

# Planning and Scheduling of Crude Oil Distribution in a Petroleum Plant

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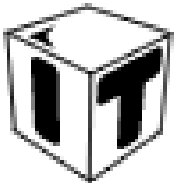
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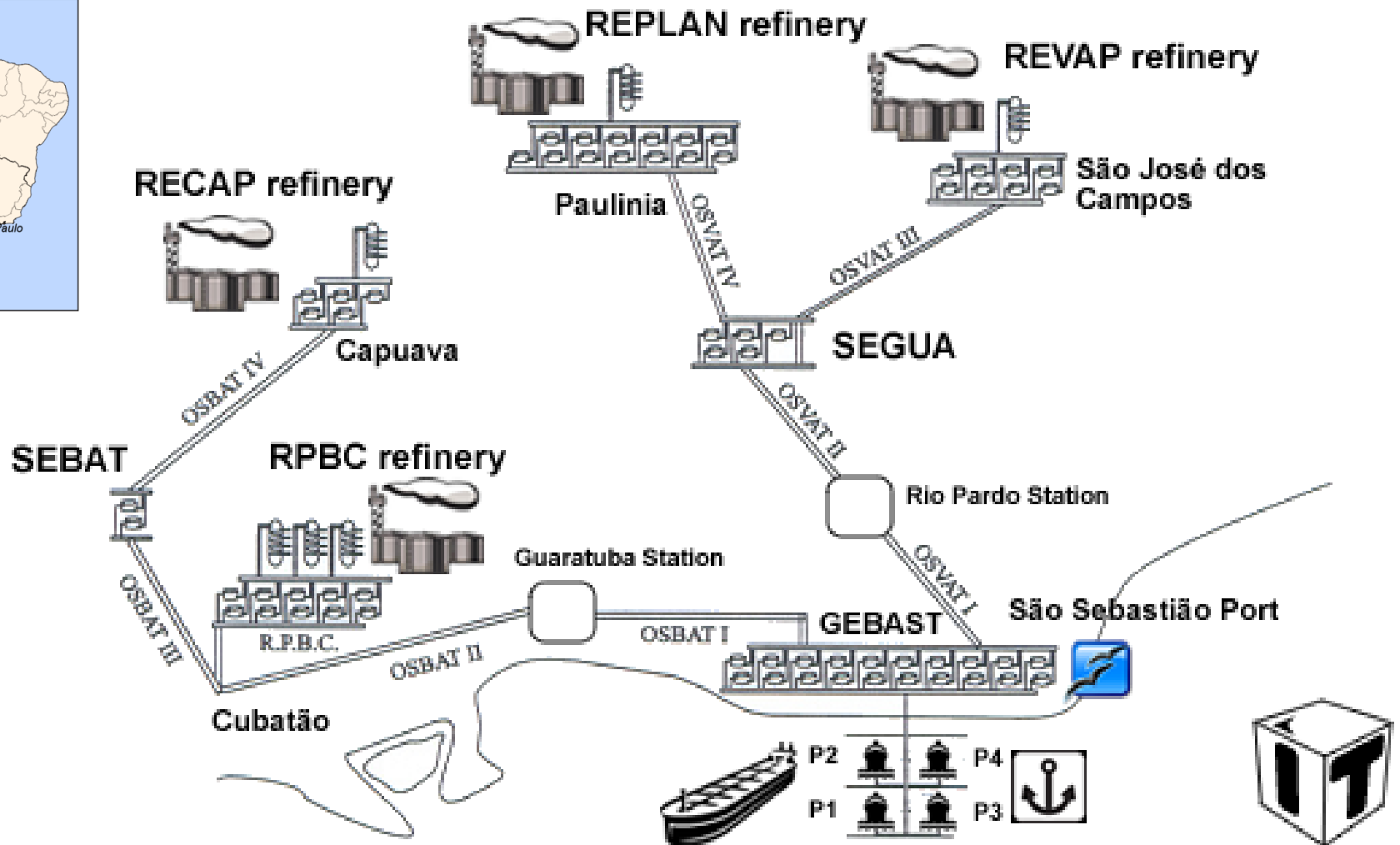
# Outline

- Crude Oil Distribution Problem
- Knowledge Engineering with itSIMPLE
- The Model
- Experimental Results
- Conclusion



# Crude Oil Distribution Problem

- **Actions:** Assignment of **tankers** to piers (docking); unload tankers to the terminal's **tanks** (storage); and send oil to **refinery** through **pipelines**
- **The goal:** maintain oil supply and reduce operational costs



# Crude Oil Distribution Problem



# Knowledge Engineering with itSIMPLE

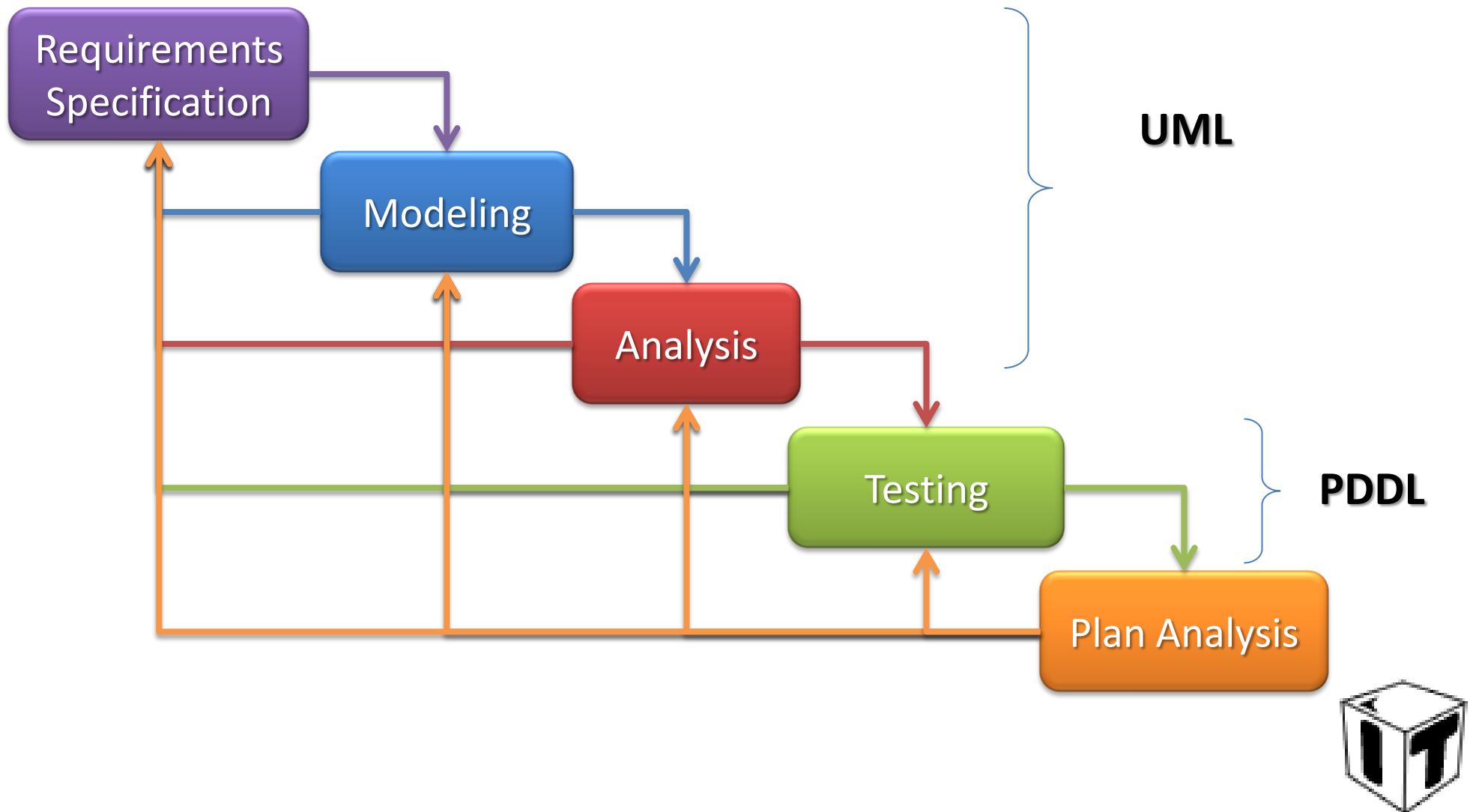
## Overview

- *KEPS tool*
- Focus on *Design Life Cycle*
- Dealing with the *initial design phase*
- Specification and Modeling *with UML*
- It provides an *input-ready PDDL model* for AI planners



# Knowledge Engineering with itSIMPLE

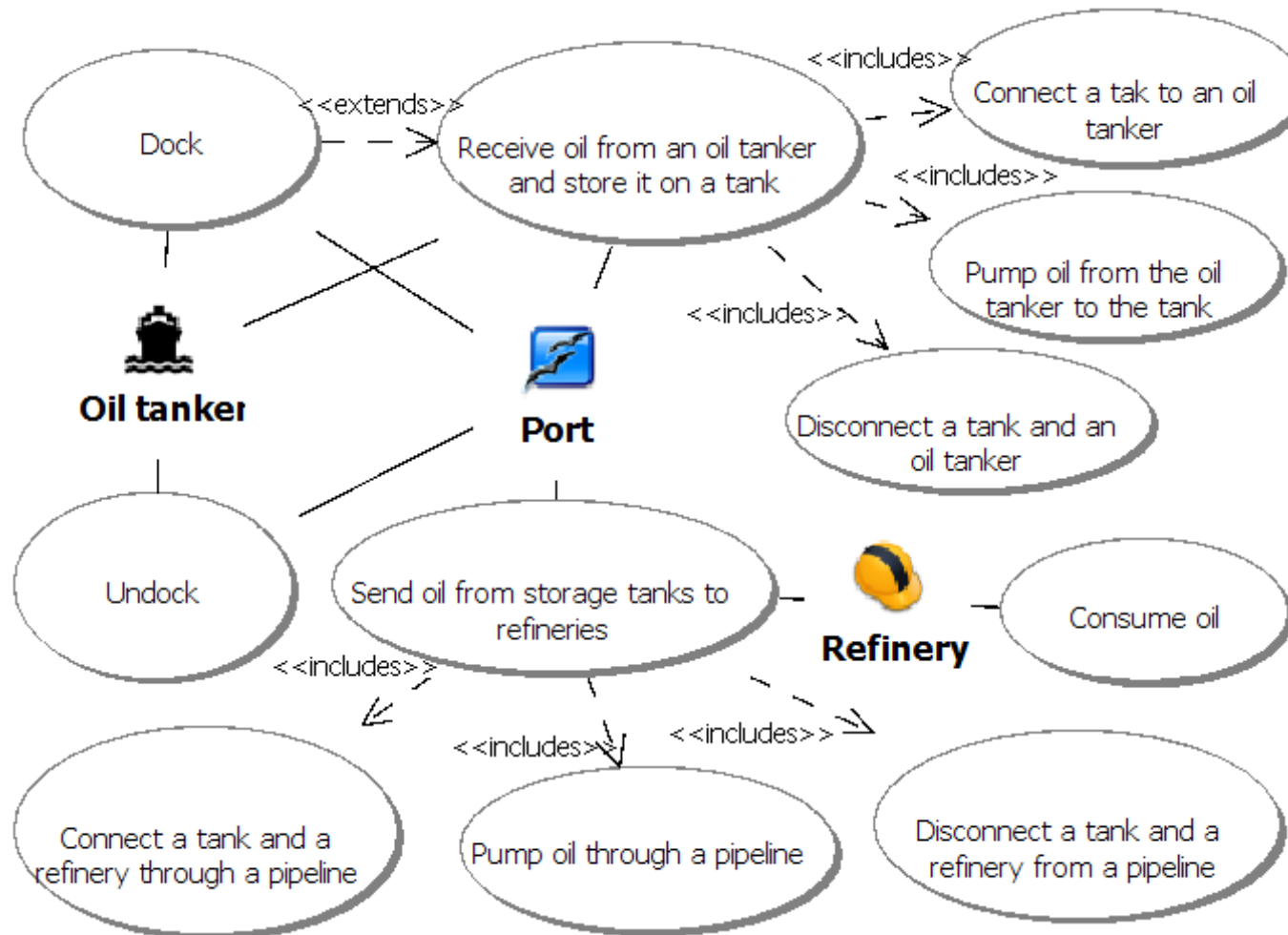
## The itSIMPLE<sub>3.0</sub> Environment/Framework



# The Model

## Specification / Modeling

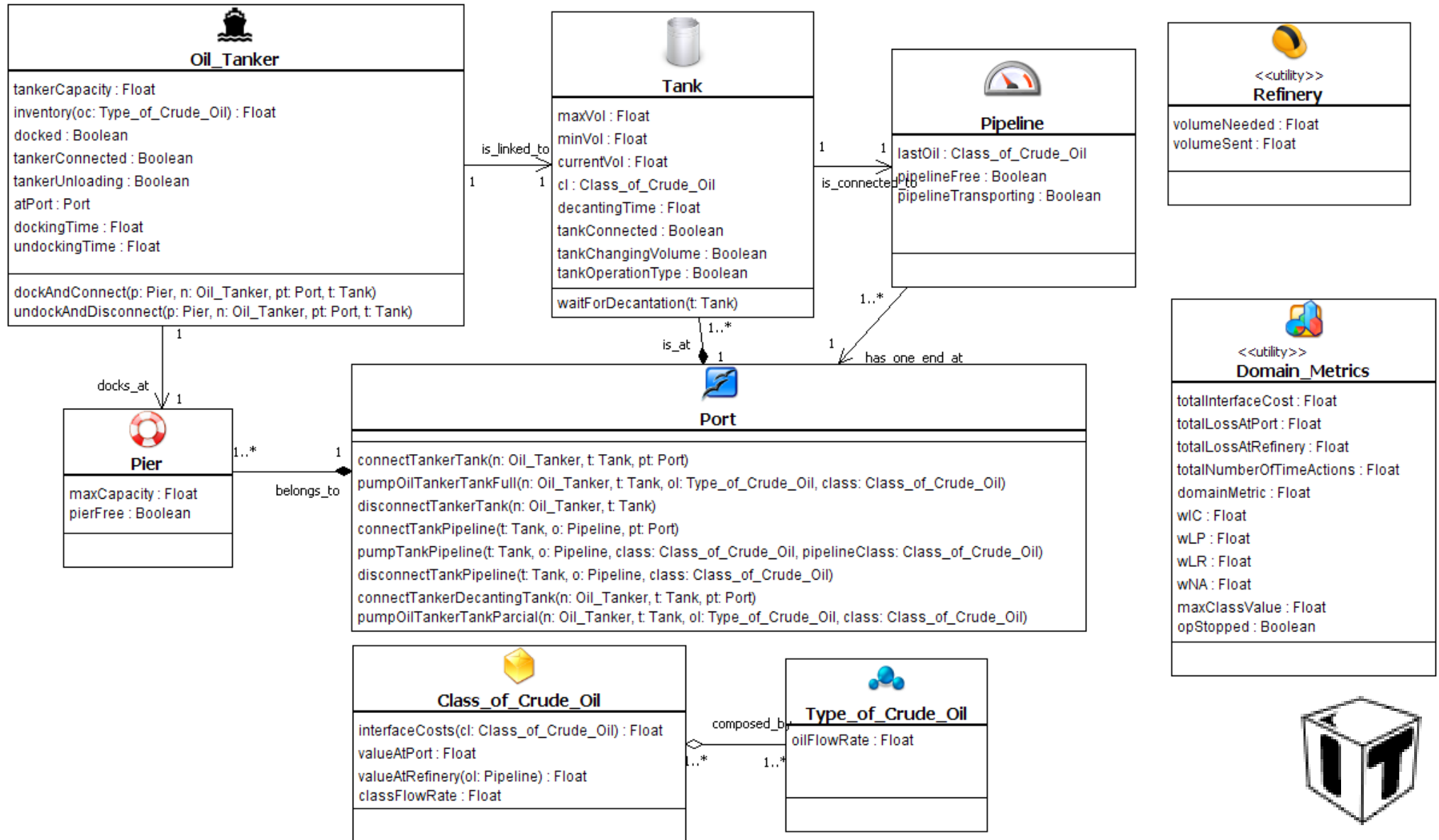
### Use case diagram



# The model

## Modeling

## Class diagram

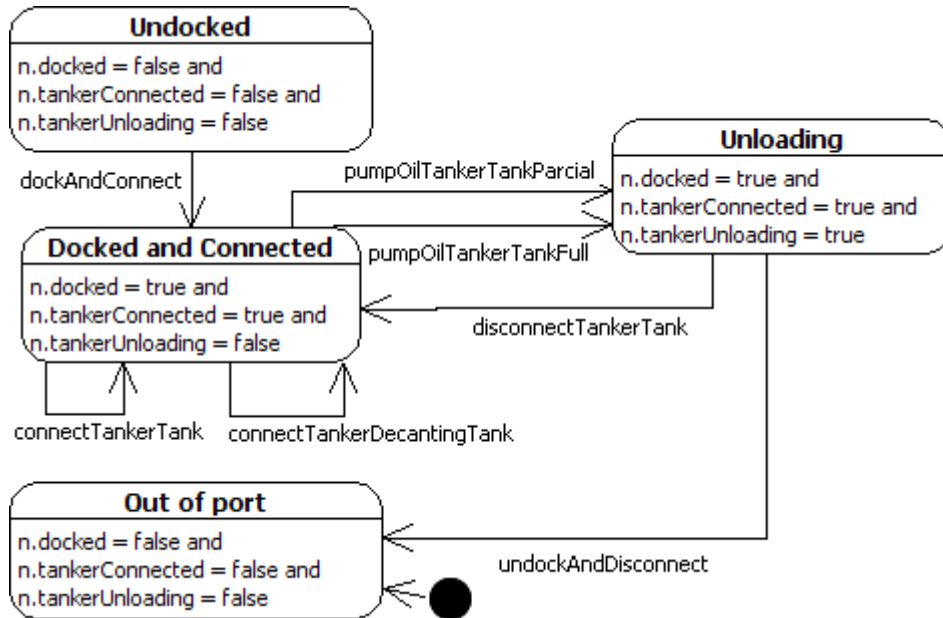




# The model

## Modeling

### State Machine diagrams



### Object diagrams (Problem definition)

init:



goal:

FrontBrea: Oil Tanker	Pedreiras: Oil Tanker
atPort(Port) =	atPort(Port) =
tankerUnloading(Boolean) = false	tankerUnloading(Boolean) = false
tankerConnected(Boolean) = false	tankerConnected(Boolean) = false
docked(Boolean) = false	docked(Boolean) = false
inventory(oc_05) = 0	inventory(oc_08) = 0
tankerCapacity(Float) =	inventory(oc_27) = 0
dockingTime(Float) =	tankerCapacity(Float) =
undockingTime(Float) =	dockingTime(Float) =
	undockingTime(Float) =



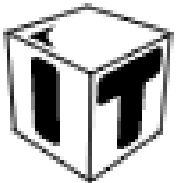
# The Model

The metrics considered so far:

- *totalLossAtPort*: losses related to storing oil in tanks that belong to a low quality class;
- *totalInterfaceCost*: sum of interface costs in the pipeline;
- *totalLossAtRefinery*: losses related to sending low quality oil to the refineries;
- *totalNumberOfTimeActions*: just the number of durative-actions.

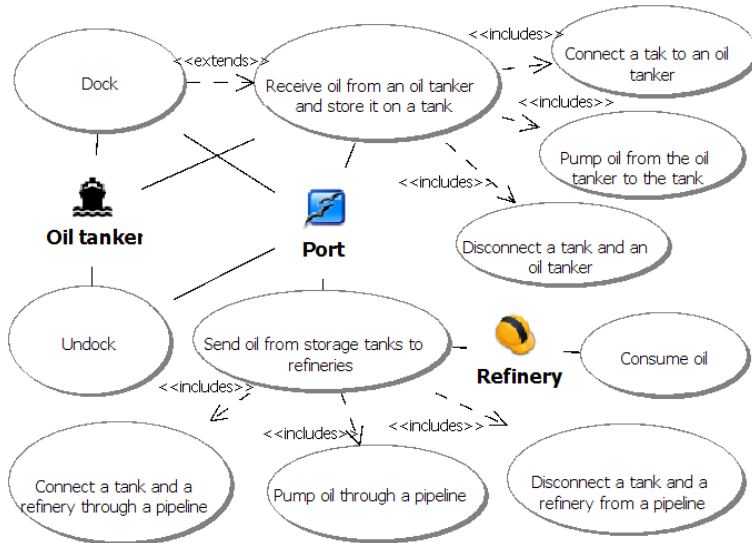
Not considered yet:

- Docking time of tankers (continuous time);
- Overtime docking costs (continuous time).

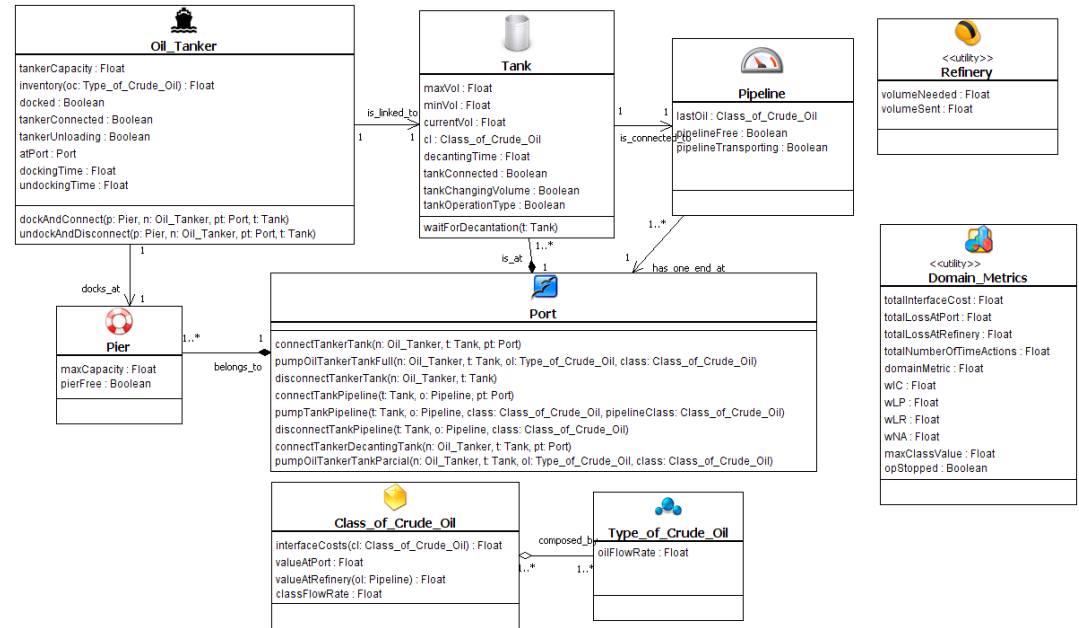


# The Model

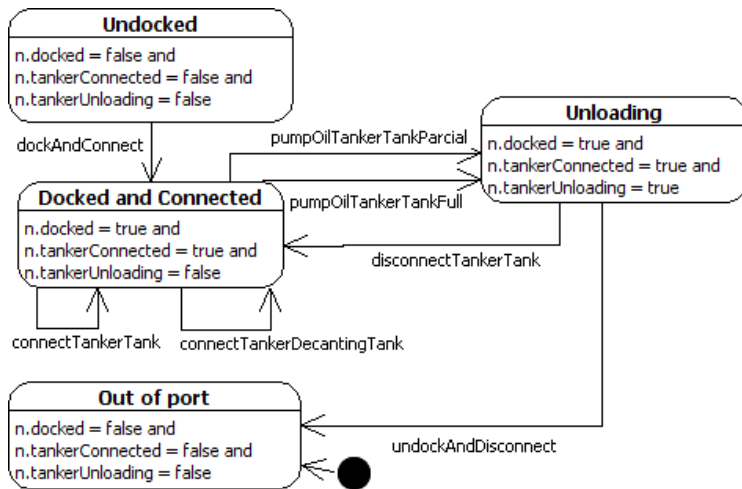
## Use case diagram



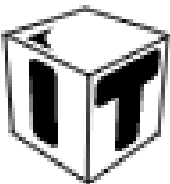
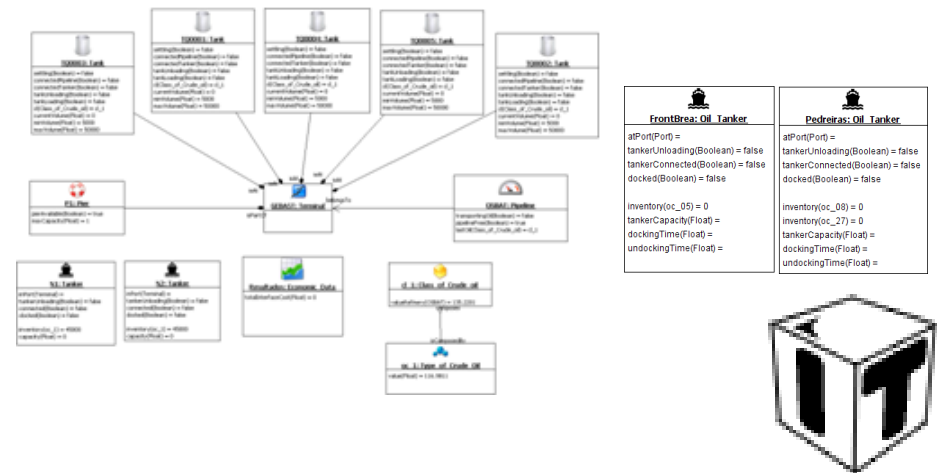
## Class diagram



## State machine diagrams

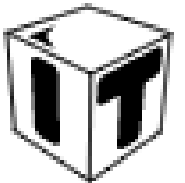


## Object diagrams (init and goal states)

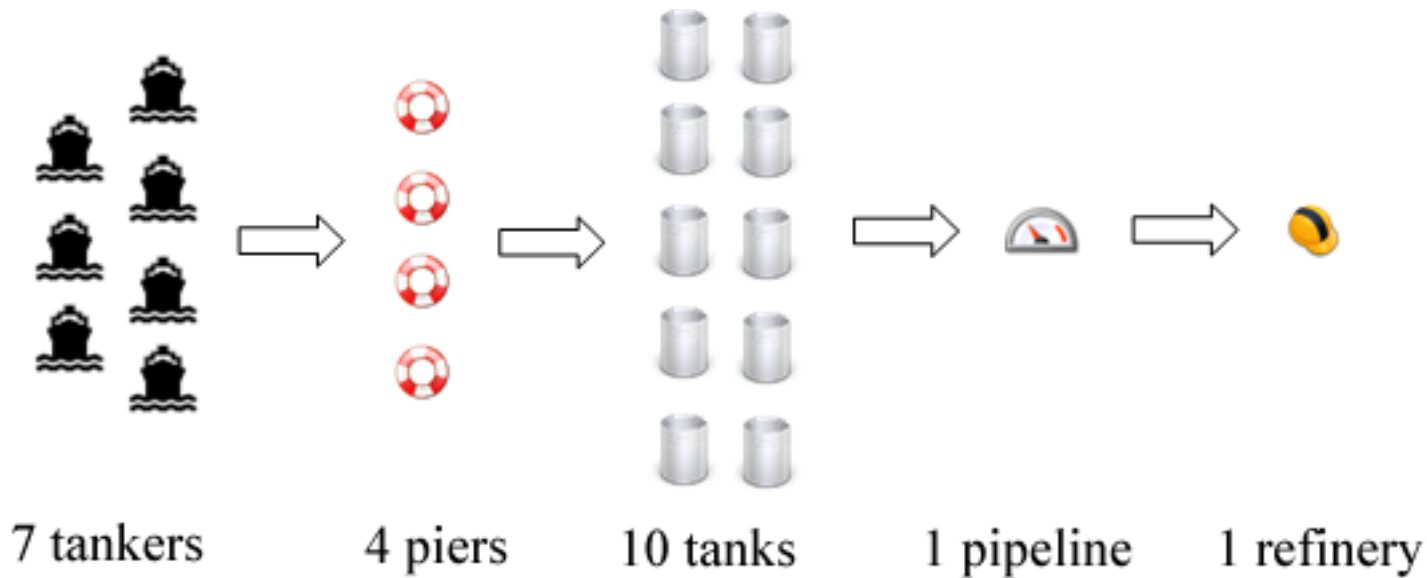


# Experimental Results

- PDDL (2.1) model generated by itSIMPLE's translator (UML to PDDL)
- Pre selection of planners with basic models
  - Results presented in IFAC 2008
- Chosen planner: SGPlan
- **Two case studies**
  - Semi realistic scenario
  - **Realistic scenario**

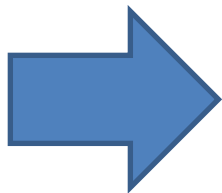


# Experimental Results: Realistic



## Planner (SGPlan) output

	1st iteration
time	210.09s
Number of actions	88
Metric value	73.789



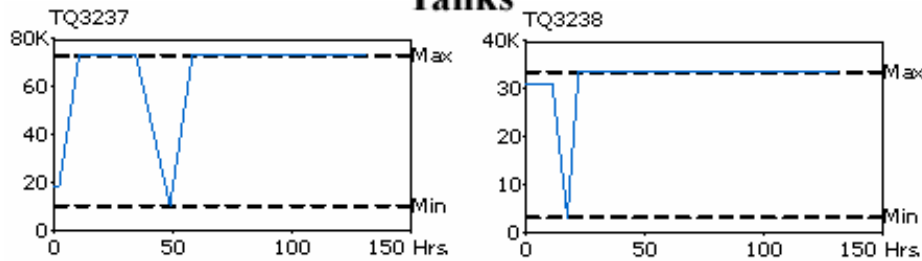
```

0.001: (CONNECTTANKPIPELINE TQ3240 OSVAT GEBAST) [0.0000]
0.002: (DOCK P1 NORTH_STAR GEBAST) [2.0000]
0.003: (DOCK P2 PRESIDENTE GEBAST) [2.0000]
0.004: (PUMPTANKPIPELINE TQ3240 OSVAT CL4 CL1) [11.1077]
2.005: (CONNECTTANKERTANK NORTH_STAR TQ3242 GEBAST) [0.0000]
2.006: (CONNECTTANKERTANK PRESIDENTE TQ3237 GEBAST) [0.0000]
2.007: (PUMPOILTANKERTANKPARCIAL NORTH_STAR TQ3242 OC26 CL5) [9.5833]
2.008: (PUMPOILTANKERTANKPARCIAL PRESIDENTE TQ3237 OC29 CL3) [8.4663]
10.475: (DISCONNECTTANKERTANK PRESIDENTE TQ3237) [0.0000]
...
    
```

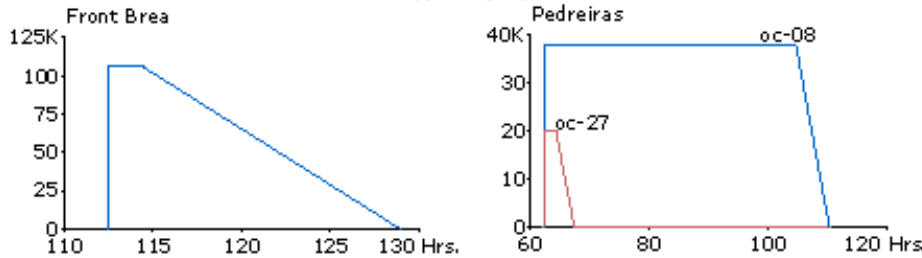


# Experimental Results: Realistic

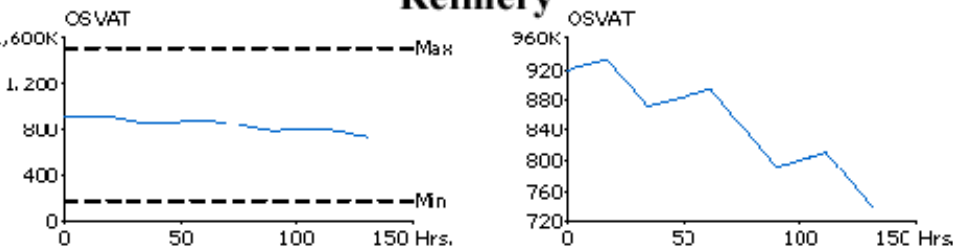
**Tanks**



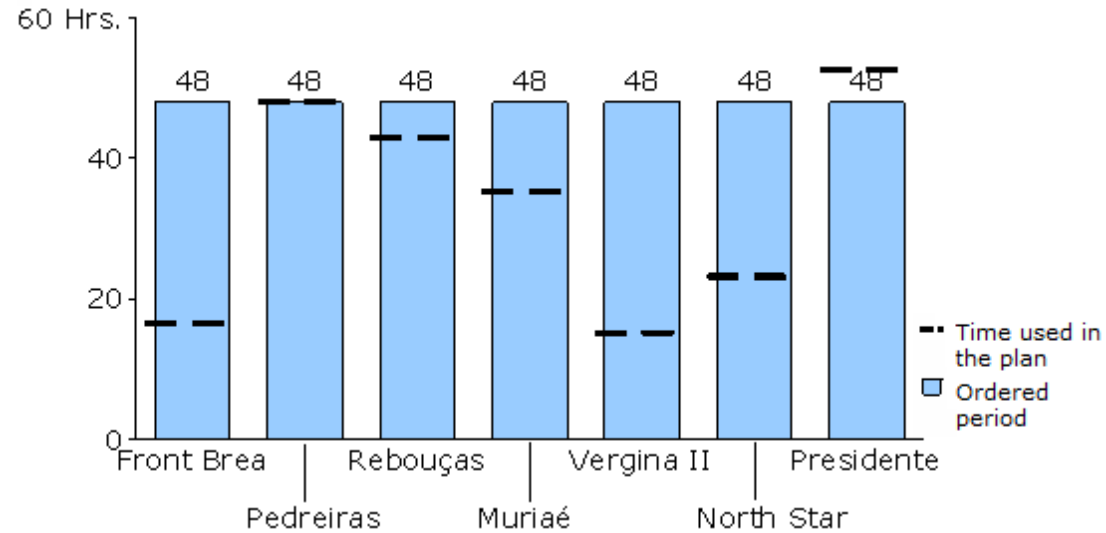
**Tankers**



**Refinery**

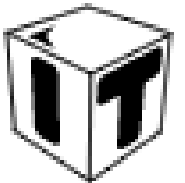


**Time**



# Conclusion

- **KE tools** such as itSIMPLE have an **essential role** in the **design process**
- The resulting model is **easily communicated**
- **Few planners** deal with such combination of PDDL features
- The resulting **PDDL model** brings **interesting challenges** even for the state-of-the-art planners



# Thanks

itSIMPLE<sub>3.0</sub> is available at

**[dlab.poli.usp.br](http://dlab.poli.usp.br)**

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