CAPABILITY STATEMENT

# Generic Simulator Tank Terminals

Manual

Client: Tank Terminals & Engineering Companies

Reference: RLP01
Status: 01/Final
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Royal HaskoningDHV
Enhancing Society Together

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# 1 Dynamic simulation

***Generic model***

A generic model of a terminal has been built with open source software “Python” and simulation module “Salabim”. This module is used to model and simulate all kinds of discrete processes. As the objects defined within the model interact dynamically, the simulation reflects reality very well. Entities arrive in queues and waiting times are recorded.

Within the generic model for terminals MOT (Modes of Transport: barges, trains and trucks) arrive according to a predefined schedule or stochastic arrival process. These MOT occupy equipment (tanks, jetties, jettylines, connection lines, headers and pumps) that are necessary to fulfil their objective: loading or discharging a certain amount of product to a certain tank. When occupied, this equipment can not be used by other MOT, thus creating queues and waiting times, which are the main KPI’s of any tank terminal.

***Objectives***

The objectives of using a simulation model for terminals are:

- Improve the design of new terminals:
  - Find bottlenecks;
  - Test the impact of adding / removing equipment;
  - Test the impact of dedicated versus flexible systems
  - Change product allocation;
- Test the impact of changes in existing terminals, for example:
  - Increase in throughput;
  - Changes in infrastructure: adding/removing equipment, changing connections;
  - Change planning from FIFO to timeslots;
  - Changes in vesselsizes, parcelsizes, frequencies;
  - Changes in product/customer portfolio.
- Test future contract details with customers
- Test future service levels with customers
- Convince stakeholders: statements on logistics of the terminal are supported by results of the model.

# 2 Process of MOT

MOT (Modes of transport) can be any transport modality to transport liquid: ships, trains, trucks, pipelines. The model assumes that will all MOT the liquid is transported in batches. Batch size and pumping capacity differ per MOT type. The number of MOT definitions in the model is endless.

## 2.1 Generation of MOT

MOT can be generated according to historical arrival data or randomly generated.
Select “General” from the menu and choose “MOT historical arrivals” or “Generation MOT SP”. (SP stands for single product).

Both tables will be used as input when data is filled in. MOT from the historical arrivals will arrive in the queue at the fixed historical arrival time in the table. Each row represents the arrival of one MOT with all its attributes.

In the generation table each row represents the arrival of a certain class of MOT's with its attributes during the total run period. The total run period is divided in time units. The duration of one time unit can be chosen. Per time unit the number of MOT's that should arrive within this time-unit is given. With the start of a new time-unit all MOT's in this time-unit will receive an arrival time that is determined by drawing a time uniformly distributed within this time-unit. The generated MOT will arrive in the queue when time equals its arrival time.

## 2.2 Process in queue

When an MOT arrives in a queue, the reservation method is started. With the reservation method per MOT in the queue(s) is determined what will be the line-up that will result in the shortest turnaround time. Reservation of equipment is organised with the first come first serve principle per MOT priority type (MOT's can be given a priority, see table MOT Types. Number 1 has highest priority) and than per MOT. When all MOT's in the queue have received their best operating sequence, the planning method will determine which MOT can go its station (when conditions are met). The order of releasing to stations is determined by MOT priority and sequence of arrival.

## 2.3 Process at station

The MOT will move towards its station, the travel time is a variable given per MOT Type (see table MOT types). When arrived at the station the MOT will first wait for documents, connection etc., summarised as pre-loading time (given in the Idle times table). After its preloading time and flushing, if flushing was required to change the product of equipment in the selected route, the MOT starts pumping with the first parcel according to the operating sequence. If the station has multiple loading arms (given in the table with stations), the MOT may start pumping several parcels simultaneously. The equipment in the routes (lineups) for pumping the parcels are occupied by this MOT. Depending on the number of parcels that can simultaneously occupy equipment (given in the equipments tables), the equipment may no longer be available for other pumping other parcels (of this or other MOT's). (@@This will change in the next version of the model: the maximum capacity of equipment will determine how much capacity is left when a parcel is pumped with a certain capacity@@).
The pumping time per parcel depends on both the pumping capacity of the ship and the pumping capacity of the route. The total pumping time depends on the pumping time per parcel and the number of parcels that can be pumped simultaneously.
After pumping the parcels, the MOT starts with the post-loading time (time for disconnecting, documents, analysis, etc.). After the post-loading time, the MOT will depart but the station will still be claimed for the duration of the change over time (attribute of the station). This change over time stands for the manouevring of the MOT at the station that prohibits other MOT to enter the station.

*Attributes of MOT*
MOT's have the following attributes

- Parcels: MOT can carry up to 10 parcels. Each parcel has a product type, a parcel size and a tank(group). With historical data these attributes can be given per parcel. When MOT are generated (at this moment) only one product type per MOT can be selected (the number of parcels depend on the total size of the cargo and the tank size).

# 3 Other processes in the model

## 3.1 Create terminal infrastructure

With the aid of tables the complete terminal infrastructure is recorded in the model: tanks, berths, jetty lines, pumping platforms, pumps, pumpheaders, headers and connection lines.
The model contains a navigation system that determines all possible routes between tanks and berths and puts them in a table. When a vessel arrives the most optimal available route for pumping the product is chosen from this table. All equipment that is part of this route is occupied when the pumping starts.
When constructing the route table the navigation system takes into account constraints like a maximum number of pieces of equipment, use only equipment of the same product group and use a suction and a pressure connection. The simulation model reads this route table before a run is started.
The navigation system works as follows:

- A table with all possible line-ups on the terminal is defined. A line up consists for example of the following sequence of equipment: 1 Tank, 2 Header, 3 Pump, 4 Header, 5 Jettyline 6 Station
- Equipment connection tables define connections between 2 equipment types. For example all connections between header and pump
- Equipment is defined in separate tables per equipment type
- A route is found by going through the equipment definitions tables and find connection according to the specific line-up and connection tables with equipment that has equal product type (or product category that contains that product type). The product of the route is determined by the product type of the tank. It is assumed that the tank will not change product during a run.
- The table with lineups determines if a lineup can be used for export, import or both.
- The pumping capacity or flowrate of the route is determined by the equipment with the lowest pumping capacity or flowrate
- The route is added to the general route table, that can be read by MOT to select the route that delivers the shortest turnaround time
- All possible lineups can be predefined in the model. At the moment only 3 lineups can be activated

A flow scheme of the construction of the terminal infrastructure is provided in appendix@@

## 3.2 Reservation

The reservation method determines per MOT in the queue(s) the route with the shortest turnaround time for this MOT. It is called the reservation method as during the selection of routes that will provide the shortest turnaround time, the equipment in the routes per MOT is reserved.
It starts with the first MOT in the queue with the highest priority and works its way down the MOT's (first come first serve) and priorities.
Per MOT in the sequence, the reservation method consecutively calculates the following:

- Determination of all possible routes per parcel per station. A route is a connection between the tank of the parcel and the specific station. A station is a berth or a loading station.
- Determination of all possible sequences of operating the parcels
- Combine all possible routes per station with all possible parcel sequences to all possible combinations
- Determine the minimum turnaround time per combination.
  Equipment in routes can be claimed by MOT that are pumping or by MOT in the queue with a reservation. (Occupation and reservation of equipment can also be caused by flushing of equipment

when a product change is required). The claimed time or the reservation time of equipment determines when a route is available. The claimed/reservered time per route per parcel determines the minimum start time of pumping per parcel. The pumping capacity of the MOT or of the route and the parcel size determine the end of the pumping time per parcel. The parcel with the largest pumping end time determines the turnaround time of this specific operating sequence.

- Select the operating sequence with the shortest turnaround time and assign this to the MOT.
- Make reservations for all the equipment in the operating sequence of the MOT (including flushing time if required).

Repeat these calculations for the other MOT in the queues (with later arrival time or lower priority).

## 3.3 Planning

The planning method determines if an MOT in the queue can move to its station.
The planning method starts with the first MOT in the queue with the highest priortity and ends with the last MOT in the queue with the lowest priority. With every MOT, the planning checks the following conditions:

- Is the station (of the best operating sequence) available: not occupied and not blocked?
- Will all the equipment (from the route of the first parcel of the best operating sequence) be available when the MOT starts pumping (after transit and pre-loading time)?
- When flushing is required for the first parcel (of the best operating sequence), check if all the equipment (from the route of this parcel) is available.

If all conditions are true, the MOT will move towards the station. The station and equipment required for pumping the first parcel is requested and claimed. Flushing of equipment of the first parcel will start if required.

## 3.4 Occupying equipment

Equipment can be occupied by MOT or by flushing.
Equipment can be occupied by multiple MOT simultaneously. The maximum number of parcels that can occupy equipment simultaneously is an attribute per equipment given in the equipment definition tables. The number of parcels that an MOT can pump simultaneously is dependent on the number of loading arms present at the station (attribute of a station).
Equipment is modelled as a resource. When an MOT requires pumping a parcel, it sends a request to occupy all the equiment in the route. When all equipment have granted permission (number of occupying parcels is smaller than the maximum), the MOT will occupy this equipment. After the pumping time (determined by parcel size and MOT flowrate or route flowrate), the MOT will release all the equipment again.

# 4 Input

The model works with a database. Only when submitted, changes to the input will be saved to database. The website saves data to the database and when the simulation is started, the model reads these data again from this database.
Every record in the tables can be changed one by one. It is also possible to upload complete tables from ".csv files". Every table has a download button.
The input consists of tables for:

- Settings
- General configuration
- MOT arrival
- Infrastructure

## 4.1 Settings

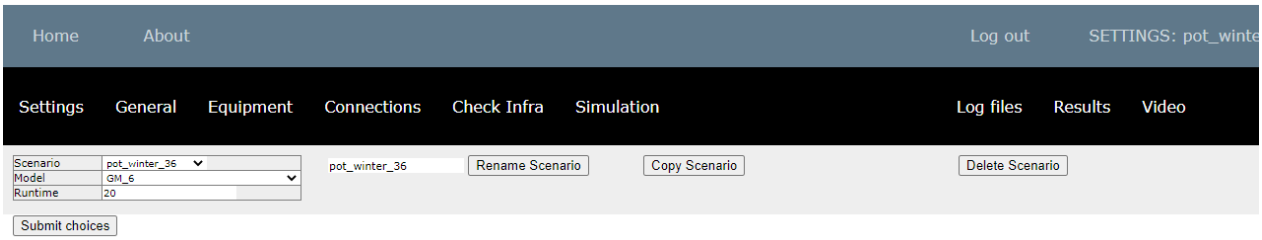



*Figure 4-1 Setting of scenario and runtime. Copy, delete and rename scenarios*

In Settings the scenario is selected. With selecting a scenario both the corresponding input and output (if present) are selected.
When the scenario is copied, all the input and output files are copied. The copied scenario is stored under the original name with extension "_1". Any scenario can be renamed or deleted (no warning before deletion!). Each choice should be validated with the "Submit choices" button to be saved in the database.
If different scenarios make use of different models, the model can be selected.
The runtime can be submitted. Usually the runtime is in hours but in theory any time unit could be chosen. (It should be reminded though that other time variables should then also be defined in this time unit, for example pumping capacity).

## 4.2 General configuration

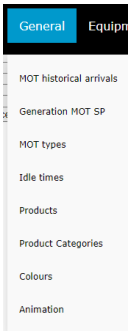



*Figure 4-2 Configuration of general topics of the simulation model*

Hovering over “General” will show the drop down menu with 8 topics. When starting with an empty model the following tables should be filled in first to create the general configuration of the scenario:

### *MOT types*

| ID | MOTname | MOTCategory | Min_P_rate | ML_P_rate | Max_P_rate | Avg_P_rate | Min_L_rate | Planning_Prio | Pre-ann | Travel_time |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | MOT1 | MCat1 | 1000.0 | 2500.0 | 4000.0 | 2500.0 | 300.0 | 1 | 0.0 | 30.0 |
| 2 | MOT2 | MCat1 | 500.0 | 750.0 | 1000.0 | 750.0 | 300.0 | 1 | 0.0 | 30.0 |
| 3 | MOT3 | MCat2 | 50.0 | 250.0 | 450.0 | 250.0 | 50.0 | 2 | 0.0 | 15.0 |
| 4 | MOT4 | MCat3 | 300.0 | 400.0 | 500.0 | 400.0 | 20.0 | 3 | 0.0 | 10.0 |
| 5 | MOT5 | MCat4 | 30.0 | 50.0 | 70.0 | 50.0 | 30.0 | 4 | 0.0 | 10.0 |

Submit

Download

Choose File No file chosen Upload

*Figure 4-3 Definition of all MOT types.*

MOT are generated from MOT types and will get the following attributes:

- MOT name: directly from table. Just for discerning one MOT type from the other. Any name can be given;
- MOT category. This attribute is not required. When filled in, it is only used for animation;
- MOT type pumping rate. The pumping rate is calculated from the minimum, the most likely and the maximum pumping rate (triangular distribution). The average and minimum pumping rate are not (yet) used in the model;
- Priority: The priority determines in which queue an MOT type will end up. The higher the number, the lower the priority. (The model will search for MOT in queues that can go to their stations first in order of priority and then in order of arrival);
- Pre-announcement (not implemented yet): represents the time that it takes before an MOT will arrive at the queue. Using this attribute would allow the model to take MOT into account that are still in transit to the terminal;
- Travel time (in minutes, when the time unit is chosen to be hours): Each MOT has its own travel time to the terminal. During travelling to the terminal/station the MOT claims the station and the equipment in the route for the first parcel to prevent that other MOT or flushing will occupy station or equipment in the meantime. Therefore this time should not be made too long as it will consume terminal capacity;

### *Idle times*

| ID | MOTname | Product | Pre_Loading | Post_Loading |
|---|---|---|---|---|
| 1 | MOT1 | ProductA | 3.0 | 0.0 |
| 2 | MOT1 | ProductB | 3.0 | 0.0 |
| 3 | MOT1 | ProductC | 5.0 | 0.0 |
| 4 | MOT2 | ProductA | 2.0 | 0.0 |
| 5 | MOT2 | ProductB | 2.0 | 0.0 |
| 6 | MOT2 | ProductC | 3.0 | 0.0 |
| 7 | MOT3 | ProductA | 1.0 | 0.0 |
| 8 | MOT3 | ProductB | 1.0 | 0.0 |
| 9 | MOT3 | ProductC | 2.0 | 0.0 |
| 10 | MOT4 | ProductA | 0.2 | 0.0 |
| 11 | MOT4 | ProductB | 0.2 | 0.0 |
| 12 | MOT4 | ProductC | 0.6 | 0.0 |
| 13 | MOT5 | ProductA | 0.0 | 0.0 |
| 14 | MOT5 | ProductB | 0.0 | 0.0 |
| 15 | MOT5 | ProductC | 0.0 | 0.0 |

*Figure 4-4 Definition of idle times per product and per MOT*

Each MOT will consume idle time when at the station, time that it is occupying the station but not pumping. The idle time is dependent on the MOT type and the product

- MOT name: The MOT type names as defined in the MOT types table should be filled in;
- Product: when the products table has been filled in, the products can be selected from a dropdown menu.
- Pre-loading time: idle time that is consumed before pumping (ropes, documents, analysing, connecting, etc.). This time is a fixed time that will delay every MOT of this type with this product
- Post-loading time: idle time that is consumed after pumping (documents, analysing, disconnecting, etc.). This time is a fixed time that will delay every MOT of this type with this product

### *Products*

| IDs | Product | Colour | Density |
|---|---|---|---|
| 1 | ProductA | IndianRed | 800 |
| 2 | ProductB | Gold | 800 |
| 3 | ProductC | Olive | 800 |
| | | | |

*Figure 4-5 Definition of products (and colours for animation)*

- Product name: this is required to define a new product.
- Colour: only required for animation purposes (the tank and MOT that are pumping get the colour belonging to the product)
- Density: not used. The user can choose if all is modelled in volume (m3, L) or in mass (tons, kg)

### *Product categories*

| ID | Category | prod1 | prod2 | prod3 | prod4 |
|---|---|---|---|---|---|
| 1 | AB | ProductA | ProductB | | |
| 2 | BC | ProductB | ProductC | | |
| 3 | AC | ProductA | ProductC | | |
| 4 | ABC | ProductA | ProductB | ProductC | |
| | | | | | |

*Figure 4-6 Definition of products in product categories*

To make it possible that infrastructure is not product dedicated, product categories are introduced. Several products (up to 10) can belong to the same product category. (Infrastructure that is defined in this category is allowed to pump all these categories).

- Category: required to name the category
- Prod1 to prod10: all the different products that belong to this category. A product can belong to more than one category. (The products are selected from a dropdown menu)

### *Colours*

| ID | Name | Number |
|---|---|---|
| 1 | IndianRed | #CD5C5C |
| 2 | Pink | #FFC0CB |
| 3 | Coral | #FF7F50 |
| 4 | Gold | #FFD700 |
| 5 | Olive | #808000 |
| 6 | Fuchsia | #FF00FF |
| 7 | LimeGreen | #32CD32 |
| 8 | Aqua | #00FFFF |
| 9 | LightSkyBlue | #87CEFA |
| 10 | Chocolate | #D2691E |
| 11 | Silver | #C0C0C0 |

*Figure 4-7 Definition of colours that are used in the animation*

This is just a table with colours that are used in the animation. The table can be expanded with extra colours but this should normally not be required.

### *Animation*

| ID | Element | col2 | col3 | col4 | col5 | |
|---|---|---|---|---|---|---|
| 1 | Xanchorage | 100 | 0 | 0 | 0 | |
| 2 | Yanchorage | 200 | 0 | 0 | 0 | |
| 3 | Xdepart | 1000 | 0 | 0 | 0 | |
| 4 | Ydepart | 290 | 0 | 0 | 0 | |
| 5 | TerminalSpec | -200 | -100 | 800 | 80 | |
| 6 | TerminalLoc | 200 | 100 | 0 | 0 | |
| 7 | Tank_Size_TextColor | 16 | 0 | 0 | 0 | black |
| 8 | BerthSpec | -40 | -5 | 40 | 5 | |

*Figure 4-8 Animation parameters*

With this table some details of the animation can be adjusted:

- Location of the queues
- Tank sizes (and text colour)
- Station sizes

## 4.3 MOT arrival

There are 2 ways of creating MOT in the model:

***Historical arrivals***

Use historical arrival data of MOT. With an existing terminal, the easiest (and most validated) way to create MOT is by using historical arrivals.

| ID | HistID | MOT_type | Operation type | NrOfParcels | TotalCargo | ArrivalTime | prod1 | prod2 | prod3 | prod4 | prod5 | prod6 | prod7 | prod8 | prod9 | prod10 | size1 | size2 | size3 | size4 | size5 | size6 | size7 | size8 | size9 | size10 | tank1 | tank2 | tank3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1001 | MOT1 | Import | 2 | 35000.0 | 1.0 | ProductA | ProductB | | | | | | | | | 20000.0 | 15000.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | T1 | T2 | |
| 2 | 1003 | MOT3 | Export | 1 | 2000.0 | 8.0 | ProductA | | | | | | | | | | 2000.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | T1 | | |
| 3 | 1004 | MOT3 | Export | 1 | 1000.0 | 16.0 | ProductB | | | | | | | | | | 1000.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | T2 | | |
| 4 | 1005 | MOT3 | Export | 1 | 1500.0 | 24.0 | ProductC | | | | | | | | | | 1500.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | T3 | | |
| 5 | 1006 | MOT3 | Export | 1 | 2000.0 | 32.0 | ProductA | | | | | | | | | | 2000.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | T1 | | |
| 6 | 1007 | MOT3 | Export | 1 | 1000.0 | 40.0 | ProductB | | | | | | | | | | 1000.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | T2 | | |
| 7 | 1008 | MOT3 | Export | 1 | 1500.0 | 48.0 | ProductC | | | | | | | | | | 1500.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | T3 | | |
| 8 | 1002 | MOT2 | Import | 3 | 10000.0 | 50.0 | ProductA | ProductB | productC | | | | | | | | 2500.0 | 5000.0 | 2500.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | T1 | T2 | T3 |
| 9 | 1009 | MOT3 | Export | 1 | 2000.0 | 56.0 | ProductA | | | | | | | | | | 2000.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | T1 | | |
| 10 | 1010 | MOT3 | Export | 1 | 1000.0 | 64.0 | ProductB | | | | | | | | | | 1000.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | T2 | | |
| 11 | 1011 | MOT3 | Export | 1 | 1500.0 | 72.0 | ProductC | | | | | | | | | | 1500.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | T3 | | |
| 12 | 1014 | MOT3 | Export | 1 | 2000.0 | 80.0 | ProductA | | | | | | | | | | 2000.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | T1 | | |
| 13 | 1015 | MOT3 | Export | 1 | 1904.0 | 88.0 | ProductB | | | | | | | | | | 1000.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | T2 | | |
| 14 | 1016 | MOT3 | Export | 1 | 1565.0 | 96.0 | ProductC | | | | | | | | | | 1500.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | T3 | | |
| 15 | 1017 | MOT3 | Export | 1 | 2000.0 | 104.0 | ProductA | | | | | | | | | | 2000.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | T1 | | |
| 16 | 1018 | MOT3 | Export | 1 | 1000.0 | 112.0 | ProductB | | | | | | | | | | 1000.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | T2 | | |
| 17 | 1019 | MOT3 | Export | 1 | 1500.0 | 120.0 | ProductC | | | | | | | | | | 1500.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | T3 | | |
| 18 | 1013 | MOT2 | Import | 3 | 10000.0 | 125.0 | ProductA | ProductB | productC | | | | | | | | 2500.0 | 5000.0 | 2500.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | T1 | T2 | T3 |
| 19 | 1020 | MOT3 | Export | 1 | 2000.0 | 128.0 | ProductA | | | | | | | | | | 2000.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | T1 | | |
| 20 | 1021 | MOT3 | Export | 1 | 1000.0 | 136.0 | ProductB | | | | | | | | | | 1000.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | T2 | | |
| 21 | 1022 | MOT3 | Export | 1 | 1500.0 | 144.0 | ProductC | | | | | | | | | | 1500.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | T3 | | |
| 22 | 1023 | MOT3 | Export | 1 | 2000.0 | 152.0 | ProductA | | | | | | | | | | 2000.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | T1 | | |
| 23 | 1024 | MOT3 | Export | 1 | 1000.0 | 160.0 | ProductB | | | | | | | | | | 1000.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | T2 | | |
| 24 | 1025 | MOT3 | Export | 1 | 1500.0 | 168.0 | ProductC | | | | | | | | | | 1500.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | T3 | | |

*Figure 4-9 Historical arrivals of MOT*

In the table with historical arrivals, each row represents a single MOT arriving at the terminal. Per MOT the following attributes are required:

- Historical ID: This is an arbitrary number to be able to track the MOT to historical arrivals (and not generated MOT)
- MOT type: this should be one of the types that are defined in under the General tab
- Operation type: export or import
- Number of parcels: an MOT may carry up to 10 parcels
- Total cargo: this should be the sum of the size of all the parcels
- Arrival time: the time that the MOT will arrive in the queue (buffer, anchorage). The MOT should be added in ascending order of arrival

- Product: the MOT can carry up to 10 parcels, the product per parcel can be any product (from the product table). (The number of parcels should comply to the number in the column with “Nr of parcels”, else an error will occur)
- Size: the MOT can carry up to 10 parcels, each with its own size. As parcel sizes are real numbers the model expects a number. So a zero has to be filled in when a parcel is not filled. (If not filled in an error will occur)
- Tank: each parcel belongs to a tank or tankgroup from the list with tanks. (If not filled in an error will occur)

***Generation of MOT***

MOT can be generated per MOT class.

| ID | mot_sp_ID | Customer | P_group | MOT_type | Op_type | High_prio | Min_q | ML_q | Max_q | Avg_q | Arr_Pattern | Shift_TBA | First_Arr | First_MOT_Day | NrOfParcels | TimeUnit1 | TimeUnit2 | TimeUnit3 | TimeUnit4 | TimeUnit5 | TimeUnit6 | TimeUnit7 | TimeUnit8 | TimeUnit9 | TimeUnit10 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1 | Toptar | Produc | MOT1 | 0 | 0.0 | 25000 | 30000 | 35000 | 30000 | 0.0 | 0.0 | 0.0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 2 | 2 | Toptar | Produc | MOT2 | 0 | 0.0 | 7500.( | 10000 | 12500 | 10000 | 0.0 | 0.0 | 0.0 | 0 | 1 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| 3 | 3 | Toptar | Produc | MOT3 | 0 | 0.0 | 1000.( | 2000.( | 3000.( | 2000 | 0.0 | 0.0 | 0.0 | 0 | 1 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 |
| 4 | 4 | Toptar | Produc | MOT4 | 0 | 0.0 | 400.0 | 500.0 | 600.0 | 500 | 0.0 | 0.0 | 0.0 | 0 | 1 | 11 | 11 | 11 | 11 | 11 | 11 | 11 | 11 | 11 | 11 |
| 5 | 5 | Toptar | Produc | MOT5 | 0 | 0.0 | 25.0 | 30.0 | 35.0 | 30 | 0.0 | 0.0 | 0.0 | 0 | 1 | 150 | 150 | 150 | 150 | 150 | 150 | 150 | 150 | 150 | 150 |
| 6 | 6 | Toptar | Produc | MOT1 | 0 | 0.0 | 25000 | 30000 | 35000 | 30000 | 0.0 | 0.0 | 0.0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 7 | 7 | Toptar | Produc | MOT2 | 0 | 0.0 | 7500.( | 10000 | 12500 | 10000 | 0.0 | 0.0 | 0.0 | 0 | 1 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| 8 | 8 | Toptar | Produc | MOT3 | 0 | 0.0 | 1000.( | 2000.( | 3000.( | 2000 | 0.0 | 0.0 | 0.0 | 0 | 1 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 |
| 9 | 9 | Toptar | Produc | MOT4 | 0 | 0.0 | 400.0 | 500.0 | 600.0 | 500 | 0.0 | 0.0 | 0.0 | 0 | 1 | 11 | 11 | 11 | 11 | 11 | 11 | 11 | 11 | 11 | 11 |
| 10 | 10 | Toptar | Produc | MOT5 | 0 | 0.0 | 25.0 | 30.0 | 35.0 | 30 | 0.0 | 0.0 | 0.0 | 0 | 1 | 150 | 150 | 150 | 150 | 150 | 150 | 150 | 150 | 150 | 150 |
| 11 | 11 | Toptar | Produc | MOT1 | 0 | 0.0 | 25000 | 30000 | 35000 | 30000 | 0.0 | 0.0 | 0.0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 12 | 12 | Toptar | Produc | MOT2 | 0 | 0.0 | 7500.( | 10000 | 12500 | 10000 | 0.0 | 0.0 | 0.0 | 0 | 1 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| 13 | 13 | Toptar | Produc | MOT3 | 0 | 0.0 | 1000.( | 2000.( | 3000.( | 2000 | 0.0 | 0.0 | 0.0 | 0 | 1 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 |
| 14 | 14 | Toptar | Produc | MOT4 | 0 | 0.0 | 400.0 | 500.0 | 600.0 | 500 | 0.0 | 0.0 | 0.0 | 0 | 1 | 11 | 11 | 11 | 11 | 11 | 11 | 11 | 11 | 11 | 11 |
| 15 | 15 | Toptar | Produc | MOT5 | 0 | 0.0 | 25.0 | 30.0 | 35.0 | 30 | 0.0 | 0.0 | 0.0 | 0 | 1 | 150 | 150 | 150 | 150 | 150 | 150 | 150 | 150 | 150 | 150 |

*Figure 4-10 Definition of MOT classes for generation*

In the table with MOT classes every row represents an MOT class. The first columns give the attributes per class. The last columns give the number of MOT’s that are generated per MOT class per time-unit. Each MOT has the following attributes:

- Mot_sp_ID: MOT single product ID: every class gets a unique ID to be able to track them afterwards
- Customer: could be any identifier. In this case this attribute is used to select a group of tanks that belong to the same customer. A tank is not a fixed attribute of the MOT class. Tanks will be selected randomly on the basis of product type, customer, parcel size and tank capacity
- MOT type: one of the types that has been defined under the general tab
- Operation type: export or import
- High priority: not used (yet). Could be used for scheduled arrivals
- Min_q, ML_q, Max_q, Avg_q: Input to a triangular distribution from which a cargo size is randomly drawn for each MOT that is generated within this class
- Arrival pattern, shift TBA, first arrival, first MOT day: not used (yet): Could be used to define regular and scheduled arrivals
- Number of parcels: If just 1 is selected, the model will define parcels according to tanksizes. If larger than 1, the model will make at least so many parcels.

- Timeunits: Periods in which the numbers per MOT class are generated. The duration of a timeunit can still be defined. Usually it chosen to represent a week or a month. (For example in timeunit1 11 of mot_sp_ID4 and 150 of mot_sp_ID5 will be generated). The MOT within a time unit receive an arrival time that is created through uniform distribution in between start and end time of the time unit

## 4.4 Infrastructure

Infrastructure is defined by filling in the tables for equipment and connections:


*Figure 4-11 Selection of tables for definition and connection of equipment*

Suppose we would like to model the PFD as in the following example:

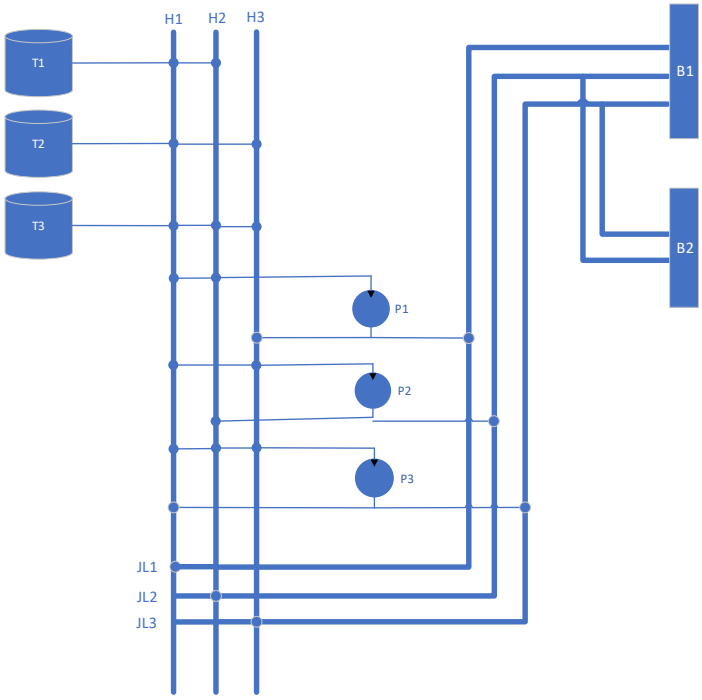



*Figure 4-12 An example of a simplified Process Flow Diagram (PFD) of a tank terminal*

First select all the line-up types that are used in the list with line-ups:

| ID | Line-up | yes/no |
|---|---|---|
| 1 | L+U:T>JL>B | no |
| 2 | L+U:T>H>P>JL>B | yes |
| 3 | L+U:T>H>P>H>JL>B | yes |
| 4 | L+U:T>H>P>H>CL>H>C | no |
| 5 | L+U:T>H>P>H>CL>JL>B | no |
| 6 | L+U:T>H>P>H>CL>CL>J | no |
| 7 | L+U:T>H>P>CL>H>Cl>Jl | no |
| 8 | L+U:T>H>P>CL>JL>B | no |
| 9 | L+U:T>H>P>CL>CL>JL> | no |
| 10 | U:B>JL>H>T | yes |
| 11 | U:B>JL>H>CL>H>T | no |
| 12 | U:B>JL>H>CL>CL>H>T | no |
| 13 | U:B>JL>CL>H>CL>H>T | no |
| 14 | U:B>JL>CL>H>T | no |
| 15 | U:B>JL>CL>CL>H>T | no |
| 16 | L+U:T>H>P>H>CL>H>Jl | no |
| 17 | L+U:T>H>P>CL>CL>H>J | no |
| 18 | L+U:T>H>P>CL>H>CL>H | no |
| 19 | L+U:T>H>P>H>T(>B) | no |
| 20 | L+U:T>H>P>H>CL>H>T | no |
| 21 | L+U:T>H>P>H>CL>P>H: | no |
| 22 | L+U:T>H>H>P>H>CL>C | no |
| 23 | L+U:T>H>H>P>H>H>T(: | no |

*Figure 4-13 Table for selection of line-ups*

In this case we have the following line-ups (T=tank, H=header, P=pump, :JL=jettyline, B=berth):

- T>H>P>H>JL>B (Load and unload)
- T>H>P>JL>B (Load and unload)
- B>JL>H>T (Unload)

So the following equipment should be defined: tank, header, pump, jettyline, berth.
In this example are defined: 3 tanks, 3 headers, 3 pumps, 3 jettylines and 2 stations (berths)
An example: definition of headers:

| ID | Name | Product | Flowrate | NrOfParcels | ChangeOverTime |
|---|---|---|---|---|---|
| 1 | H1 | AB | 3000.0 | 1 | 0.0 |
| 2 | H2 | BC | 3000.0 | 1 | 0.0 |
| 3 | H3 | ABC | 3000.0 | 1 | 0.0 |

*Figure 4-14 Table for the definition of Headers*

Headers have the following attributes:

- Name: A header should always have a name, format is free (however no spaces are allowed).
- Product: This is a dropdown menu with all products and product categories. If equipment is not dedicated to a product, a product category could be defined (see general) and selected
- Flowrate: every equipment has a certain maximum allowed flowrate or pumprate. The equipment with the lowest flowrate in the line-up determines the capacity of the route (line-up)
- Number of parcels: equipment could be used by several MOT's simultaneously (2 trucks from the same pipeline). This is the maximum number
- Change over time: This is the time that it takes to change the product of the equipment when the product attribute is a product category. The equipment in the line-up that has the longest change over time determines the change over time of the complete line up.

The following connections should be created: T-H, H-P, H-JL, P-JL, B-JL.

A connection between 2 types of equipment is created by entering a value at the crossing. For example the connections between tanks and headers are as follows in our example:

| H-T | T1 | T2 | T3 |
|---|---|---|---|
| H1 | 1 | 1 | 1 |
| H2 | 1 | 0 | 1 |
| H3 | 0 | 1 | 1 |

*Figure 4-15 Connection table between tanks and headers*

When a number is filled in and the table is submitted (sent to the database), the cell turns pink.

With the pump-header connection table, a 1 is the suction side of the pump, a 2 is the pressure side and a 3 can be both:

| H-P | P1 | P2 | P3 |
|---|---|---|---|
| H1 | 1 | 1 | 3 |
| H2 | 1 | 2 | 1 |
| H3 | 2 | 1 | 1 |

*Figure 4-16 Connection table between headers and pumps*

After filling in all the connection tables, the construction of the infrastructure could be checked by selecting “Check Infra”. 3 types of representation of the infrastructure can be selected, each with a different configuration. The different types of infrastructure have different colours (tanks: purple, stations: aquamarine, jettylines: pink, headers: olive, pumps: red):

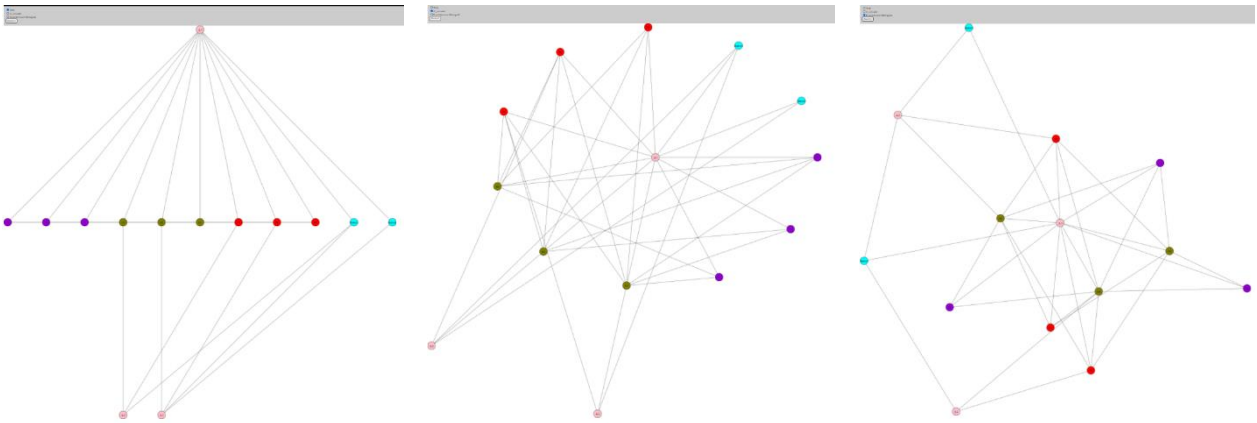


*Figure 4-17 Visualisation of the input for construction of the infrastructure*

# 5 Animation

The simulation may be supported by an animation of the concerning terminal. An animation makes checking of the model easier and it simplifies the explanation of the working of the model. Moreover it convinces people of the dynamics and reliability of the model.


*Figure 5-1 Stream animation, record video or neither (Simulation button).*

By selecting “Animation”, the animation is streamed while the model is running. A simple animation is automatically generated by setting the animation parameters mentioned in 0.
When “Record video” is selected, an MP4 file is generated that can be downloaded afterwards. It is advised to stream or record only for a short period (few minutes) as this process consumes much memory and slows down the run.

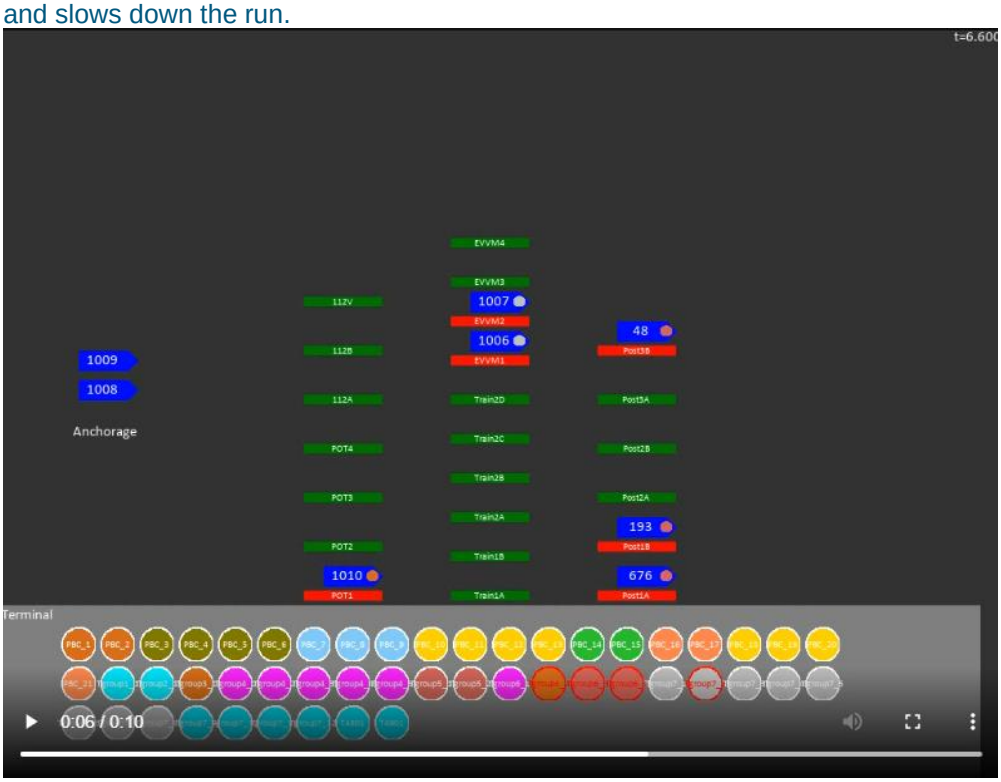



*Figure 5-2 Example of an animation of a run of a simulation model*

When only interested in the results of the simualtion, “None” should be selected as this is the fastest way to run the model. Only the progress of the run is visible as a percentage of the total duration.

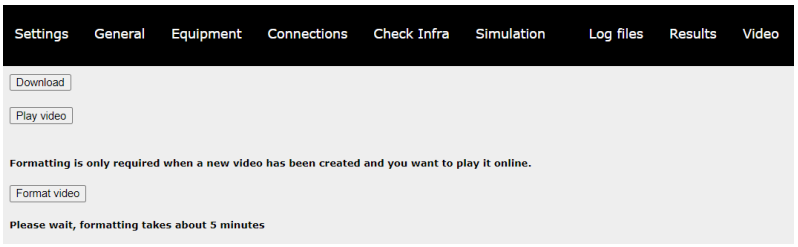



*Figure 5-3 Downloading, playing and formatting video of animation*

After recording the video can be downloaded with the menu that appears after selecting “Video” in the main menu.
If you would like to play the video online, the file should first be formatted. (Be patient, this takes some time). If formatted, the video can be played online with “Play video” button.
A video can be used to view stills of a certain situation. This is not possible when streaming the animation while running.

# 6 Results

Normally a run of the model represents a whole year of operation of the terminal. So the results are averages over one year.
The results, KPI's of the terminal, are usually presented in predefined tables and graphs, for example:

- Berth occupation: specified to any MOT attribute: vesselclass, productgroup, customer, etc.;
- MOT waiting time: specified to any MOT attribute or cause: non availability of berth, tank or infrastructure (pipelines, pumps etc.);
- Turnaround times of MOTs: same specification as waiting time;
- Equipment utilization rates: averages and level during the year;
- Tank levels: averages and level during the year;

The most important KPI to find bottlenecks in a terminal, to judge the performance of a terminal or to save investment costs during the design phase is the waiting time of MOT. Waiting time is caused by non-availability of equipment: berth, infrastructure (pipelines, pumps, headers, etc.) and tanks. Especially the waiting time for infrastructure should be paid attention to as this time can mostly be reduced by simple and inexpensive measures. In most times investment in an extra jetty can be postponed. (More examples of types of results are collected in the appendix)

The results of the simulation consist primarily of the log files. From these log files abovementioned management information can be retrieved. The following logfiles can be viewed or downloaded (as .csv files):

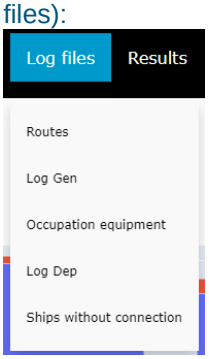



*Figure 6-1 View of the drop down menu with log files*

### *Routes*

| ID | Route_ID | Tank1 | Berth | Tank2 | Product | Flowrate1 | Flowrate2 | Eq1 | Eq2 | Eq3 | Eq4 | Eq5 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1 | T1 | Station1 | None | ProductA | 1500.0 | None | H1 | P2 | H3 | JL3 | None |
| 2 | 2 | T1 | Station2 | None | ProductA | 1500.0 | None | H1 | P2 | H3 | JL3 | None |
| 3 | 3 | T2 | Station1 | None | ProductB | 1500.0 | None | H1 | P1 | H2 | JL2 | None |
| 4 | 4 | T2 | Station2 | None | ProductB | 1500.0 | None | H1 | P1 | H2 | JL2 | None |
| 5 | 5 | T2 | Station1 | None | ProductB | 1500.0 | None | H3 | P3 | H2 | JL2 | None |
| 6 | 6 | T2 | Station2 | None | ProductB | 1500.0 | None | H3 | P3 | H2 | JL2 | None |
| 7 | 7 | T3 | Station1 | None | ProductC | 1500.0 | None | H2 | P3 | H3 | JL3 | None |
| 8 | 8 | T3 | Station2 | None | ProductC | 1500.0 | None | H2 | P3 | H3 | JL3 | None |
| 9 | 9 | T1 | Station1 | None | ProductA | 1000.0 | None | H1 | P1 | JL1 | None | None |
| 10 | 10 | T2 | Station1 | None | ProductB | 1000.0 | None | H1 | P1 | JL1 | None | None |
| 11 | 11 | T3 | Station1 | None | ProductC | 1500.0 | None | H2 | P3 | JL3 | None | None |
| 12 | 12 | T3 | Station2 | None | ProductC | 1500.0 | None | H2 | P3 | JL3 | None | None |
| 13 | 13 | T3 | Station1 | None | ProductC | 1500.0 | None | H3 | P3 | JL3 | None | None |
| 14 | 14 | T3 | Station2 | None | ProductC | 1500.0 | None | H3 | P3 | JL3 | None | None |
| 15 | 15 | T1 | Station1 | None | ProductA | 1000.0 | None | H1 | JL1 | None | None | None |
| 16 | 16 | T2 | Station1 | None | ProductB | 1000.0 | None | H1 | JL1 | None | None | None |
| 17 | 17 | T3 | Station1 | None | ProductC | 2000.0 | None | H3 | JL3 | None | None | None |
| 18 | 18 | T3 | Station2 | None | ProductC | 2000.0 | None | H3 | JL3 | None | None | None |

*Figure 6-2 Log file: route table (all possible line-ups on the terminal*

The route table contains all the routes that have been created before the run starts. Each route has the following attributes:

- Route_ID: unique number to identify the route
- Tank1, Tank2: A route always contains one tank (Tank1). If the route is meant for internal transfer, a second tank (Tank2) could be part of the route (not implemented yet)
- Berth: station, if the route is between a tank and a station
- Flowrate: this is the maximum nominal flowrate of the route, determined by the equipment in the route with the lowest flowrate (usually, pump or jettyline)
- Equipment: name of all the equipment in the route in between tank and station (or tank). This is now limited to 10 but can easily be increased, if required

If results are not according to expectations, this table will primarily be used to check if all intended routes have been produced by the model

### *Log Gen*

| ID | HistID/ClassNr | MOT_Type | MOT_Prate | T_Creation | T_Arrival | Product1 | Product2 | Product3 | Product4 | Product5 | Product6 | Product7 | Product8 | Product9 | Product10 | Size1 | Size2 | Size3 | Size4 | Size5 | Size6 | Size7 | Size8 | Size9 | Size10 | Tank1 | Tank2 | Tank3 | Tank4 | Tank5 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 101 | MOT1 | 3592.75 | 0.0 | 39.6 | ProductA | | | | | | | | | | 30425.52 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | T1 | | | | |
| 2 | 102 | MOT2 | 935.38 | 0.0 | 102.73 | ProductA | | | | | | | | | | 8462.46 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | T1 | | | | |
| 3 | 102 | MOT2 | 777.59 | 0.0 | 131.89 | ProductA | | | | | | | | | | 11026.87 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | T1 | | | | |
| 4 | 103 | MOT3 | 386.15 | 0.0 | 134.04 | ProductA | | | | | | | | | | 2203.37 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | T1 | | | | |
| 5 | 103 | MOT3 | 192.75 | 0.0 | 58.09 | ProductA | | | | | | | | | | 1956.85 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | T1 | | | | |
| 6 | 103 | MOT3 | 307.85 | 0.0 | 118.84 | ProductA | | | | | | | | | | 1898.04 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | T1 | | | | |
| 7 | 103 | MOT3 | 360.09 | 0.0 | 36.37 | ProductA | | | | | | | | | | 2163.6 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | T1 | | | | |
| 8 | 103 | MOT3 | 250.68 | 0.0 | 137.93 | ProductA | | | | | | | | | | 2119.02 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | T1 | | | | |
| 9 | 103 | MOT3 | 105.64 | 0.0 | 72.71 | ProductA | | | | | | | | | | 1972.77 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | T1 | | | | |
| 10 | 103 | MOT3 | 240.45 | 0.0 | 132.45 | ProductA | | | | | | | | | | 2076.49 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | T1 | | | | |
| 11 | 103 | MOT3 | 239.75 | 0.0 | 6.6 | ProductA | | | | | | | | | | 1986.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | T1 | | | | |
| 12 | 103 | MOT3 | 251.03 | 0.0 | 7.75 | ProductA | | | | | | | | | | 1534.15 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | T1 | | | | |
| 13 | 103 | MOT3 | 140.67 | 0.0 | 138.65 | ProductA | | | | | | | | | | 2873.54 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | T1 | | | | |
| 14 | 103 | MOT3 | 328.56 | 0.0 | 3.33 | ProductA | | | | | | | | | | 1253.67 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | T1 | | | | |
| 15 | 103 | MOT3 | 343.25 | 0.0 | 120.84 | ProductA | | | | | | | | | | 1549.82 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | T1 | | | | |
| 16 | 103 | MOT3 | 266.45 | 0.0 | 14.29 | ProductA | | | | | | | | | | 1189.95 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | T1 | | | | |
| 17 | 103 | MOT3 | 412.59 | 0.0 | 152.86 | ProductA | | | | | | | | | | 1642.82 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | T1 | | | | |
| 18 | 103 | MOT3 | 272.22 | 0.0 | 156.98 | ProductA | | | | | | | | | | 1905.51 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | T1 | | | | |
| 19 | 103 | MOT3 | 231.84 | 0.0 | 112.96 | ProductA | | | | | | | | | | 1068.32 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | T1 | | | | |
| 20 | 103 | MOT3 | 213.38 | 0.0 | 31.63 | ProductA | | | | | | | | | | 2163.73 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | T1 | | | | |
| 21 | 103 | MOT3 | 300.53 | 0.0 | 8.17 | ProductA | | | | | | | | | | 2165.99 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | T1 | | | | |

*Figure 6-3 Log file "Log Gen" a table with all generated MOT*

Log Gen is a log file with all generated MOT, both from historical data and generated from MOT classes. Every row represents the creation of an MOT. The order of MOT, is the order of generation. This will not necessarily be the order of arrival as the arrival time is generated uniformly within a time unit.

This file is used to assess if the input has been correct, if for example the number of MOT or the throughput in the output is lower than expected. Also can be checked what MOT were still busy in the model at the end of the run.

### *Log Dep*

| ID | Ship | Berth | T_Creation | T_Arrival | T_Sail | T_Berth | T_Start_P | T_End_P | T_Depart | WaitBerth | WaitInfra | WaitBI | WaitPlan |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 112 | 105 | Station2 | 0.0 | 0.1 | 0.1 | 0.13 | 0.13 | 0.59 | 0.59 | 0.0 | 0.0 | 0.0 | 0.0 |
| 226 | 110 | Station2 | 0.0 | 0.46 | 0.82 | 0.85 | 0.85 | 1.43 | 1.43 | 0.35 | 0.0 | 0.0 | 0.0 |
| 437 | 115 | Station2 | 0.0 | 0.93 | 1.66 | 1.69 | 1.69 | 2.25 | 2.25 | 0.72 | 0.0 | 0.0 | 0.0 |
| 427 | 115 | Station2 | 0.0 | 1.42 | 2.47 | 2.51 | 2.51 | 3.05 | 3.05 | 1.05 | 0.82 | 0.0 | 0.0 |
| 247 | 110 | Station2 | 0.0 | 1.65 | 3.27 | 3.31 | 3.31 | 4.01 | 4.01 | 1.63 | 0.8 | 0.0 | 0.0 |
| 44 | 105 | Station2 | 0.0 | 1.73 | 4.24 | 4.27 | 4.27 | 4.98 | 4.98 | 2.51 | 1.77 | 0.0 | 0.0 |
| 366 | 110 | Station2 | 0.0 | 1.76 | 5.2 | 5.24 | 5.24 | 5.78 | 5.78 | 3.44 | 2.73 | 0.0 | 0.0 |
| 129 | 105 | Station2 | 0.0 | 2.16 | 6.01 | 6.04 | 6.04 | 6.54 | 6.54 | 3.85 | 3.53 | 0.0 | 0.0 |
| 377 | 113 | Station1 | 0.0 | 0.79 | 0.79 | 1.04 | 1.04 | 10.26 | 10.26 | 0.0 | 0.0 | 0.0 | 0.0 |
| 383 | 113 | Station2 | 0.0 | 4.44 | 6.6 | 6.85 | 6.85 | 22.48 | 22.48 | 2.16 | 0.0 | 0.0 | 0.0 |
| 14 | 103 | Station2 | 0.0 | 3.33 | 22.49 | 22.74 | 22.74 | 34.31 | 34.31 | 3.28 | 0.0 | 0.0 | 15.89 |
| 556 | 1005 | Station2 | 0.0 | 24.0 | 28.34 | 34.56 | 36.56 | 41.13 | 41.13 | 2.87 | 4.34 | 0.0 | 0.0 |
| 553 | 1001 | Station1 | 0.0 | 1.0 | 10.01 | 10.76 | 13.76 | 43.82 | 43.82 | 9.01 | 0.0 | 0.0 | 0.0 |
| 149 | 105 | Station2 | 0.0 | 2.25 | 43.39 | 43.42 | 43.42 | 44.23 | 44.23 | 24.62 | 40.92 | 0.0 | 0.0 |
| 476 | 115 | Station2 | 0.0 | 2.88 | 44.46 | 44.49 | 44.49 | 45.1 | 45.1 | 25.05 | 16.91 | 0.0 | 0.0 |
| 329 | 110 | Station2 | 0.0 | 3.32 | 45.32 | 45.36 | 45.36 | 45.86 | 45.86 | 25.48 | 40.07 | 0.0 | 0.0 |
| 404 | 115 | Station2 | 0.0 | 3.37 | 46.09 | 46.12 | 46.12 | 46.58 | 46.58 | 26.2 | 16.52 | 0.0 | 0.0 |
| 97 | 105 | Station2 | 0.0 | 4.12 | 46.81 | 46.84 | 46.84 | 47.35 | 47.35 | 26.17 | 39.15 | 0.0 | 0.0 |
| 52 | 105 | Station2 | 0.0 | 4.17 | 47.58 | 47.61 | 47.61 | 48.37 | 48.37 | 26.89 | 39.15 | 0.0 | 0.0 |
| 318 | 110 | Station2 | 0.0 | 4.28 | 48.59 | 48.63 | 48.63 | 49.39 | 49.39 | 27.8 | 39.11 | 0.0 | 0.0 |

*Figure 6-4 Log file: "Log Dep", a table with all MOT that have completed their processes*

The Log Dep is a log file containing all departures of MOT. Each row represents an MOT that has completed its process at the terminal. This is probably the table that is mostly used to produce management information on the KPI's of the terminal. From each MOT the following data is presented:

- ID: unique ID of the MOT that is also used in other tables (makes cross reference possible)
- Ship: ID that represents the historical ID from the historical arrivals or the mot_sp_gen_Id from the MOT classes that have been generated
- Berth: the station where the MOT has been (un)loaded
- T_creation: the creation time in the model, not necessarily the arrival time
- T_arrival: the arrival time (in hours) of the MOT in the queue (anchorage)
- T_sail: the time that the MOT starts travelling from the queue to the station. The time between T_arrival and T_sail represents the most important KPI of the terminal: the total waiting time of the MOT
- T_Berth: the time that the MOT arrives at the station. T_Berth-T_Sail should equal the transit time from the input
- T_Start_P: the time that (un)loading of the MOT starts. T_Start_P-T_Berth is dependent on the pre-loading time (from input), flushing time (if required) and planning mistakes (equipment may still be occupied by other MOT, unplanned).
- T_End_P: the time that (un)loading of the MOT ends. T_End_P – T_Start_P is called the pumping time and is dependent on: number of parcels, parcel sizes, simultaneous loading of parcels, waiting for equipment to be available in between (un)loading of parcels and flowrates.
- T_Depart: the time that the MOT leaves the station: T_Depart – T_End_P is only determined by the input parameter "post loading delay", which is fixed per MOT type and product
- WaitBerth: the total time that an MOT has been waiting for a berth. Normally an MOT has the possibility to reach its tanks through different stations. If all these stations are occupied, the MOT is waiting for a berth

- WaitInfra: the total time that an MOT has been waiting for infrastructure. Normally an MOT has the possibility to reach its tanks via several routes (regardless of station). If all these routes are occupied, the MOT is waiting for infrastructure
- WaitBI: the time that an MOT has been waiting for a wrong combination of availablity of station and route. Infrastructure may have been available but at an occupied station and vice versa.
- WaitPlan: the time that an MOT has been waiting until its planned station with infrastructure is available. A berth with suitable infrastructure may have been available but the planning module has scheduled the MOT to another (better) combination of station and infrastructure. (Because of quicker turnaround time or changed availability of resources)

### *Occupation equipment*

| ID | Ship | Equipment | OccuStart | OccuEnd |
|---|---|---|---|---|
| 1 | 112 | T2 | 0.13 | 0.59 |
| 2 | 112 | H1 | 0.13 | 0.59 |
| 3 | 112 | P1 | 0.13 | 0.59 |
| 4 | 112 | H2 | 0.13 | 0.59 |
| 5 | 112 | JL2 | 0.13 | 0.59 |
| 6 | 112 | Station2 | 0.13 | 0.59 |
| 7 | 226 | T2 | 0.85 | 1.43 |
| 8 | 226 | H1 | 0.85 | 1.43 |
| 9 | 226 | P1 | 0.85 | 1.43 |
| 10 | 226 | H2 | 0.85 | 1.43 |
| 11 | 226 | JL2 | 0.85 | 1.43 |
| 12 | 226 | Station2 | 0.85 | 1.43 |
| 13 | 437 | T3 | 1.69 | 2.25 |
| 14 | 437 | H3 | 1.69 | 2.25 |
| 15 | 437 | P3 | 1.69 | 2.25 |
| 16 | 437 | JL3 | 1.69 | 2.25 |
| 17 | 437 | Station2 | 1.69 | 2.25 |
| 18 | 427 | T3 | 2.51 | 3.05 |
| 19 | 427 | H2 | 2.51 | 3.05 |
| 20 | 427 | P3 | 2.51 | 3.05 |
| 21 | 427 | H3 | 2.51 | 3.05 |
| 22 | 427 | JL3 | 2.51 | 3.05 |
| 23 | 427 | Station2 | 2.51 | 3.05 |
| 24 | 247 | T2 | 3.31 | 4.01 |
| 25 | 247 | H1 | 3.31 | 4.01 |
| 26 | 247 | P1 | 3.31 | 4.01 |
| 27 | 247 | H2 | 3.31 | 4.01 |
| 28 | 247 | JL2 | 3.31 | 4.01 |
| 29 | 247 | Station2 | 3.31 | 4.01 |

*Figure 6-5 Log file Occupation equipment:, table with timestamps of occupation of equipment*

The log file with the occupation of equipment gives occupation data of the equipment during the run. Each row in the table represents an occupation period of one piece of equipment. The following data are tracked:

- Ship: the MOT that has occupied this equipemnt in thos period. If the equipment is occupied due to flushing, both the ship's ID and "flushing" is mentioned
- Equipment: the name of the equipment that has been occupied
- OccuStart: the time that the occupation of the equipment has started
- OccuEnd: the time that the occupation of the equipment ended

This table is mostly used to determine the occupancy rates per equipment. In combination with the waiting time for infrastructure, this parameter will give directions for determining bottlenecks in equipment.

### *Ships without connection*

| ID | Ship | Berth | T_Creation | T_Arrival | T_Now |
|---|---|---|---|---|---|

*Figure 6-6 Log file, ships without connection (empty in this example)*

It may occur that MOT arrive that cannot find a connection. Just to be able to trace the ship, the following attributes are recorded:

- ID: MOT ID, could be checked with Log Gen file
- Ship: MOT class ID from generation file or historical ID
- Berth: station is not filled in (as no connection was found)
- T_Creation: time that the MOT was created
- T_Arrival: time that the MOT was planned to arrived in the queue (anchorage)
- T_now: time that the model discvored that the MOT has no connection

Examples when this situation may occur:

- MOT has different parcels that cannot be loaded at the same station
- Tank definition has a different product than in historical data (in reality tanks may change product, while in the model this should not occur).
- Mistakes in infrastructure connection tables
- Mistakes in product dedication of equipment definition tables

This table helps to find mistakes in the input of the model

***Graphs***

Pushing the “Results” button will result in overview of the most used graphs to view the status of the terminal:


*Figure 6-7 Results: standard graphs that represent the status of the terminal with this scenario*

If required the number of standard views can easily be expanded. At this moment the following graphs are presented:

- Waiting time: the average waiting time per MOT type
- Occupancy rate: the occupancy rate (fysical occupation/total duration, 1=100%) of the station divided in pumping time and idle time

- Occupancy rate: the occupancy rate per station and per MOT
- Waiting time per station and per MOT

Waiting time and occupancy graphs with breakdown to products could be one of the additional graphs.

(By the way, just to be sure that something is visible the example was set up in such a way that results are (unrealistic) large unrealistic waiting times)

# 7 Required information

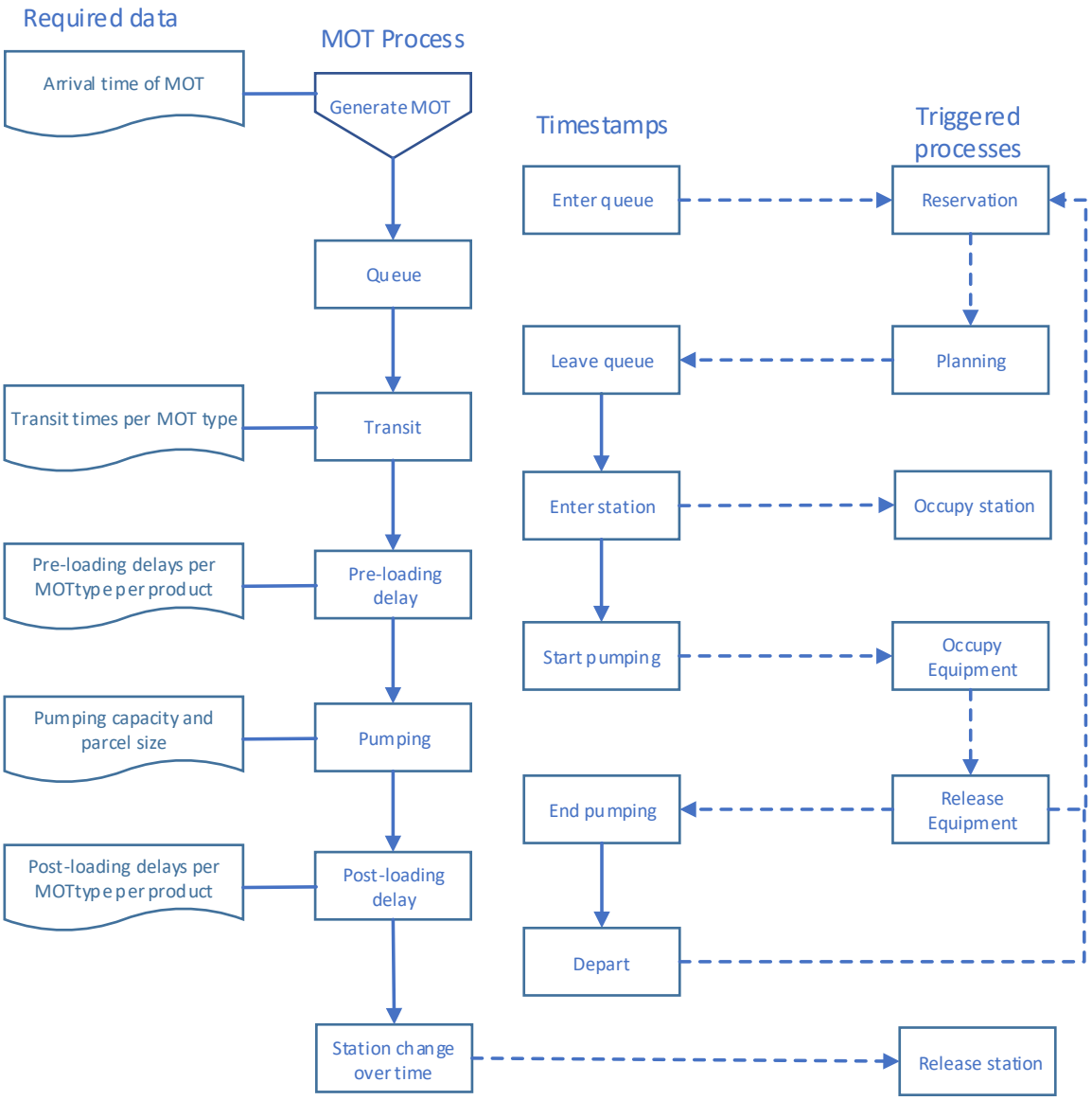
To be able to make a model of a terminal the following information should be available at minimum:

- A PFD of the terminal;
- Tanks with volumes, type of product and customer (if results are required per customer);
- Type of MOT: frequency, product, customer, size.
- Historical arrival data of MOT (if available, to be able to validate the model)

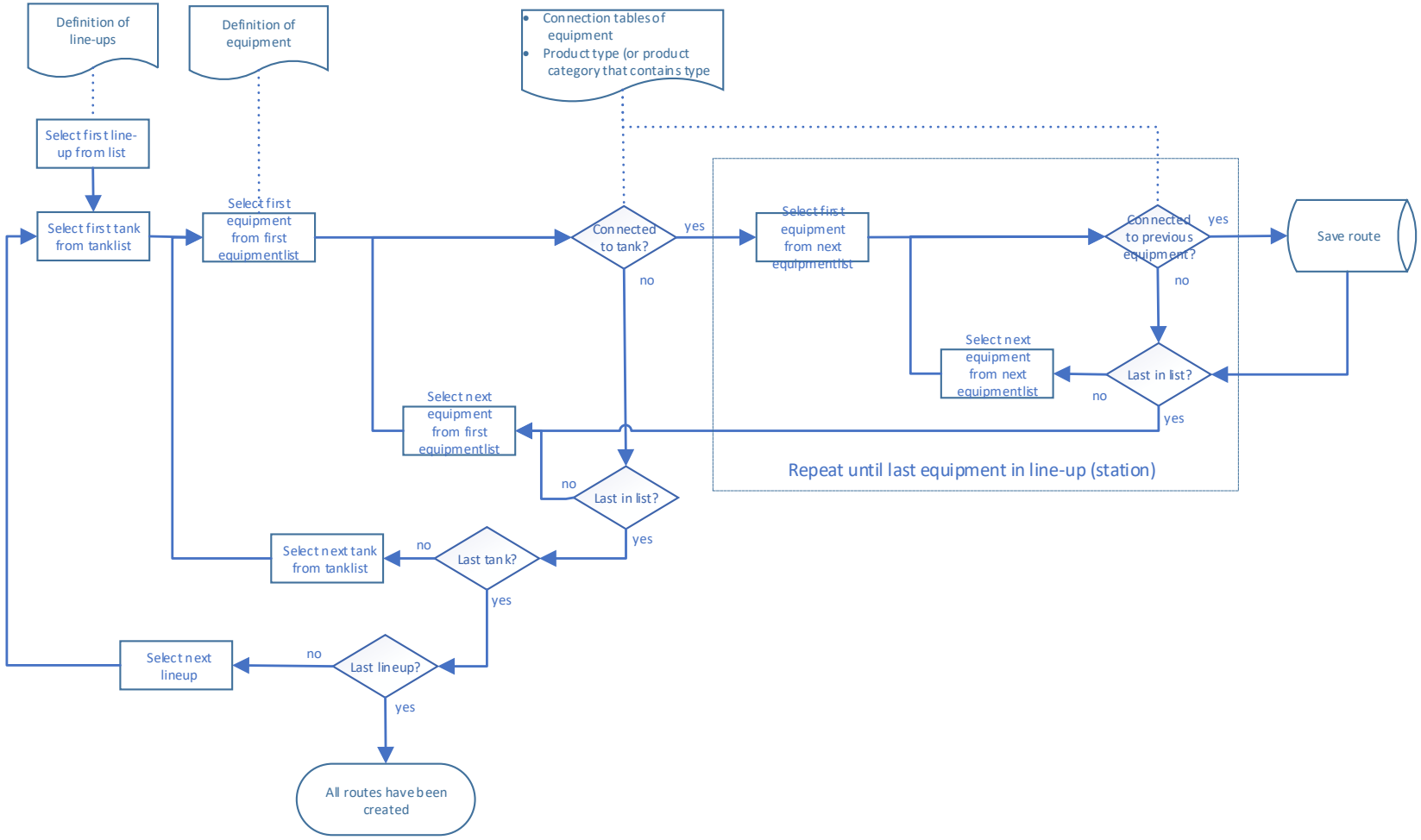
Other useful information may be:

- Weather information;
- Channel occupation;
- Idle times of vessels

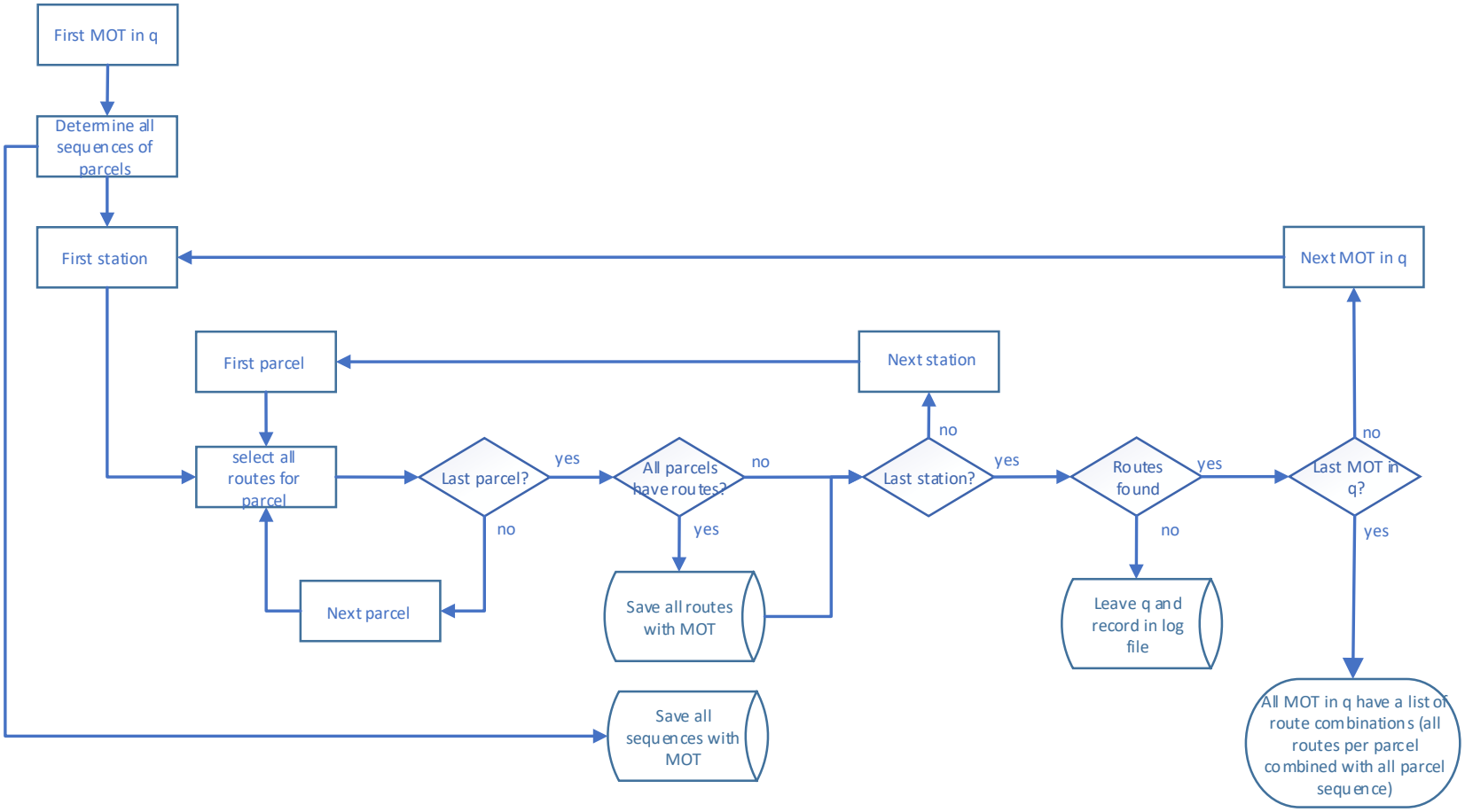
# A1 MOT process



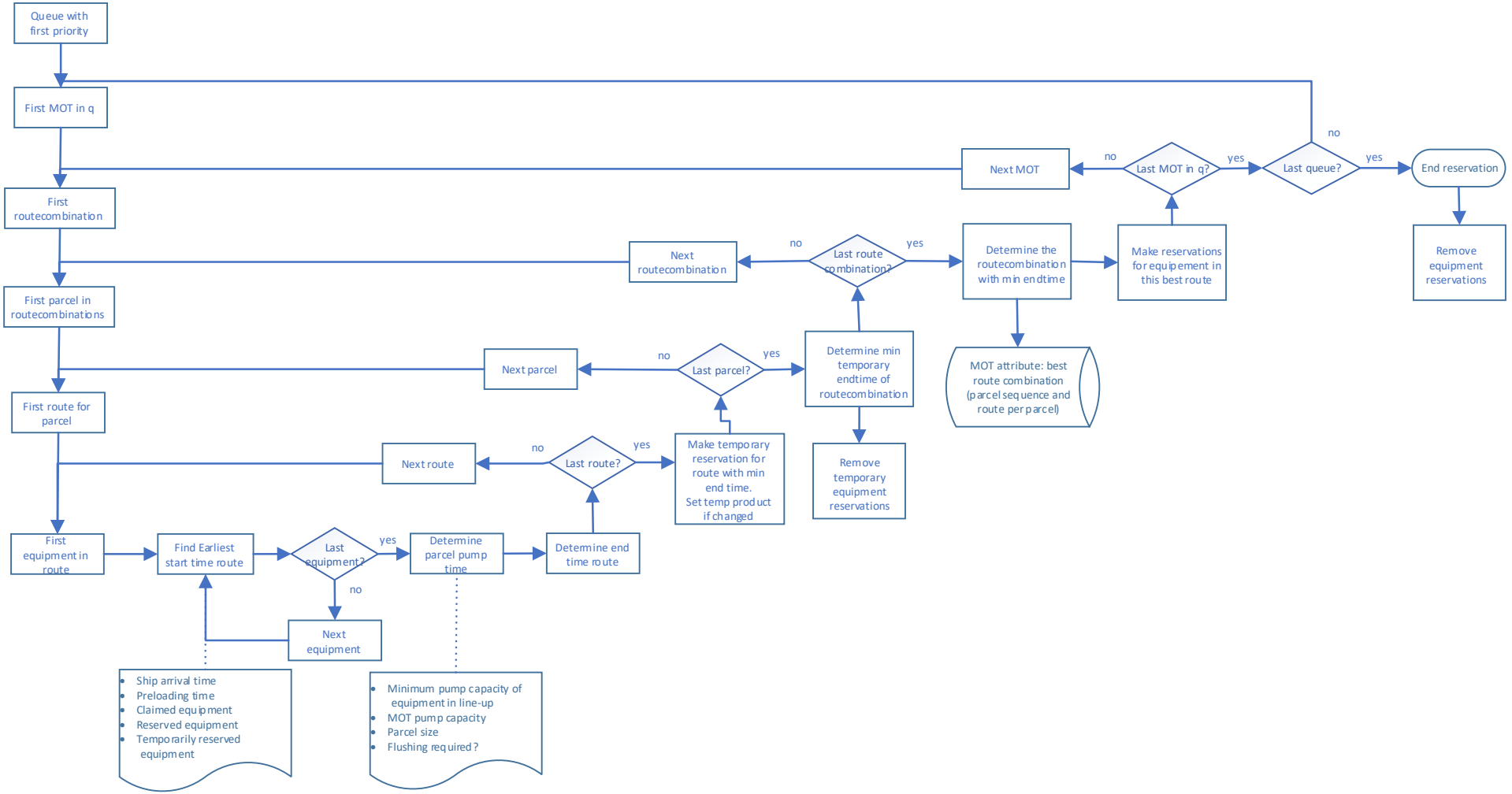
# A2 Build infrastructure



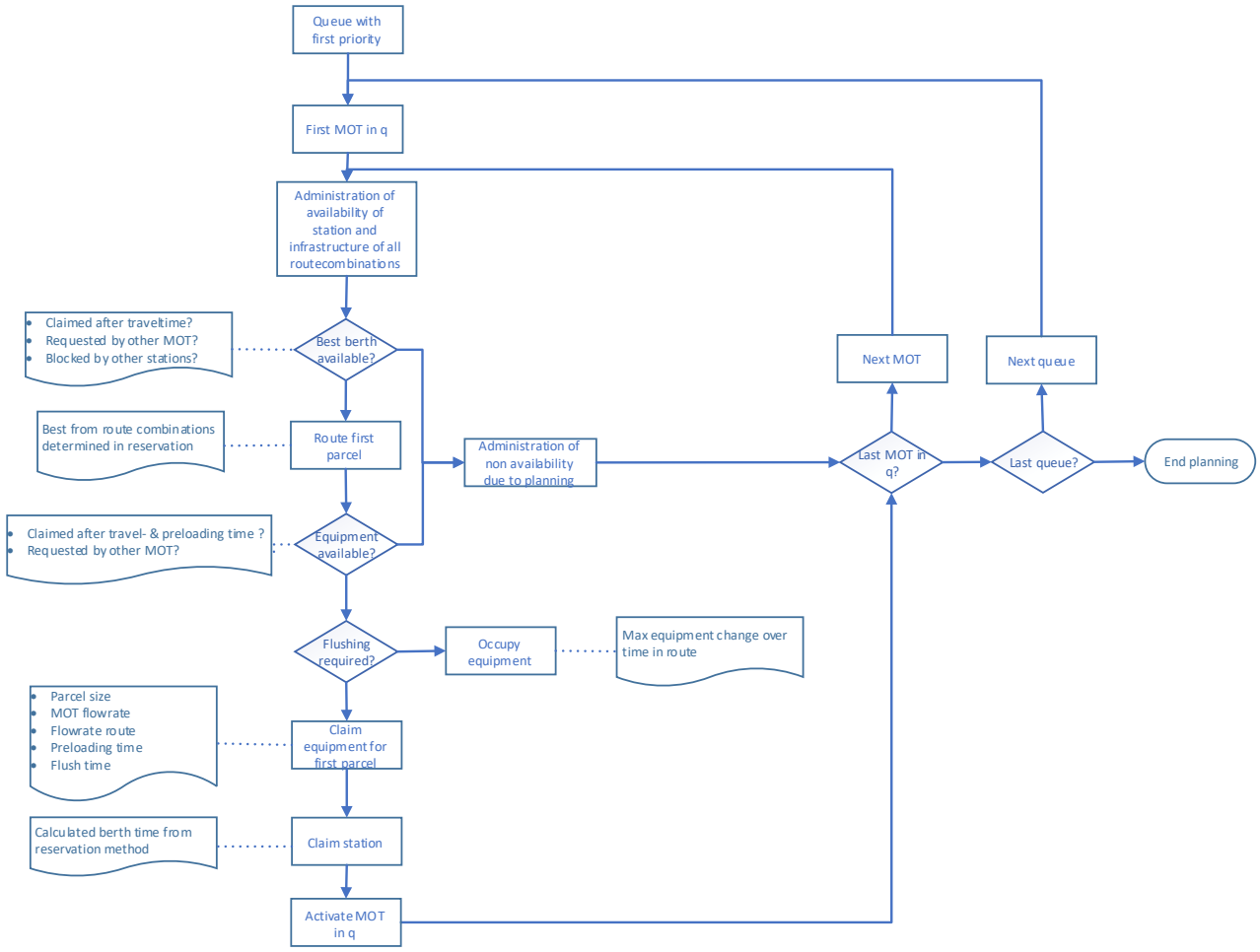
# A3 Reservation: find all route combinations



# A4 Reservation: find best route for MOT



# A5 Planning


Queue with first priority
First MOT in q
Administration of availability of station and infrastructure of all routecombinations
Claimed after traveltime?
Requested by other MOT?
Blocked by other stations?
Best berth available?
Best from route combinations determined in reservation
Route first parcel
Administration of non availability due to planning
Next MOT
Next queue
Last MOT in q?
Last queue?
End planning
Claimed after travel- & preloading time ?
Requested by other MOT?
Equipment available?
Flushing required?
Occupy equipment
Max equipment change over time in route
Parcel size
MOT flowrate
Flowrate route
Preloading time
Flush time
Claim equipment for first parcel
Calculated berth time from reservation method
Claim station
Activate MOT in q

# A6 Occupy & Release