Modelling of Voltri Terminal Europe in Genoa Using System Dynamic Model Simulation

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Abstract: The Voltri Terminal Europe is one of the more important terminal of the Mediterranean Sea, having a strategic position in Europe and a good operational efficiency. The terminal has been modelled using Systems Dynamics in order to provide a way of integrating ERP and Data Mining into a Decision Cockpit.

Keywords: Systems Dynamics, Logistics, ERP, Decision Cockpit

1. Introduction
The Voltri Terminal Europe - V.T.E. is the greatest terminal containers of the Port of Genoa and one more efficient than the Mediterranean Sea, with a present ability of 1,5 million annual TEU’s (Figure 1).

It is characterised by a good operational efficiency, immediate berthing, fast vessel turnaround time and fast gate clearance, (less than an hour for a complete cycle including documentation, discharging of export and loading of import).

The VTE has an internal security service which controls the terminal 24 hours a day. A control room, manned 24h by the terminal security staff, assures the surveillance of the whole territory. Genoa port authority has fixed strict procedures to grant permissions to enter the port area after VTE approval. VTE directly issues daily permissions. All internal staff is identified by a personal badge. Each container arriving at the terminal is subject to a strict control of the documentation. In addition an accurate seal check is performed. A scanner provided by Italian Customs, which allows the X-ray inspection of the containers, is available at the terminal.

Several inspections of the goods in the containers are performed at the terminal on a random basis. VTE offer following services:

- Two controls per day are scheduled.
- VTE operators use radio data terminals which are constantly connected to the central data base.
- VTE operators regularly input temperature values and every possible anomaly they may find, by using special codes, notes, etc. Those data are stored into the central database for each container.
- Companies are requested to define procedures to manage anomalies. Usually the information is forwarded to the company and to a reefer maintenance worker entrusted by the company itself.
- VTE does not supply any repair service but only a service of control and first level diagnosis. In case of emergency small repairs on electrical components can be carried out as well (cables, etc).
- Import containers can be subject to sanitary controls by direct inspections. In such case, containers are moved to the sanitary inspection area within the terminal.

VTE has extensive shipping connections (Figure 2) with all world regions (Far East, Middle East, North, Central/South America) and dedicated direct road and rail connections provide the access to an excellent inland transportation network. It ha also over 30 shipping companies as customers.
As it has already been said, thanks to his geographical location, the VTE has great railway network connections (Figure 3) with the biggest European customers, that means fast and save cargo transportations to European countries. Many European countries use this type of transportation from VTE. For example, to Germany and to northern European countries there are 20 trains per day.

Figure 3: Railway connections

VTE offers also another type of delivery, by trucks (Figure 4). Main south European markets are linked within a maximum of 2 days trips.

Figure 4: Road connections

2. Container Terminal Modelling

The Voltri Terminal Europe has 3 berths, it means that maximum 3 vessels can be served at once. So, when a container vessel arrives, the pilot boat pulls vessel into the berth where several quay cranes discharge it. They pick up containers from ship bays and put it down to loading/unloading trucks, which transferred it to the container yard. At container yard there are working gantry cranes, which place containers into blocks in a container yard by picking them up from loading/unloading trucks. If it is necessary to re-arranging containers in container yard to minimize delivering operations, marshalling trucks are used. After discharging, containers wait until they are carried on a train, external truck or another vessel, or go to custom inspection on import. The same procedure happens vice versa, when container arrives with external transport and continue transportation by vessel.

The model takes care of the number of cranes which will make unloading/discharging work and the manpower who works on cranes. It will influence on productivity of unloading/discharging operations: the other terminal operations will have the same coefficient of productivity Figure 5 represent scheme of container terminal and Table 1 displays technical data of it.

Figure 5: Scheme of VTE

Terminal operating time is 363 days/year, 24 h / 24 h (with the exception of December 25th and May 1st). There is 4 daily shifts of 6 hours each:

- 1st shift 06:00 - 12:00
- 2nd shift 12:00 - 18:00
- 3rd shift 18:00 - 24:00
- 4th shift 00:00 - 06:00
<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
<th>Technical data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total area</td>
<td>The borrowed area of VTE container terminal</td>
<td>900,000 sqm</td>
</tr>
<tr>
<td>Berths</td>
<td>Berths for coming vessels, on which vessels loading/discharging operations occur</td>
<td>3 berths with general length 1400 m.</td>
</tr>
<tr>
<td>Quay cranes</td>
<td>Cranes which are responsible for loading/ discharging of vessels.</td>
<td>8 cranes with 40 to 50 tons lift capacity</td>
</tr>
<tr>
<td>Container yard</td>
<td>Place for containers. One part of yard is intended to export containers, they are received by overland routes and are loaded into container vessels, after which they begin their voyage by sea. Other part of container yard is intended for import containers, which are transmitted by container vessel and are delivered to customer by land with trucks or railway.</td>
<td>12 rows and 5 columns of place</td>
</tr>
<tr>
<td>Yard gantry cranes(RTG)</td>
<td>Yard gantry cranes place containers into blocks in a container yard.</td>
<td>23 cranes with lifting capacity from 35 to 45 tons</td>
</tr>
<tr>
<td>Rail gantry cranes(RMG)</td>
<td>Rail gantry cranes for rail operations</td>
<td>3 cranes with lifting capacity from 35 to 45 tons</td>
</tr>
<tr>
<td>Loading/ discharging trucks</td>
<td>Truck which move containers from berth to container yard and vice versa. Quay cranes pick up containers from ship bays and load them onto trucks.</td>
<td>8 loading/unloading trucks x 700 m</td>
</tr>
<tr>
<td>Marshalling trucks</td>
<td>Trucks which are engaged with arranging containers in a container yard to minimize re-handling in loading and delivery operations</td>
<td>4 marshalling trucks x 500 m</td>
</tr>
<tr>
<td>Trucks</td>
<td></td>
<td>8 trucks + 2 truck lanes, lift capacity 45 t</td>
</tr>
<tr>
<td>Road Gate</td>
<td>Through the Road Gate arrive external trucks, which are be able to deliver container to customer.</td>
<td>Road gate intended from 12 computer assisted lanes. It’s capacity over 2000 trucks per day.</td>
</tr>
<tr>
<td>Rail Gate</td>
<td>Through the Rail Gate arrive trains, which are being able to deliver container to customer by railway.</td>
<td>Present max capacity: 120 trains per week</td>
</tr>
</tbody>
</table>

### Table 1: Technical data of VTE

Rail operations include:
- Opening of railway gate and interchange station (Voltri Mare): from Monday 06:00 to Sunday 6:00.
- Working gangs for loading / discharge of trains operate 24h / 24h.
- Max Length of operated trains: 550 meters.
- Present max capacity: 120 trains per week.
- Dangerous goods accepted (if already containerized)

- High Cube containers accepted (on dedicated link via Voltri- Borzoli-Ovada also on normal wagons)

Road Gate opening time:
- From 6:00 to 22:00 - Monday-Friday
- From 6:00 to 14:00 Saturday
- Sunday and national holidays: closed
3. Simulation Model Description

The dynamic model is constructed with Powersim Studio 7 Express, which allows to build advanced dynamic simulation models of system. Powersim Studio has several features to help quick and efficient work while creating simulation models. When creating simulations in Studio users have different needs than when running and experimenting with simulations. Studio therefore offers an option of switching between Design and User mode. Model consists of flows, levels, rates and constants.

Model of container terminal can be divided on 3 common parts. One part is responsible for container ship coming and connected with it mooring and unloading procedures. First part (Figure 6) can be divided also for 2 sections, on mooring and unloading sections.

In the first part of model there are 3 levels: ‘Ships’, ‘Moored Ships’ and ‘Container Yard’. These levels types are reservoir (cannot be depleted below zero). In ‘Ships’ level is accumulated the number of incoming ships. The incoming ships, how was written before, are moored and the number of moored ships is accumulated in the ‘Moored Ships’ level. ‘Container Yard’ level count the number of incoming and outgoing containers.

Constant ‘Ship Coming Coefficient’ content the number of incoming ship per day. It’s connected with the auxiliary ‘Coming Ships’. Since it is not possible to know beforehand the exact number of ships coming in a particular day, in the rate ‘Coming Ships’ the function EXPRND(‘Ship Coming Coefficient’) is used. This function generates random numbers that are exponentially distributed with a mean value of constant ‘Ship Coming Coefficient’. So in a simulation period every day different number of ships will come.

![Figure 6: Mooring and Unloading parts of the model](image-url)
Constants ‘Boats’ and ‘Pilots’ content number of boats and pilots. Pilots function is to pull ship into the berth by boat. In auxiliary ‘Staff’ is used a formula, which defines the availability of mooring staff considering that for one boat is necessary two pilots. Constant ‘MooringBoat’ is the number of ships that can be served by the mooring staff per day. So, general mooring productivity is in auxiliary ‘Mooring Productivity’, that is obtained multiplying the available number of mooring staff by the mooring staff productivity. Auxiliary ‘Mooring Productivity’ is connected with rate ‘Mooring Ships’, where coming ships from level ‘Ships’ pass in the status of ‘Moored Ships’ with speed defined in Auxiliary ‘Mooring Productivity’. The second section is dedicated to unloading procedures. Common conditions of unloading are described by berths number, which define how many ships can be served in the same time and that number is stored in constant ‘Berths’. The other important condition is the available number of quay (total and per berth): those numbers are stored in constants ‘Quay Cranes’ and ‘QuayCranesBerths’. Quay cranes can’t work by themselves, so it is necessary have human resources who control the quay cranes. That number is stored in constant ‘Human Resources’. Three factors: number of quay cranes, human resources and necessary number of human resource to one quay cranes define the unloading staff (auxiliary ‘UnloadingStaff’). The next step is to define in constant ‘UnloadingCranes’ the quay crane productivity, in other words, how many containers can unload one quay crane in the time unit. So, the general possible unloading productivity is in auxiliary ‘Unloading Productivity’ and it is equal with available unloading staff multiplied with one crane unloading productivity. Quay cranes unload containers from ship, so, it is necessary to know how much containers are in ship. It’s average value stored in constant ‘AvgTEUShips’. Final coming containers are calculated in auxiliary ‘NumContainers’, as the moored ships multiplied by the average number TEU per ship.

On Figure 7 the second and the third parts of divided model are shown, and they are responsible for trains and trucks coming and loading.
A separate flow is created for trains incoming, where in rate ‘ArrivingTrain’ it is defined the time shifts when empty trains arrive and a quantity of arriving trains per hour. The number of arrived trains is accumulated in level ‘EmptyTrain’. In auxiliary ‘TrainTEU’ counted containers the quantity of arrived trains by multiplying number of arrived trains from level ‘EmptyTrains’ with average number of containers per one ship from constant ‘AvgTEUTrain’. So, in auxiliary ‘TrainTEU’ there is the number of necessary containers, that have to be taken from container yard. Now there is the need to define loading productivity. For that the available number of rail cranes, human resources and productivity of one rail crane per hour are requested. All that data are stored in constants ‘RMG’, ‘HR’, and ‘LoadingRMG’. General loading productivity is in auxiliary ‘Loading productivity’: it is null if there are no train arriving, and it is equal to the real productivity if it is smaller than maximal loading productivity, or to this one if it is bigger (maximal productivity is the available loading staff multiplied with one rail crane productivity). Rate ‘Loading to Train’ is connected with level ‘ContainerYard’ and with auxiliaries ‘TrainTEU’, ‘Loading productivity’. Its task is to take off containers of container yard. So, that way happens loading to train procedure.

Truck loading scheme is similar with train loading scheme. Difference is in the logic of arrival. In auxiliary ‘RandomNum’ is used random function. The random function generates a series of random numbers that are distributed according to the uniform distribution, with a minimum value of min, and a maximum value of max. It’s mean that every day will arrive different number of trucks in interval between of defined min and max number.

4. Conclusions

This study illustrates the effectiveness of the application of Systems Dynamics in treating complex decision making problems where a strict interaction with ERP and Data Warehouse can play a crucial role.

More the proposed approach can be regarded as a practical application of the Business Performance Management paradigm that will represent the upcoming evolution of the more recent ERP Systems, especially in the field of maritime applications. The resulting computer models were then tested using computer simulation to see if the hypothesized model structure produced the same type of behavior observed in reality, this experimental gave interesting results of great fidelity.

5. Acknowledgments

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6. References


