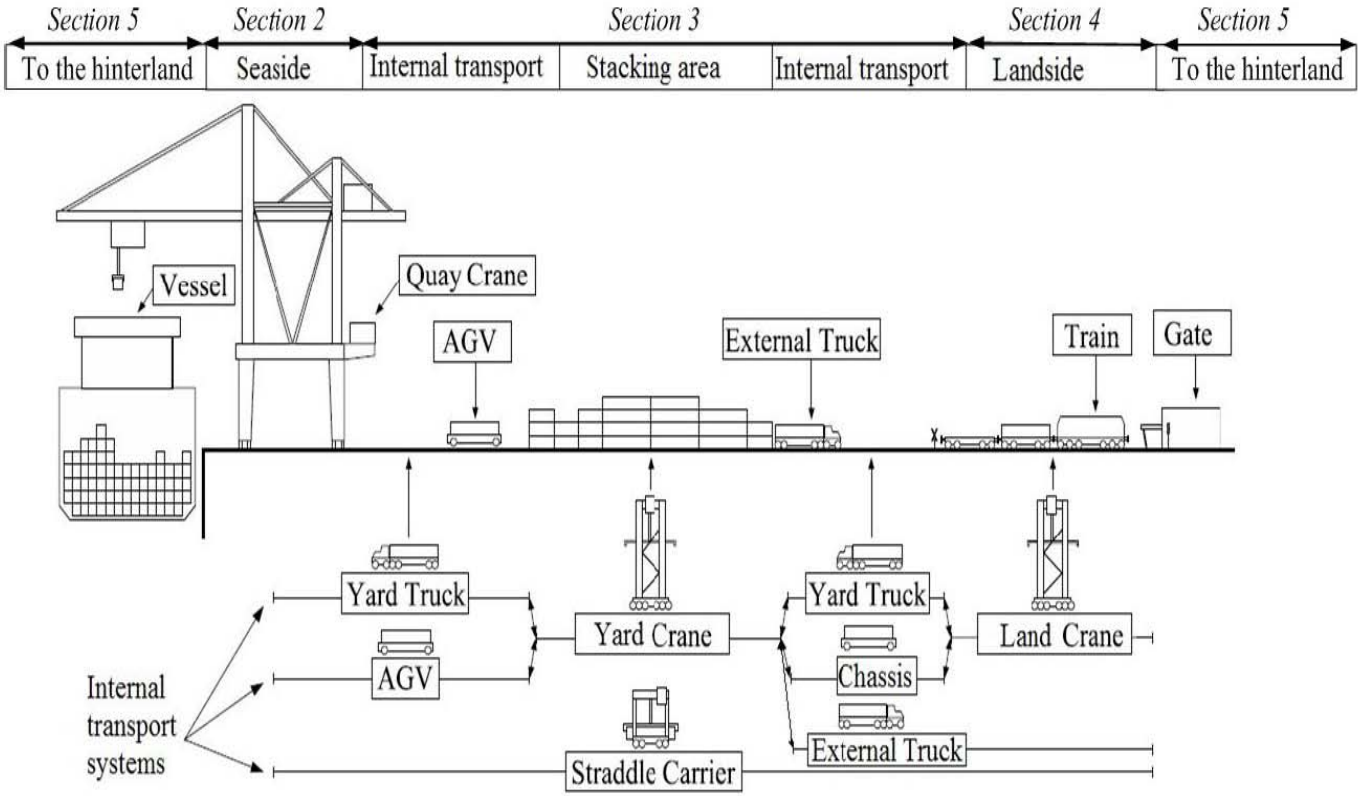
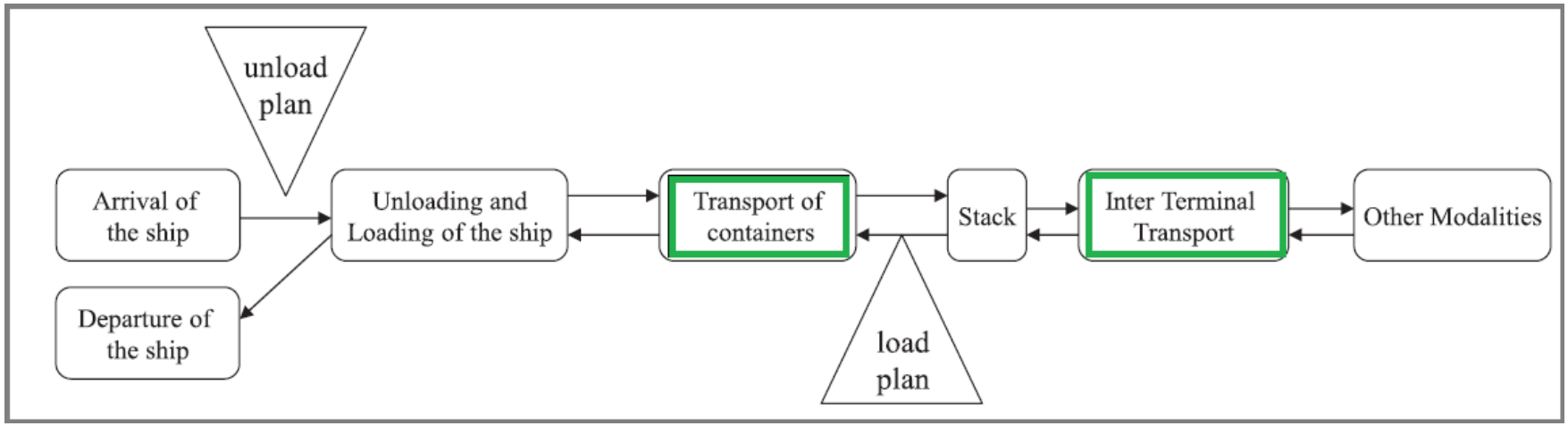


Figure 2: Loading and unloading processes of containers at a typical container terminal (adapted from Brinkmann, 2010 and Meisel, 2009)


unload plan
Arrival of the ship
Unloading and Loading of the ship
Transport of containers
Stack
Inter Terminal Transport
Other Modalities
Departure of the ship
load plan

Sub - Problems of a Container Terminal Operations

- Seaside operations planning
  - Berth Allocation
  - QC scheduling
  - Stowage planning
- Internal Trucks allocation to QCs
- Internal Trucks Routing
- Container Stacking planning
- Yard Cranes Allocation & scheduling
- Gate / land side Operations

Terminal Operating Systems & Terminal Emulation Systems

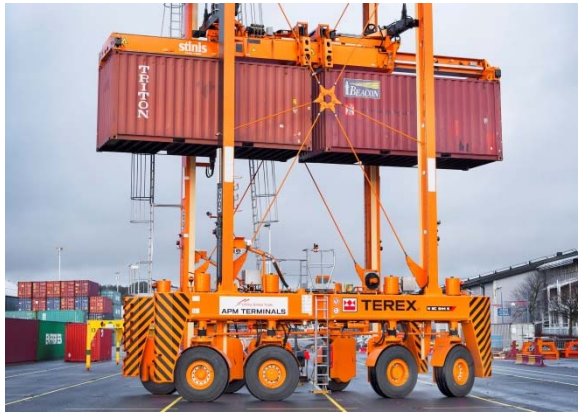
- core processes in a terminal are supported by a TOS
  - quay side planning
  - vessel planning
  - yard planning
  - equipment control
  - gate management
- TES allow dry testing of
  - equipment control rules
  - remote quay crane control
  - stack storage methods

Quay crane and berth operations planning

- **tactical and operational decisions**
  - minimum terminal cost and delay
- **BAP**
  - spatial constraints
    - draft requirement for ship berthing, ship size, space availability, and the distance between the berthing location to the stacks
  - temporal constraints
    - static versus dynamic arrival of ships
- **assigning QCs**
  - interference between QCs
  - improving crane productivity
- **scheduling QCs**

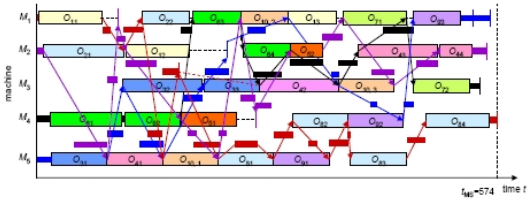
Internal Transport Operations

- Varying degrees of automation and functionalities
- Types of vehicles
- Vehicle guide path types (closed-loop and cross-lane)
- Different Layouts
- Vehicle tracking and tracing
  - Re-plan & reschedule
- Coordination among vehicles
  - Smaller fleet size
  - Empty travel times can be reduced

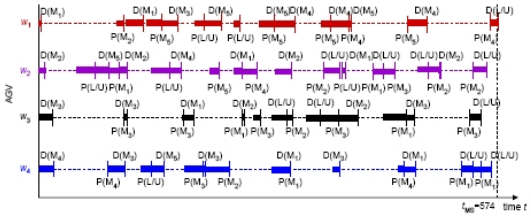


IE models to Optimization of Transportation operations

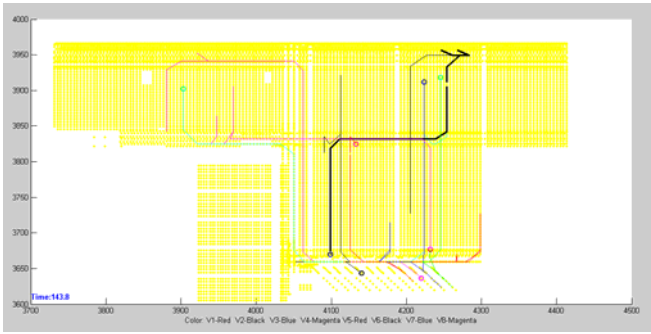
- Fleet size
- Decide on vehicle routing
- Operation schedules
- Expected waiting times
- Shortest-path travel times
- To determine the optimal routes
- Assignment of transport requests
- Scheduling vehicles



(a)



(b)



How to overcome challenges

- Mostly sub problems are addressed in isolation
- Interactions among the decisions
- Optimize the terminal operations
- Can we do this by handling each sub problem separately?
- Not always due to interdependency for solutions
- What is the way out?
  - Look at sub-problems in an integrated framework
  - Can we wait to get optimal results (trade off between quality & cost)
  - Solve them to get overall best results (Satisfactory results)

Integrated Terminal Management Through Optimization

- Berth and QC allocation
- QC & Internal Trucks scheduling (Simultaneously)
- Internal Trucks – Task allocation and path planning
- Autonomous vehicles (AGV, ASC) - Task allocation and collision free path planning
- Path planning and selection of storage location

Optimal Resource Allocation Strategies and Operations Excellence

- Pooling the Internal trucks , ASC, AGVs
- Dual Cycle operations
- Pooling Internal Trucks for sea side, landside and remarshaling operations
- Routing to ease traffic congestions
- Move towards Multi Criteria Decision Making
- Adapt Lean & Green concepts

Tools & Techniques available

- Mathematical tools
  - Conventional Optimization techniques
  - Non conventional optimization techniques
- Development of ICT
  - Artificial Intelligence techniques
  - Computational intelligence techniques
  - Simulation techniques
    - General purpose (Arena, AnyLogic, Matlab Simulink etc.)
    - Specific to CT (Chesscon, Flexsim etc..)
  - Data Analytics
  - Cloud Computing

Greening & Sustainability of Ports

- Shipping emissions
  - 18 m.T of CO2, 0.4 m.T of NOx, 0.2 m.T of SOx and 0.03 m.T of PM10 in 2011
  - Around 85% of emissions come from containerships and tankers.
  - Containerships have short port stays, but high emissions during these stays
- Approximately 230 million people are directly exposed to the emissions in the top 100 world ports (Shipping Emission report: International Transport forum, 2014)
- Noise levels
- Social Aspects (QoL, WLB)

Ongoing Research

- Development of DSS to identify different allocation scenario's of yard vehicles in order to optimize transportation operations of a container terminal
- As a MCDM problem
  - Simultaneous Job allocation & Path planning
  - Path planning & Storage location Selection
  - Ease of Traffic Congestions
  - Single / dual load carriers
  - Ease of gate area traffic congession
  - Use Lean Concepts in Container Stacking
  - Optimal fleet sizing with dynamic demand fluctuations

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