Universidade Técnica de Lisboa
Instituto Superior Técnico

A 15 to 20 minutes presentation on:

"Tactical Management of Freight Transportation Services by Rail: Evaluation of Yard Performances

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Contents

Motivation or Awkward Situation

Over the last 5 years we have studied rail freight operations by CP Carga, the Portuguese Rail Freight Provider!

The yard personnel are used to say: ”*the superiors consider the shunting to be executed for 20 - 30 minutes, we cannot perform it because only the break test takes about 20 minutes…moreover, they planned too many freight cars to stay in the yard, there is not enough space, we need lines to execute our work, therefore in every opportune case we send freight cars away to ensure space for the incoming freight trains*!”

In response to this situation **the planning personnel** are used to say: “*we planned well what was required by the commercial department but the operation did not execute it as we planned*!”

There is a problematic cycle involving Planning and Operation and the intended Scheduled Operation is actually quite an Improvised one !!!

Results:

- This awkward situation between the planning and operation of course contributes to:
  - **low utilization** of moving assets
  - **low efficiency** in providing the freight transportation service

- Consequences - from CP Carga point of view:
  - Accumulation of **a huge amount of average costs** in long term
  - CP Carga experiences "**diseconomies of scale**"

- Consequences - from Customer point of view:
  - **Unreliable service** seen in **infeasible contracts**, **unfulfilled expectations**
  - Customer **dissatisfaction** and CP Carga **loses its reputation** as a reliable provider of freight transportation

Objective

Because of **incomplete methodology** at Planning Level seen in disregarding the maximum processing capabilities of the Yards, the CP plans appear to be unfeasible and therefore the operations encounter difficulties to fulfil them.

This specified:

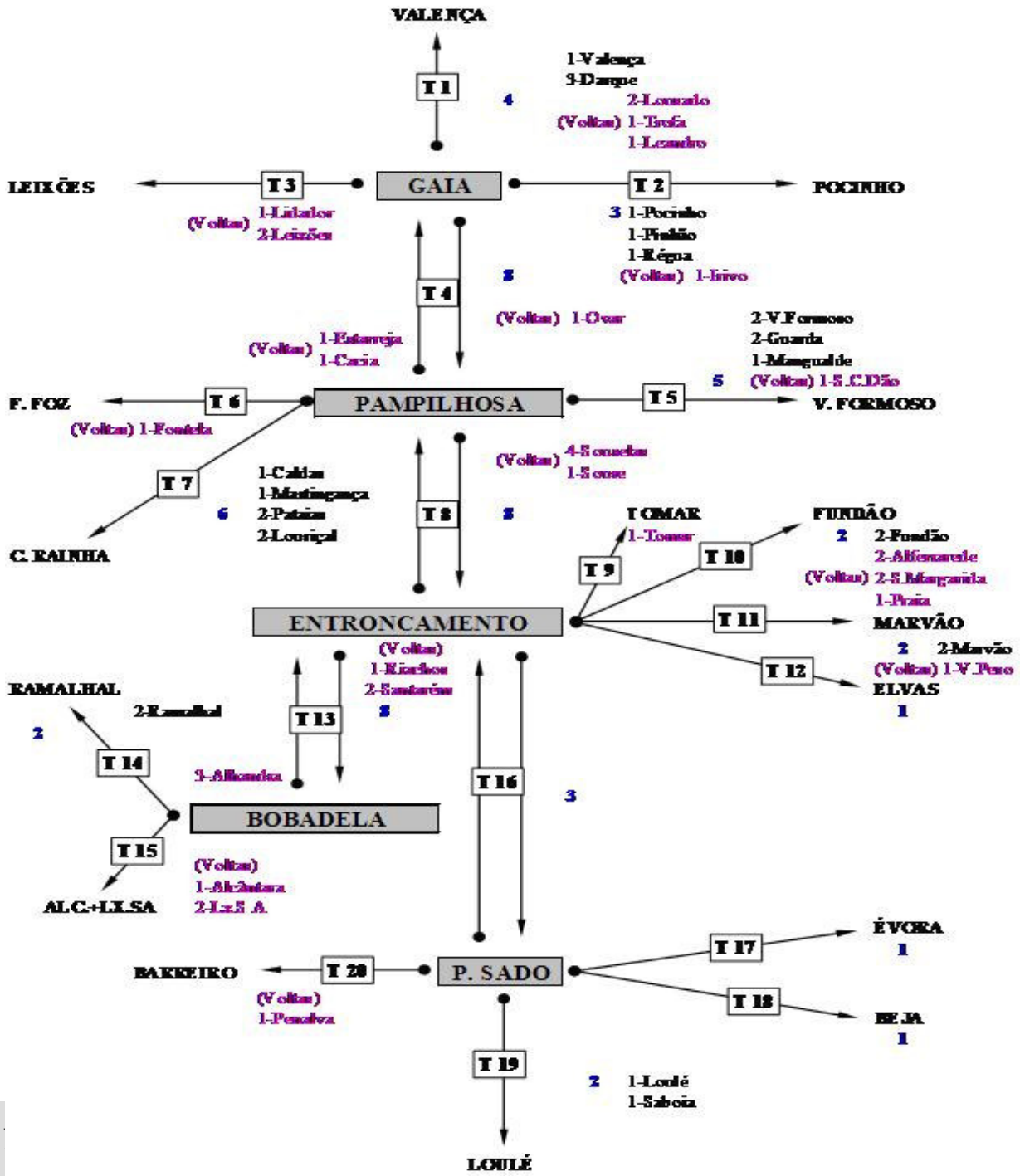
The main objective of the conducted study is to provide reliable tools for analysis and evaluation of the performance capabilities of rail yards (both performing individually and in a network) using an appropriate approach.

Methodology

- Systems approach

  - Formulation
    - detect and formulate the problem
  - Modelling
    - scrutinize and understand the problem
  - Evaluation
    - analyse and evaluate the system through meaningful measures of performances
    - provide alternative scenarios
  - Decision
    - identify best alternatives according to company objectives

The Railway Network of Portugal depicted with red lines!



The Production Scheme in Opration …

Systems Approach in Yard Performances/ Formulation

- Data collection/Preliminary Studies - results that attracted our attention:
  - Low commercial speed (16.7 km/h)
  - A significant average starting delay from the yards (40 min)
  - A significant average time the car spends in the yards (42 hours)
  - A significant average time of the car spends in the dispatch and terminal stations (55 hours)

- Next steps:
  - Interviews, Desk-top studies, and Frequent observations of CP Yards in operation
  - Thus the problems at the yards have become much more apparent, i.e., the yards encounter difficulties to fulfill what is planned

Systems Approach in Yard Performances/ Modelling (1)

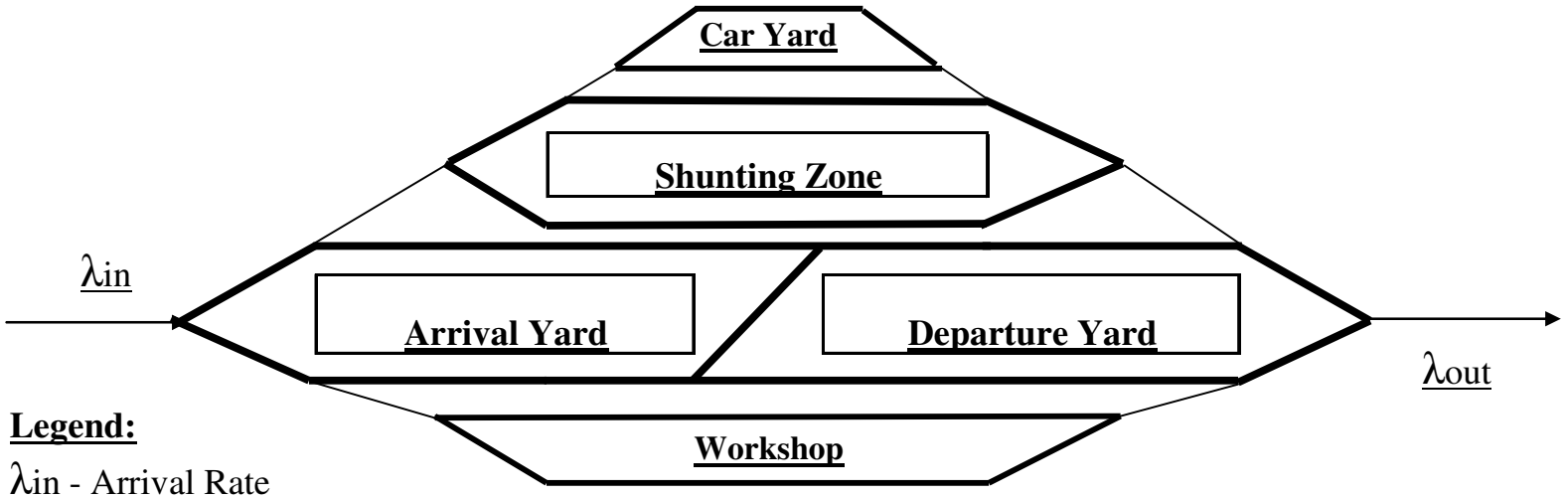
- In the Literature, Yard Performances are studied by:
  - **Deterministic Analytical Methods** – used to estimate the absolute minimum number of yard tracks. However, they do not estimate operation factors and shall not be used for evaluation purposes (!)
  - **Queueing Methods** – used to predict yard throughput average time subject to yard characteristics. These methods quickly provide insights into yard performances and without detailed data. However, they are not able to replicate in detail the yard being studied as well as they do not deal with non-stationary arrivals (!)
  - **Simulation** – provides more realistic replication of the real operation. However, simulation requires detailed empirical data and good knowledge of the system under study. Also, one needs a specific simulation tool. (!)

Systems Approach in Yard Performances/ Modelling (2)

Our concept for modelling yard performances is **A two step approach** employing **queues** and discrete-event-oriented **simulations**

- 1st step employs G/G/m queues – Allen-Cunneen Formulas are used (Preliminary Study)
- 2nd step employs Event-based simulations by SIMUL 8 - Basic Study involving two simulation modelling methodologies:
  - *Micro Level* - deals with simulation modelling of a single yard performance
    - based on the **Decomposition Approach** as the yard is decomposed into areas, i.e.: Arrival Yard, Shunting Zone, Departure Yard, Workshop…
  - *Macro Level* - deals with simulation modelling of yard performances in a network
    - based on the **Decomposition Approach** as the entire railway network is decomposed into areas, i.e.: Dispatch/Terminal Yards, Rail Stations, Lines and Formation yards …

Modelling (3) / Decomposition



Legend:
λin - Arrival Rate
λout - Departure Rate

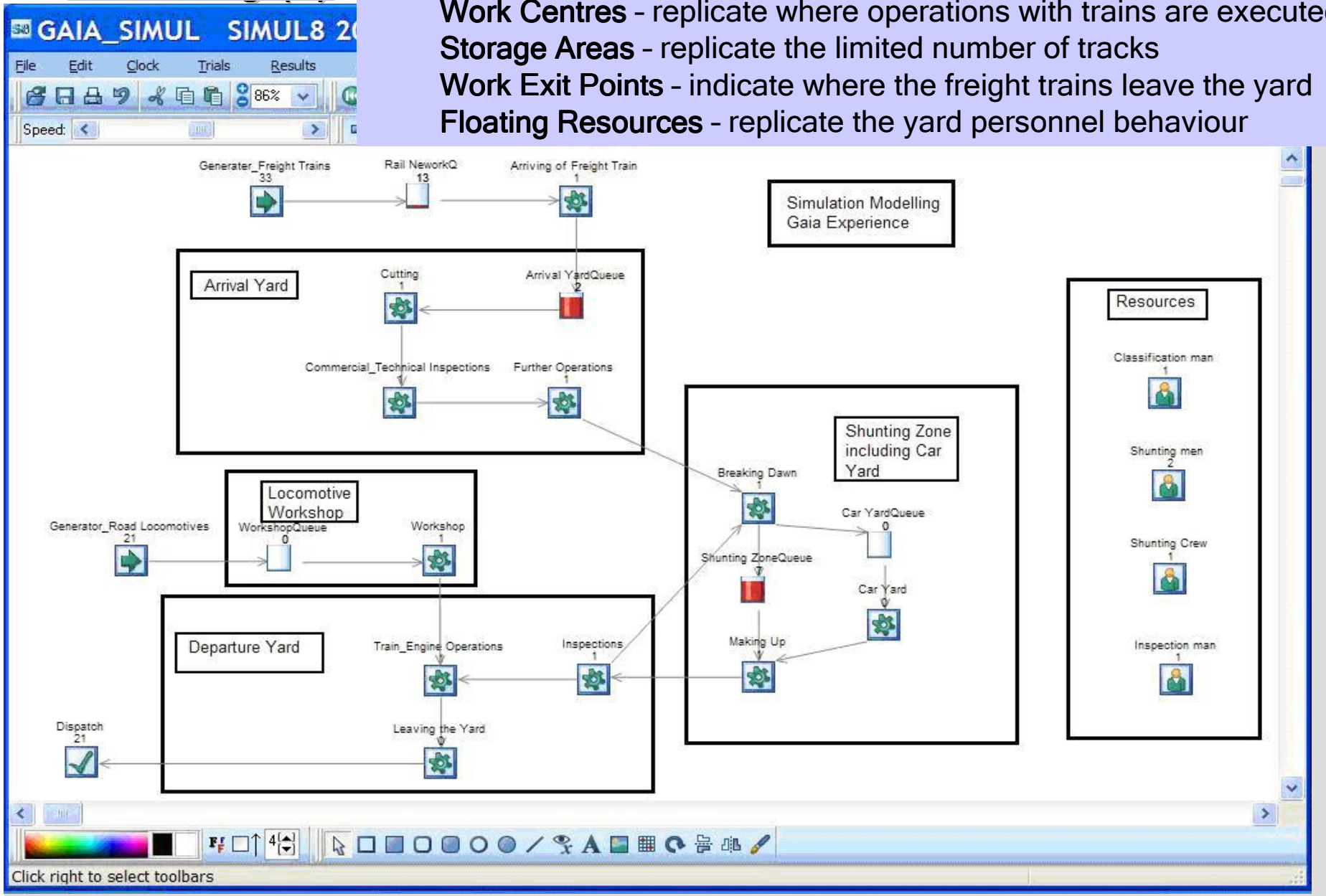
A two step approach:

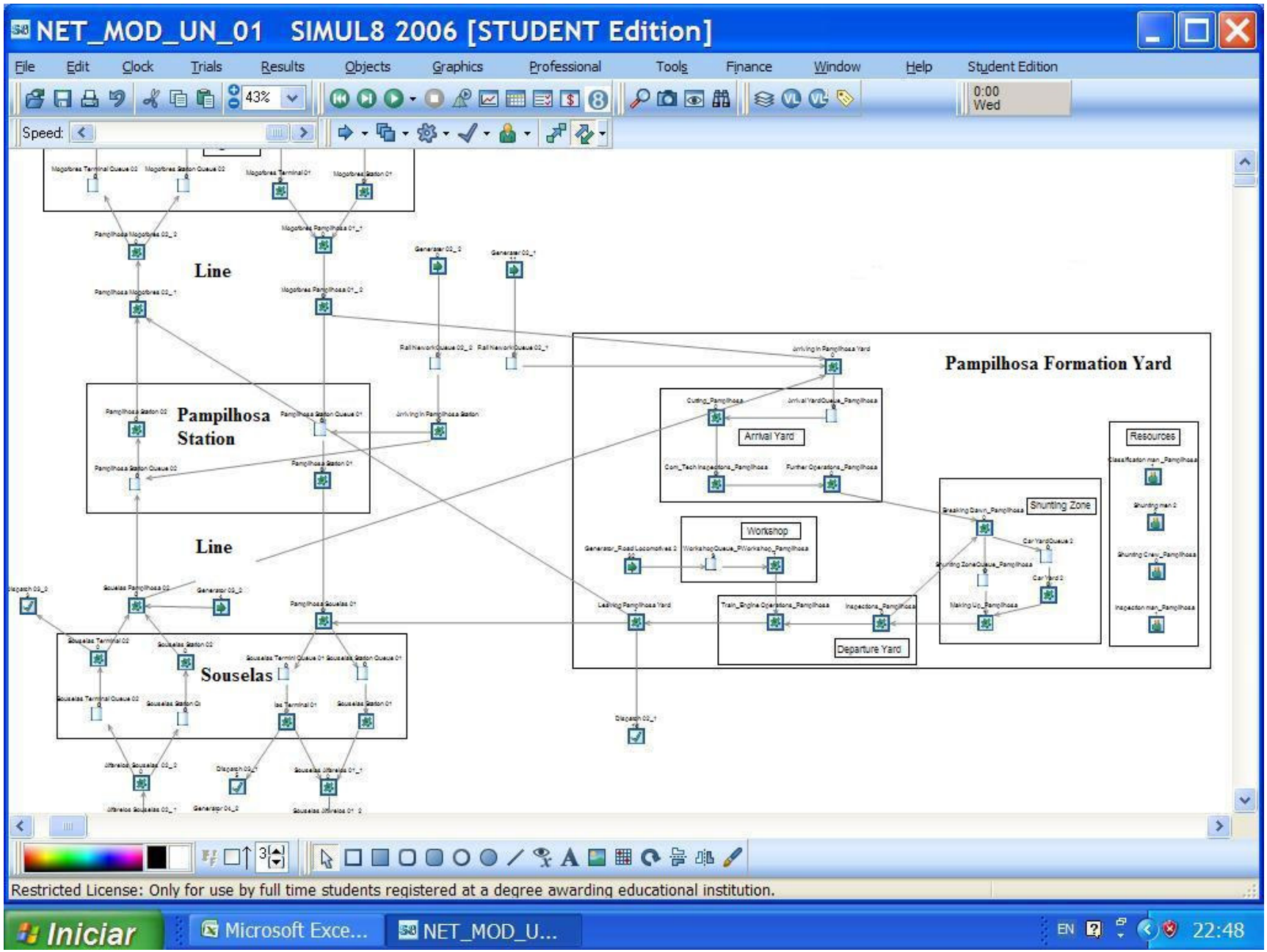
The **first stage** employs G/G/m queues - Preliminary Study.
Expected freight trains in queue of Gi - Lq,Gi - computed by **Allen and Cunneen** approxim.
The **second stage** employs event-based simulations by SIMUL 8
(verifies to some extent the results obtained by the Preliminary Study) - Basic Study.

Modelling (3)

SIMUL 8 attributes:

Work Entry Points – generate freight trains
Work Centres – replicate where operations with trains are executed
Storage Areas – replicate the limited number of tracks
Work Exit Points – indicate where the freight trains leave the yard
Floating Resources – replicate the yard personnel behaviour

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Systems Approach in Yard Performances/ Evaluation (1)

The proposed two step approach has been implemented in terms of three formation yards, i.e., Gaia, Pampilhosa and Entroncamento

More precisely:

Considering a single yard, we have examined:

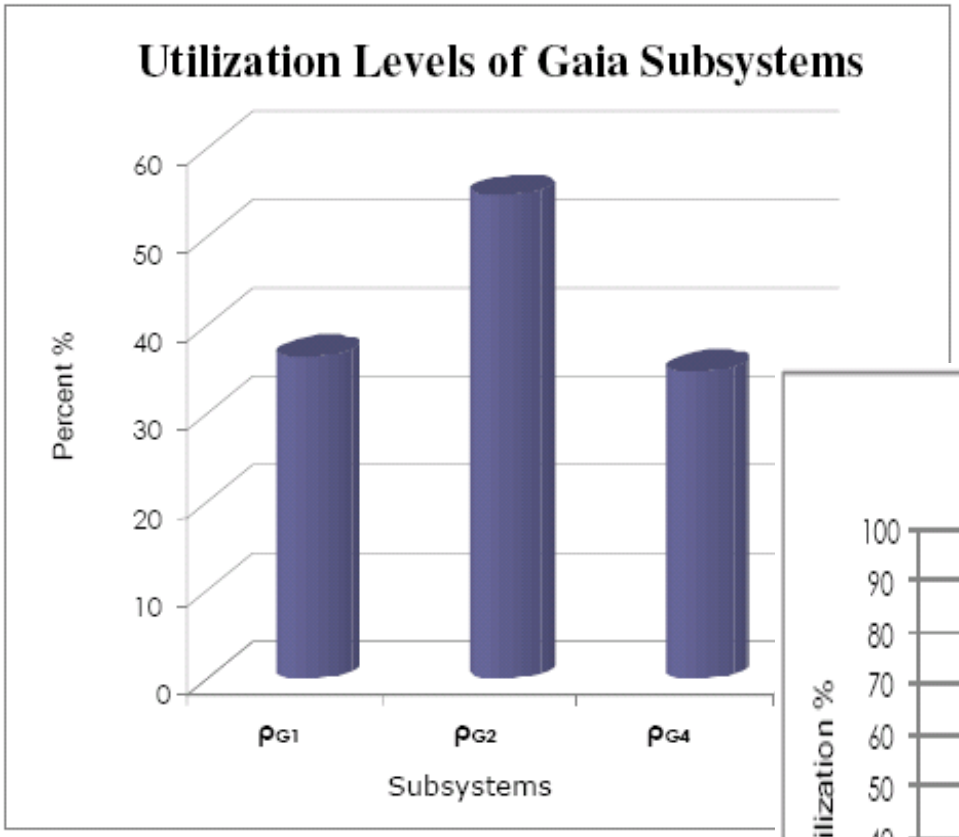
- ✓ The Current Practices
- ✓ Levels of Variability in both Arrival and Service Process
- ✓ Traffic Rules
- ✓ Performance of Critical Yard Subsystems (road locomotive availability, e.g.,)
- ✓ Changes in Dynamic Resources

Considering yards in a network, we have explicitly examined:

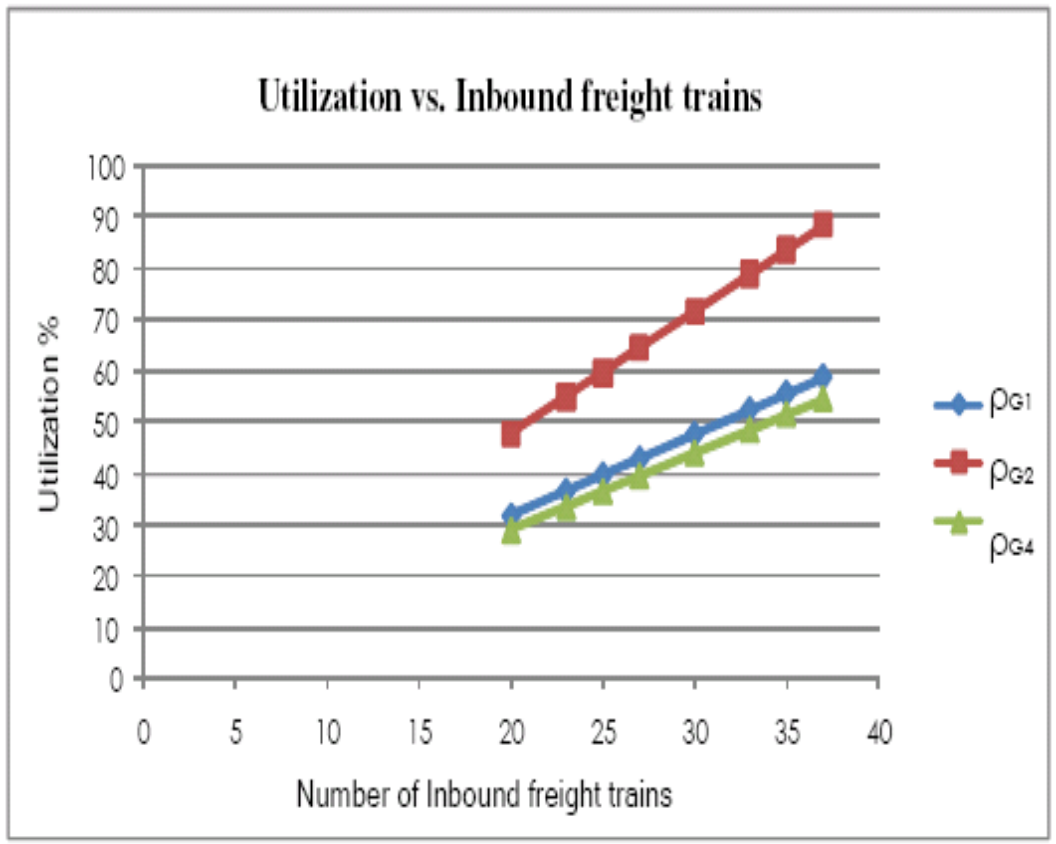
- ✓ Yard performances under improvised and disciplined operation

Measures of interest: utilization rates, throughput time, time in queue

Evaluation (2) Utilization rates – results obtained by G/G/m queues

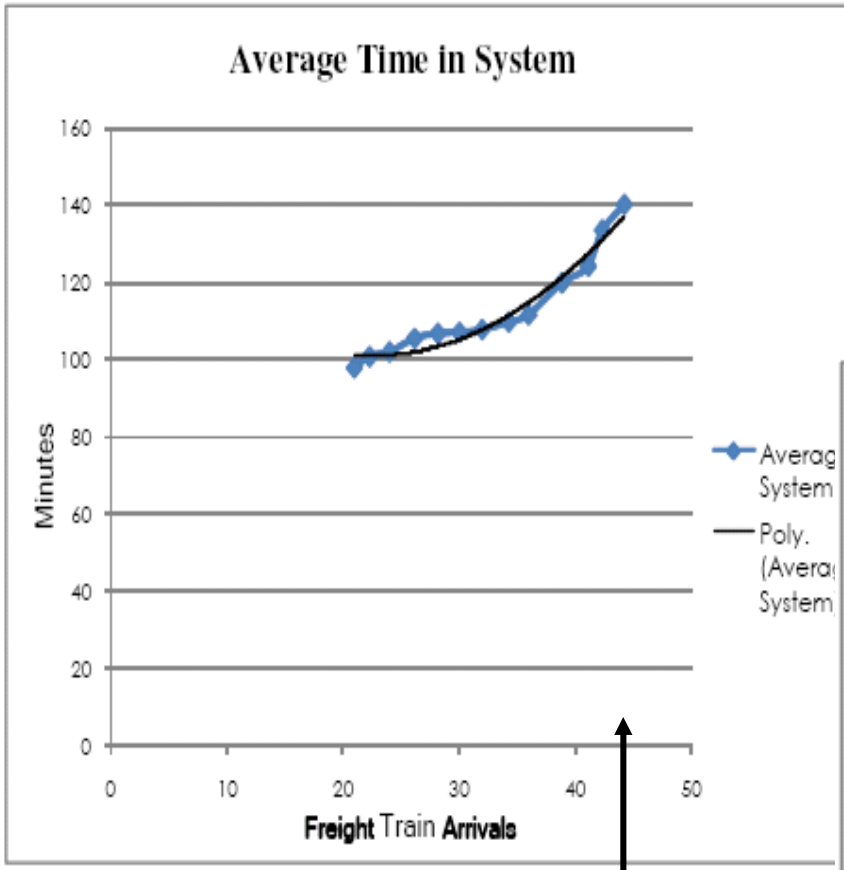


Increases in the arrival rate results in increases in Utilization Levels of yard subsystems (!)

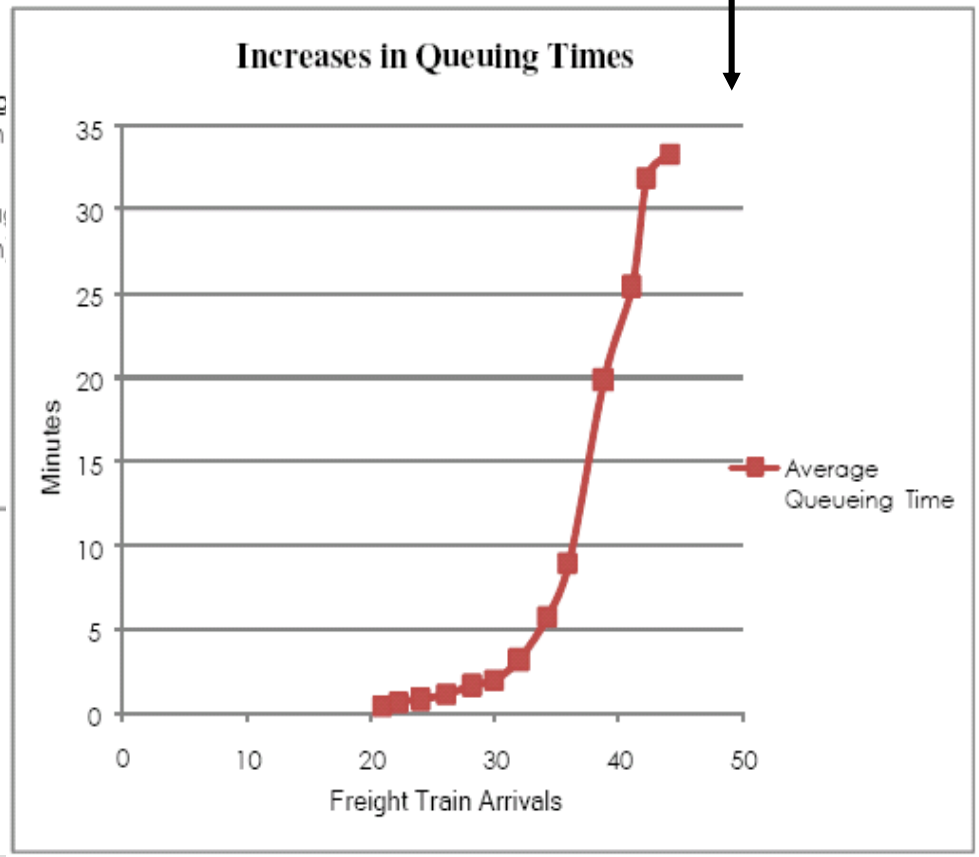


Increases in the arrival rate results in increases of Time in Queue, however (!)

Evaluation (3) - Throughput time and Time in Queue – results by SIMUL8



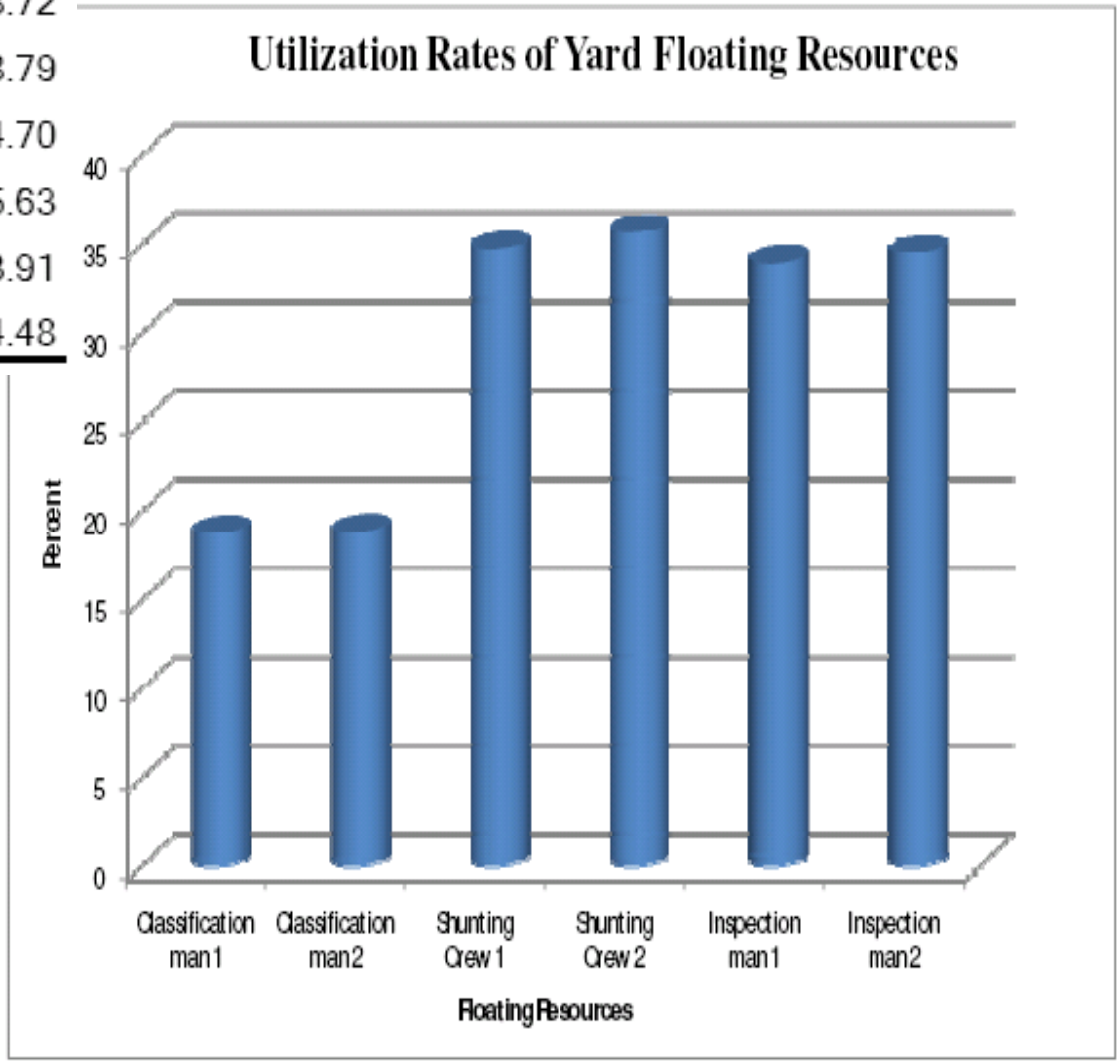
Note how the queues materialize in increases of freight trains!



Note how the Yard throughput time increases with increases in freight train arrivals!

Evaluation (4) – Utilization rates of yard personnel – results by SIMUL8

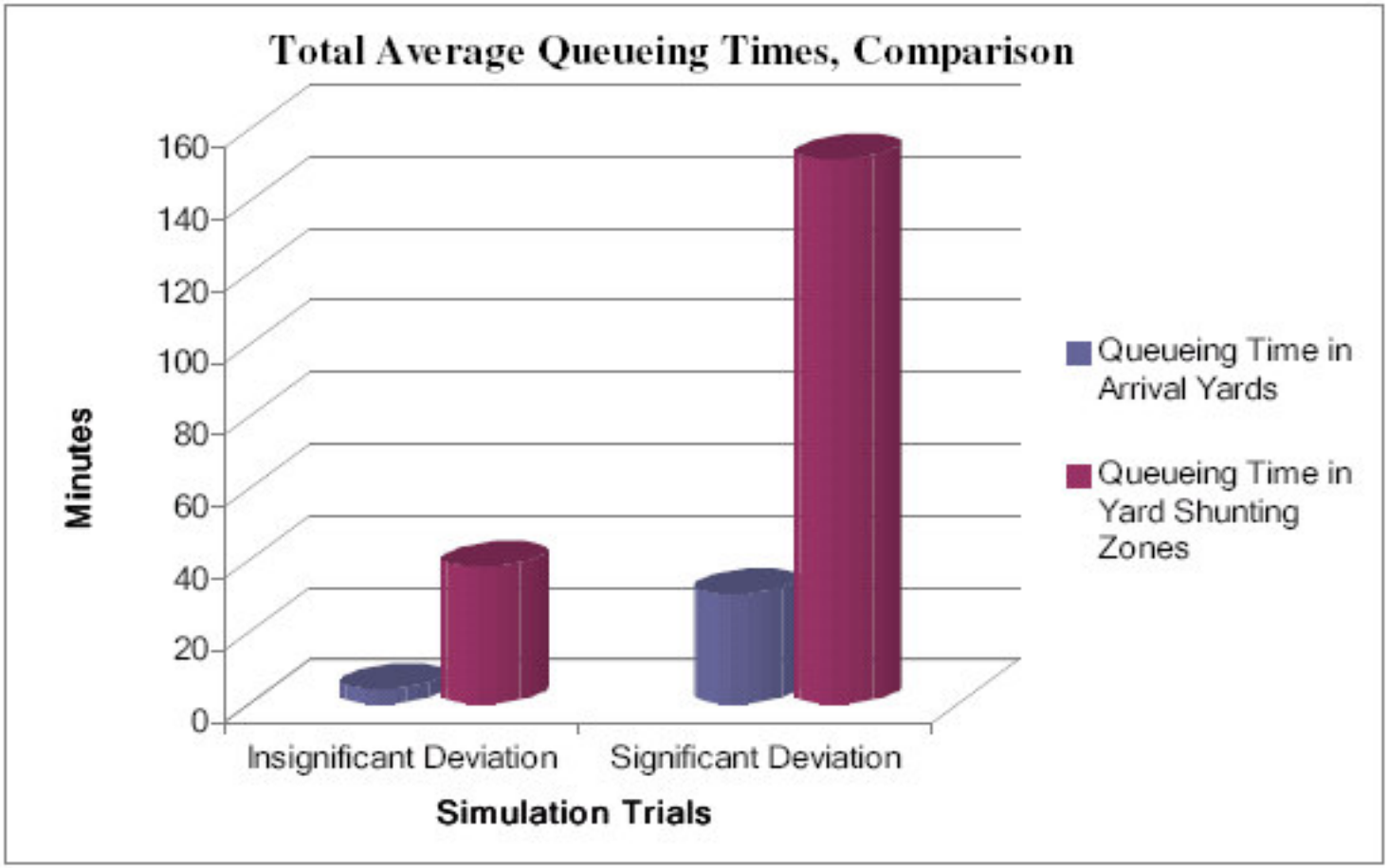
Utilization Rates. %	
Floating Resource	**Estimate**
Classification man 1	18.72
Classification man 2	18.79
Shunting Crew 1	34.70
Shunting Crew 2	35.63
Inspection man 1	33.91
Inspection man 2	34.48



Results obtained for the Current Situation in one of the yards under study…

No Comment!

Evaluation (5) – Aggregate Time in Yard Queues – results by SIMUL8
"Disciplined operation vs. Improvised Operation"



✓ The more disorganized the freight train movement becomes, the larger the yard queue grows and vice versa (!) and hence the operating costs are on the increase and the operator deals with Diseconomies of Scale (!)

Decision

The decision making should be explicitly focused on the accomplishment of the scheduled freight train operation *without violating the performance capabilities of the yards*, which will lead to continuous improvements.

Simply, this can be achieved by specifying an upper bound properly indicating the maximum processing capabilities of these facilities and therefore:

Yards should be thought as Pull Production Systems – i.e., systems that limit the amount of work in process (!)

- In order to experience a seamless-low-cost yard operation one better keeps the yard workload (just) below the upper bound at which the queues apparently start to build up by **controlling the number of inbound freight trains to be processed** (i.e., the input that requires service by the yard).
- Thus, the freight trains will move through the yard subsystems "*unimpeded*".
- … which is a main rule of LEAN Thinking
  – "Lean Today – Win Tomorrow" !!!