PortSim – A Port Security and Visualization Tool

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October 9, 2007

Motivation

- Concern about threat materials in seaport shipping containers (WMDs)
- Mandatory inspections may have huge impact on normal port operations
- Simulations aid decision makers in evaluating trade-offs
- Visualization allows simulation results to be easily understood

Scope

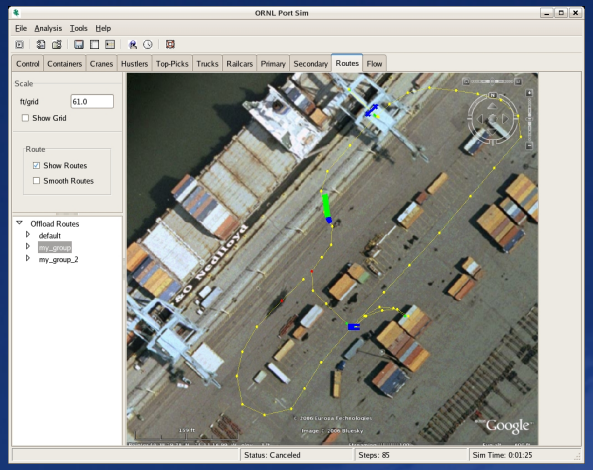
- Focus is to improve port security in U.S.
- Over 150 ports on coasts and rivers
- In 2006 over 27 million TEUs entered U.S.
- U.S. Government mandated 100% inspection
- Many threat types (chemical, biological, radiological, nuclear, explosive – CBRBNE)
- Many different sensor technologies

Goals

- Develop a simulation and visualization tool to investigate impact of various inspection procedures
- Tool should incorporate elements from both operations and cost
- Should be easy to use by non-specialist
- Should be scalable and functionally extensible

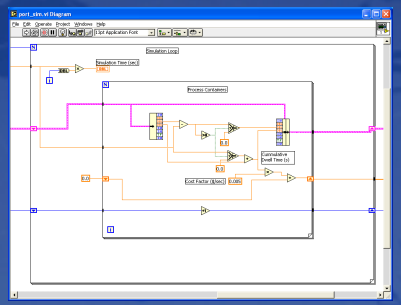
Elements

Cost Model



Graphical User Interface

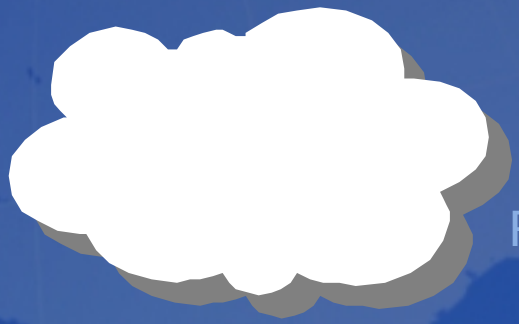
HPC



Info Flow

3D Con-ops Model

Policies DB



Real-time Data

Design Approach

- Design should allow end-user to run additional simulations
- Should be cross-platform with a graphical user interface (GUI)
- Scalable for use on supercomputers
- Open-source to allow modifications by others
- Should allow rapid application development (RAD)

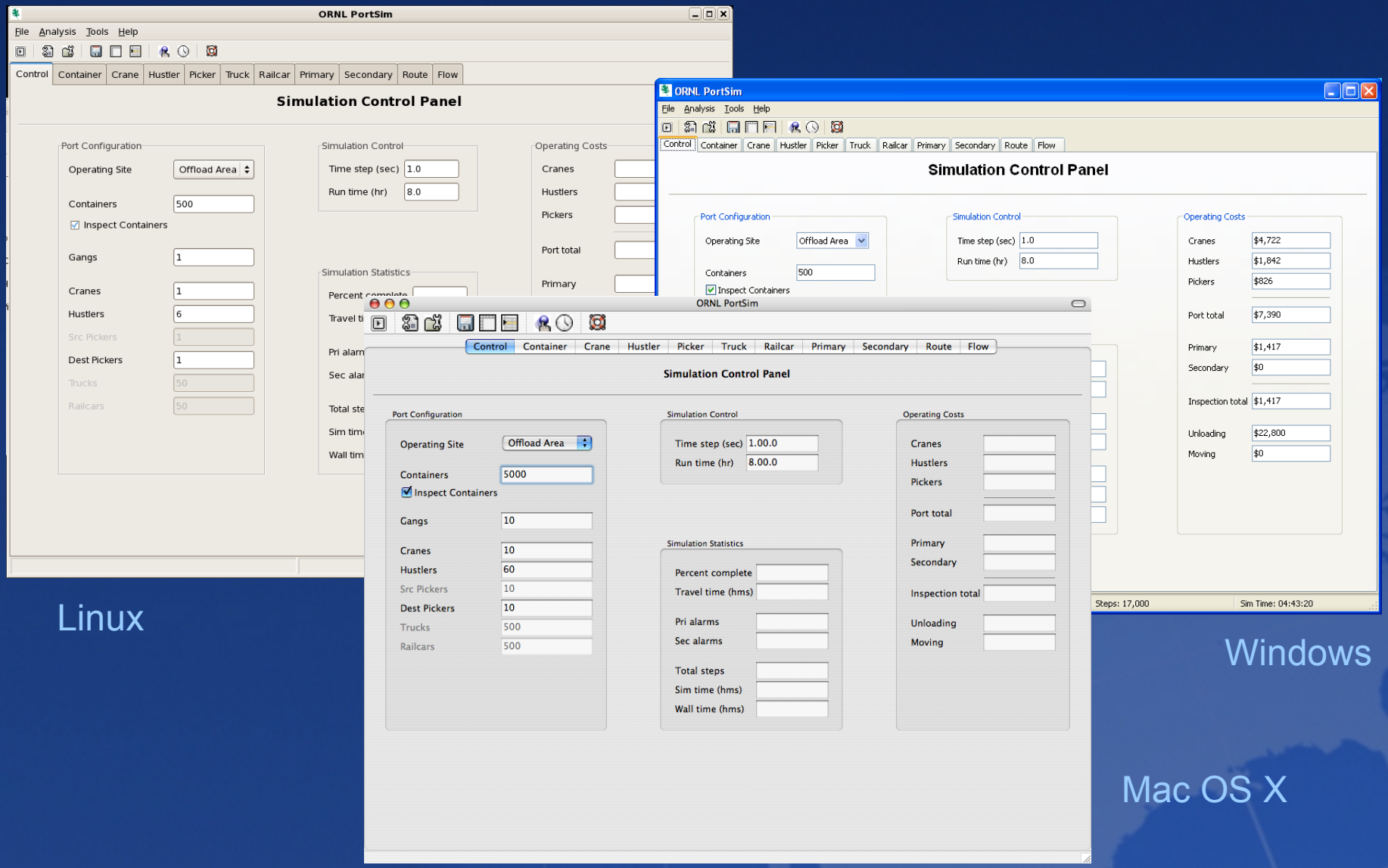
Programming Language

- Python chosen to satisfy cross-platform and RAD needs
- Similar to Java – uses byte-code interpreter (compiler available too)
- Useful for scripting, procedural, and object-oriented programming
- Large, active user base since 1991

GUI Toolkit

- wxPython chosen to satisfy cross-platform and license-free distribution needs
- Based on C++ wxWidgets library (since 1992)
- Resulting GUI has native look-and-feel of host OS (Windows, Linux, MacOS)
- Active user base since 1998

Screens



Linux

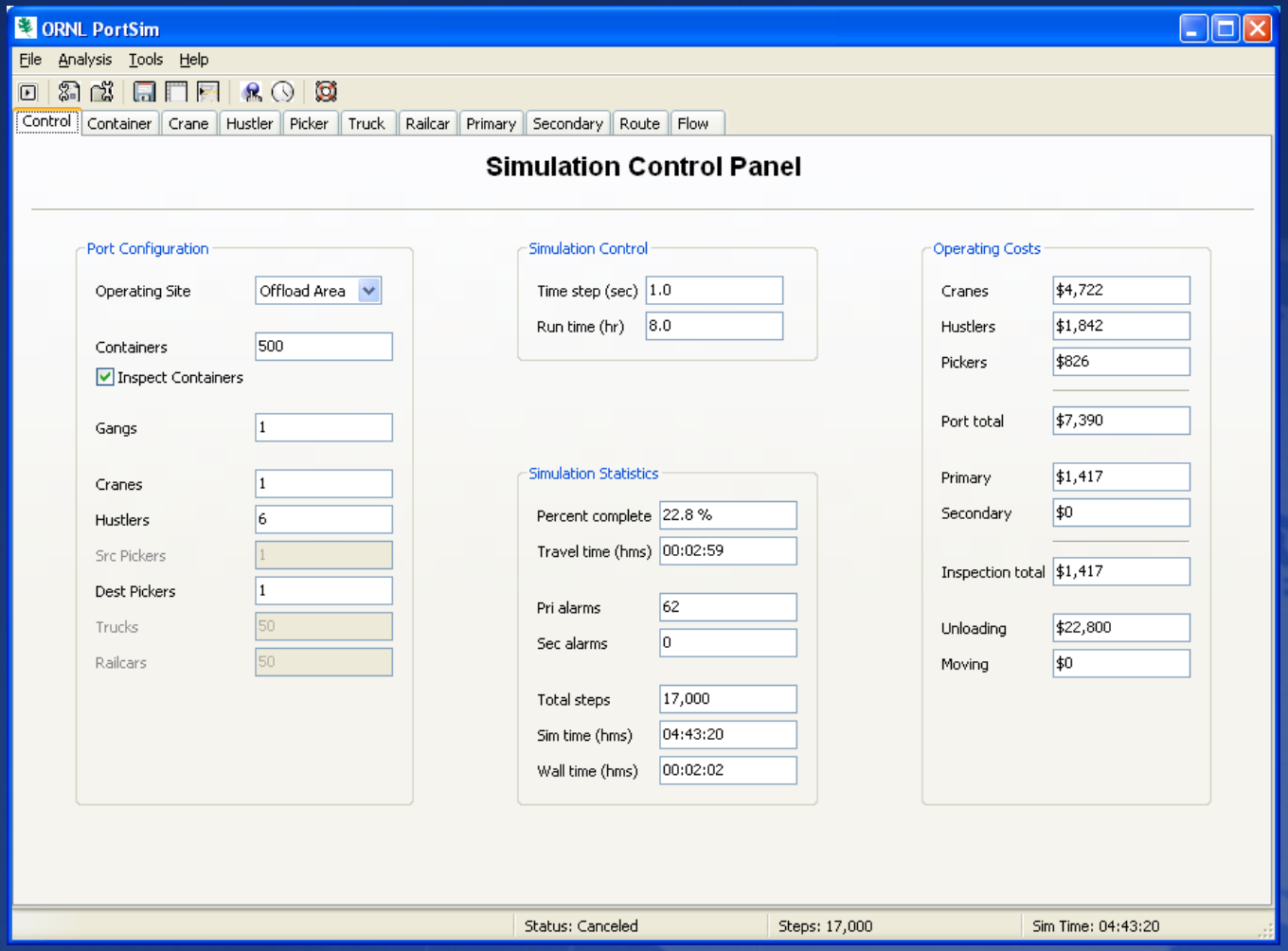
Windows

Mac OS X

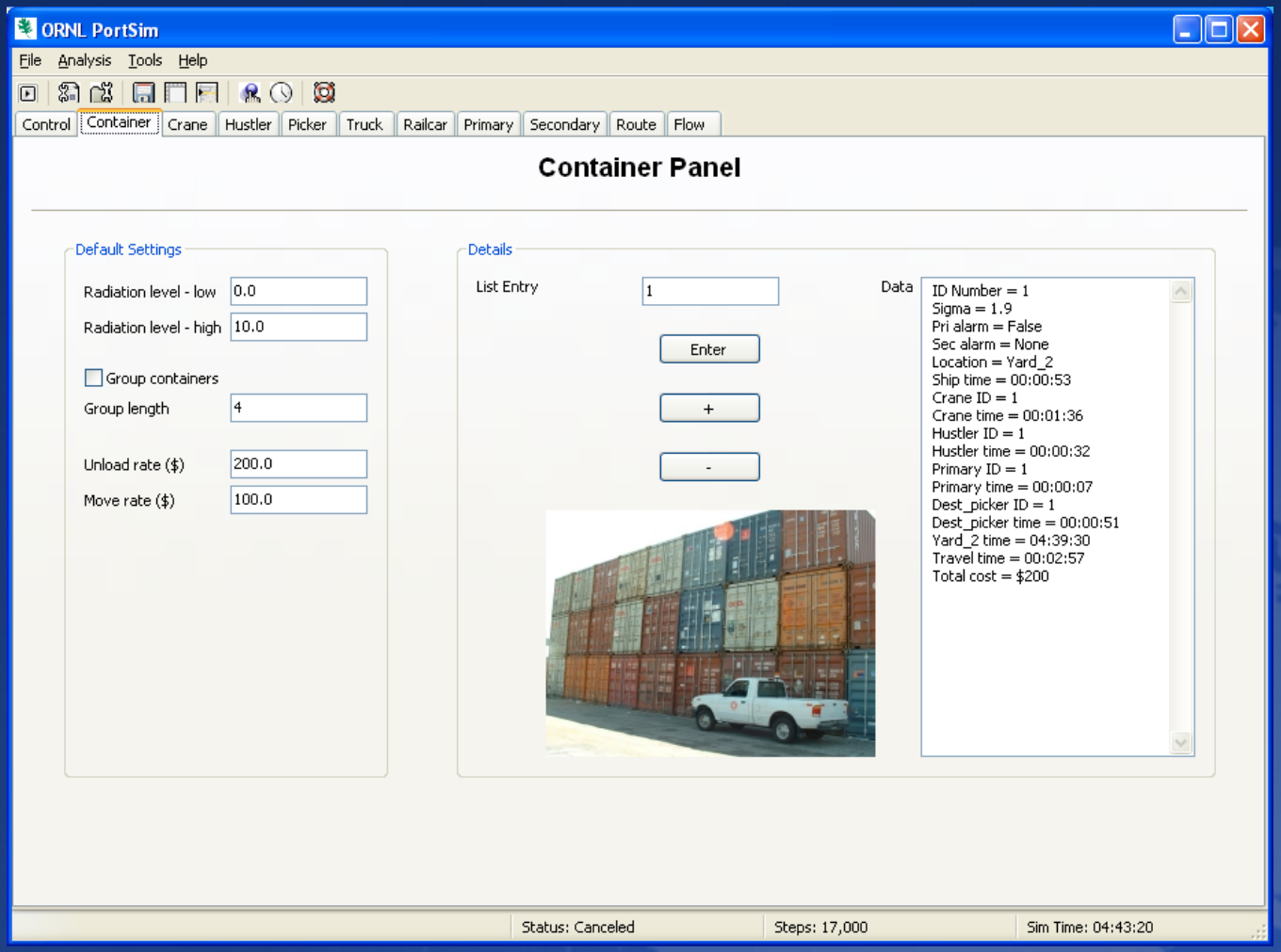
Software Design

- Architecture consists of a discrete-time, stochastic simulation engine with a GUI overlay
- Gaussian and uniform random variables are used for process times and other settings; binomial for decision points
- Batch, timed, and single-step execution modes are provided

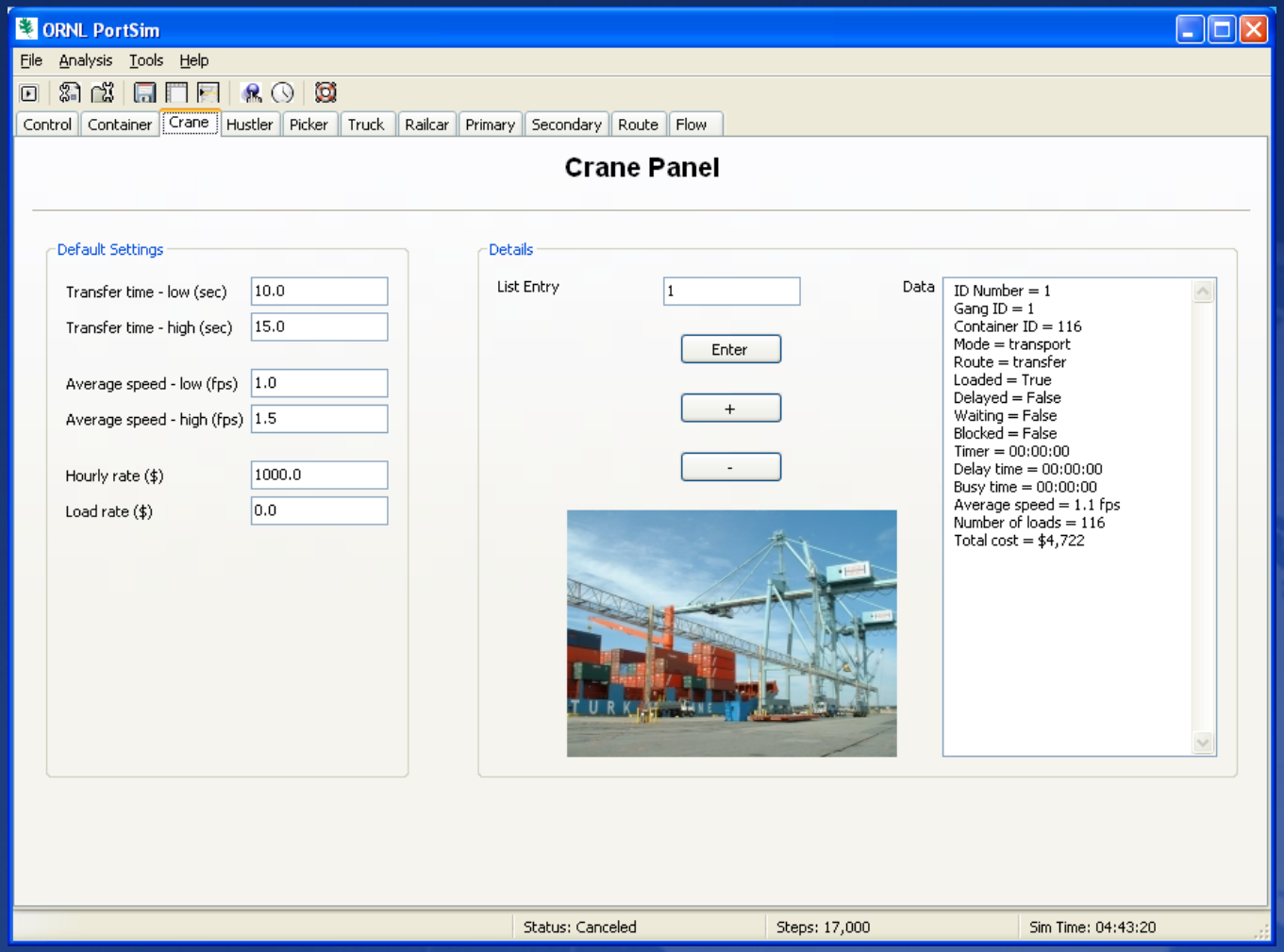
Simulation Control Panel



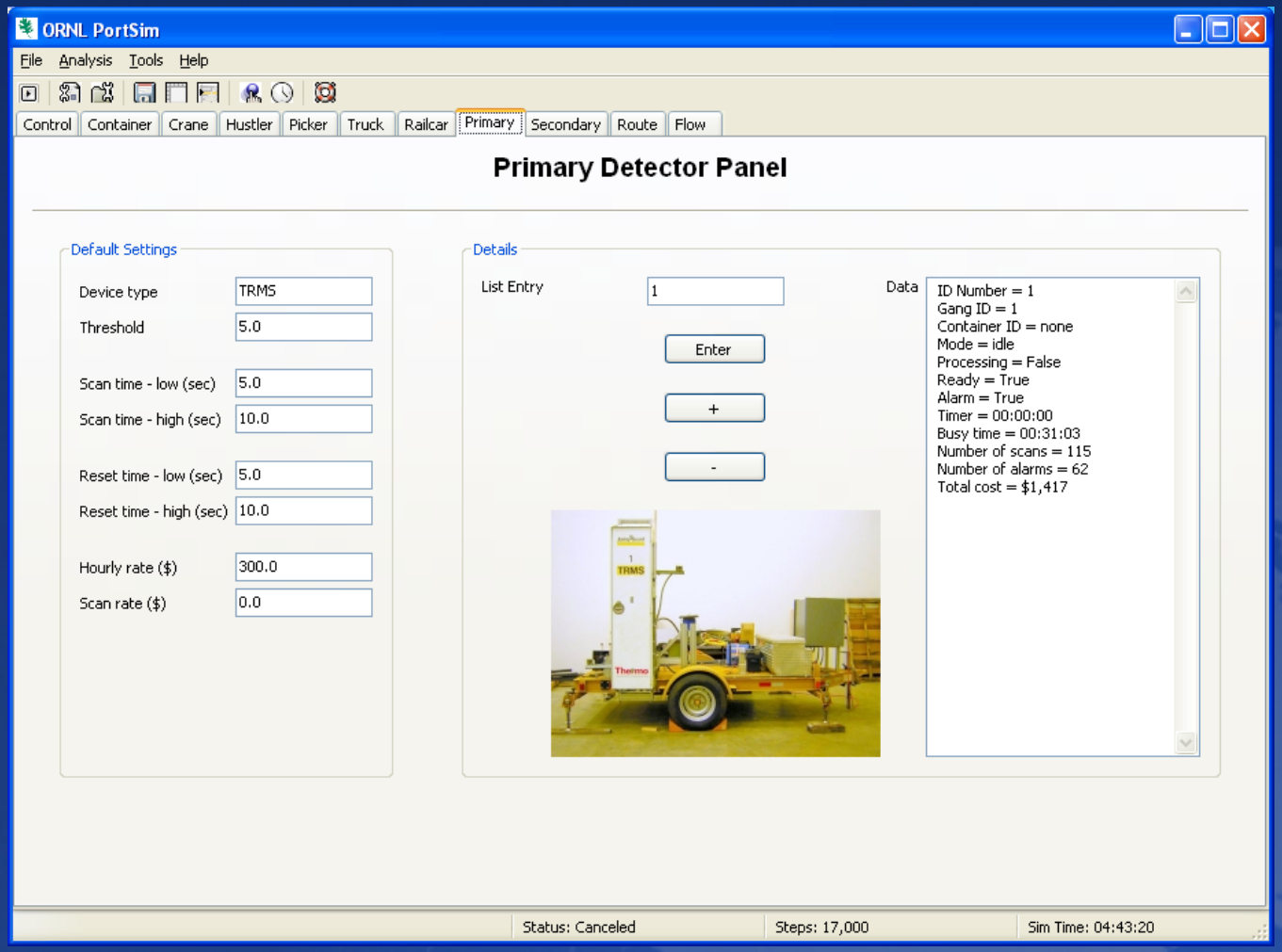
Container Panel



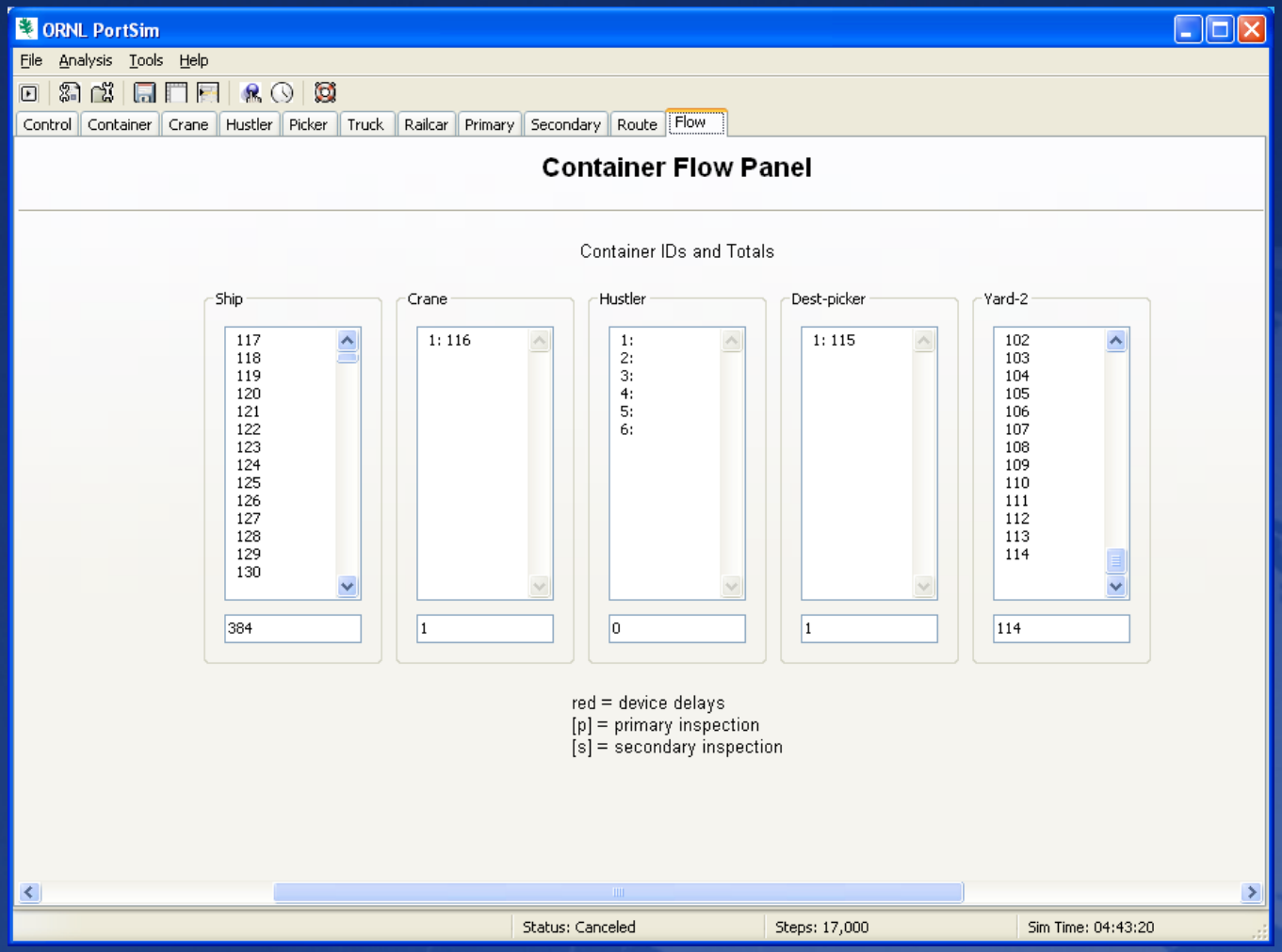
Crane Panel


ORNL PortSim
File Analysis Tools Help
Control Container Crane Hustler Picker Truck Railcar Primary Secondary Route Flow
Crane Panel
Default Settings
Transfer time - low (sec) 10.0
Transfer time - high (sec) 15.0
Average speed - low (fps) 1.0
Average speed - high (fps) 1.5
Hourly rate ($) 1000.0
Load rate ($) 0.0
Details
List Entry 1
Enter
+
-
Data
ID Number = 1
Gang ID = 1
Container ID = 116
Mode = transport
Route = transfer
Loaded = True
Delayed = False
Waiting = False
Blocked = False
Timer = 00:00:00
Delay time = 00:00:00
Busy time = 00:00:00
Average speed = 1.1 fps
Number of loads = 116
Total cost = $4,722
Status: Canceled
Steps: 17,000
Sim Time: 04:43:20

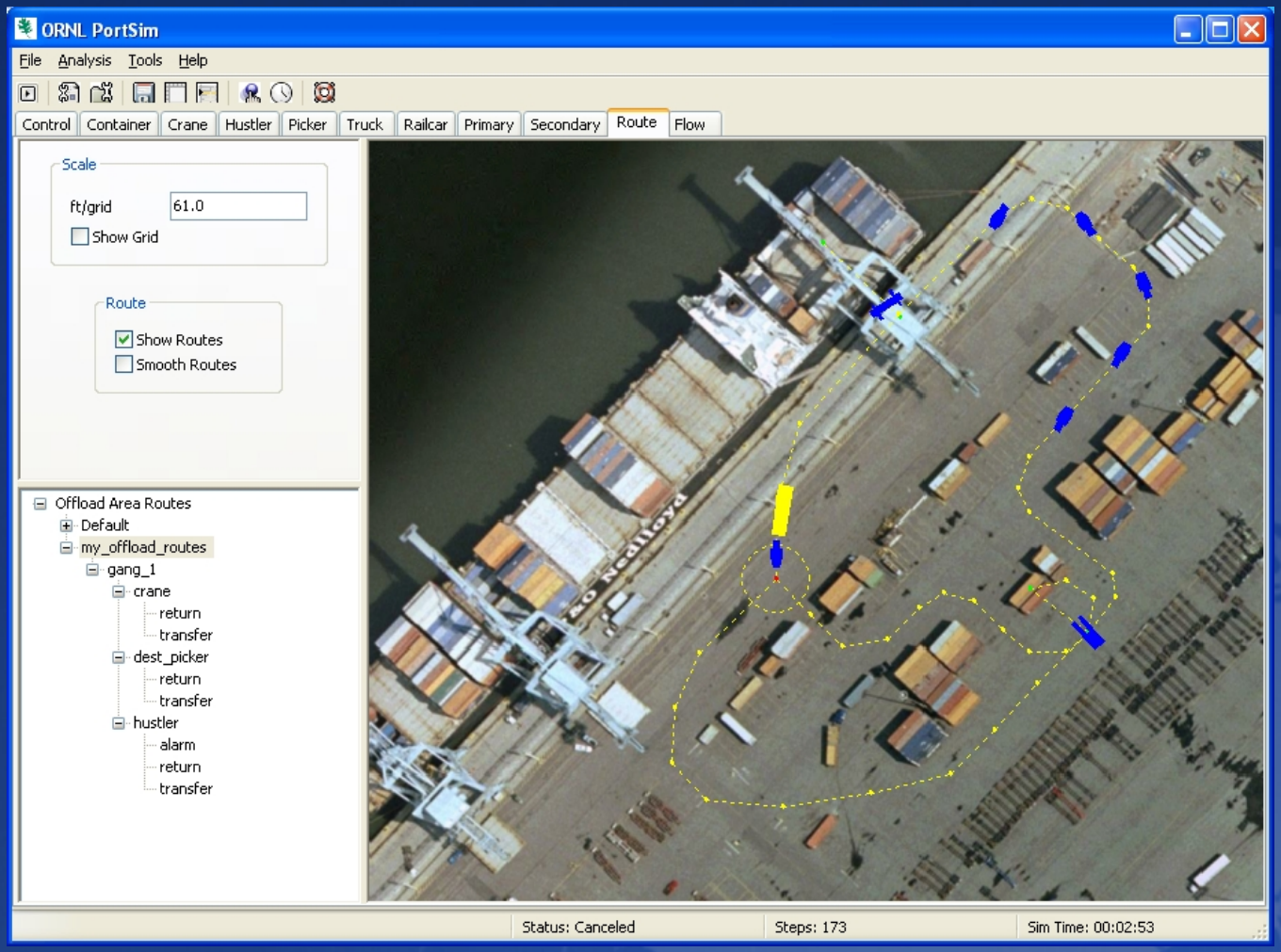
Detector Panel



Flow Panel


ORNL PortSim
File Analysis Tools Help
Control Container Crane Hustler Picker Truck Railcar Primary Secondary Route Flow
Container Flow Panel
Container IDs and Totals
Ship
117 118 119 120 121 122 123 124 125 126 127 128 129 130
384
Crane
1: 116
1
Hustler
1: 2: 3: 4: 5: 6:
0
Dest-picker
1: 115
1
Yard-2
102 103 104 105 106 107 108 109 110 111 112 113 114
114
red = device delays
[p] = primary inspection
[s] = secondary inspection
Status: Canceled
Steps: 17,000
Sim Time: 04:43:20

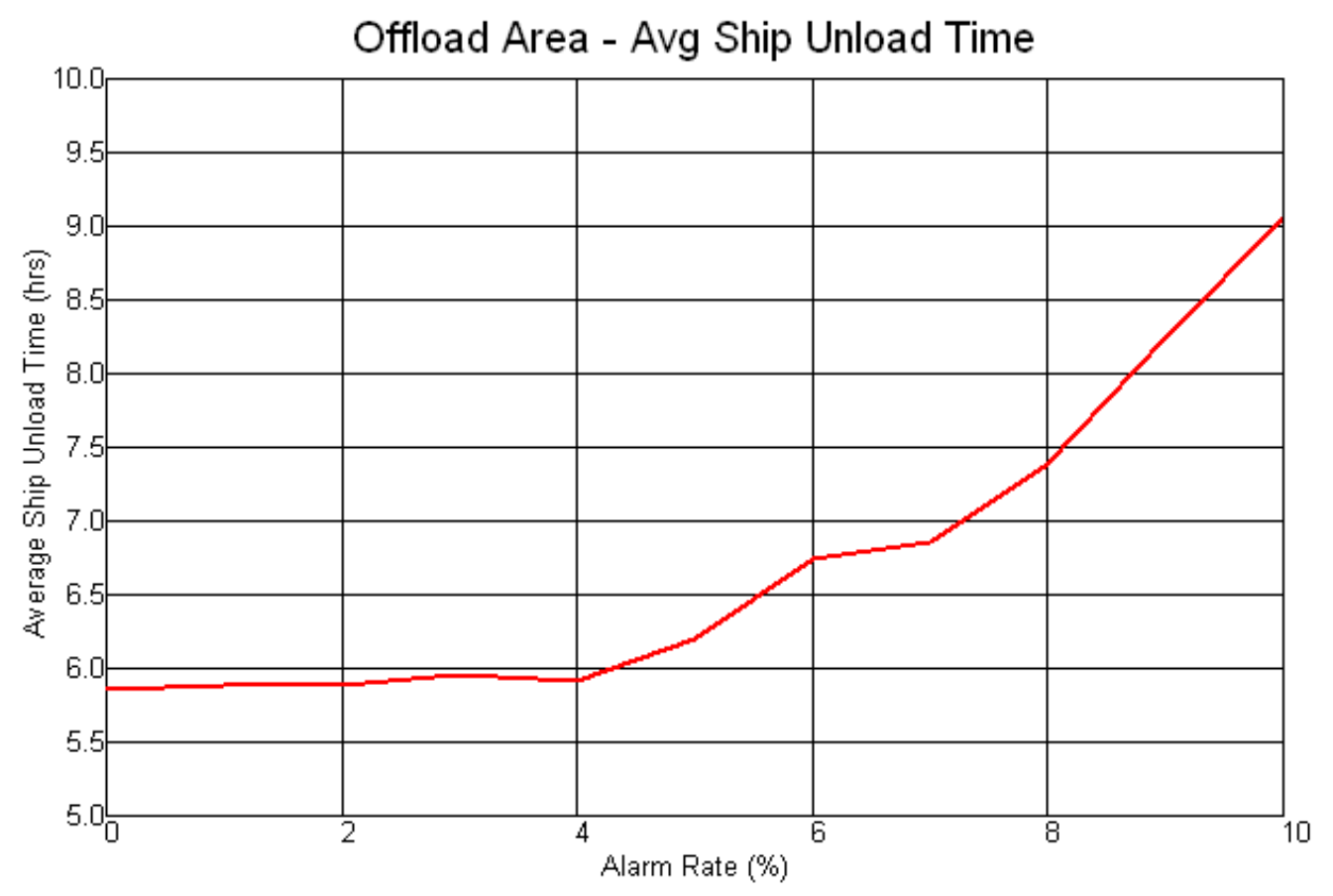
Route Panel


ORNL PortSim
File
Analysis
Tools
Help
Control
Container
Crane
Hustler
Picker
Truck
Railcar
Primary
Secondary
Route
Flow
Scale
ft/grid
61.0
Show Grid
Route
Show Routes
Smooth Routes
Offload Area Routes
Default
my_offload_routes
gang_1
crane
return
transfer
dest_picker
return
transfer
hustler
alarm
return
transfer
Status: Canceled
Steps: 173
Sim Time: 00:02:53

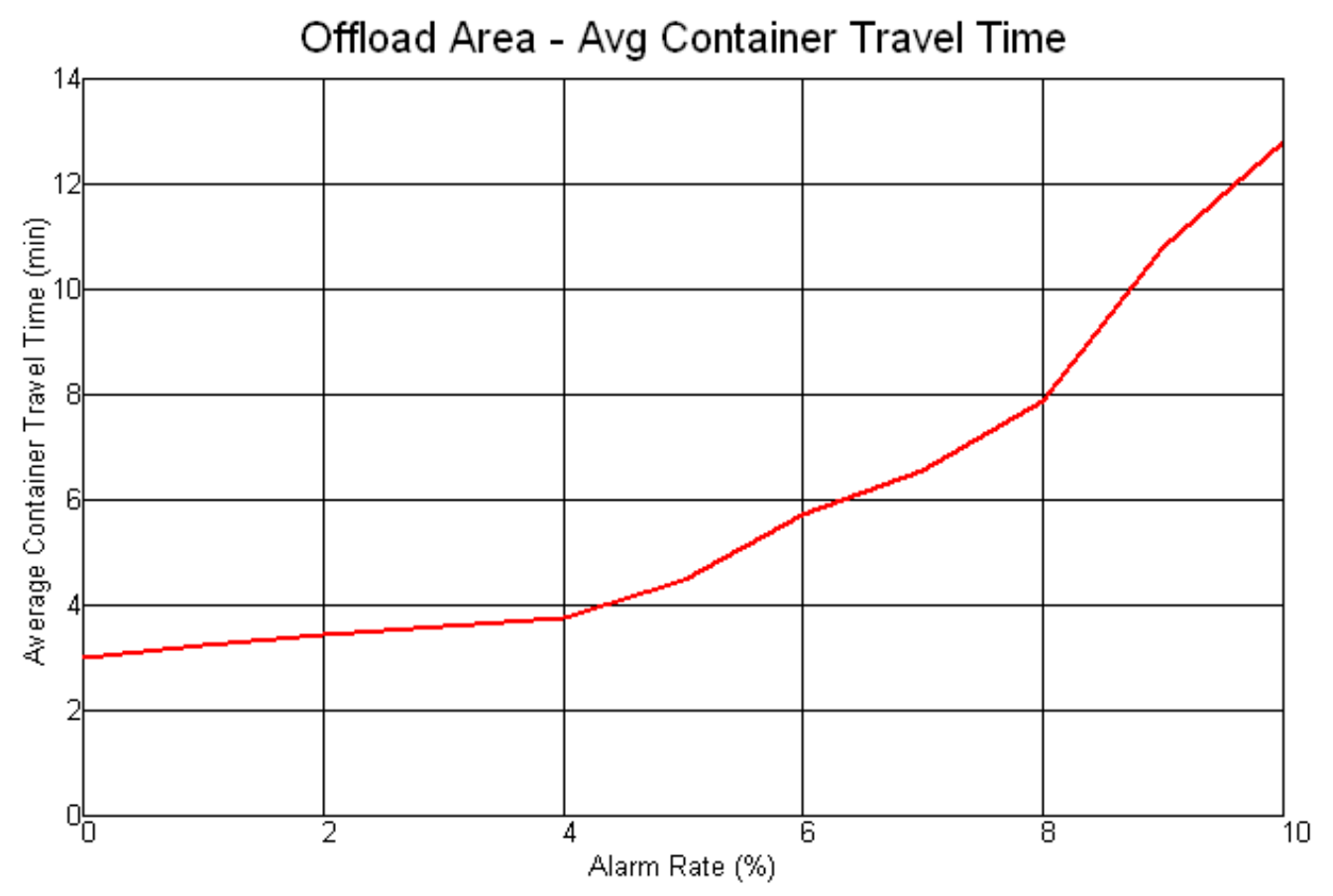
Simulation Outputs

- Execution speed – 1,000 containers require 2 minutes of real time (11 hours simulation time) on a 2 GHz desktop PC
- Outputs may be selected by user
- Several runs are averaged together for statistical smoothing
- Application includes plotting capability

Ship Unload Time



Container Travel Time



Future Work

- Add GIS component
- Convert visualization from 2D to 3D
- Port code to a high performance computing platform for regional simulations
- Add prediction module
- Apply to other problems

Questions?

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