A holistic approach to your terminal design process

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What you need depends on your specific situation

Flexible Layouts

Short investment horizon
Low Capex
Easy to resell equipment

Higher Opex
Capacity limitations

Long investment horizon
High Capex
Fixed assets

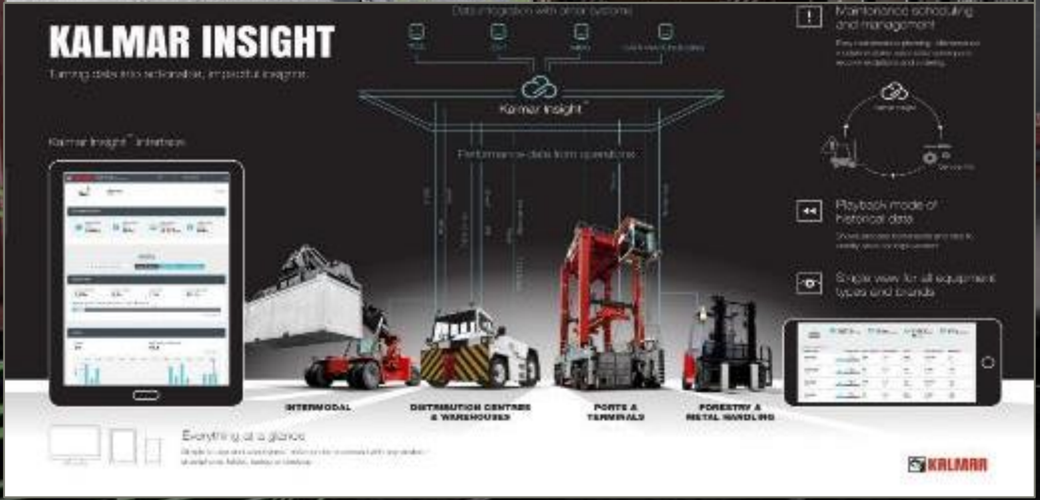
Lower Opex
Less capacity limitations

What to consider here?

Fixed Layouts

Examples of options with a limited investment horizon

- Buy an eco-efficient RS with fuel saving guarantee and save ~25% on fuel cost and emissions
- Invest in data-based information and control
- Future ready design: prepare your yard for the implementation of a RTG at a later point in time
- Take control of your future:
  - Analyze, understand, optimize
  - Align with all stakeholders (customers, local authorities, rail network manager etc.)
  - Share data and improve the quality of data
  - Plan, execute, check, re-plan



Don’t save on the planning phase

Project progress

High-level design	Terminal layout • Equipment • Infra • IT & SW	Business case	Validation, Simulation	Automation levels & organization	Project evaluation
Detailed design	Terminal layout detailed design	Detailed Infra - equipment alignment	Simulation of sensitivities	Detailed BPM & Prelim. Operational Hazard Analysis	Project approval
Final specification & procurement	Civil works contracts	Equipment contracts	Software / IT contracts	Change management program building	Project master plan
Implementation	Civil works	Equipment deliveries	SW deliveries	Organization change & recruitment	Testing & training
Operation	Go Live	Continuous improvement	Upgrades	Maintenance	Training

$

10$

100$

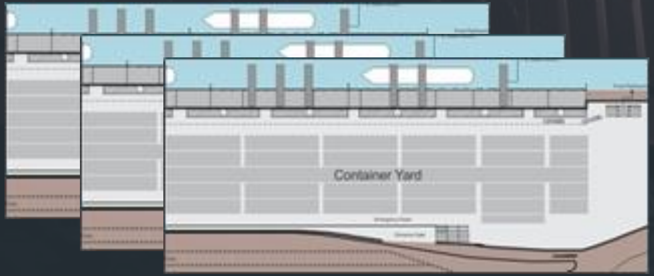
1000$

Commercial representation of the design process

Investigate

Map the options for Terminal Design alternatives to meet the objectives

- Identify different layout options high level



Qualify

Research the alternative solutions and numerically assess the feasibility of the options

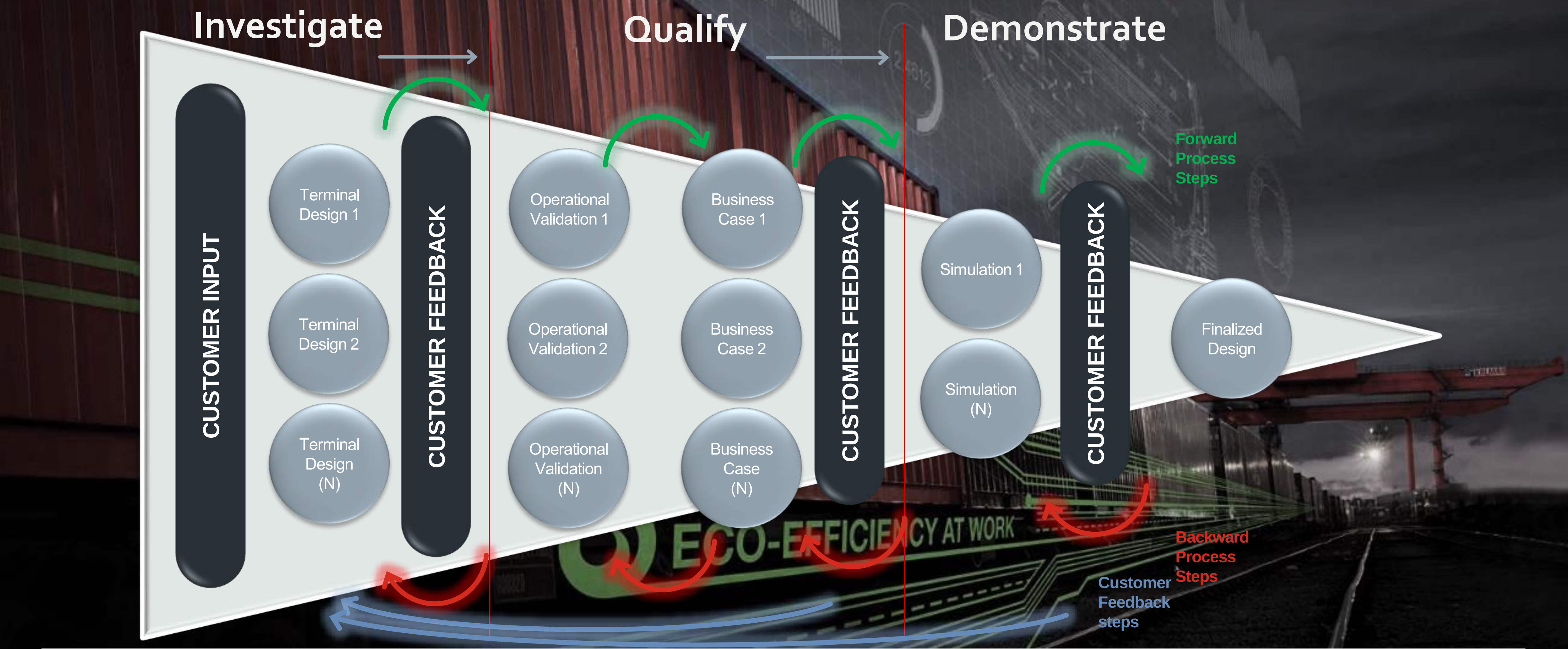
- Full range of layout options
- Full business case calculations including CAPEX, OPEX and ROI analysis on preferred options
- High level delivery and project plan
- Terminal capacity calculations and fleet size estimations

Demonstrate

Demonstrate and validate that ´the selected option can meet the objectives

- Terminal simulations to demonstrate the design
- Verify the design in different scenarios
- 3D modelling of preferred terminal design

Actual representation of the design process



Design problems and challenges noted

Problems and challenges:

- Business case comprehensiveness
  - Equipment, IT, Infrastructure
- Risk and scenario comprehensiveness
  - Sensitivity analysis and alternative scenarios
- Involving all required skills throughout the project.
- Later refinements or additional information
  - Not always fed back into the models to verify if the chosen concept is still the optimal choice.
- Not enough time for a proper analysis.

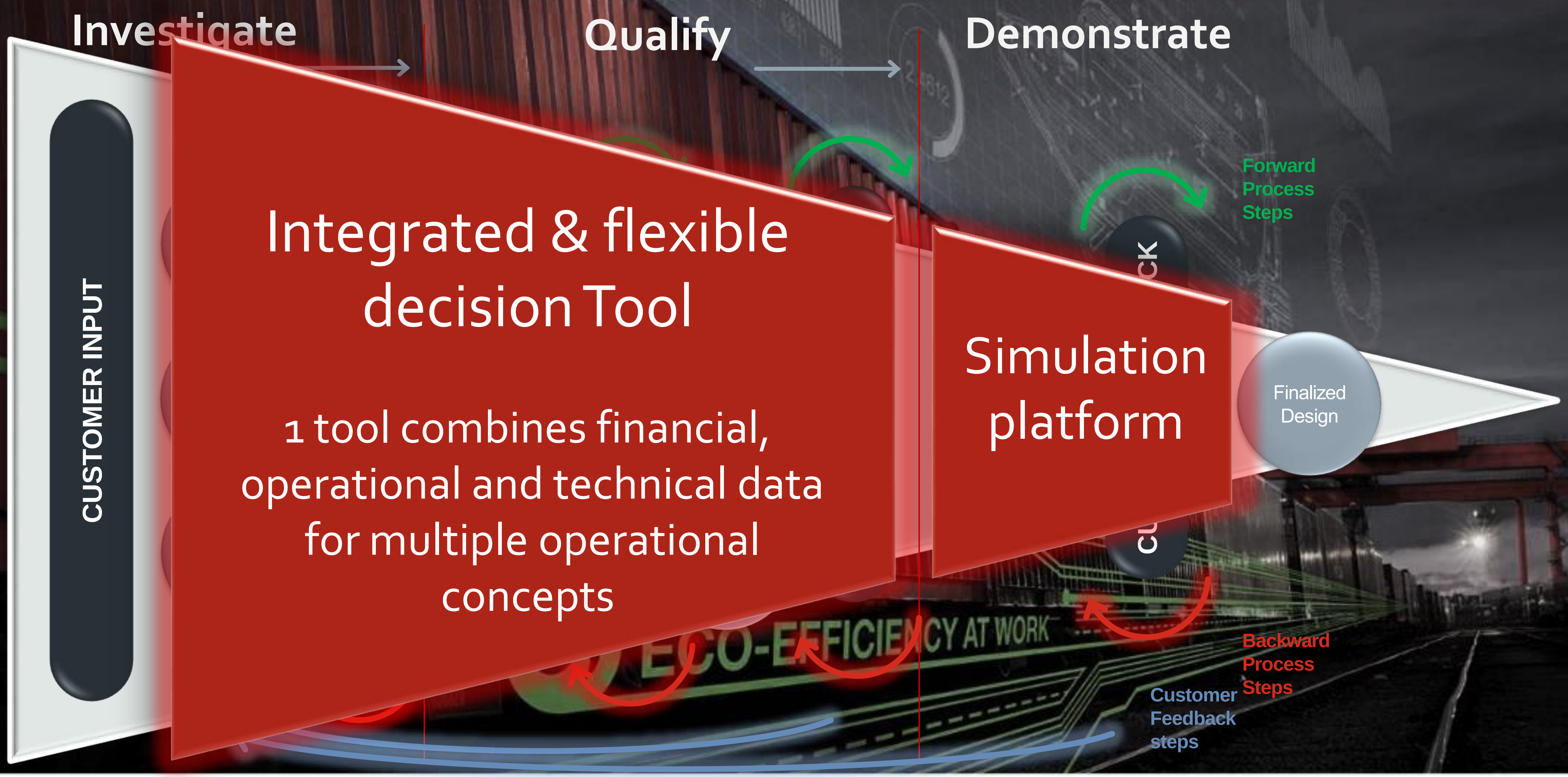
Result:

In order to meet time, skill and budget limitations

Too early focus on 1 operational concept, lacking solid checks of sensitivities and alternative scenarios.

ECO-EFFICIENCY AT WORK

Real representation of the design process



Flexible Decision Tool – High level overview

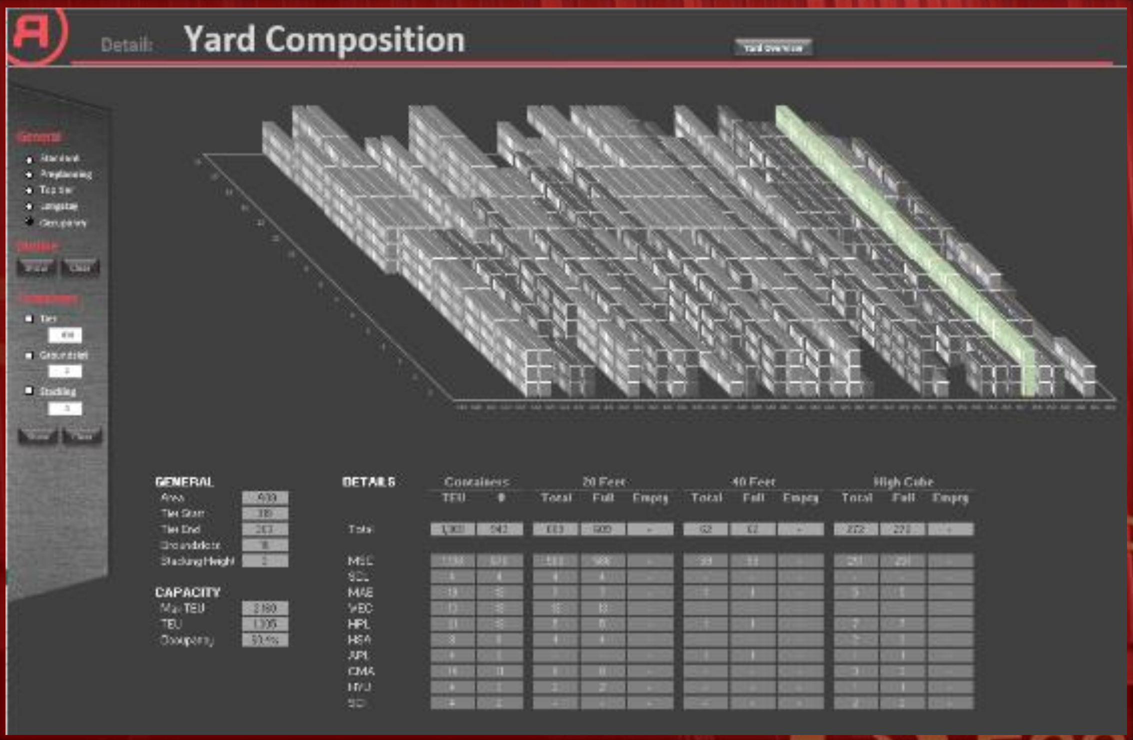
Inputs include amongst others:

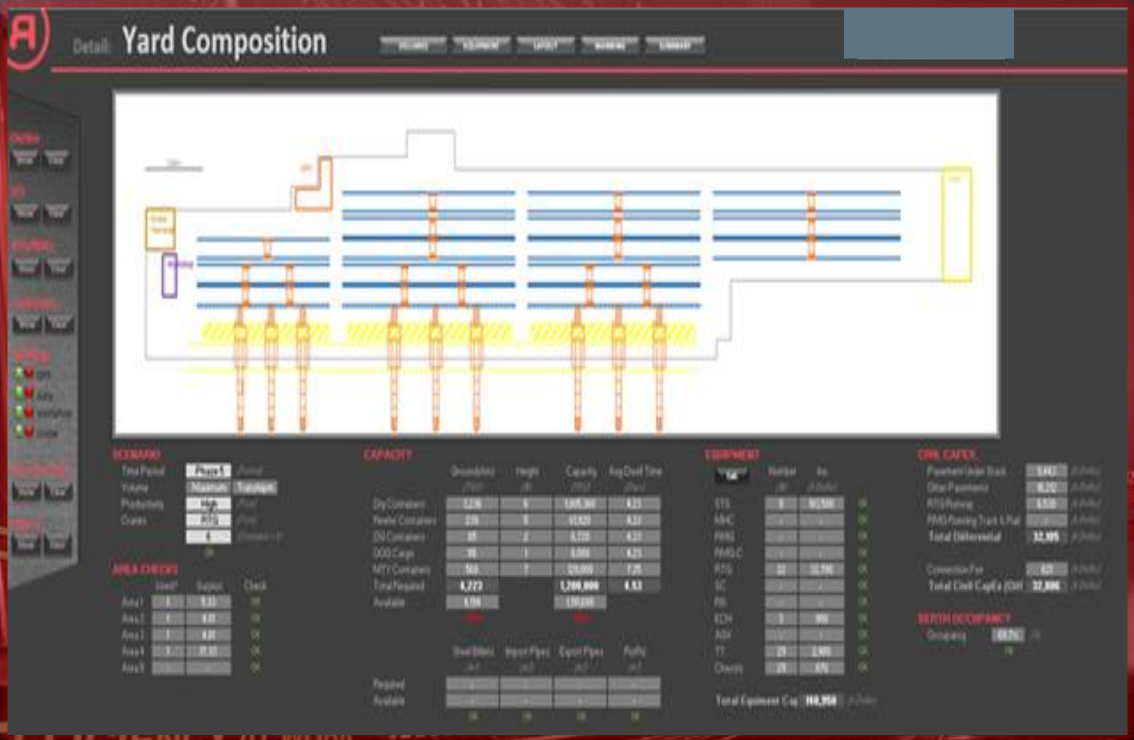
- Timing aspects
- Financing assumptions
- Terminal parameters
- Activity statistics
- Equipment parameters
- Investment cost
- Other operational cost
- Revenues per container type

Outputs for each scenario include amongst others:

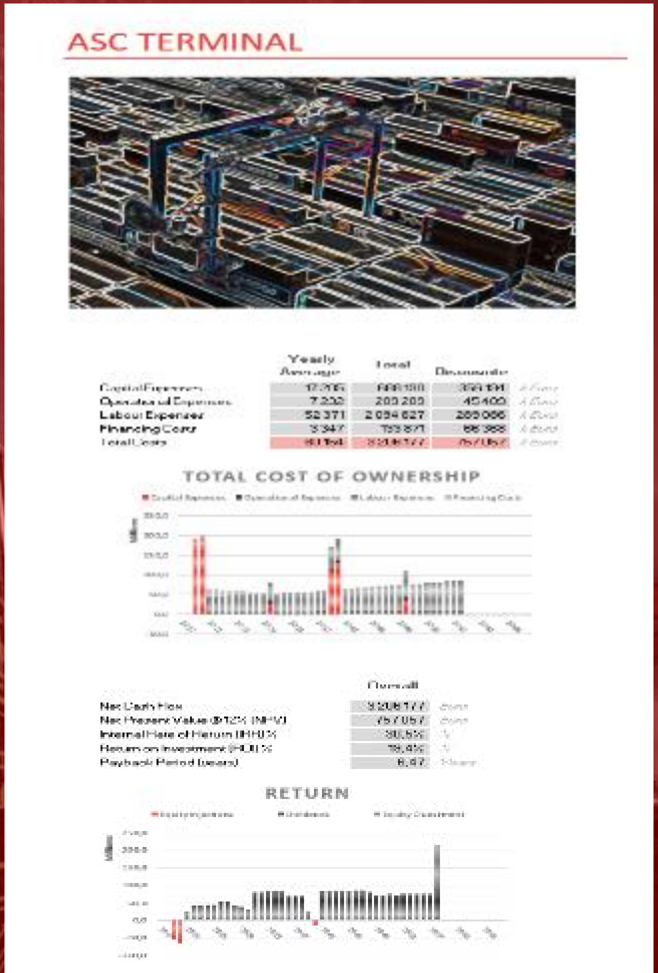
- Total cost of ownership, IRR, NPV
- Cash flow statement
- Balance sheet

The Flexible Decision Tool includes 2D and 3D visualization of container terminal operations



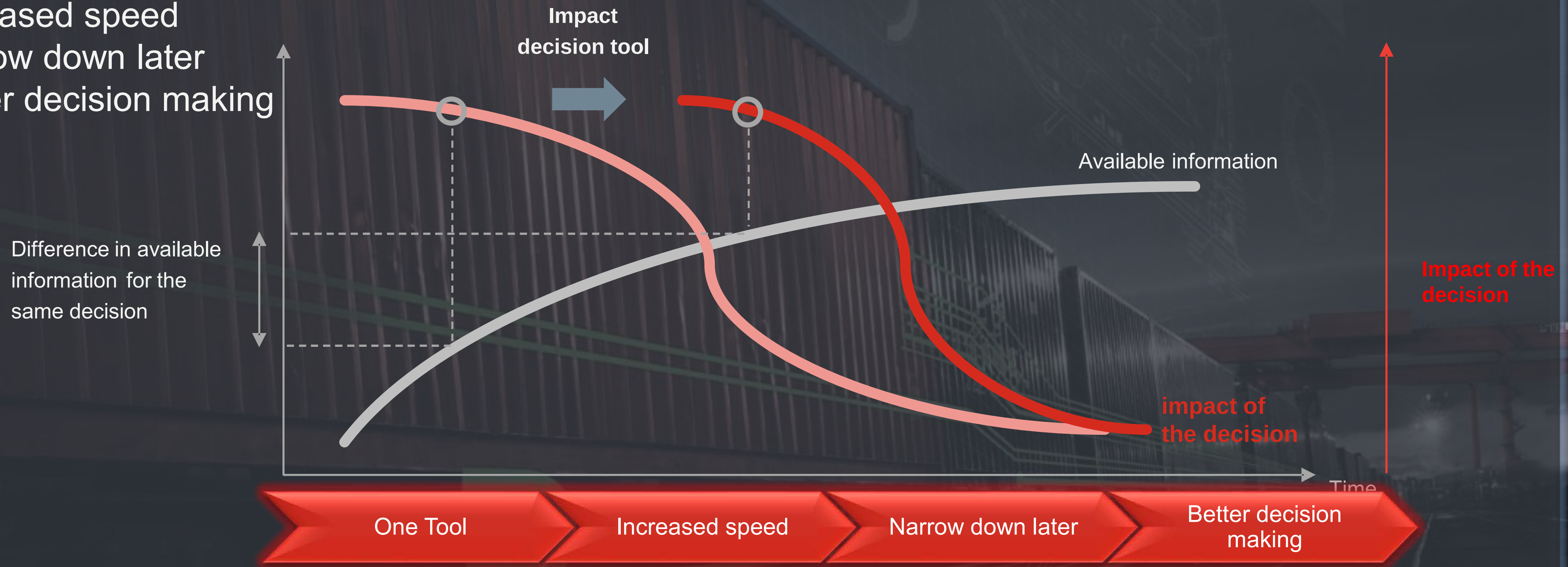


Outputs of the flexible decision tool



Implication of using an integrated & flexible decision tool

One Tool
Increased speed
Narrow down later
Better decision making



Note: The flexible decision tool is to be kept up to date during the entire design process to enable ongoing verification that the chosen operational concept is the optimum choice

360-degree perspective on value creation

Financial Value

Customer Value

Social Value

Strategic Value

Static models are not sufficient

"Don't validate only 1 future, test the design sensitivity by creating different scenarios and use cases"

Technology

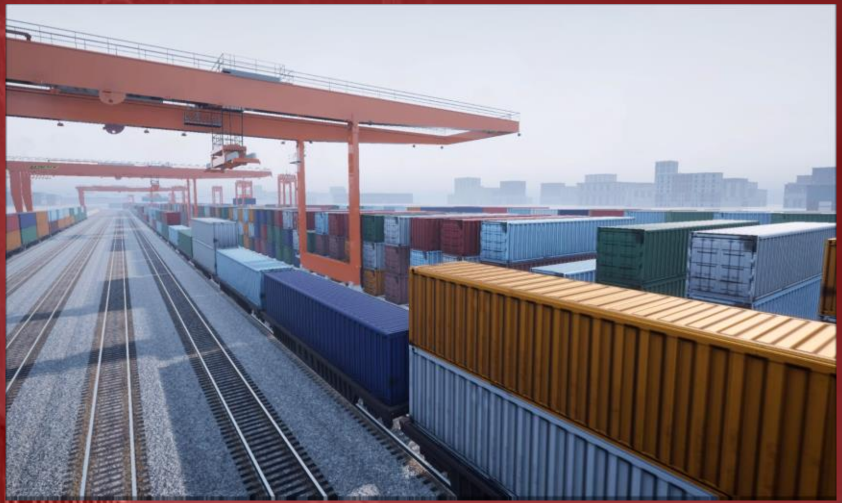
Impact of:

- Speeds and delays
- Fleet sizes
- Variances to reveal bottlenecks
- Traffic arrival patterns
- Stacking height
- Unexpected changes
- TOS decision making modeling
- Humans decision making during operation

Data

Usage:

- Access restrictions to the main lines
- Shunting capacity
- 3D equipment models can reveal space issues overlooked
- Share your historical and current data to use as an input for the simulation
- Feed back the outcomes of the simulation into the static model to review the potential impact on the business cases

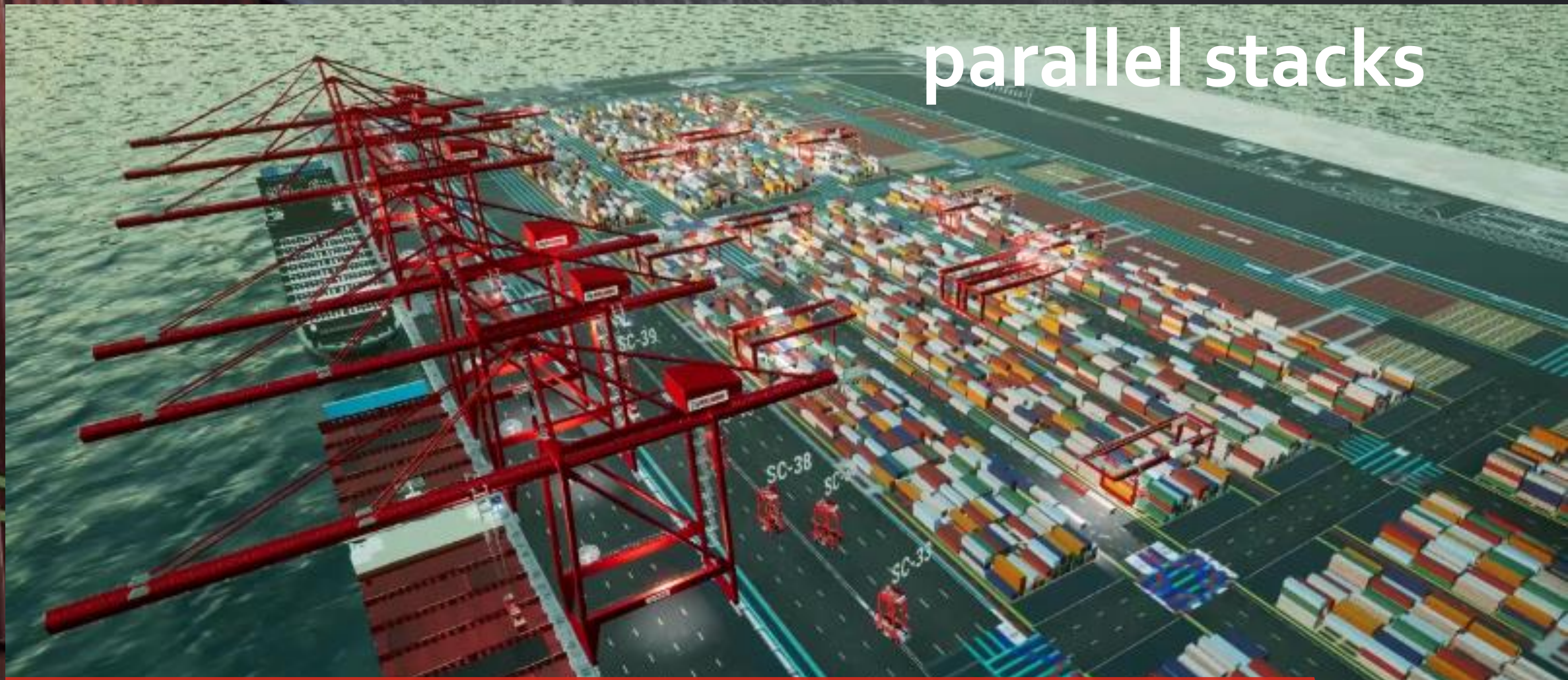


Example of a simulation exercise

Is that statement still valid when looking with a holistic perspective ?

What is the difference between coupled and decoupled horizontal transport systems when looking at:

- STS crane performance
- Yard crane performance
- Possibilities for optimization



Typical statement heard from industry:
"In parallel C-RMG concept the horizontal transportation system travel distances increase so much, that a decoupled system does not add value anymore. Therefore AGV or AutoTT is the way to go."

Simulation scenarios

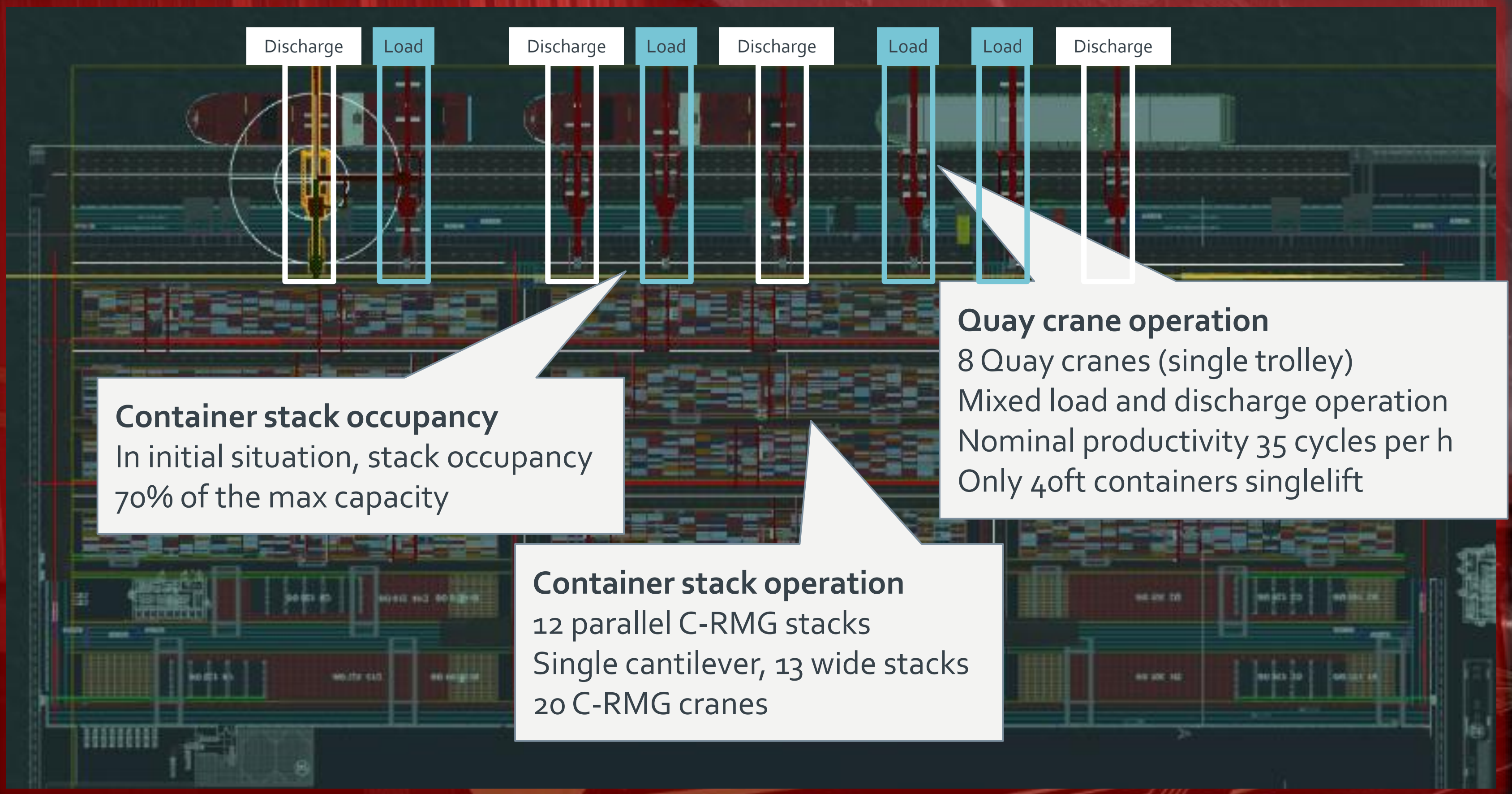
Scenario 1 (coupled system)

LoLo AGV operation
Exchange under QC portal
Parallel buffer for waiting behind QC
AGV fleet sizes varying between 24...64

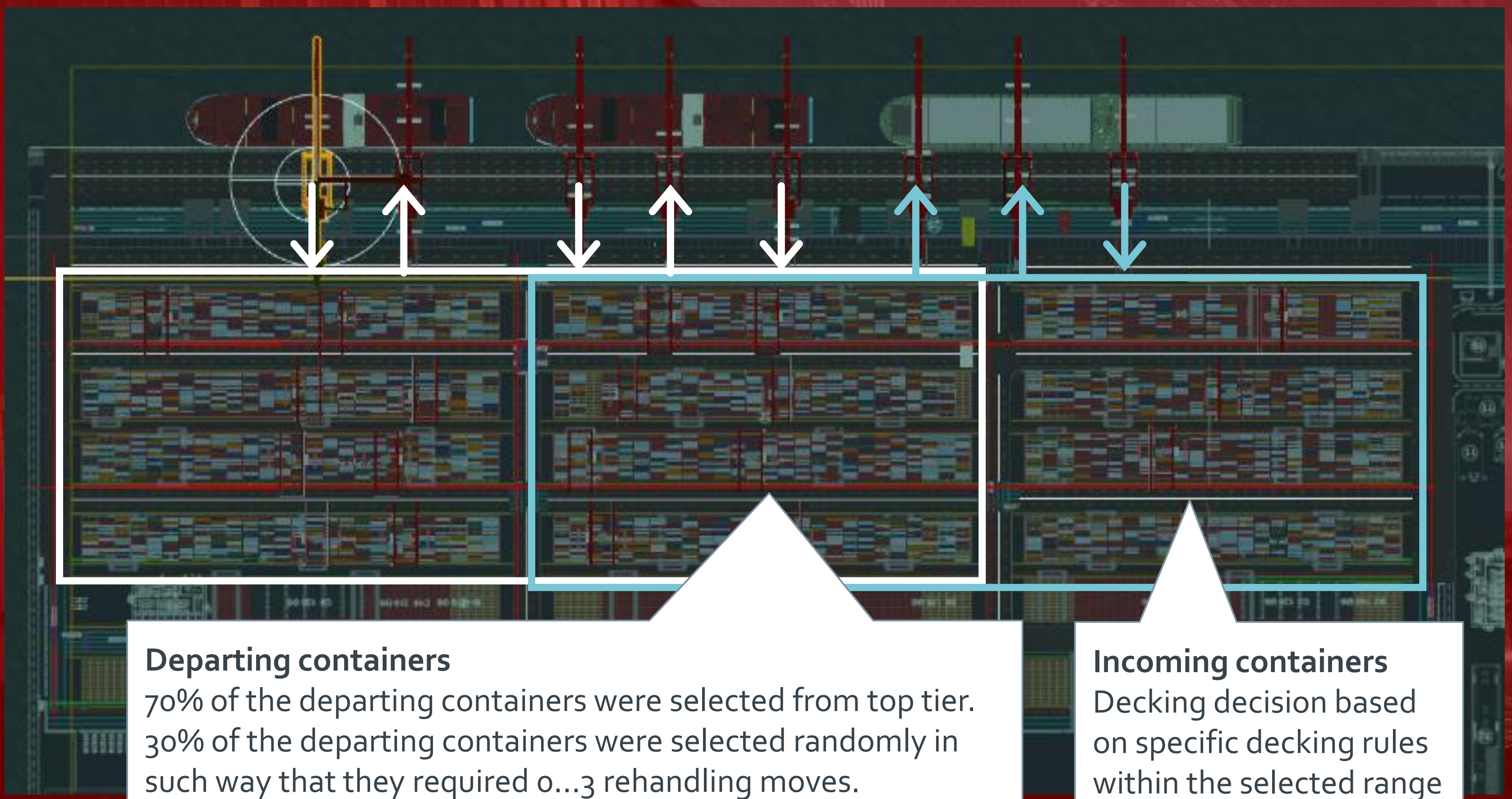
Scenario 2 (decoupled system)

AutoShuttle operation
Exchange under QC backreach
No parallel buffer or waiting area on the apron
AutoShuttle fleet sizes varying between 24...36

Simulation environment



Decking of incoming and selection of departing containers



Departing containers
70% of the departing containers were selected from top tier.
30% of the departing containers were selected randomly in such way that they required 0...3 rehandling moves.
Random selection of containers from the assigned blocks

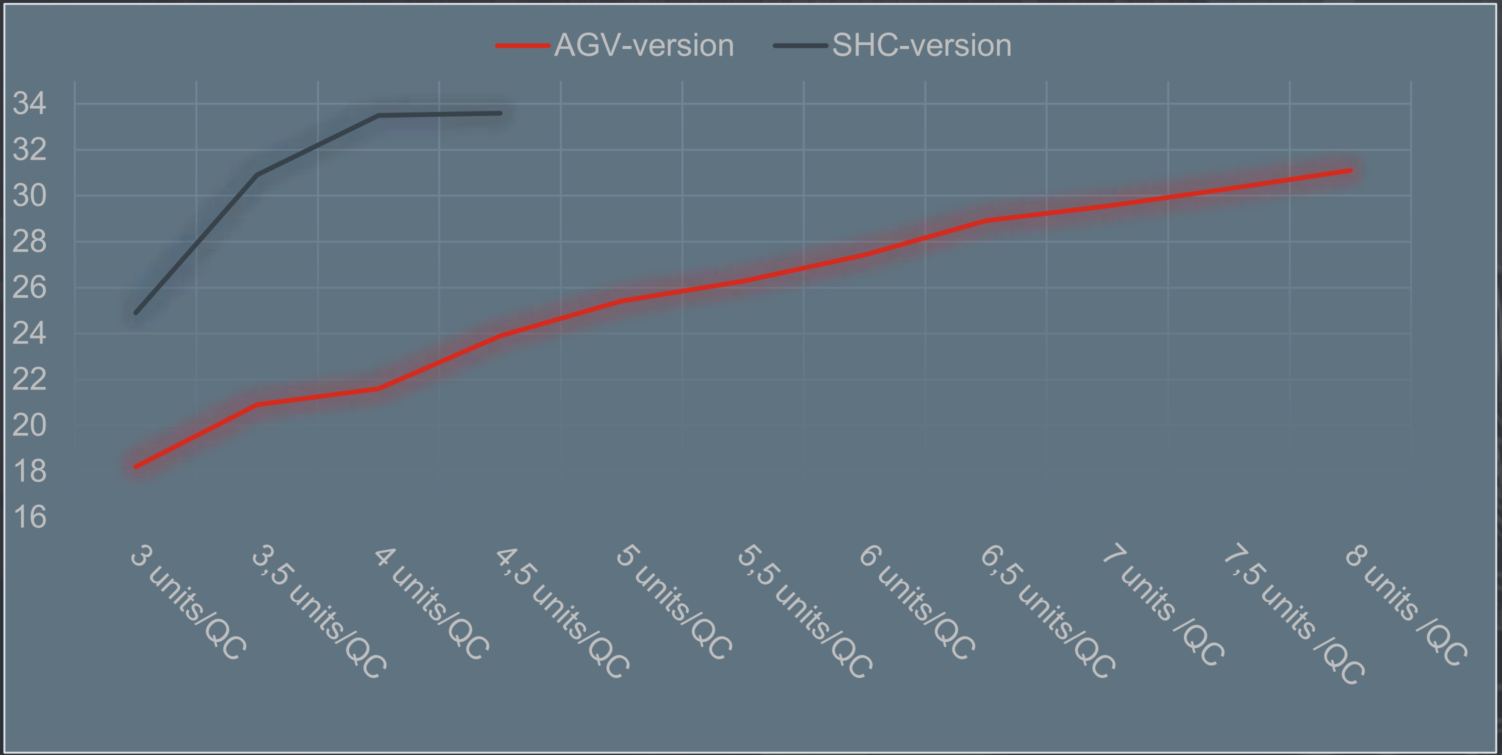
Incoming containers
Decking decision based on specific decking rules within the selected range of stacking blocks.

Decking rules for incoming containers

- Balancing workload between stacks
  - The stack with less occupied transfer lane gets higher score
  - Length of the working queue (with 30 min. look ahead)
- Aiming to take benefit from dual cycling opportunities of HT equipment
  - The positions in the close proximity to where there is a high priority export container waiting get higher score
- Keeping the stack levels equal
  - The stack positions with lower stack height gets higher score
- No stacking of incoming and departing containers on top of each other. No other categorization of containers.

Simulation results - Quay crane productivity

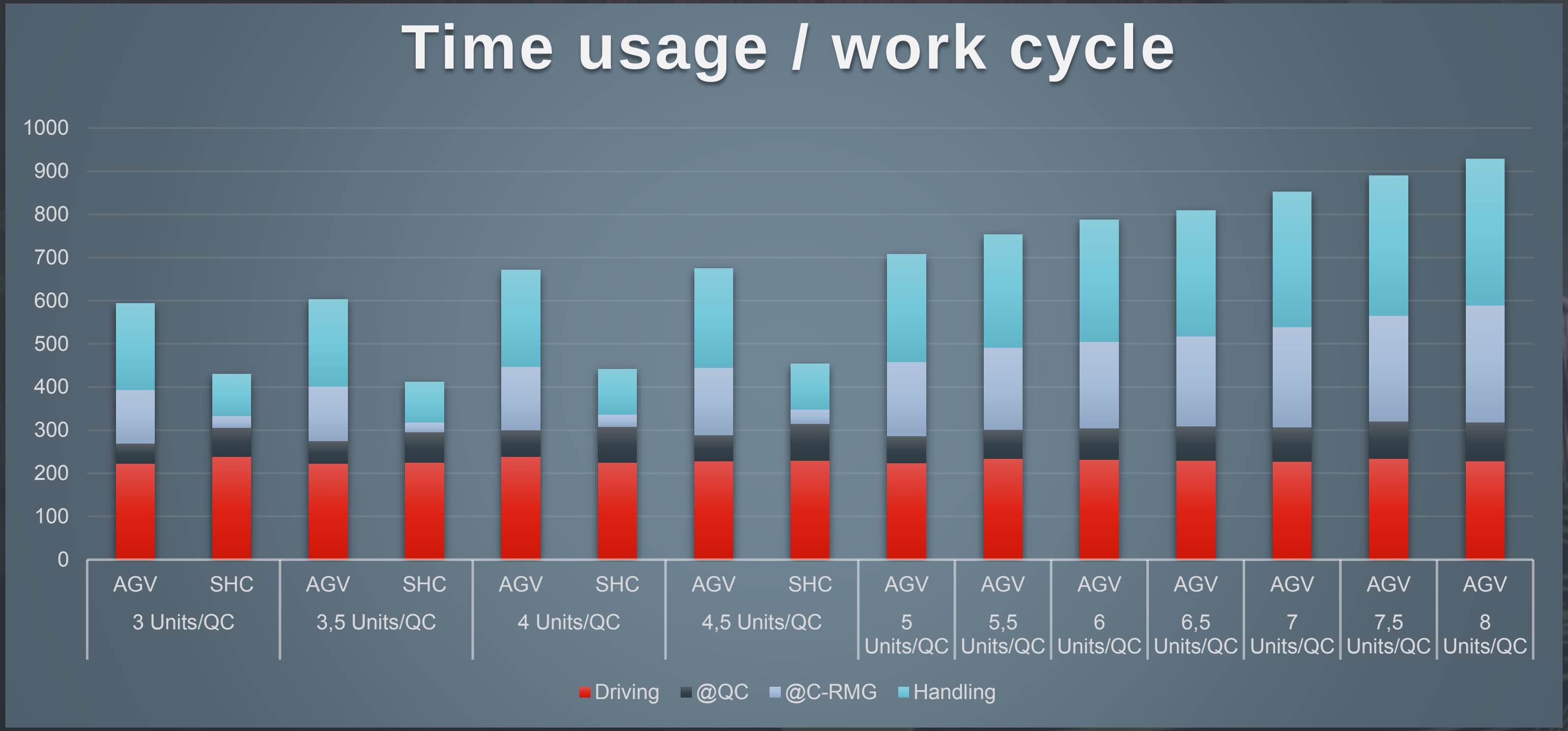
QC performance



In AGV scenario the QC productivities grow linearly as the fleet size grows. In the simulation the maximum average QC productivity 31,3 mph is reached with fleet size of 64 units

With AutoShuttle solution the maximum average QC productivity of 33,6 mph is reached already with fleet size of 32 units, after which increasing fleet size does not increase productivity anymore.

Simulation results - Time usage by HT units



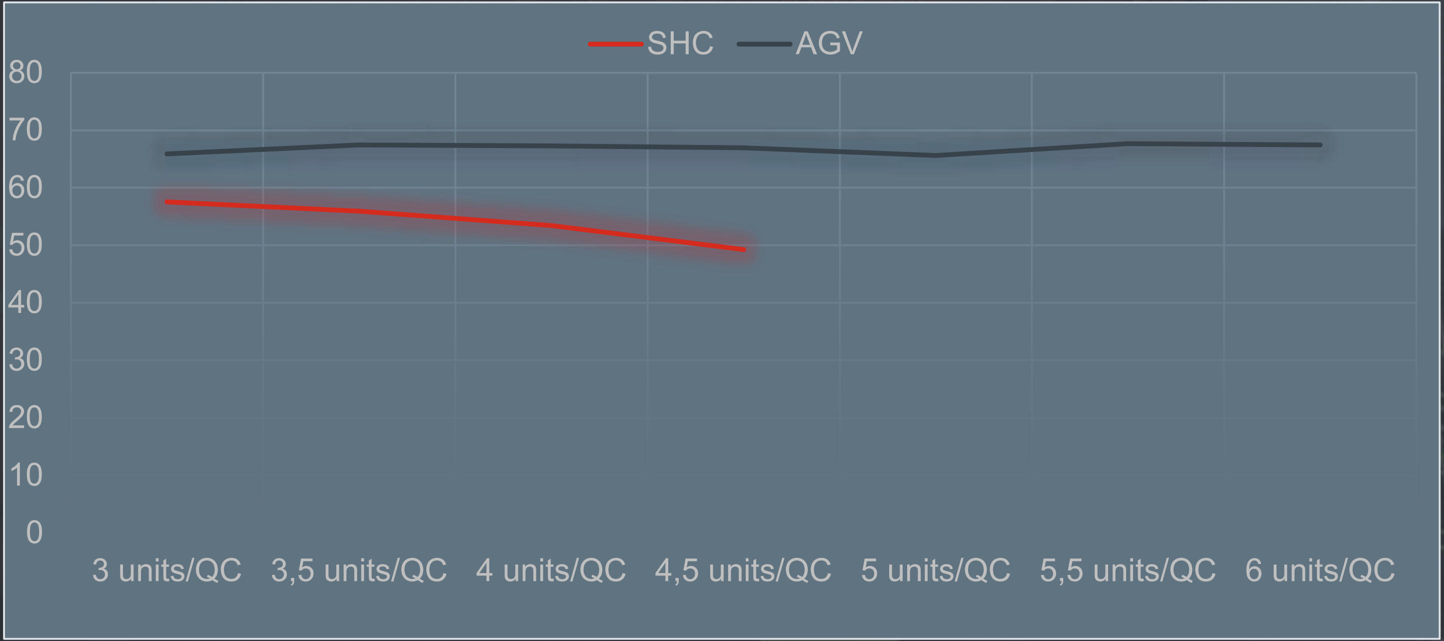
In the attached graph it can be seen, that the time spent for driving per HT unit is approximately same for both AutoShuttle and AGV scenarios.

Big differences can be seen in waiting times at handling position. This is where the conceptual difference between decoupled and coupled system is seen, as decoupled units don't need to wait for crane.

Second big difference is in waiting time to access the C-RMG handling position. In decoupled scenario the transfer lanes get congested, AGV:s block the way from each other. AutoShuttle has the benefit of being able to travel over containers sitting on the transfer lanes.

Simulation results - Gantry time for yard crane

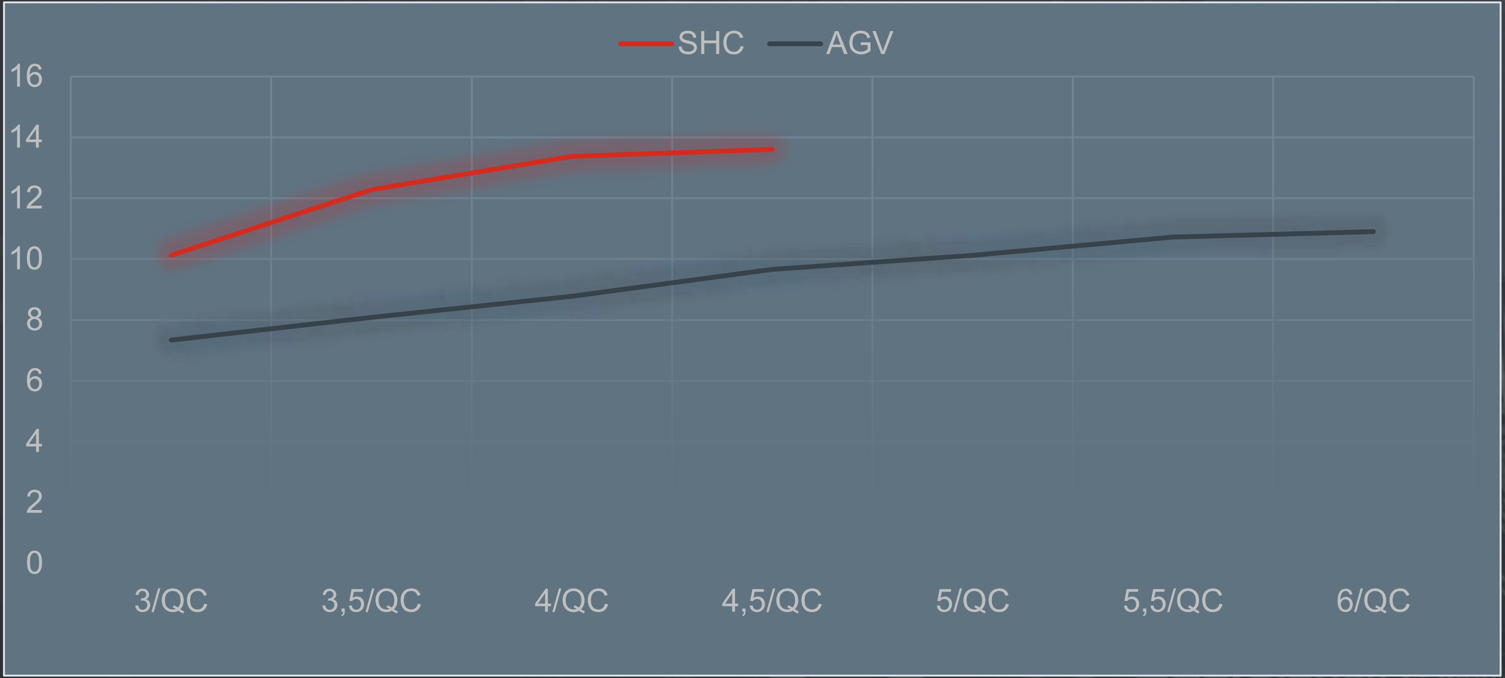
Yard crane gantry time / productive move



Attached graph indicating average C-RMG gantry movement time per productive move shows a clear difference between coupled and decoupled horizontal transportation system. As the import and export containers can be buffered on the transfer lane, this leaves a lot more room for optimizing the best possible execution order for the jobs (and especially handle the import jobs when time allows and in an optimal order). This reduces average gantry movements 15 - 25%.

Simulation results - Yard crane productivity

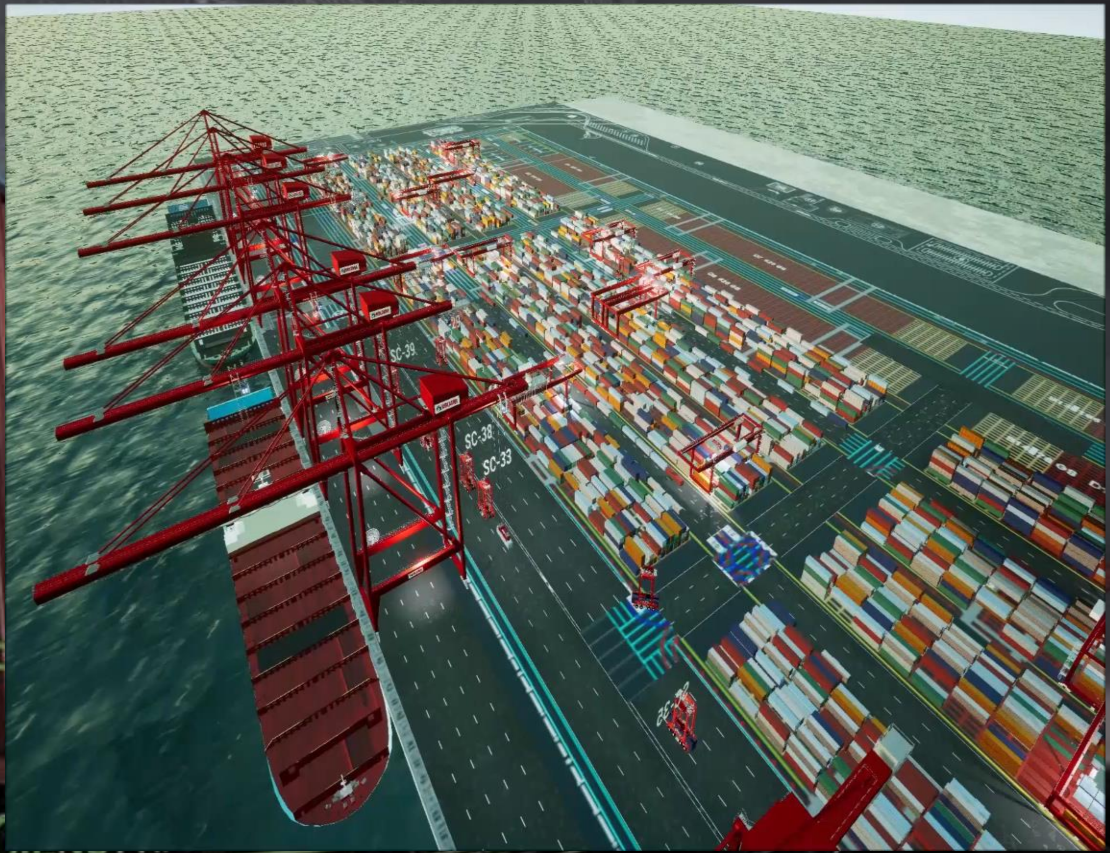
Yard crane productive moves/hour

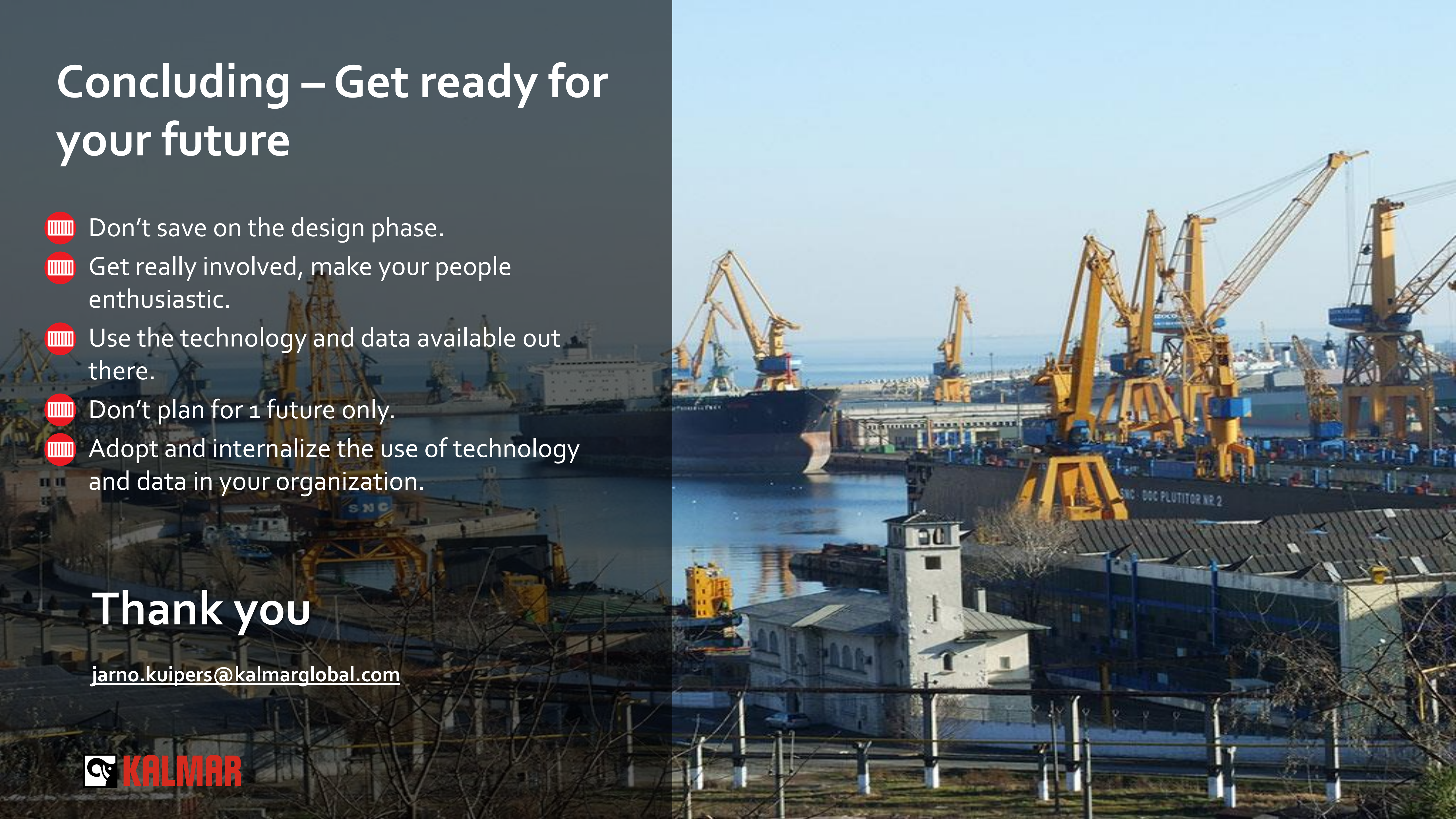


Using decoupled horizontal transportation system gives a lot more flexibility to optimize the execution order of the jobs on the transfer lane. Crane gantry travelling distances can be optimized, as departing containers can be buffered on the transfer lane beforehand, and incoming containers can be lifted into the stack when they fit to the plan. This improves yard crane productivity up to 20% compared to operation with the coupled horizontal transportation.

Simulation exercise conclusions

- The simulation project shows that in combination with parallel C-RMG stacks, a decoupled horizontal transportation system provides significant advantages compared to coupled horizontal transport system.
- Eliminating most of the waiting time between crane and HT units
  - Reducing congestions especially in the stack interchange lanes
- With the capability to buffer containers on transfer lanes
  - Optimization opportunities for yard crane job sequencing
  - Flexibility to handle peak load situations
  - Higher quay crane productivity
- This requires re-thinking the whole concept of how to use the parallel transfer lane, but the advantages are significant
  - 20% higher yard crane productivity
  - 7% higher quay crane productivity
  - 50% higher HT equipment utilization





Concluding – Get ready for your future

- Don't save on the design phase.
- Get really involved, make your people enthusiastic.
- Use the technology and data available out there.
- Don't plan for 1 future only.
- Adopt and internalize the use of technology and data in your organization.

Thank you

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