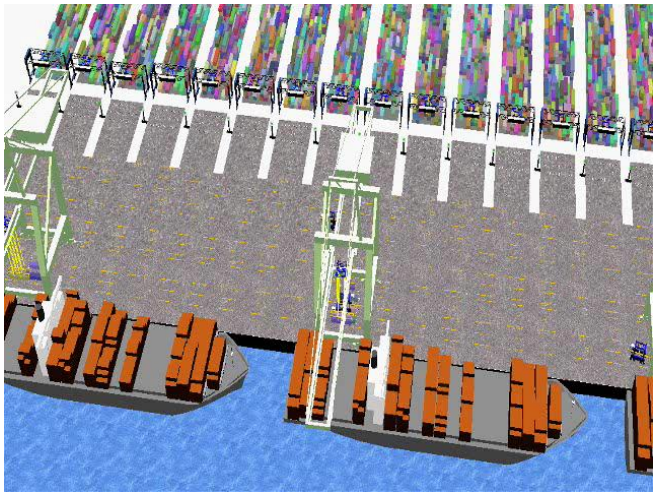
# Designing semi-automated terminals

## *Using dynamic modelling tools*



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# Contents of presentation

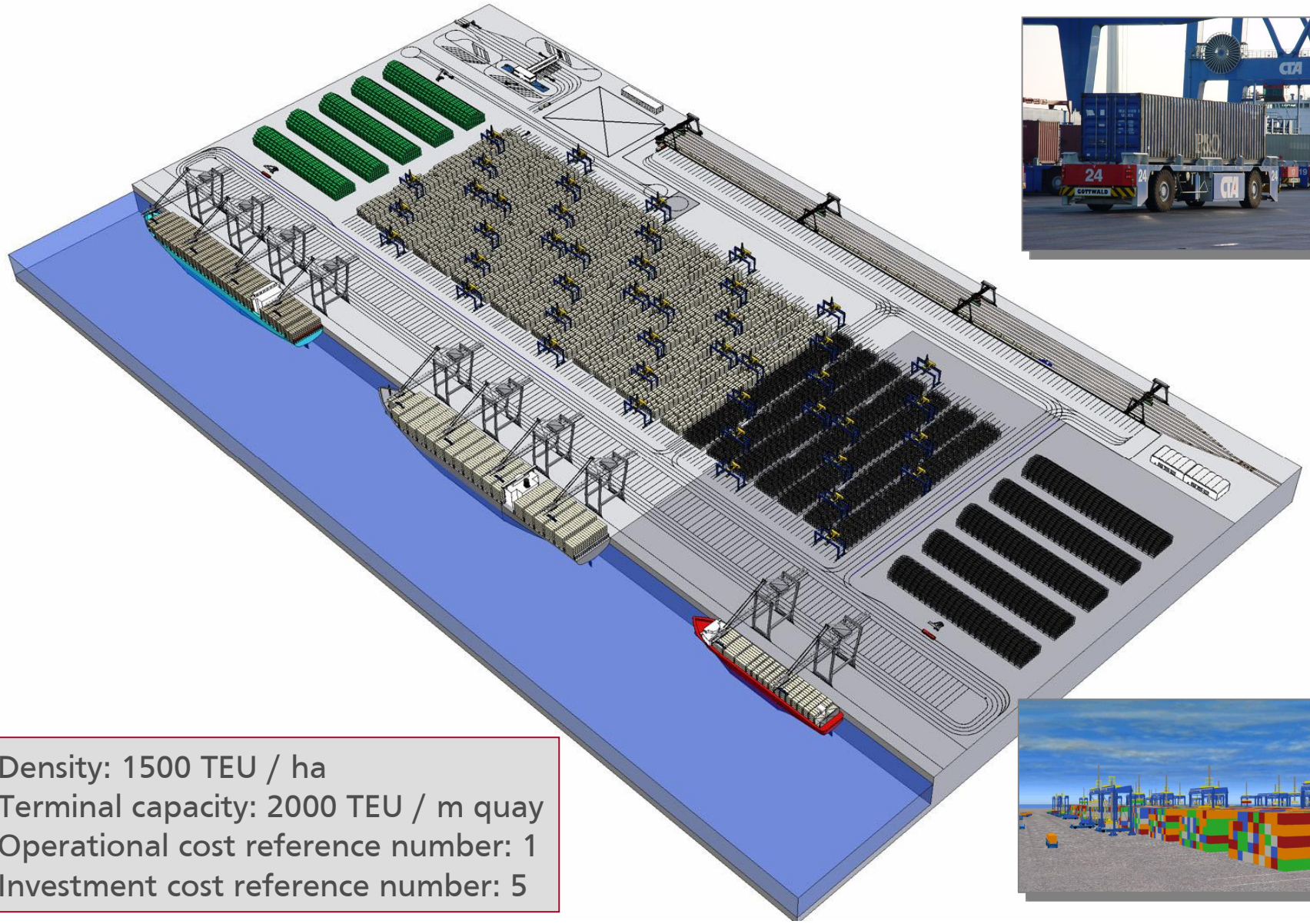


1. Automated terminal amid their main competitors
2. Design approach (semi-) automated terminal
3. Emulation as tool to ensure software quality
4. Concluding remarks

# Automated terminals amid their main competitors

# The most efficient (semi-) automated concept nowadays
## 4. RMG + AGV







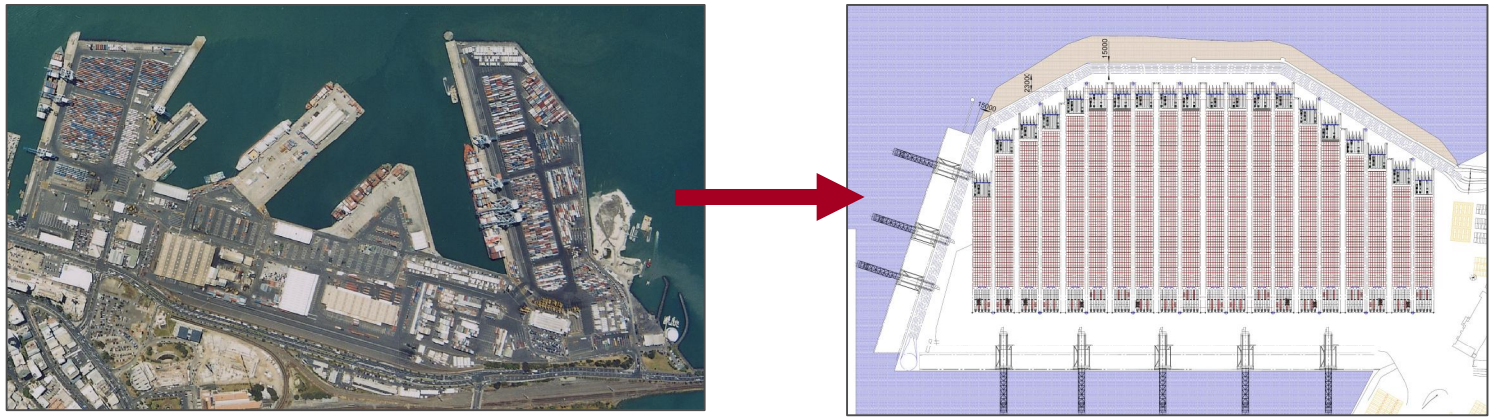


- Density: 1500 TEU / ha
- Terminal capacity: 2000 TEU / m quay
- Operational cost reference number: 1
- Investment cost reference number: 5

# Why automate?



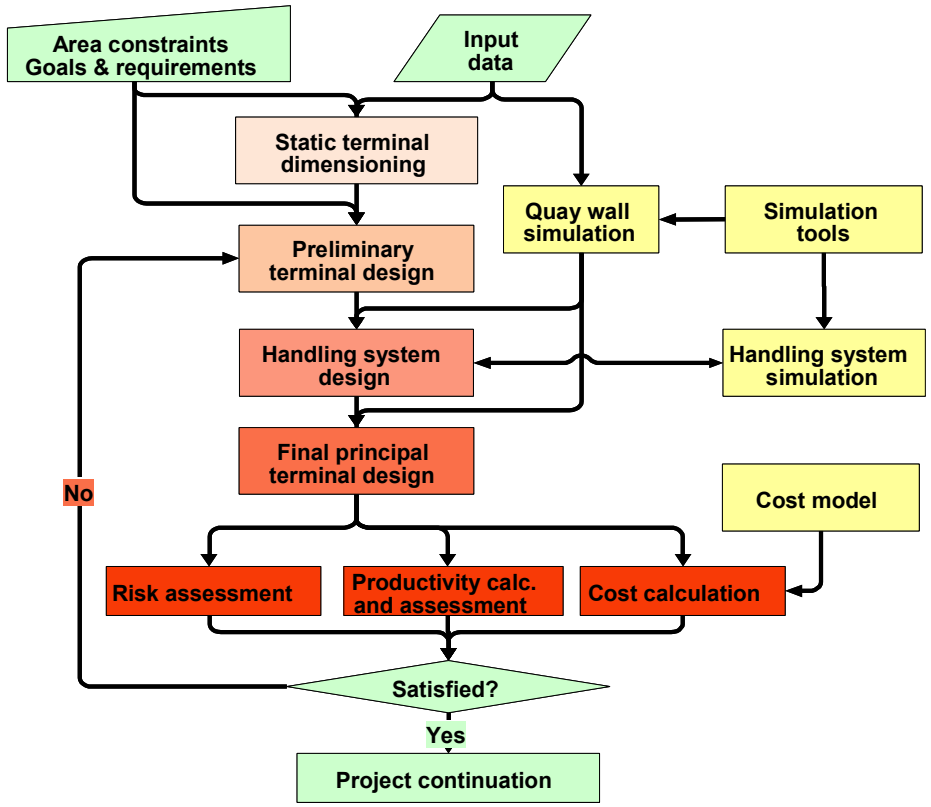
# Designing a semi-automated container terminal



# Simulation approach for robust design of an automated terminal

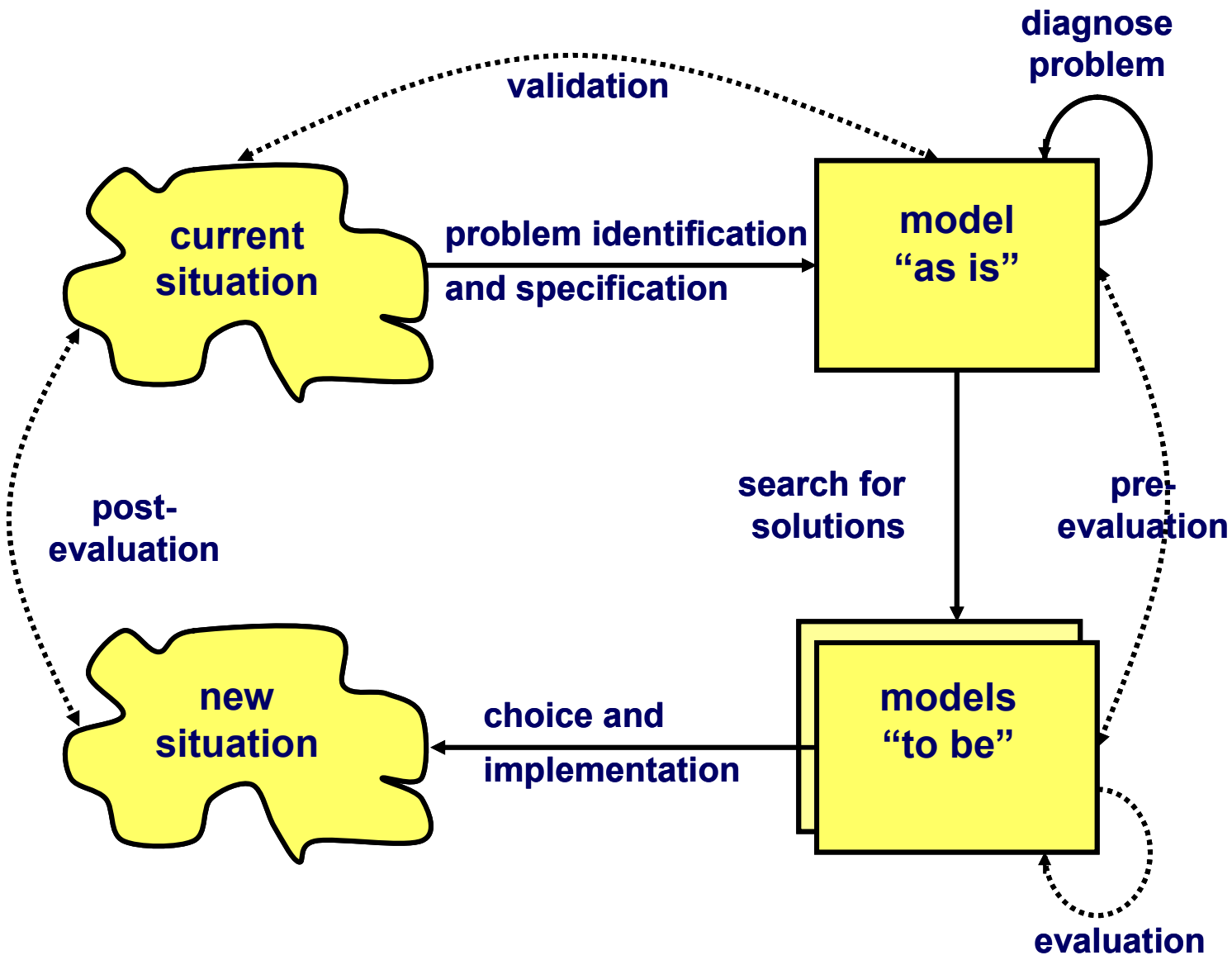


- S.M.A.R.T. definition of goals and KPI's
  - Realistic operational scenarios
  - Performance targets
  - Operational costs / investment
- Static terminal design:
  - Berth capacity
  - Storage capacity
- Simulation of quay operations „setting the scenarios"
- Initial drawings of alternatives
- Simulation (alternative) terminal operations „productivity assessment"
  - Equipment selection
  - Dimensioning of „handling system"
  - Defining the logistical concept
  - Defining business logic
- Simulation of terminal during 6 weeks
- Terminal cost calculation (investment and operational)
- Implementation plan



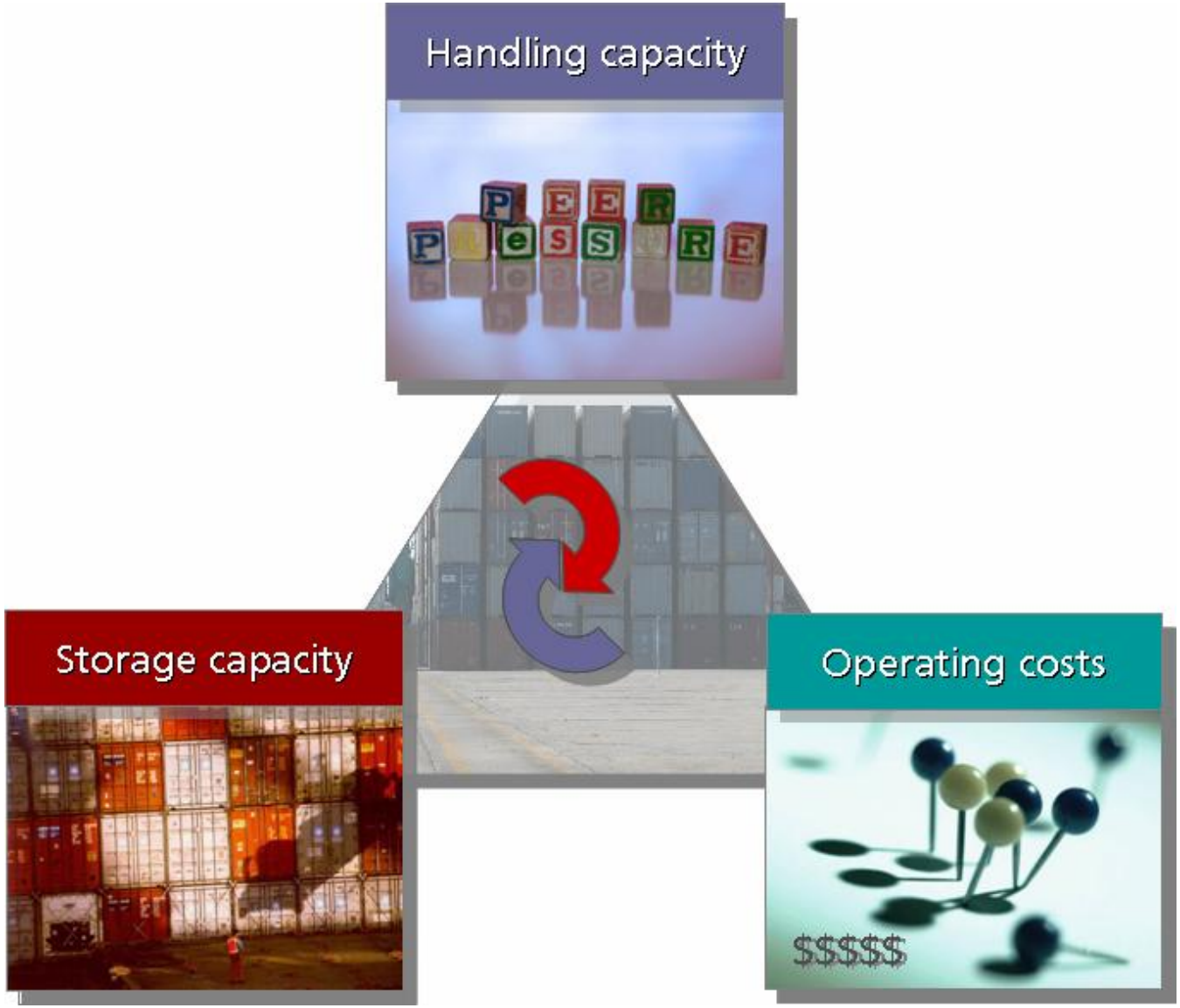
# Simulation cycle (in each phase)





# The key: balanced design of the yard





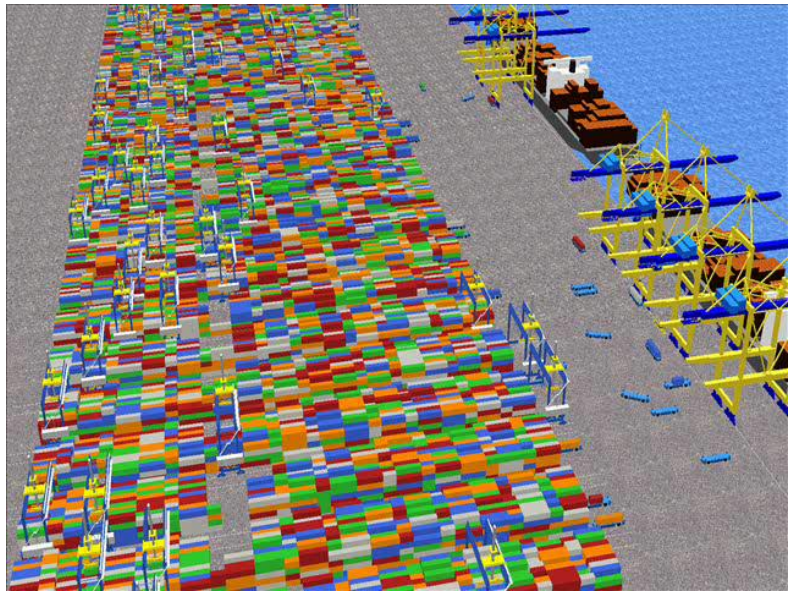
# Right balance / right design

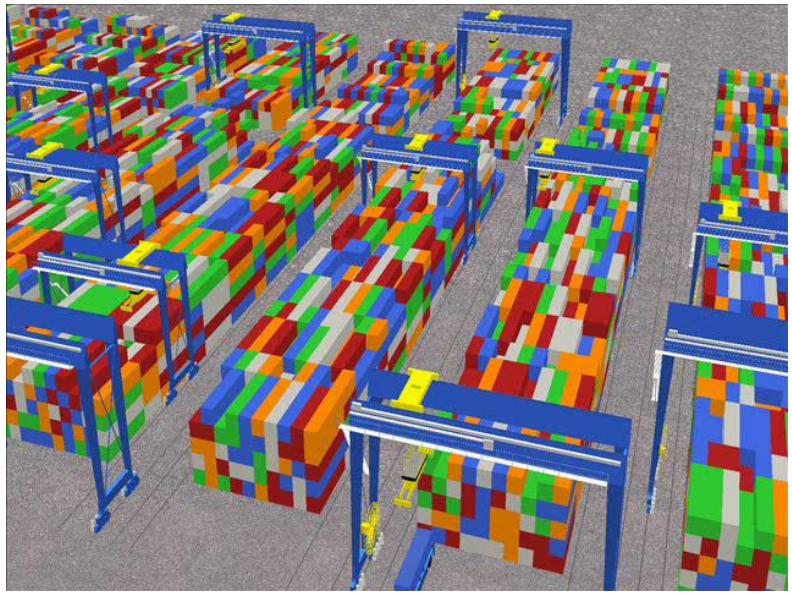


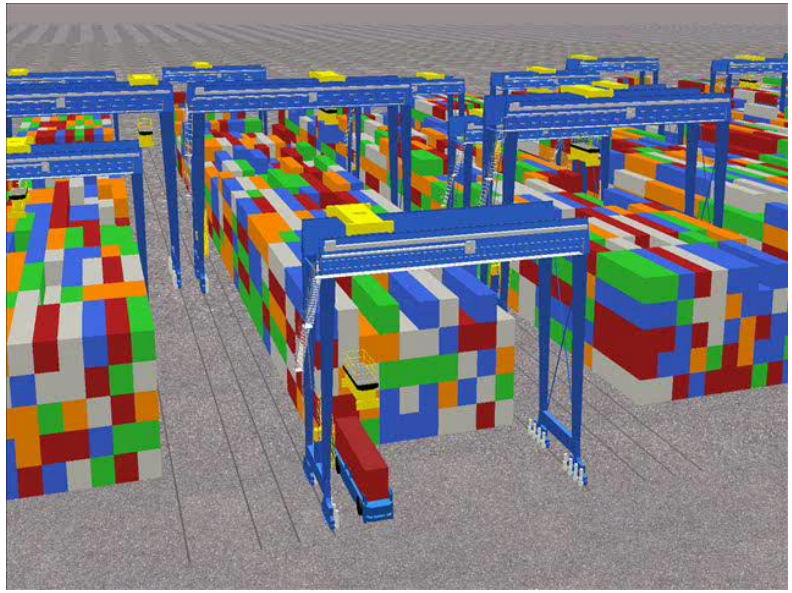
- Target productivity waterside – capable of handling future demands?
  - Peak loads (twin lift, tandem 40, dual cycling, reefer handling, MTs)
  - How many QCs on one vessel?
- Peak at the landside, gate + rail?
- Typical peak scenario: how many out of all QCs are actually in operation?
- How many stacking cranes to meet this demand, in relation to their specifications:
  - Length of stack module
  - Gantry speed & acceleration
  - Hoist speed and acceleration
  - Design of the waterside interchange zone (“buffering”)
  - Rolling percentage (effective rehandling)
  - Landside operation (remote operation)
  - Safety rules (e.g. access to interchange zones)
- Which automated transportation system is the most cost efficient?
- How much waterside equipment to meet demands?
  - Interaction between yard equipment and transportation equipment
  - Sequence during vessel loading
  - Etc.

# Right design / which stack handling system?





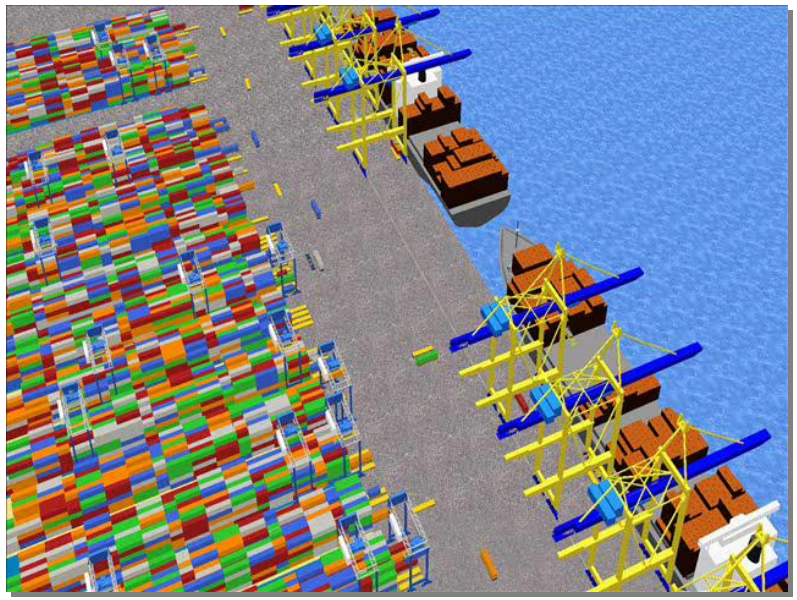




- The Twin RMG:
  - 2 similar RMGs on one track
  - Ability to mutually support
- The cross-over twin RMG:
  - One large, one smaller RMG on 2 tracks
  - Ability to pass, and work on either side
- The cross-over tri RMG:
  - One large, two smaller RMG on 2 tracks
  - One small RMG for either side
  - Ability to pass, and work on either side

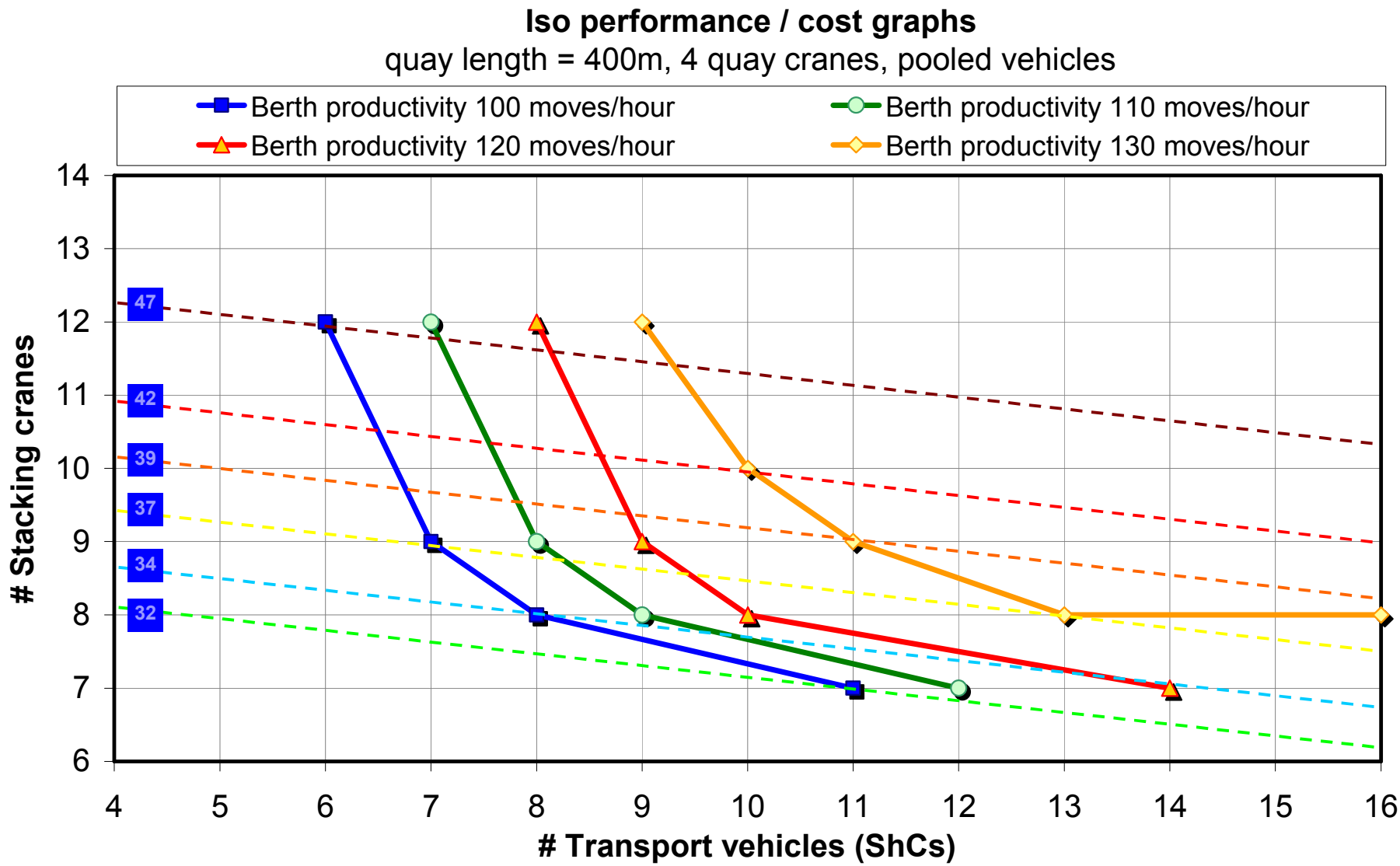
# Right design / which transportation system?





# Various combinations of yard and transportation equipment (example)





# Various terminal designs depending on local circumstance



- Terminal 1:
- 2.0 M TEU
- 5% transhipment
- Dwell time: 9 days
- Peak productivity (WS/LS): 550/400
- Configuration: 30 modules, 60 TEU long, 8 wide

- Terminal 2:
- 3.5 M TEU
- 50% transhipment
- Dwell time: 5 days
- Peak productivity (WS/LS): 720/400
- Configuration: 52 modules, 45 TEU long, 10 wide

- Terminal 3:
- 4.5 M TEU
- 45% transhipment
- Dwell time: 4.5 days
- Peak productivity (WS/LS): 840/450
- Configuration: 48 modules, 36 TEU long, 10 wide

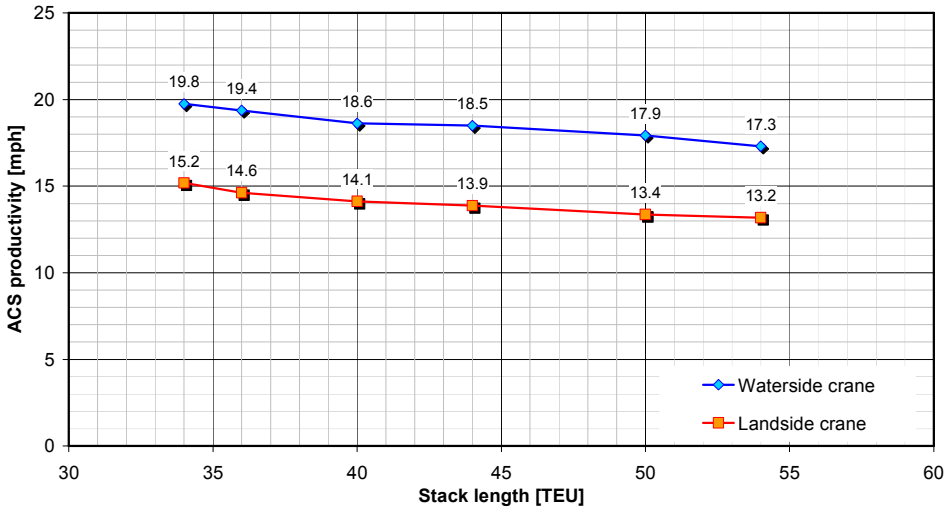
- Terminal 4:
- 1.8 M TEU
- 5% transhipment
- Dwell time: 4 days
- Peak productivity (WS/LS): 375/300
- Configuration: 24 modules, 26/52 TEU long, 11/8 wide

# ASC specification



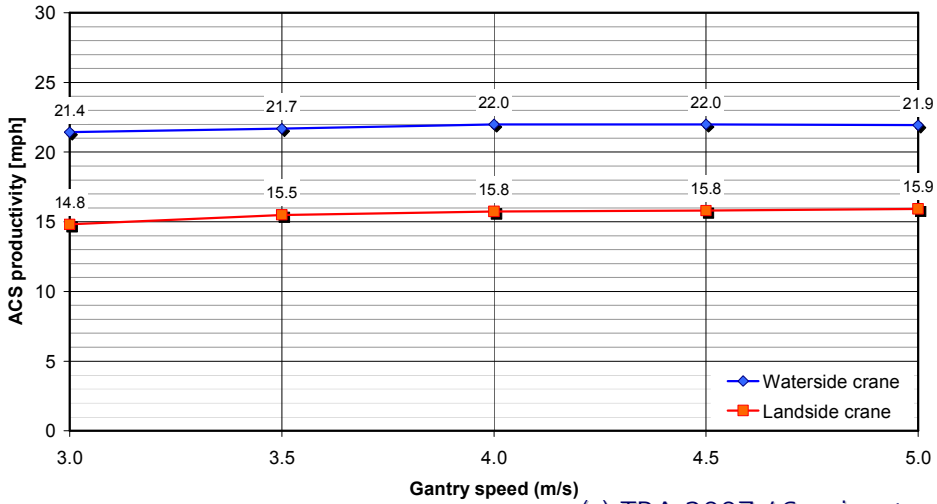
**Effect of the stacklength**

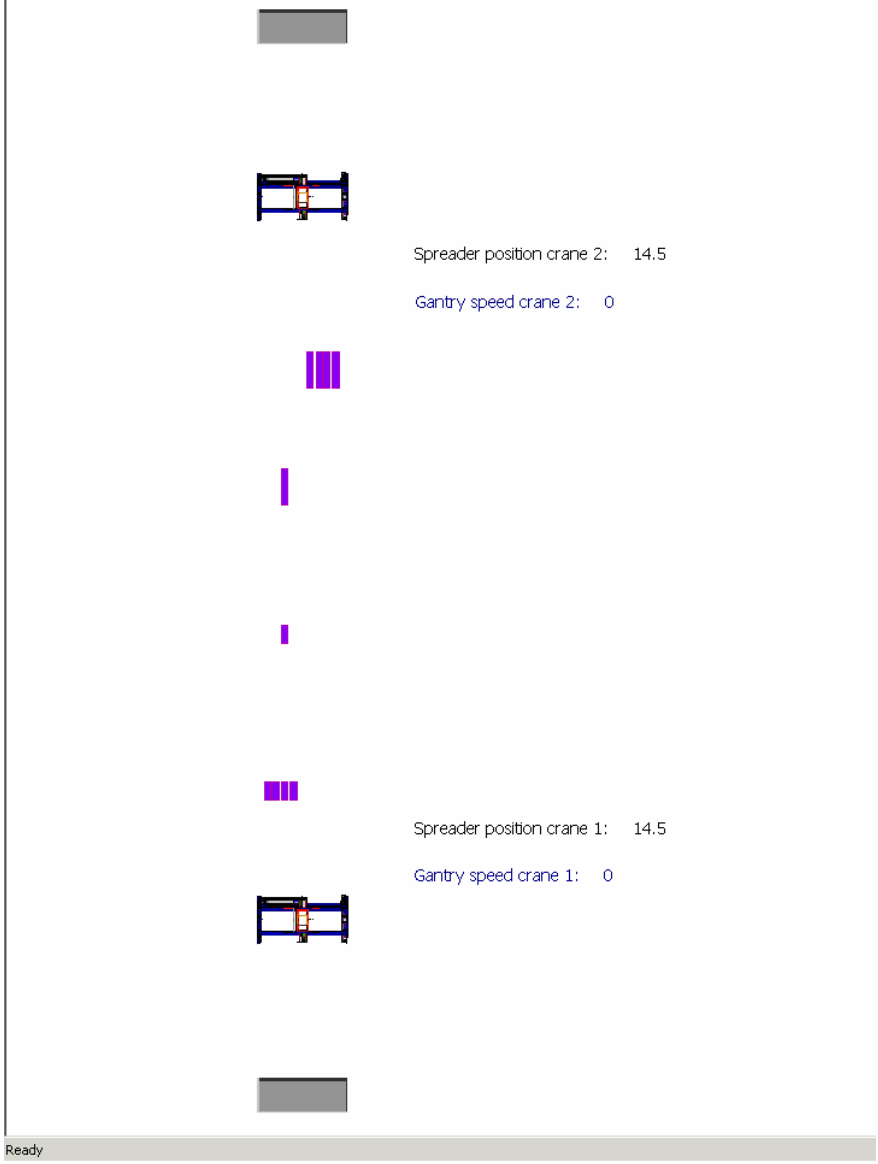
**2-8 Corridor - Vgantry = 4,0 m/s - Agantry = 0,3 m/s2 - Vtrolley = 1,0 m/s - Atrolley = 0,3 m/s2 - Vhoist = 1,0 m/s - Ahoist = 0,33 m/s2 - Scenario 3**




**Effect of gantry speed**

**Agantry = 0.3 m/s2 - Vtrolley = 1,0 m/s - Atrolley = 0,3 m/s2 - Vhoist = 1,0 m/s - Ahoist = 0,33 m/s2**

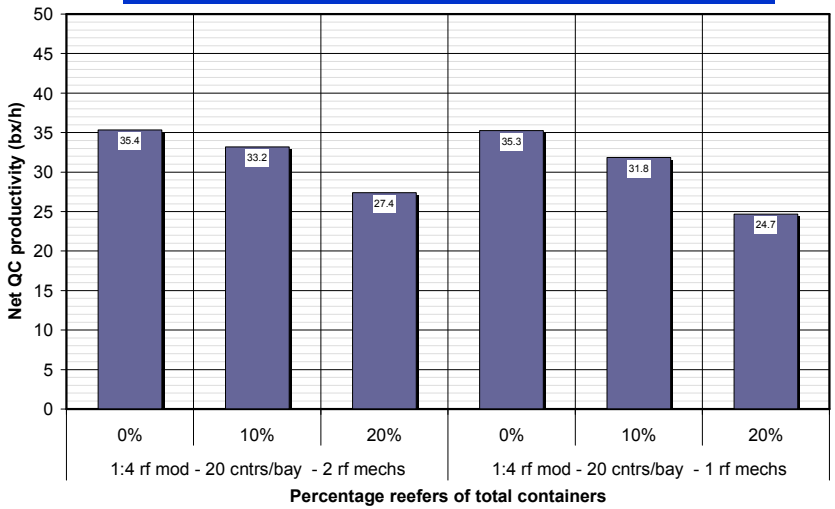


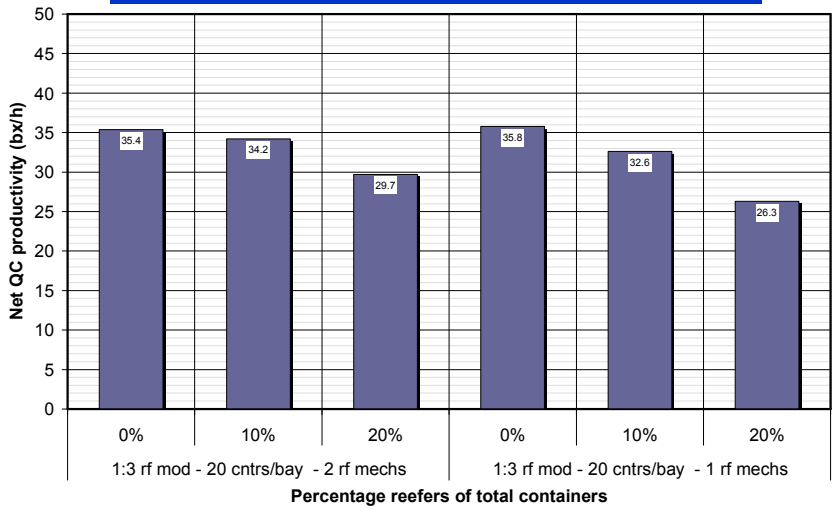
# Design of the reefer solution



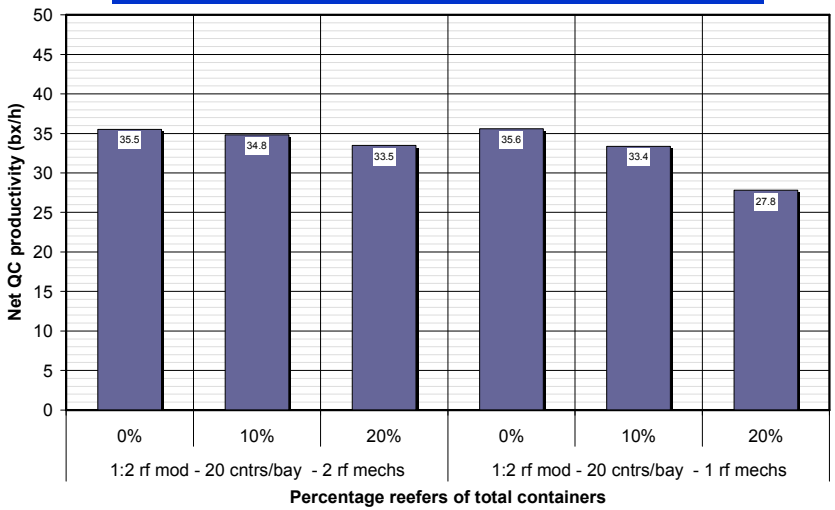
## 1 out of 4 blocks with reefers




## 1 out of 3 blocks with reefers




## 1 out of 2 blocks with reefers



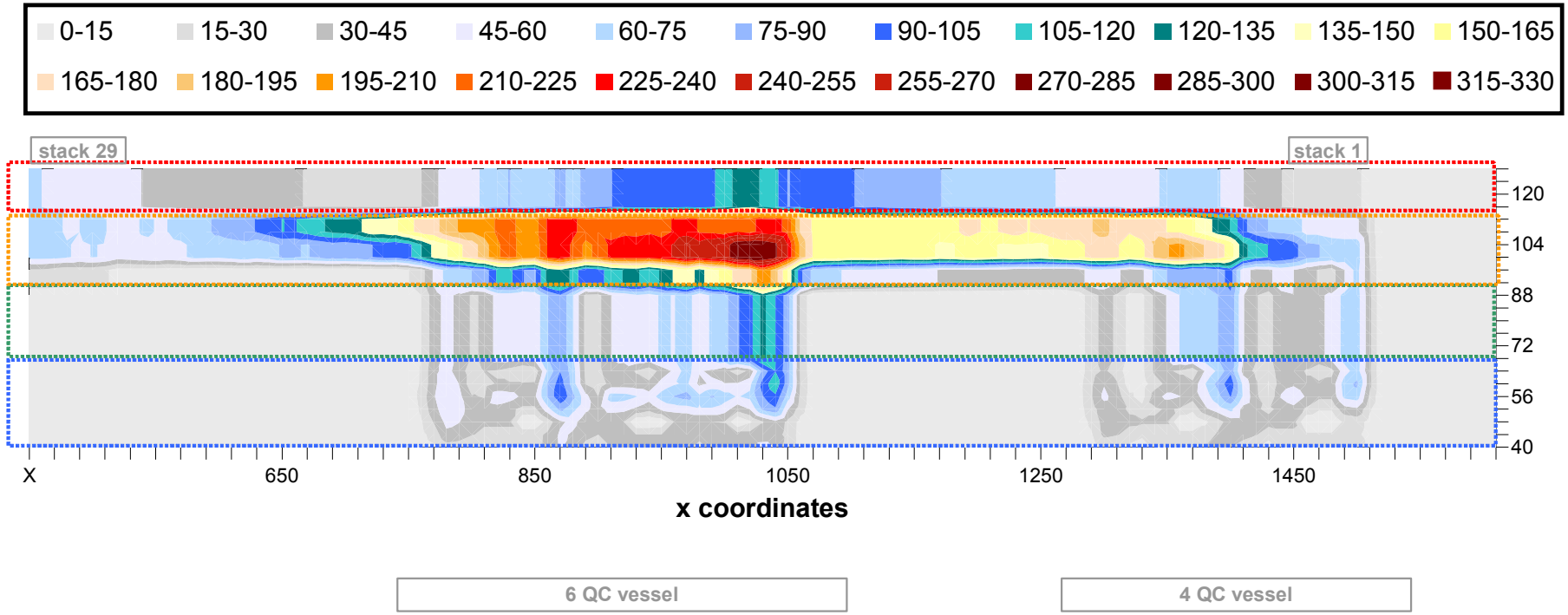

§ Reefer solution:

- Dependent on reefer share
- Dependent on # reefer mechanics
- Dependent on reefer solution (location in the stack module, access, ASC restrictions)

## Traffic density

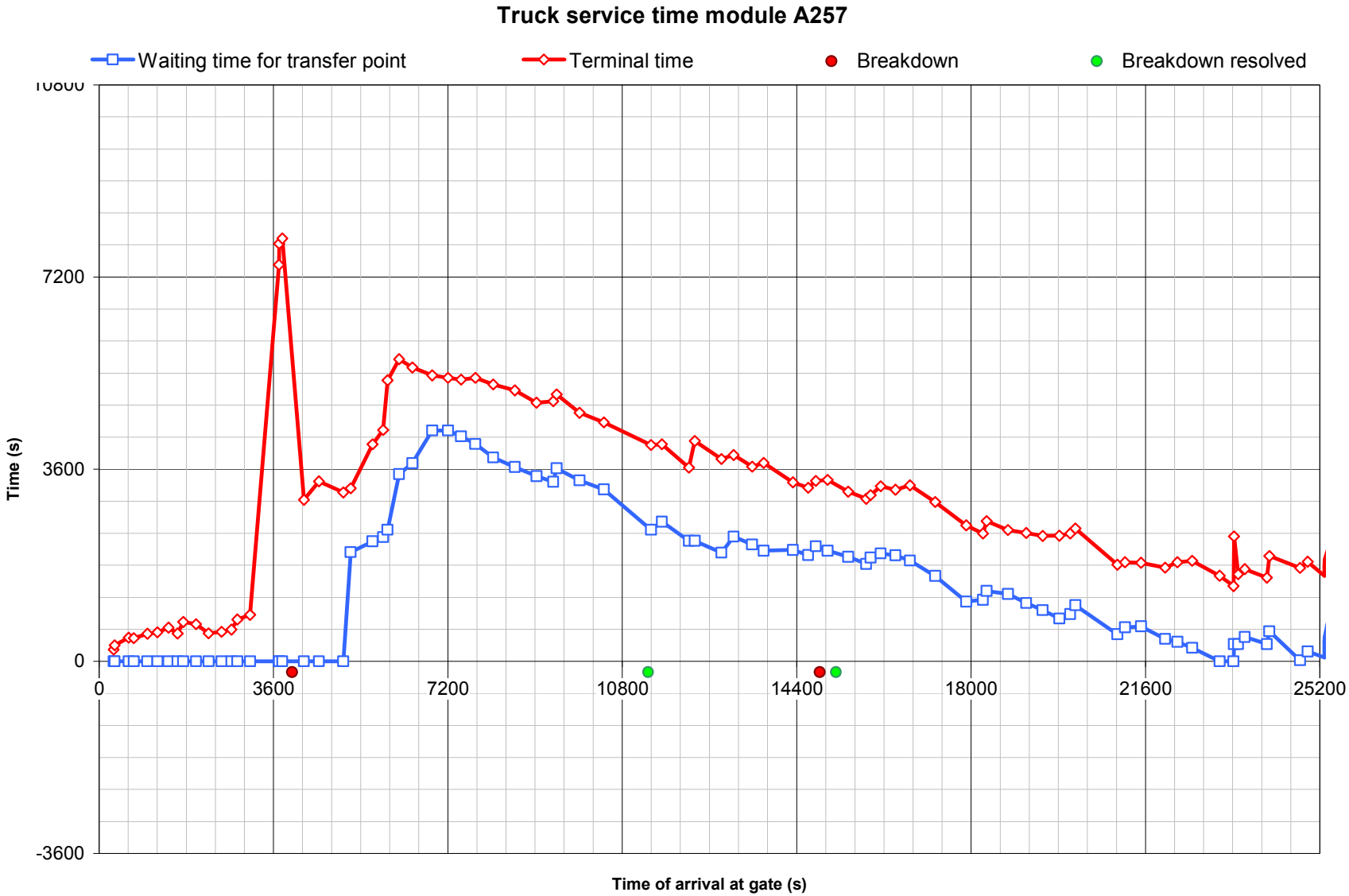
**22 QCs - 88 lift AGVs - correct berthing**

Right side of terminal - average number of vehicles per hour



# Performance under break-down circumstances (example)





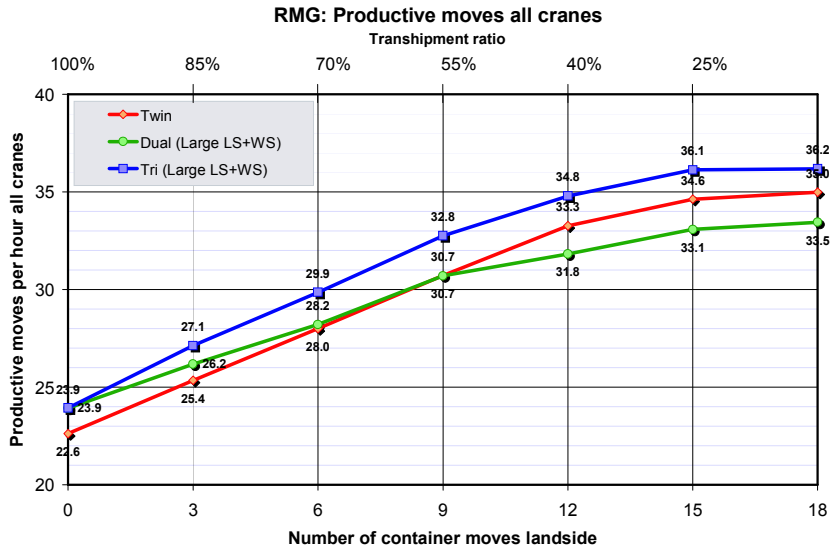
# Typical deliverables of a design study

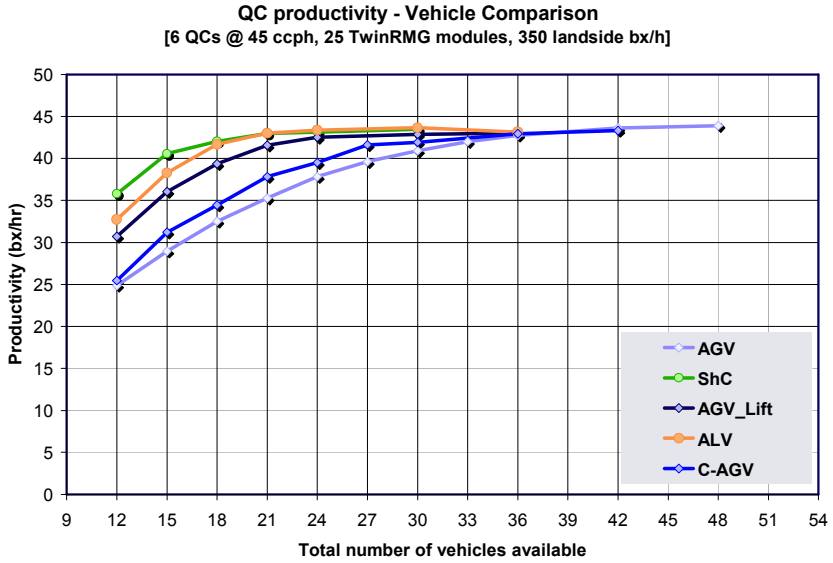


§ Berth simulation:
- Berth occupancy
- Quay crane utilization
- Vessel service times
- Yard occupation throughout the year
- Handling peaks waterside & landside

§ Handling system simulation:
- Required numbers of yard cranes & shuttle carriers
- Optimized yard design
- Reefer solution
- Design of interchange zones
- Effect of breakdown and mitigation strategies
- Algorithms for dispatching, scheduling and grounding

§ Other:
- Solution (conceptually) for scheduling / dispatching ASCs
- Solution (conceptually) for scheduling / dispatching ShCs



# Typical deliverables of a design study



# Emulation as a way to ensure software quality and performance

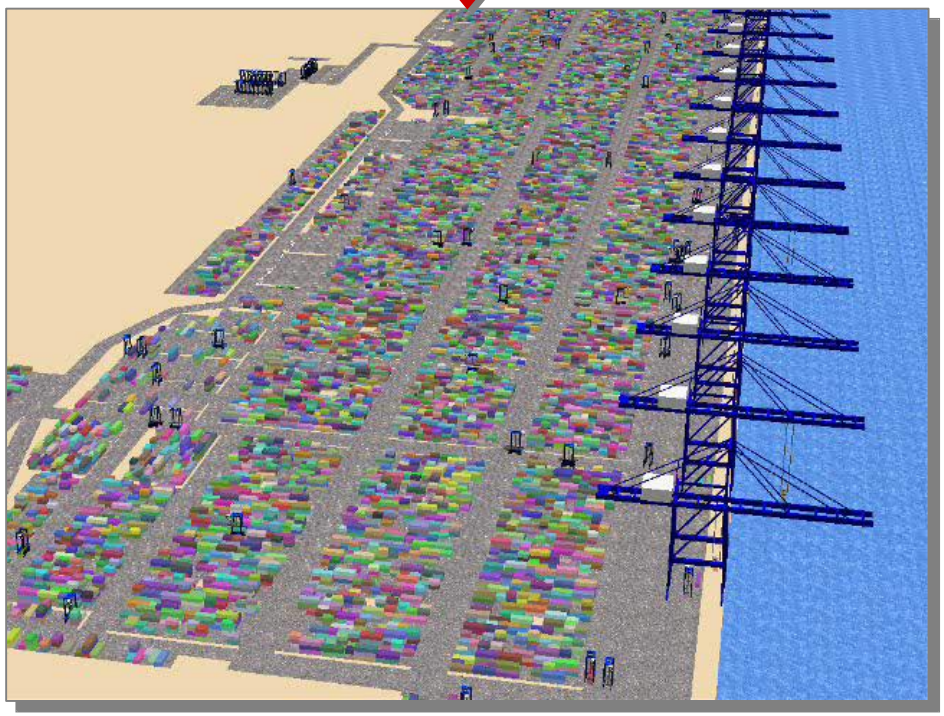
or

# Link software to a virtual terminal (CONTROLS)



TOS (control system)

TOS (control system)



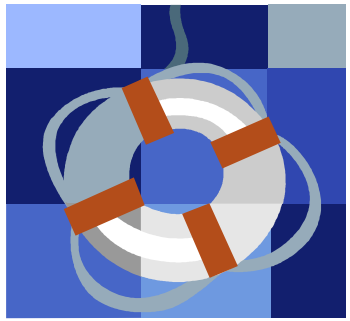
Real terminal

Virtual terminal

# Key properties of *dynamic models*

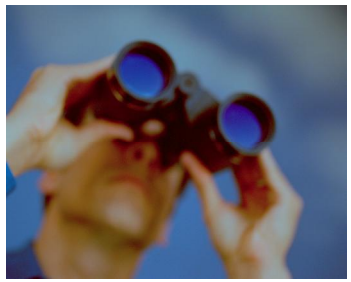


1. Dynamics



2. Safe and inexpensive trial and error environment

3. Analysis of non-repetitive events

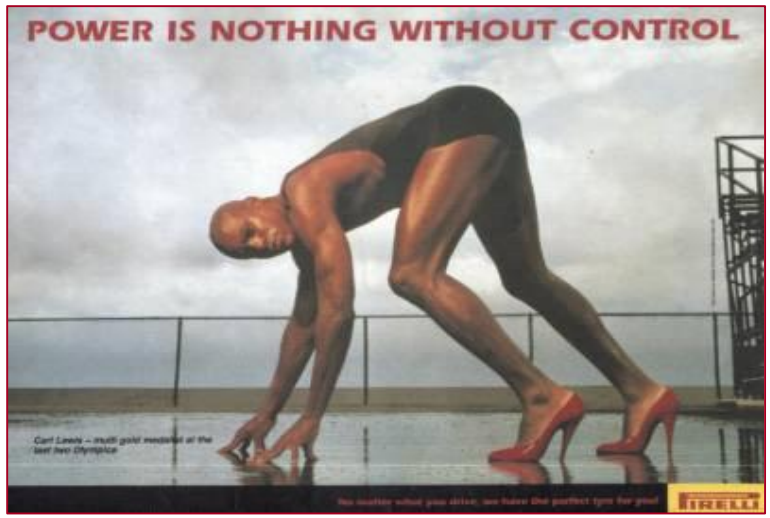


4. See process

5. Quantify and prioritize

# 3T-Concept: Testing, Tuning and Training






Key references:

- § Pusan Newport (Zodiac)
- § MSC Home (SPACE/TRAFIC)
- § APMT Virginia (SPARCS)
- § Eurokai Hamburg (TOP-X)
- § APMT Rotterdam (SPACE/TRAFIC)
- § Euromax (SPARCS / TEAMS)
- § APMT Aarhus (SPARCS)

- Test new software:
  - Reducing risk
  - More focus on performance
  - Knowing problems earlier in process
  - Insight for non software experts

, Tune your operation:

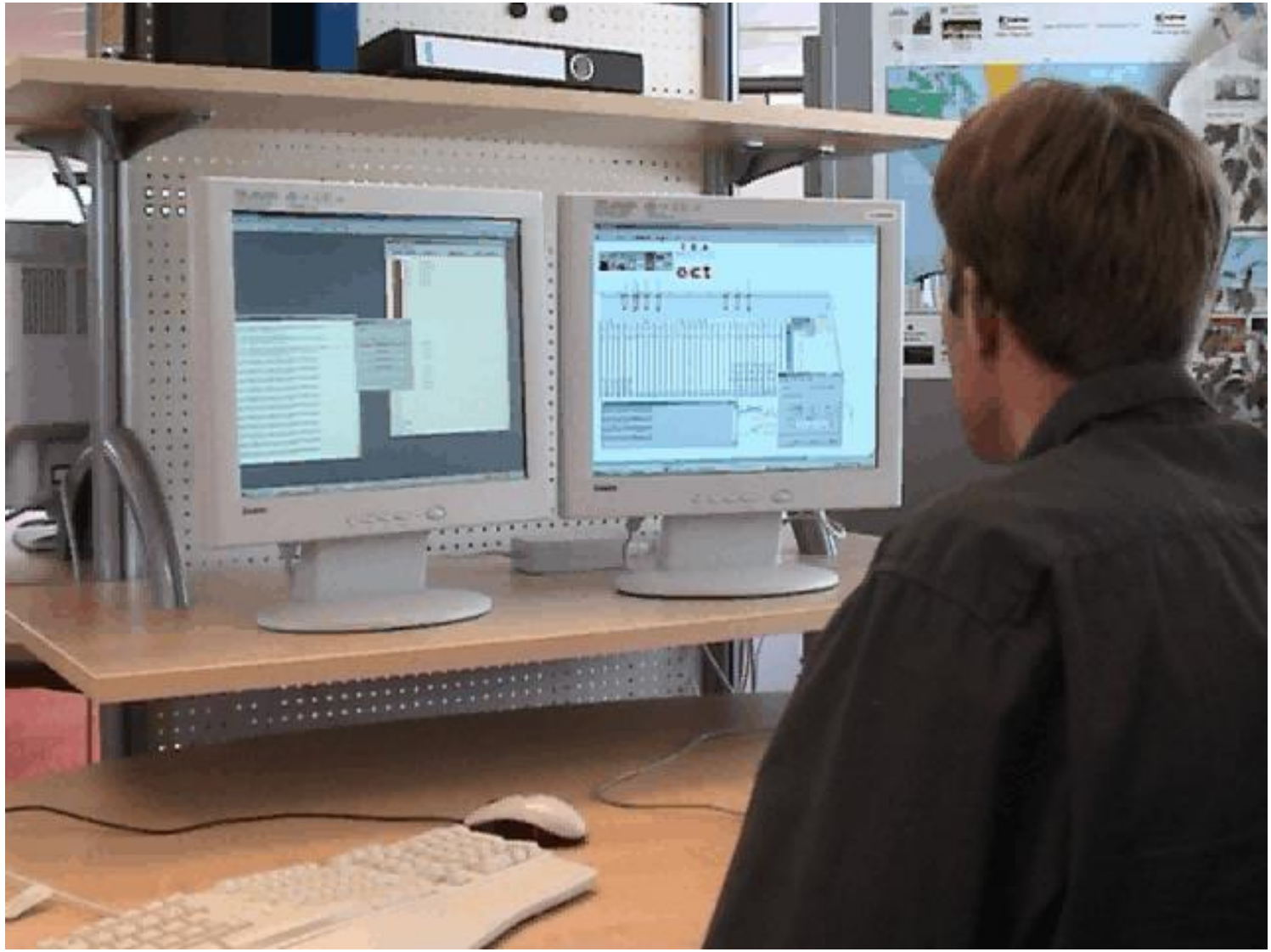
- Anticipation on problems
- Validation of planning
- Replay of operation
- Running future growth scenarios

*f* Train "control room" operators:

- Operate a virtual terminal
- No "learning" impact to operation
- Get immediate feedback
- Practice on irregular operations

# Example: testing the TOS





# Concluding remarks

or

# Conclusions



- With the right approach, and the proper tools, automated terminals can be designed and implemented:
  - Without major risk
  - Within time
  - Within budget
  - Delivering the targeted productivity

- The design will very from site to site, as many conditions determine the “optimal” design

- Automated terminals – more than any other type of terminal – require proper planning, with a long term vision on service levels and handling capabilities

# Contact details



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