Maritime Container Terminals

Integrating discharge/loading services with internal transfer services

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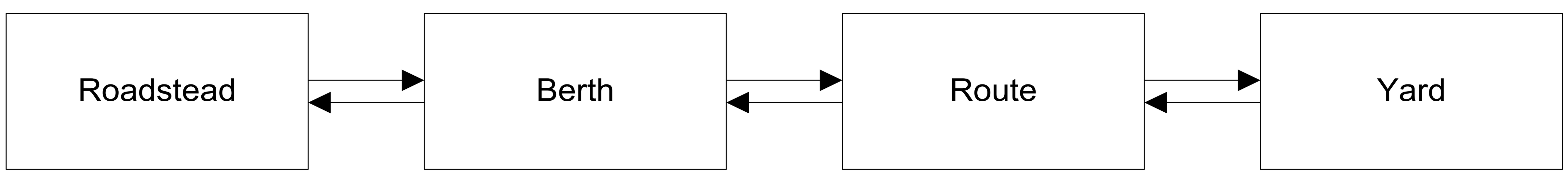
Context Description

The complex system under investigation is a pure transshipment terminal in which vessel arrivals occur with and without time windows and container transfer to and from these vessels is performed by a fleet of straddle carriers (SCs). Logistic operations provided in a container terminal are carried out by four interacting sub-systems:



The main logistic processes are run within the above sub-systems:

- vessel arrival, entrance/exit channel control for access to the port (Roadstead);
- vessel berthing, crane assignment, crane deployment, crane scheduling (Berth);
- container transfer from quay to yard and vice versa by SCs (Route);
- container stacking/retrieval, container housekeeping (Yard).

Our current modeling effort is focused on **housekeeping**: the process according to which a container is moved from one yard position to another during its stay in the terminal's storage area; it usually occurs due to the great distance between the points for container discharge and loading. It is performed by multi-trailer systems (MTSs) which use a combination of SCs and multi-trailers (i.e. tractors hauling a set of trailers, each carrying one 40-foot container or two 20-foot containers).

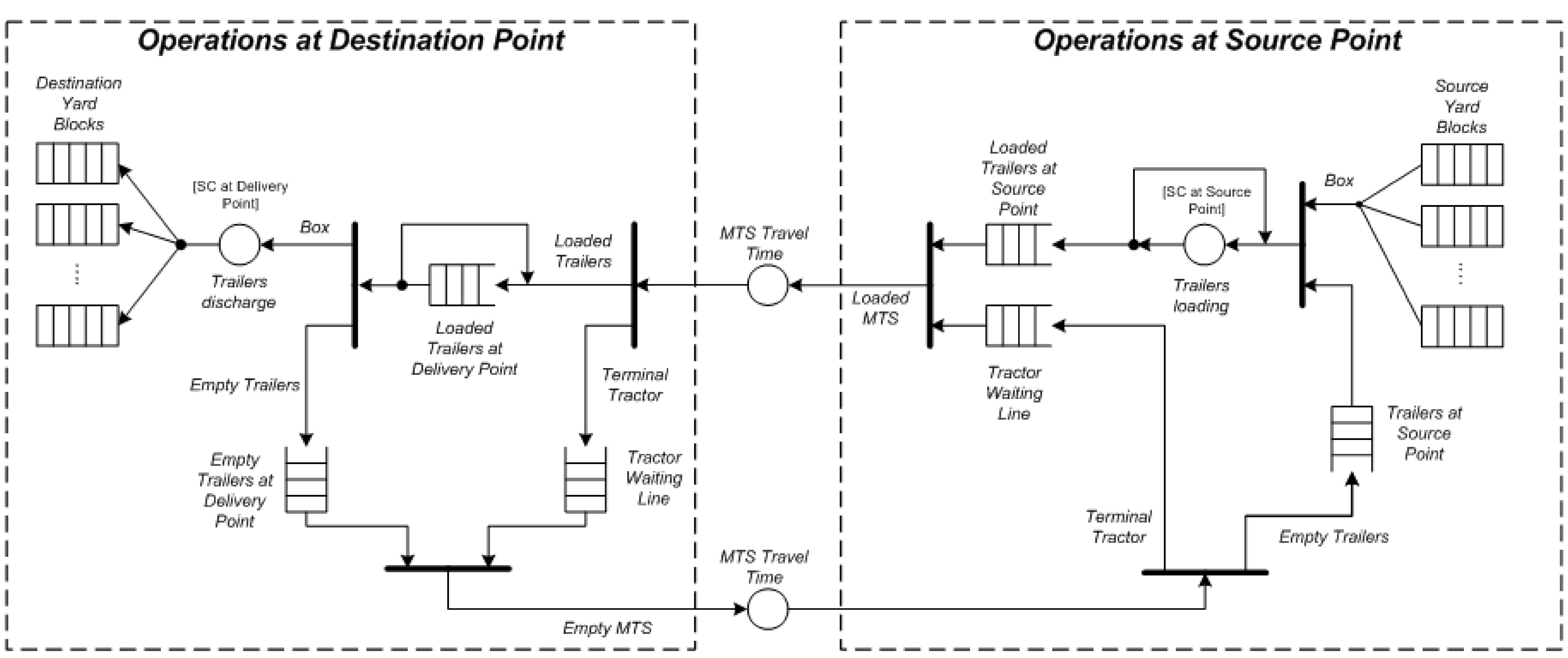
Goal

As requested by the terminal manager, the goal consists in building a Simulation Optimization framework meant to minimize the overall distance/cost related to the vehicles involved in housekeeping with respect to:

- container transfer schedules and related due dates;
- optimal management of available vehicles (straddle carriers, multi-trailers);
- housekeeping policy (e.g. designation of destination blocks).

The Queueing Network Model

Besides non-standard service stations, the housekeeping process also asks for forking and joining features following which blocking and starvation are likely to occur.



The development and tuning of the simulation model of this real-life queueing system is one of the objects of a **€5,000,000.00** project entitled ***Innovative methods and tools of systems engineering for supporting container handling processes and equipment maintenance at the maritime terminal in Gioia Tauro*** (funded by the Italian Ministry for University and Education).

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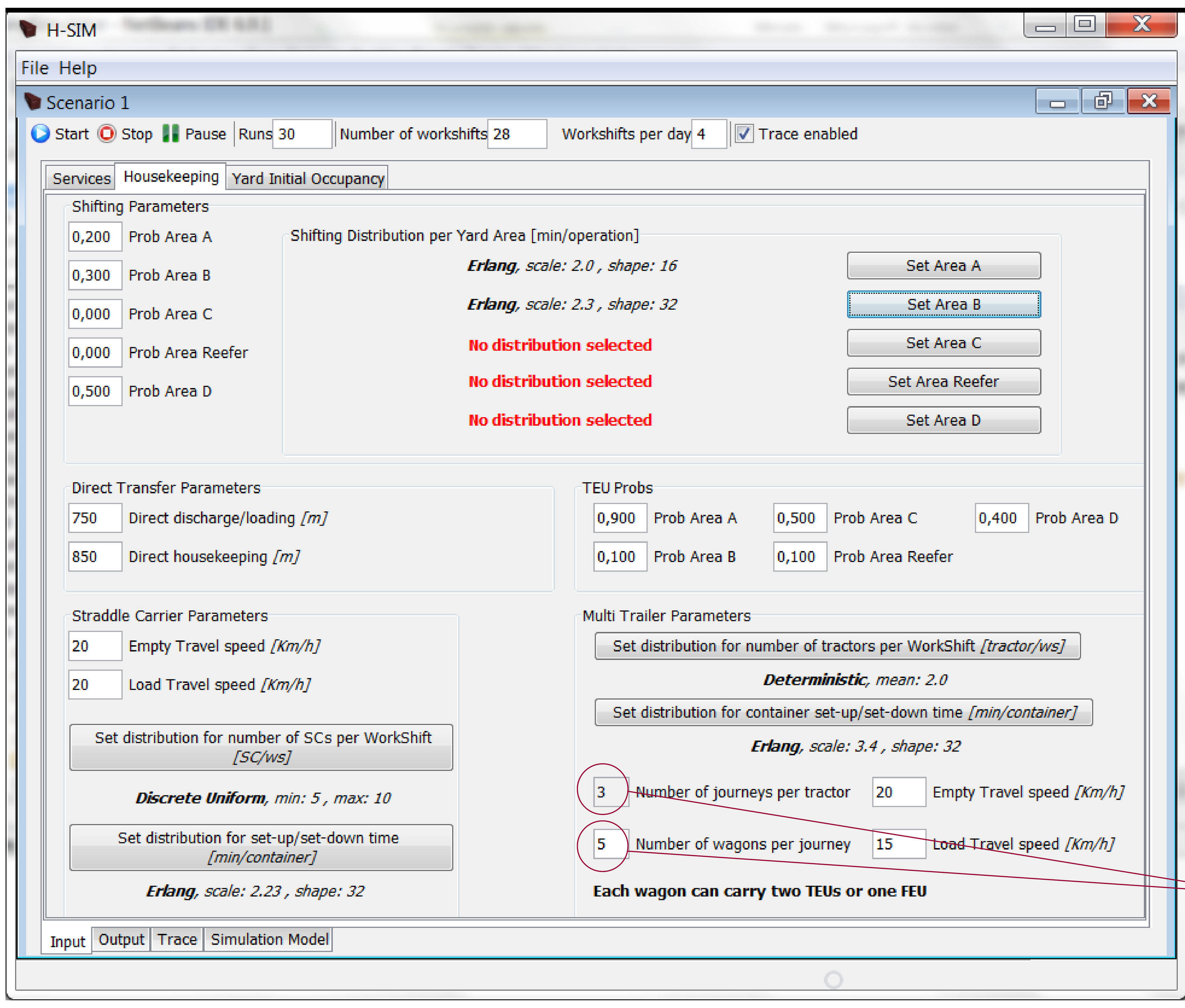
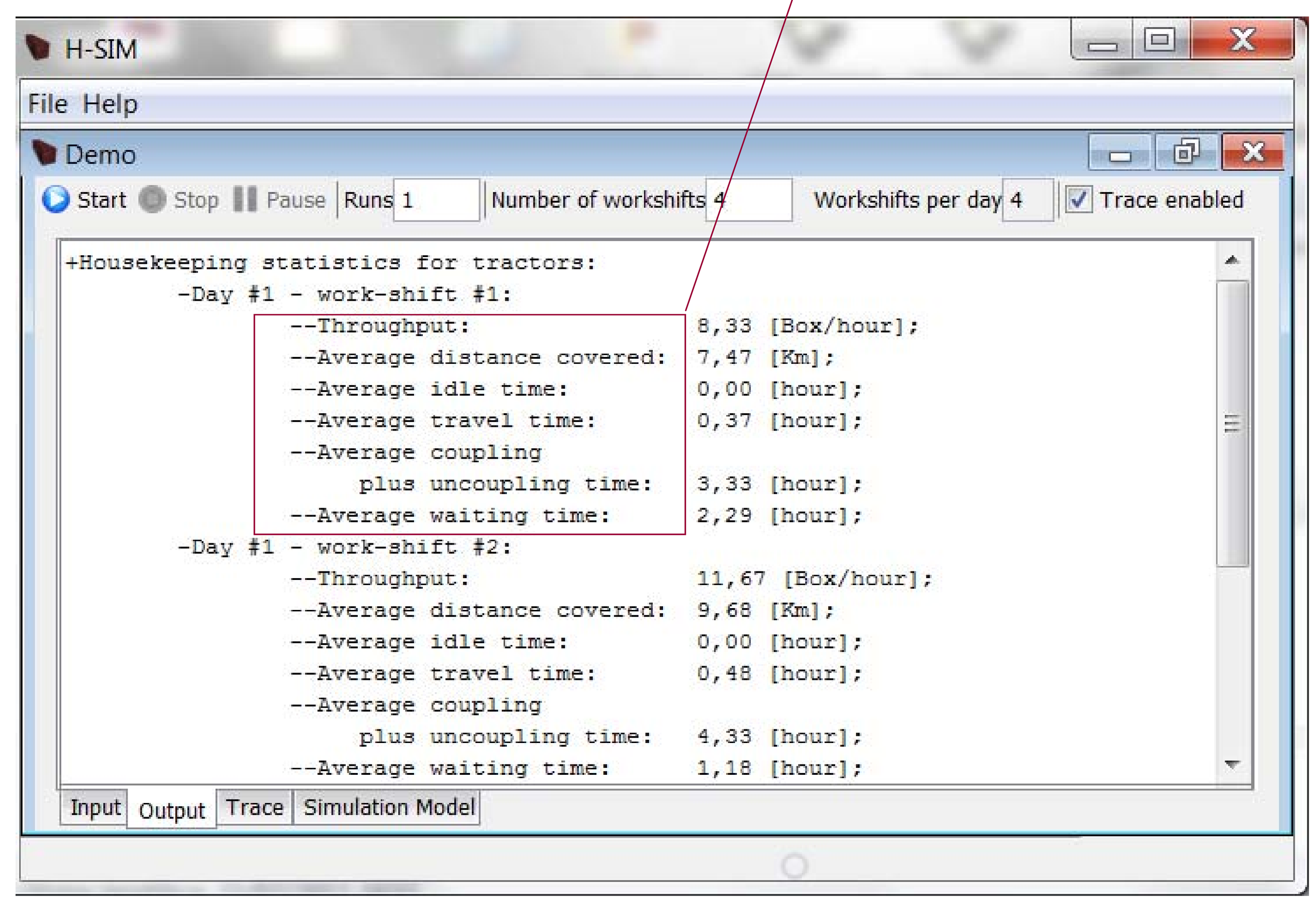
Research Issues

The Simulation Framework



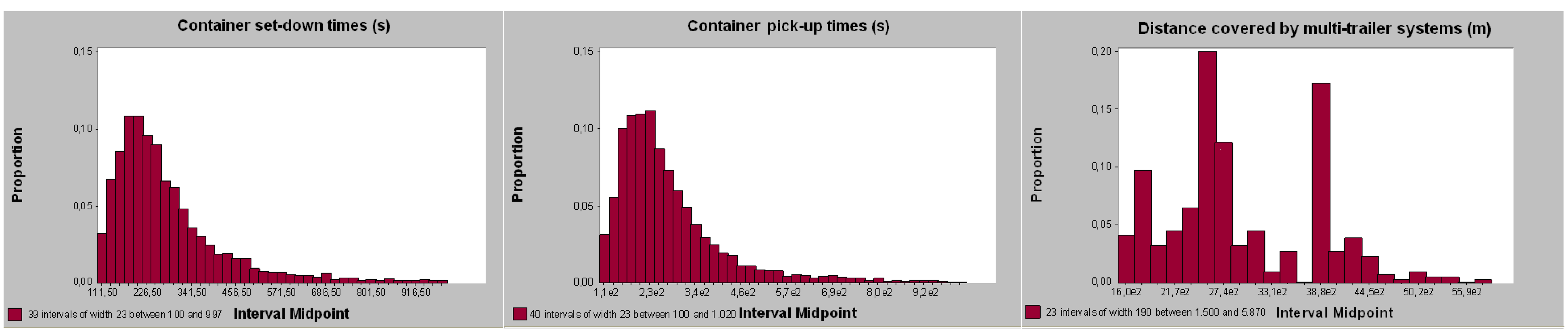
Performance indices for tractors per workshift.



What-if analysis can be performed on the number and/or composition of the multi-trailer systems.

Data Modeling

In the housekeeping process some elements, such as multi-trailer loading time and multi-trailer discharge time, are easy to model with conventional distribution functions (i.e. Beta); others, such as the distance covered by MTSs, require further investigation (testing the departure of the sample form from unimodality and resorting to mixture distributions).



Underlying Opimization Model (when pursuing optimum-seeking by simulation)

Given the following notation

C set of *n* tasks (i.e. group of containers moved between yard blocks), *K* set of *m* multi-trailer systems
T time horizon
S, *F* starting and final depot of an MTS, s_i, f_i source and destination block for the containers of group *i*
c_{ij} cost required to perform task *i* before task *j*
p_i processing time of task *i*, r_i release time of task *i*, d_i due date for task *i*
t_{ij} time for an MTS to move from task *i* to task *j*
t^k_{Si} time for MTS *k* to move from its initial position *S* to the location of *i*
t^k_{iF} time for MTS *k* to move from the location of *i* to its final location *F*
δ minimal time distance to keep between two tasks located in the same block and to be assigned to different MTSs

and given the following decision variables

$$X^k_{ij} = \begin{cases} 1 & \text{iif task } i \text{ is performed by MTS } k \text{ right before task } j \\ 0 & \text{otherwise} \end{cases}$$

$$Y^k_i = \begin{cases} 1 & \text{if task } i \text{ is assigned to MTS } k \\ 0 & \text{otherwise} \end{cases}$$

$$Z_{ij} = \begin{cases} 1 & \text{if task } i \text{ is completed before task } j \text{ starts} \\ 0 & \text{otherwise} \end{cases}$$

B_i is the beginning time of task *i*,

the objective of the (undisclosed) IP model is to minimize the overall cost for servicing the container groups.