SCHOOL OF MECHANICAL, INDUSTRIAL & AERONAUTICAL ENGINEERING

UNIVERSITY OF THE WITWATERSRAND JOHANNESBURG

BUSE 7005 RESEARCH REPORT

Topic: Development of a Simulation Model of a Company X Shunting yard.

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Due Date: 26 March 2015

Declaration

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INDIVIDUAL DECLARATION WITH TASK SUBMITTED FOR ASSESSMENT

I **Aphane, A. Thabiso (427579)**) am registered for Course No: **BUSE 7005** in the year 20**14**. I herewith submit the following task, "**Development of a Simulation Model of the Town Y Company X Shunting yard.**" in partial fulfillment of the requirements of the above course.

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Abstract

It was realised that there are inefficiencies at Company X’s plant K shunting yard; service time was long and the idling time of the locomotives was long. Locomotives can be utilised for other purposes in the plant. This has implication in resource planning and productivity in the company.

The study deals with the simulation of the Company X rail network in plant K. The focus is on how shunting and product transportation takes place. A background on the study is given, taking into consideration elements which have been included in the study. These include the locomotives and the Block Train Rail Tanker Cars (RTCs). These containers transport different products from Town L to Town M. The study focuses on the transportation of five products. The study also includes the domestic and international Product E trains arriving at the Product E loading and offloading zone. Simulation model which represents the current-state situation was developed, using SIMIO software package. The study examined how service speed during the process of loading and offloading of products in the plant can be improved. The study also focused on locomotives travelling speed and idling time. Conclusions and recommendations have been made on the model developed. The results obtained were also discussed and analysed.

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Definitions of terms

Table 1: Definition of terms

SIMIO:	Statistical software package used to simulate.
Block Train:	Rail Tanker Cars or wagons which carry Company X Products from Town M to Town L.
Product E Trains:	Trains transporting Product E from Company X mine for export purposes.
RTCs:	Rail tanker cars or wagons used to carry products.
Shunting yard 1	Site where the Transnet Freight Rail (TFR) and Company X TRCs are exchanged.
Single line	A line used by Company X Block Train as well as international and local Product E trains.
TFR	Transnet Freight Rail are Transnet locomotives transporting products to Company X.
SARS	South African Revenue Services – tax collection.
Shunting yard 3	An exchange yard in the primary area where shunting occurs.
Product A	One of the products Company X produces.
Product B	One of the products Company X produces.
Product C	One of the products Company X produces.
Product A Loading and off loading zone	The site where Product A is loaded.
Product B and Product C loading and Off-loading zone	The site where Products B and C are loaded and offloaded.
Company X Town M Plant	The Company X production site in Town M.
Company X locomotives	Locomotives owned and used by Company X to transport products between exchange yard 1 to Shunting yard 3 and to the different loading and off loading zones in the Company X plant.
Transnet Locomotives	Transnet locomotives owned and used by Transnet to

	transport the Block Train, domestic Product E trains and international Product E trains from different sites.
SPC	Senior Process Controllers controlling trains as per schedules entering and leaving Company X plant.
Product E	One of the products produced at Company X.
Car puller	A small car used in the loading and offloading zones to place the RTCs or wagons between tanks after the locomotives have dropped off the RTCs.
Pre Admin	Administration done before loading and off-loading of products in the loading zones.
Export Product E Trains	International Product E trains transporting Product E from other countries to Company X Town M Product E section.
Standard Library document	Report detailing how the simulation model was developed.

1. INTRODUCTION

1.1 Background Information

The study deals with the simulation of the railway system at Company X plant K which is situated in Town M. The shunting yard and product transportation in the plant and out of the plant is included (See figure 1).

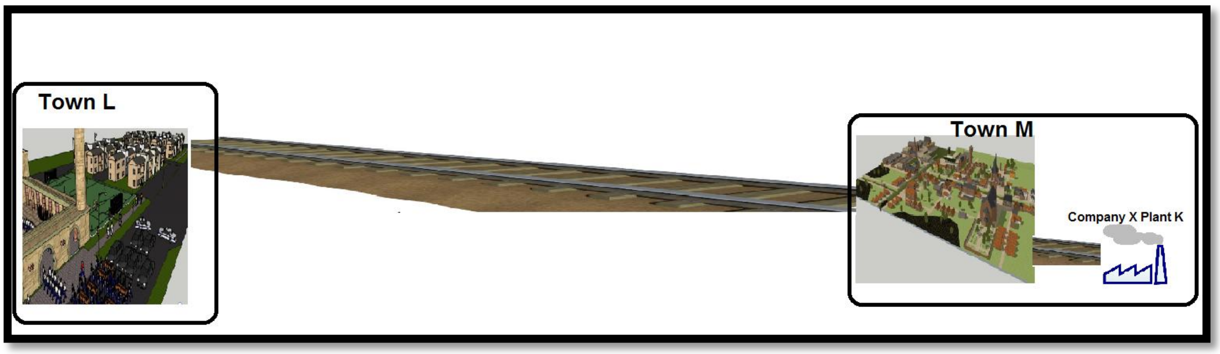


Figure 1: Town L and Town M diagram

The study's focus is on developing a simulation model which will simulate the current situation at Plant K. According to De wet (2008) simulation is a technique for modelling dynamics that can augment static value-stream analysis. For example, simulation can be used to estimate the effectiveness of alternative configurations of a lean business process prior to actual implementation. Simulation can often clarify the exact nature of the trade-off between custom satisfaction and cost-effective delivery of service, and allow the service provider to choose the right level of resources. Given the simulation explanation above simulation was chosen as appropriate tool for the analysis of this situation. In this study SIMIO software will be used in order to simulate Plant K railway networks.

The study includes the locomotives used during shunting, and the so-called Block Train. The Block Train is a train used by Company X to transport products from Town L to Town M; it consists of 40 (RTCs) or wagons. The products transported by the Block Train include Products A, B, C and D. The Block train transport these products between the two towns namely Town L and Town M.

Product A, B and C are used at Town L and M manufacturing plant to manufacture other products including Product D and all these products are transported by Block train. Apart from the Block Train there are other trains which transport other products. The RTCs transport more than one kind of product but each RTC only contains one product. The products are loaded and offloaded at different locations in the plant (See figure 2 and 3). The RTCs are transported by Transnet locomotives between Town L and Town M. The other products are used to manufacture product A, B, C and D. There are other trains used to transport other products which are used in the manufacturing of product D. There are other products which are not transported by Block train which are being used in other offloading loading zone not included in the study.

The plants in Town L and M complement each other. The other products are being transported to different loading zones in the plant K. That implies that all the products are manufactured in Town L plant and also in Town M plant K depending on the capacity of the plant at a given time. The Block Train travels from Town L to Town M and back, and is pulled by Transnet Freight Rail (TFR) locomotives. Figure 2 shows the Company X rail network layout in the plant K used by Block Train and Product E train. The Transnet Company owned locomotives which drop off the RTCs at plant K shunting yard 1.

The Company X locomotives take over from the Transnet locomotives from shunting yard 1 to move the RTCs to the plant Shunting yard 3 and to the different loading zones (See figure 2). The Block Train is divided in sets of ten maximum or less RTCs at shunting yard 3 (Figure 2). The reason for the train to be divided in sets of ten RTCs or less at shunting yard 3 is because the loading zones can only take 10 RTCs or less at a time and due to load destination. After the loading has taken place all the RTCs will be taken back to shunting yard 3 by a Company X locomotive from the different loading zones and then a full train will be assembled and taken to shunting yard 1 (figure 2). Shunting yard 3 has inbound lines and outbound lines for the locomotives and are situated in the plant. This is where the Block Train is assembled and parts (ten sets of RTCs or less) are moved to different off-loading and loading zones. This is also where the locomotives park while they are idling (See figure 3).

The railway network in the plant is also used by both international and domestic Product E trains. Product E trains are from other locations nationally and internationally and these trains transport Product E to Company X Product E offloading and loading zone. Product E is used to manufacture product A, B and C and these products are then used to manufacture Product D. Product E trains and the Block Train share single track (figure 3) at the rail network at Company X plant K.

Senior Process Controllers (SPCs) controls the movement of trains in the plant K rail network. The SPCs control the movement of trains from shunting yard 1 to Shunting yard 3, and to the loading and off-loading zones, and back to Shunting yard 3. They also control the trains when they exit the plant (Figure 43).

Locomotives leaving the Company X plant are monitored to avoid collision with oncoming trains by Transnet Senior Process Controllers situated at Shunting yard 1 and Company X Senior Process Controllers (SPC) situated in the Company X plant K. The Transnet locomotives can only take RTCs as far as shunting yard 1 in plant K.

At the single track section trains have to wait for other trains to pass. There are control signals at this point which are also controlled by both Transnet and Company X Senior Process Controllers (SPC). Control measures are in place in the form of automated signals which control the movement of the trains on the single track. These signals use interlocking systems which means that once there is a locomotive using the line the signals lock automatically. Locomotives leaving the Company X plant are monitored to avoid collision with oncoming trains by Transnet Senior Process Controllers (SPC) and Company X Senior Process Controllers (SPC).

Products A, B, C and D are liquid and are transported in RTCs, whereas Product E is granular and is transported in wagons. Product E is transported to Company X Product E offloading zone by Transnet locomotives. Transnet locomotives transport product E wagons directly to the Product E loading zone. A Transnet Freight Rail (TFR) locomotive brings the train in. It then offloads and the train is taken out from the Product E offloading zone by the same locomotive. The Senior Process Controllers (SPC) communicates on a regular basis to control the movements of the locomotives from one site to the other. The SPCs also control the movement of product E trains in and out of the plant K. The SPC communicates with the Transnet Freight Rail shunter/controller located at Shunting yard 1. There is no exchange of locomotives that takes place for Product E trains.

The maintenance of locomotives takes place at the locomotive shed where they are serviced and maintained (See figure 3).

The research is concerned with developing a simulation of the activities of the Block Train, Product E trains arriving and leaving the Company X plant, and the shunting taking place. The restrictions in the model have been used as signals to control the movement of trains at a single track (See figure 3). Simio object resources have been used to restrict the movement of trains in the single track section.

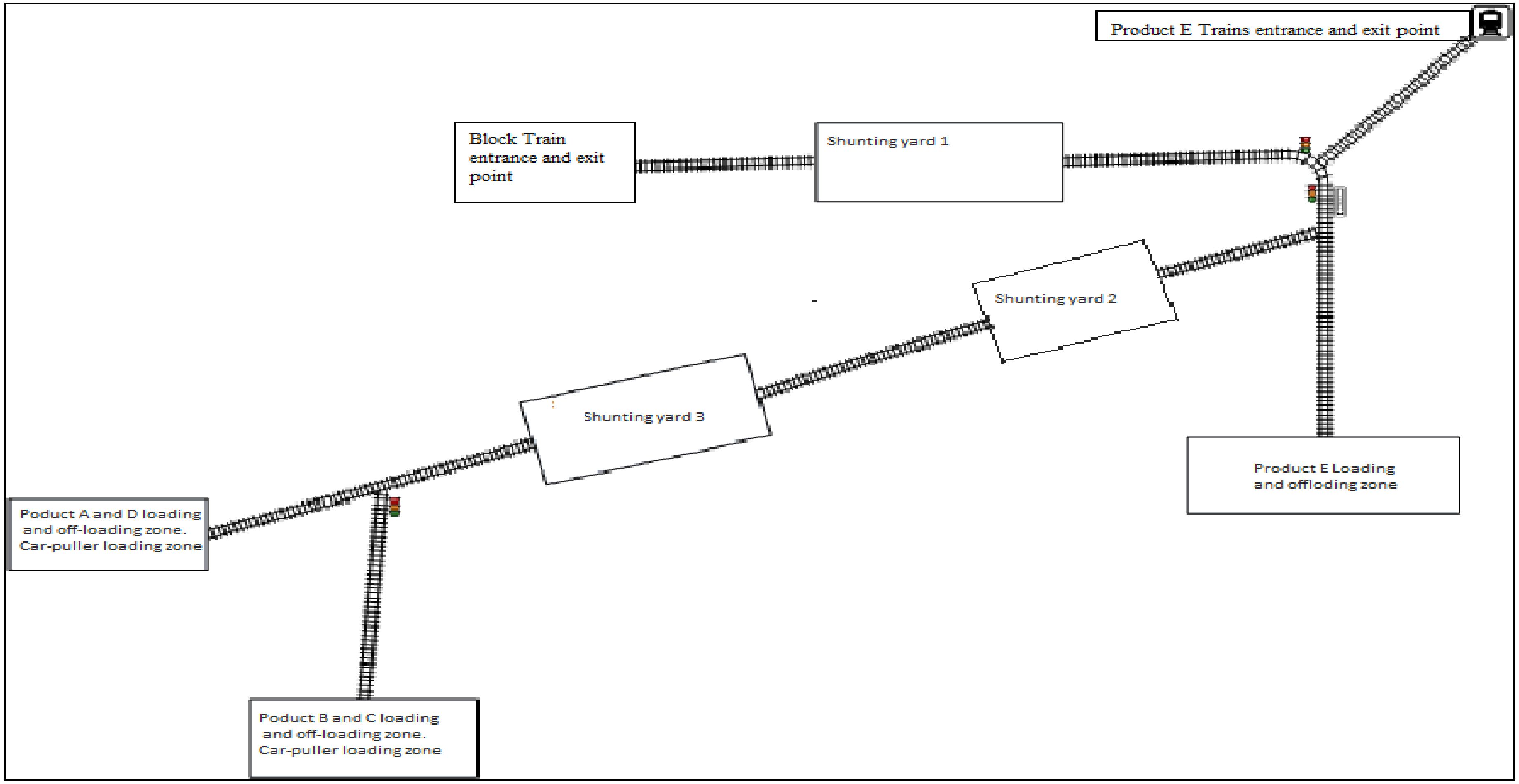

Product E Trains entrance and exit point
Block Train entrance and exit point
Shunting yard 1
Shunting yard 2
Shunting yard 3
Product E Loading and offloding zone
Poduct A and D loading and off-loading zone. Car-puller loading zone
Poduct B and C loading and off-loading zone. Car-puller loading zone

Figure 2: Company X Plant K rail network layout

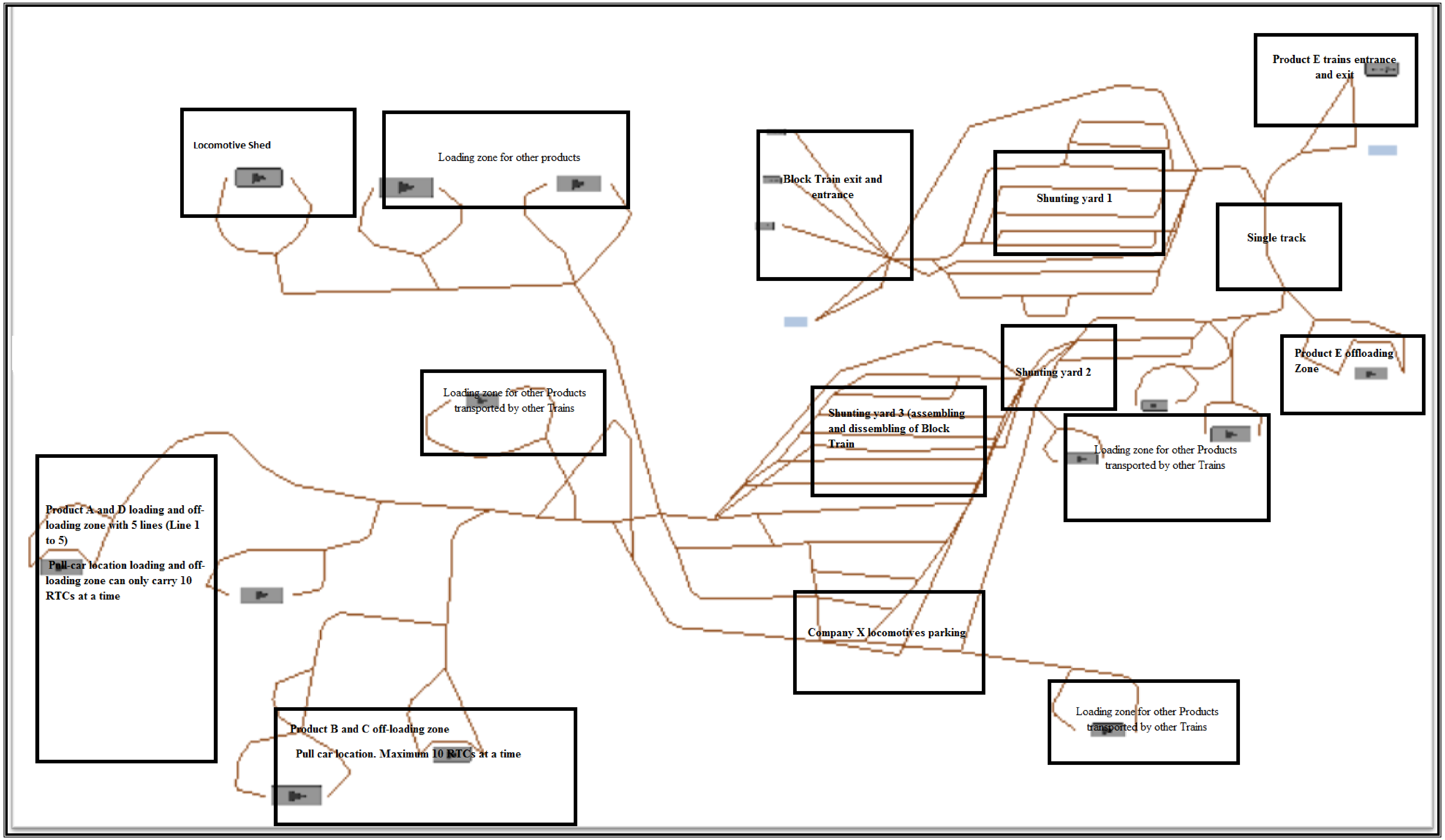
The Block train and the shunting areas will be simulated in order to show the exchange of RTCs from the Transnet locomotives to Company X locomotives.

The Block train comes with Product A; B, C from Town L. These products are used to manufacture Product D and other products. All the products are loaded after they have been manufactured.
Two locomotives are used to transport the RTCs from Shunting yard 1 to shunting yard 3 in the primary area of plant K, and back to Shunting yard 1. There are other loading zones in plant K which are used by other trains other than the Block train.

Figure 2 shows the rail network of Company X Plant K where all the loading zones are included. It includes loading zones which are used by the Block Train and other trains delivering other products in the plant. The other trains use the same rail network as Block train to transport other products to the different loading zones in plant K.

The Block Train arrives in Town M on Monday, and leaves on Wednesday. It will return to Town L from Town M on Thursday, and then leave on Sunday. The trains arrive according to schedules, and loading and offloading is controlled by Senior Process Controllers (SPCs). The train schedules are used to enable the smooth transportation of these products. They also assist Transnet in knowing how many locomotives to allocate for that particular day, and at what time. The SPCs control the movement of trains from Shunting yard 1 to shunting yard 3 and to the different loading zones in plant K.
Car-pullers are used in all the loading and offloading zones. They are used because the locomotives are large and will not fit in the required locations. The capacity of the loading and off-loading zones has limitations. The loading zone can only handle ten RTCs at a time. The Car-puller is used in the loading and offloading zones to place the RTCs or wagons next to the tanks after the locomotives have dropped off the RTCs (See figure 3). The product from the tanks will be pumped into the RTCs.
A simulation model has been developed to simulate the loading and unloading of products. SIMIO software has been used to simulate the Company X, Plant K railway network.

Figure 3: Company X Shunting yards in Plant K



Product E trains entrance and exit
Locomotive Shed
Loading zone for other products
Block Train exit and entrance
Shunting yard 1
Single track
Shunting yard 2
Product E offloading Zone
Loading zone for other Products transported by other Trains
Shunting yard 3 (assembling and dissembling of Block Train
Loading zone for other Products transported by other Trains
Product A and D loading and off-loading zone with 5 lines (Line 1 to 5)
Pull-car location loading and off-loading zone can only carry 10 RTCs at a time
Company X locomotives parking
Loading zone for other Products transported by other Trains
Product B and C off-loading zone
Pull car location. Maximum 10 RTCs at a time

Figure 3 shows how the Block Train arrives at Company X plant K. The Block Train arrives at Shunting yard 1. The Transnet Freight Rail (TFR) locomotive detaches the RTCs at shunting yard 1, and then the Company X locomotives take them to Shunting yard 3 in the primary area (See figure 3). The Company X locomotive with the Block Train will pass at the single track section which is also used by Product E trains as illustrated in figures 2 and 3.

It is important to note that safety is one of the important considerations when modelling rail transportation systems focused on controlling the movement of RTCs. Safety precautions have to be in place all the time to avoid collisions. Only one train is allowed to use the line at any given time. The SPCs are there to ensure that the movement of trains in the Company X railway network is well managed. An automated signalling system is used to control access to the line. In the simulation model it will be assumed that there is one train travelling on a certain line at a particular time. No two trains going in the opposite direction are allowed to enter the single track. The transit speed along the track is 15km/h.

1.2. Problem statement

Management were concerned about inefficiencies at Company X's plant K shunting yard. Service times and the idling times of the locomotives were considered too long. Locomotives can and should also be utilised for other purposes, besides shunting, in the plant. This has implications for resource planning and productivity in the company.

A method to identify inefficiencies and to test alternative system configurations was needed, such that cost-benefit studies could be undertaken. Therefore, a computer simulation model of the system was needed.

Therefore problem under investigation is whether the Plant K rail system can be successfully modelled using simulation. The simulation model will focus on Block Train RTCs coming from Town L to Town M Company X Plant K. Shunting within Plant K will also be included in the model. The model will focus on Block Train RTCs entry into the plant, and how they are transported to the different loading and off-loading zones within the plant and also Product E trains and other trains. Simulation was chosen as the method of analysis as it can provide measurable metrics for assessing the performance of a model and SIMIO software was chosen as the simulation tool for the study. In this case the network is developed by putting together the entities and these entities are joined by defining the behaviour of the nodes in the network and then connecting the nodes together using defined connections. This is done in order to develop a simulation model that will illustrate what is actually happening in Company X Plant K.

2. OBJECTIVE

The objective of the study is to evaluate whether the Company X Plant K rail network system can be simulated such that the resultant model can be used to compare system design changes.

3. LITERATURE REVIEW

3.1. Simulation modelling.

The techniques and tools of simulation modelling have been used to research and investigate various systems in a wide range of areas such as commerce, computer networks, defence, health, manufacturing and transportation (Taylor et al, 2009). Simulation is one of industry's most used operations research techniques. Its uses range from answering questions on work-in-process and production feasibility, to comparing alternative plans for system routing and scheduling. Opinions about its efficacy as an industrial decision support tool vary greatly in spite of (or because of) its broad user base (Cochran et al, 1995).

A number of studies have found simulation to be one of the most effective management science methods used today (Christy and Watson, 1983). According to Hwarng (2001) decision makers often use simulation because of the complexities of their problems. Simulation helps business managers design their business services and processes, just as it has helped engineers to design products and processes.

3.2. SIMIO

3.2.1. What is SIMIO?

Pegden (2009) defines Simio as a tool for building and executing dynamic models of systems in order to see how they perform. It acts out and displays a 3D animation of a system over time. Simio enables a user to see the proposed systems in operation before building and changing them. It makes modelling dramatically easier by providing a new object-based approach. The user selects objects from libraries and places them graphically in the model. Objects represent the physical components in the system, such as workstations, conveyors, and forklift trucks in a manufacturing facility, or the gantry in a hospital emergency room (Pegden 2009). Object-based modelling is a very natural and simple approach to simulation modeling. Simio makes 3D animation a simple and natural part of the modelling process. By using Simio a model can be laid out with realistic spatial relations that depict the real life system accurately (Pegden. 2009).

SIMIO uses processes to define steps. Examples can be found in Appendices A. long wording in the software will not be stated on full. There software use a shorthand and abbreviations where is necessary.

3.2.2. Benefits of simulation

Pegden (2009) points out the following benefits of using Simio:

- Simio simulation enables the user to see the impact of change (Pegden. 2009).
- With Simio simulations the user can make changes to the model quickly to test out ideas, without disrupting the real life system (Pegden. 2009).
- With Simio simulation the user can make mistakes in the model, and not in the real life situation. Simulation enables the user to separate the improvements from the failures and optimize his/her situation (Pegden. 2009).
- Simio simulation enables the user to validate proposed designs and make the best use of limited capital to focus resources where they will make the most impact on results. Simio simulation brings each individual user's ideas to life, providing an animated preview of a proposed change (Pegden. 2009).
- It provides records, and graphically displays key performance measures for each system. This helps in analysing proposed changes, as well as communicating the benefits of those changes to the other stakeholders (Pegden. 2009).
- A Simio simulation allows the user to account fully for variations in each system and the impact these will have on the system performance overall (Pegden. 2009).
- Simulation assists the user to avoid the critical problems created by applying traditional static analysis in an attempt to understand and predict the behaviour of a variable and complex dynamic system (Pegden. 2009).

3.2.3. Definition of objects in SIMIO.

According to Pegden (2009) the definitions of objects in Simio are stated below (figure 3).

A source object is used to generate entity objects of any type (Pegden 2009).

A server object is used to define time processing (Pegden 2009).

A sink object is used to destroy entity objects which have finished processing in the model (Pegden 2009).

A combiner object is used to model a process matching the multiple entity objects, forming those entities into a batch, and then attaching the batched members to a parent entity (Pegden 2009).

A separator object is used to model a process matching the multiple entity objects, forming those entities into a batch, and then separating the batched members to a parent entity object or making copies of an entity object (Pegden 2009).

An entity object is used to represent an object.

A vehicle object is used to transport an entity object between node locations. An “on demand” routing type vehicle can be used as a movable resource that is seized and realised for non transport related tasks by the model process logic (Pegden 2009).

A worker object is used as a movable resource which is seized and realised for tasks by the model process logic. A worker can also be used to transport entity objects between node locations (Pegden 2009).

A resource object is used to model resource constraint with capacity that can be seized and realised by other objects (Pegden 2009).

A transfer node is used as an entity to transfer into and out of the object. The object may also be used to define the intersection point in the network of links. Optional entity destination selection and transport logic is provided (Pegden 2009).

A basic node is used by entity to transfer into and out of the object. The object may also be used to define the intersection point in the network of links (Pegden 2009).

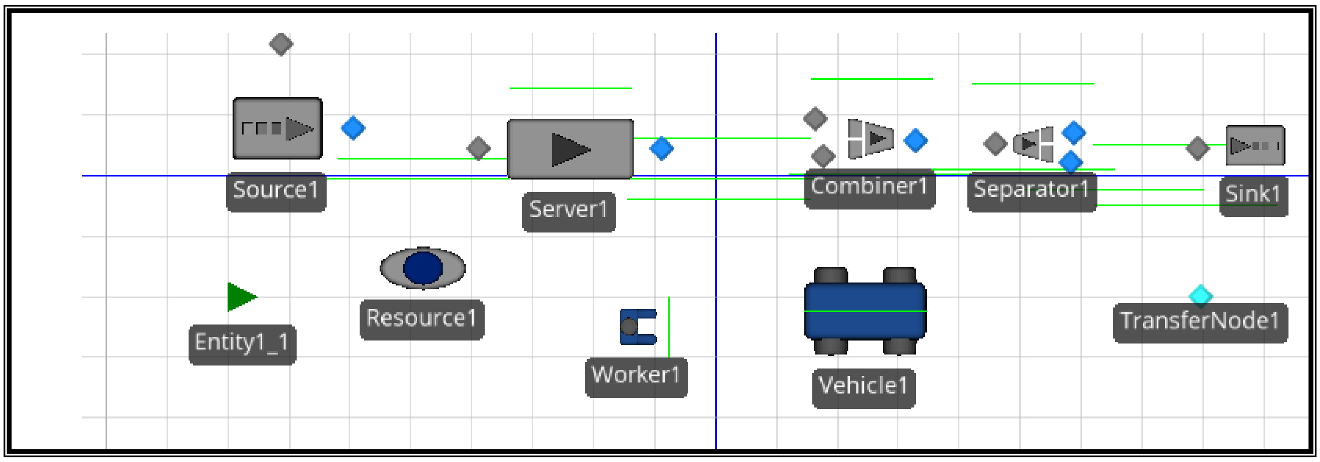


Figure 4: Scanned depiction of objects used in SIMIO (Pegden. 2009).

A path is used to define a pathway between two node locations where the travel time is determined by the path length and travel entity speed. Passing may or may not be allowed (Pegden 2009). (Figure 5)

A workstation object is used to model a constraint resource which has a single capacity. Each operation processed at workstation is performed as a sequence of three activities, that is, setup, processing and teardown. An optional secondary resource makespan and material requirements may be specified (Pegden 2009) (Figure 5).

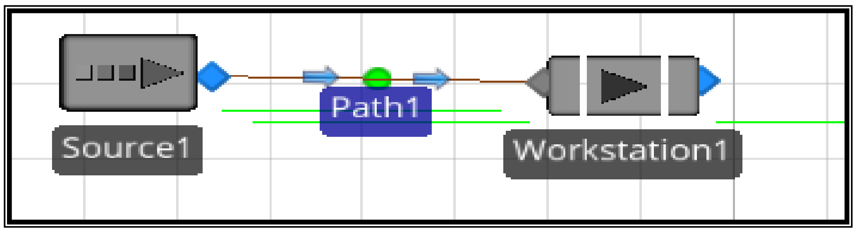


Figure 5: Scanned depiction of object i.e. path and workstation used in SIMIO (Pegden. 2009).

A connector is used to define a direct, zero travel distance connection from one node location to another (Pegden 2009). (Figure 6)

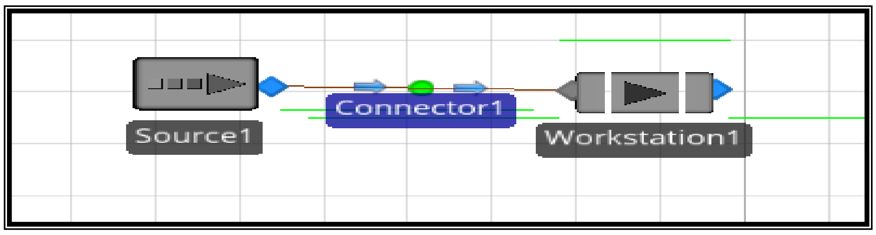


Figure 6: Scanned depiction of object i.e. connector used in SIMIO (Pegden. 2009).

A timepath used to define a pathway between two node locations where the travel time is use-specified (Pegden 2009). (Figure 7)

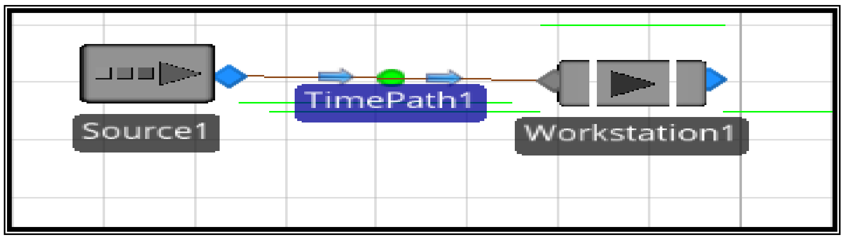


Figure 7: Scanned depiction of object i.e. TimePath used in SIMIO (Pegden. 2009).

A conveyor is used to move travel entities between two node locations using an accumulating or non-accumulating conveyer (Pegden 2009). (Figure 8)

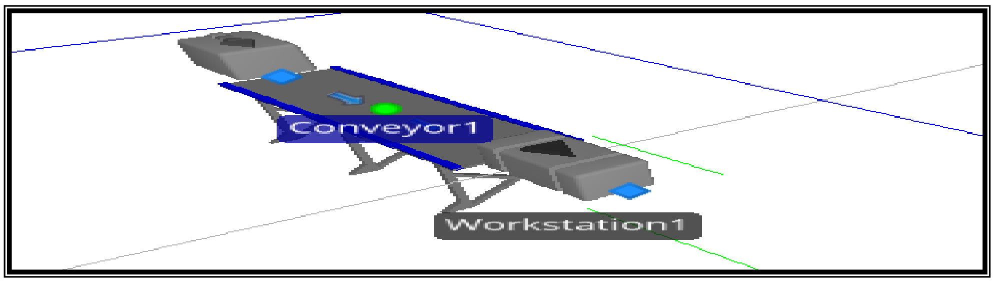


Figure 8: Scanned depiction of object i.e. conveyor used in SIMIO (Pegden. 2009).

3.3. Railway Shunting yards

3.3. 1 Definitions and descriptions of railway shunting yards

According to Marinov et al. (2009) yards are a very important part of railway freight operation. Depending on the yards' performance, the quality of the railway freight network operation could be improved. Yards dictate freight train movement on the network. They consume a significant amount of the available resources in order to receive, accommodate and send freight trains as a provided service. In other words, the yards execute reassembly processes with freight trains based on the delivery requirements of the customers. The yards are, however, characterized by a limited number of tracks, meaning that their performances are confined by bounds. These performance bounds identify the yards' processing capabilities, and when they are stretched, then the yards malfunction. This phenomenon contributes to rail freight services of poor quality (Marinov et al. 2009).

A marshalling yard or shunting yard is generally a place where goods trains and other loads such as wagons coming in from nearby shunting yards are received, sorted according to a plan, and new trains formed and dispatched onwards. Marshalling yards were indispensable in earlier times, and were built at all strategic junctions and intersections. Their need arose because of an inherent feature of goods transportation by rail, namely, that goods arriving at a loading point did not always materialize in such quantities to make up a full train load at a time, and even when a train-load of products was offered, the material might not all be booked for the same destination (Bhalerao. 2008).

According to Bart (2007), average train lengths in Europe currently vary between 600 and 700 meters. This might be increased up to 1,000 meters, but the maximum length is limited by double locomotive power which is rarely deployed. At the hub-exchange facility, either rail wagons (at a shunting yard) or load units (at a terminal) are exchanged. In terminal operations, trains remain as they are all the time, without decoupling, and cranes and an internal transport unit transfer load units from one train to another.

Bart (2007) and Bhalerao (2008) state that four different hub-exchange facilities exist; Flat shunting yards, Hump shunting yards, Road-rail terminals (intermediate terminals), and New-generation terminals.

3.3.2 Flat yards

Flat-Shunting Yards are yards in which the tracks lead into a flat shunting neck at one or both ends of the yard, where the freight cars are pushed and pulled by a shunting engine which sorts onto the assigned track (Marinov et al. 2014).

3.3.3 Gravity yards

According to Marinov et al. (2014) wagons are shunted with the help of gravity and therefore there is no need for special shunting engines. Only one engine is needed to push the wagons on top of the hump. Gravity yards are cheap because of the natural topography.

3.3.4 Hump yards

In this type of yard the wagons of a complete train will roll down an incline to get reassembled for their departure. To achieve this kind of process the yard must have a specific layout. Hump yards consist of four different components: the receiving yard, hump, classification yard and departure yard (Marinov et al. 2014).

Most hump shunting yards are one-directional meaning that trains can enter the facility from only one direction. The number and length of tracks might vary in each yard, depending on the required capacity. The shunting hill area most often consists of one track leading to the shunting hill. A large yard might have two shunting hills. They have automated switches downhill, leading to the sorting and departure yard. Tracks at the beginning of the sorting yard, and the middle of the sorting yard are equipped with automated braking equipment. Large yards might have installed automated equipment for train assembly between the tracks in the sorting yard. Arrival yards and sorting/departure yards are equipped with one or several locomotives (Bart .2007).

3.4. Internal processes at flat shunting yards.

Flat yards show the three basic aspects of every yard: the reception yard, the classification yard, also known as the sorting yard, and the departure yard. A goods train is received in the reception yard, and the engine is sent to the locomotive shed. Adjacent to the reception yard, is the classification yard, where each line is reserved for wagons going in a particular direction (Bhalerao. 2008).
Marshalling yards are selection and delivery points which include flat yards, stations in which the initial train is split, cargoes are sorted according to their destination, and new trains formed. The cargoes are situated near railway stations, being a direct continuation of them. Hazards found in the yards are associated with the activities in a marshalling yard which originate from the hazardous nature of the substances handled (Christou.1999).

According to Lehnfeld, and Knust (2014) storage of items leads to different kinds of optimization problems. The unloading problems arise if the outgoing items need to be retrieved from the storage area. Therefore it has to be decided which items will leave the storage, and in which specified order. Before marshalling occurs the items have to be sorted inside the storage area so that all of them can be retrieved without any further reshuffling afterwards. If incoming items need to be stored while outgoing items need to be retrieved, combined loading/unloading problems might arise.

In Sendera, and Clausena (2011) flows of single wagons with different origins and destinations are consolidated on their way through the network via at least one shunting yard. These yards are part of hierarchical network, while their size, function, technical equipment, and shunting process might differ. These factors influence the capacity of the formation yards. The wagons are transported through the network using several railway engines (trains). The capacity of these trains is limited. The presented hub location problem covers a lot of the specific characteristics of wagonload traffic.

Lin (2012) presents a formulation and solution for the train connection services (TCSs) problem in a large-scale rail network in order to determine the optimal freight train services, the frequency of services, and the distribution of classification workload among yards. The TCS problem is modelled as a bi-level programming problem.

A Cozzani et al (2007) state that the risk analysis of marshalling yards is complex, because of the variety of operations to which the railcars are subject to. A first possibility is that a train might simply pass through the marshalling yard, usually at reduced speed. Secondly the train might be subject to a simple stop and stay, leaving after some time without undergoing any other operation. Thirdly the train might be subject to a change-over of locomotive or shunting procedure, which consists of the splitting of the arriving trains and the formation of new ones.

In Motraghi (2013) the focus is on rail yards and terminals in order to ensure the movement of passengers and freight in the railway network system. It is important to note that most of the transit time is spent in transhipment and shunting operations. Continuous improvement of processes is important and should always be optimised, in order to ensure that yards and terminals keep up with changes taking place. These days the materials transported by rail have changed from being heavy goods, to light-weight, palletised goods, and this has had an effect on both trains and terminals.

The optimization of railway systems leads to a variety of planning and scheduling problems. For instance, when several freight trains arrive at their terminal railway stations, it is often necessary to split them, and rearrange their cars into other trains. Of course this should be done quickly and with only a limited number of moves, while observing all the restrictions arising from the local infrastructure. Such train rearrangement problems have been modelled, classified, and surveyed. The main result states that arranging a departing train in a depot is NP-complete, even if each track in the depot contains only two cars. The study proved that even the following two highly restricted special cases of this problem are NP-complete (1) the case where every track contains at most three cars and (2) The case with at most two car types (Eggermont et al 2009).

Javadiana (2011) states that a yard capacity study assesses how many cars, blocks and trains can be handled within the existing infrastructure and resources. An optimisation formulation and a solution procedure for the determination of the capacity of rail yard stations had been developed with respect to the optimal number of shunting and reclassification operations at the nodes of the rail network. In order to resolve this problem, a simulated annealing (SA) algorithm was proposed. This had to work efficiently on a neighbourhood search within the space, acceptance probability, and inferior solutions. It resulted in providing a new managerial tool for planning and analysing yard capacity more effectively and efficiently.

Javadiana (2011) describes a yard analysis tool. The newly developed model provided network information, such as yard capacity, unmet demands, and number of loaded and empty rail car at any given time and location.

In Nel et al (2004) coal is transported by Spoornet, the national rail operator, from approximately 40 collieries in the Mpumalanga and KwaZulu-Natal provinces of South Africa. Trains can only carry a maximum pay- load of 16,800 tonnes, and a standard length of 2.7 km consisting of 200 wagons. Up to 24 trains a day can use the system. When the line was built it was envisaged that the line would carry approximately 2.5 million tonnes of coal per annum; today it carries almost 70 million tonnes to different mines in South Africa and abroad. This figure is projected to rise to over 80 million tonnes from the Richards Bay Coal Terminal (RBCT). It is predicted that this will increase the value of coal exports by US$400 million per year through a joint venture between RBCT and the National Ports Authority. The RBCT is the biggest single customer of the South African rail system, accounting for approximately 50% of gross tonnage moved (Nel et al .2004). The coal is being exported.

3.5. Simulation of yards.

In Marinov et al (2011) yards play an important role in the quality of rail freight services. These facilities function as reassembly hubs in rail freight networks and incorporate a significant amount of static and dynamic resources. Yards are considered an element which adds little value to the final product from the customer’s perspective. Yards are regarded as a main source of delay and loss of business from the yard operator’s viewpoint. Therefore, running yards inefficiently is not acceptable. Marinov et al (2011) studied a double-ended flat shunted yard using G/G/m queues. The results demonstrated significantly low utilisation levels of the yard subsystems in question.

Therefore, possible improvements through changes in traffic rules and production schemes are discussed.

Marinov et al (2013) focus on organising, planning and managing the train movement in a network where three levels of management for rail planning are introduced: strategic, tactical and operational, and are then followed by decision support systems for rail traffic control. Marinov et al (2013) further discuss train operating forms, railway traffic control and train dispatching problems, rail yard technical schemes that are the operations in the network and performance of terminals, as well as timetable design. A description of simulation techniques and specific computer packages for analysing and evaluating the behaviour of rail systems and networks is also provided (Marinov et al. 2013).

Marinov and Viegas (2009) write about simulation modelling methodology for analysing and evaluating flat-shunted yard operations. A yard simulation model has been created and implemented using a computer package for event-based simulation, SIMUL8. The main idea behind the simulation modelling approach is to simulate the flat-shunted yard operations dividing the yard into segments so that each aspect of each segment can be described and analysed separately.

In Marinov and Viegas (2009) the objectives of the study were to provide an adequate methodology accompanied with a reliable tool for estimating, analysing and evaluating the performance capabilities of rail yards using an appropriate approach for the purposes of a rail freight operator.

Di Stefano (2004) proposes a graph theoretical approach to the problem of train shunting in a railway depot. The focus is at night where the trains have to be parked in a shunting depot in such a way that the operations can start as smoothly as possible the next morning. In general this is a most difficult problem, and includes many sub-problems. The study further focuses on the sub-problem of how to arrange the trains in the correct order on the available tracks to avoid shunting operations for outgoing trains in the morning.

García,and García (2012) describe a simulation-based flexible platform developed to support strategic and tactical decision-making related to terminal design and redesign. The study concentrates on interior terminals which interchange containers between rail and road transport. In addition, these terminals might have a classification yard which could have various uses. It could be used to exchange railcars between trains to brake long trains which cannot be processed in the loading/unloading tracks of the terminal, or as a waiting area for incoming and outgoing trains.

Boysen et al (2010) state that efficient computerized scheduling procedures are indispensable, in order to enable rapid container transhipment between freight trains in modern rail–rail transhipment yards. A dynamic programming approach is used in this regard. It determines yard areas for gantry cranes, so that the workload is spread evenly among the cranes and, thus, train processing is accelerated. In the simulation of transhipment yard operations, the effect of optimal crane areas vs. equally sized areas was examined. The results indicated a remarkable speed-up in train processing if optimal crane areas were applied (Boysen et al.2010).

3.6. Conclusion

The literature deals with locomotives and shunting areas. Most companies highlighted in the literature review intended to improve the manner in which the railway system, that is, the shunting was being handled by introducing new technologies or improving the current internal processes. The focus was on investigating other ways of improving the process and service speed in different terminal or loading and off-loading zones. Simulation has been successfully employed in a number of studies.

4. SIMULATION METHODOLOGY

Simulation input data was collected by Operations Research and Rail representatives at Company X through observations. The simulation results will help in making informed conclusions and recommendations on how the Company X Plant K railway system works. The simulation model will be used with the intention of improving the process of trains shunting, travelling and loading and offloading products at Company X, plant K. This would help to improve the loading and offloading times while allowing the process to run smoothly without delays. These would include aspects such as waiting time within its operating centres and generally improving the service rate in the work stations. The investigation will focus on simulating shunting yards which include arrival and departure times of RTCs and locomotives at the plant.

Simio Software will be used to simulate primarily the Company X trains and the movement of the products they carry.

By effectively reducing the bottlenecks within the process, the improved Company X railway network would lead to better returns on investment. The railway network process and how the simulation model of this rail network was developed will be explained in this report.

SIMIO software was chosen as the simulation tool for the study. In this case the network was developed by putting the entities together. These entities were joined by defining the behaviour of the nodes in the network and then connecting those nodes using connections.
The simulation output data can be captured and evaluated during the simulation. This data can also be monitored during the run. The following aspects of the simulation data will be excluded for the purpose of this study:

A. The loading of Product E trains will only be modelled as a delay of the Block train at the single track section in the rail network.
B. Movement of Transnet Freight Rail (TFR) locomotives
C. Shunting details at Shunting yard 1
D. Production processes and storage of products
E. Failures/accidents of vehicles en route to destinations
F. Workforce absenteeism
G. Breakdown/failures of loading/offloading equipment

5. SIMULATION MODEL INPUT DATA

The data used in this the study was collected by the Company X, Operations Research Department in 2013. The data was extracted from observations made on the Plant K rail network system by Operations Research and Rail department.

- Shunting of RTCs transporting Products A, B, C and D takes 15 minutes minimum, average 20 minutes and 30 minutes maximum at all the shunting yards. Product D loading takes place in lanes 1, 2, 3 and 5 in the loading and offloading zone in plant k. Products A, B and C loading and off-loading take place at line 4 of Product A, B and C loading zones.

- Administration (the completion of paper work) takes 35 minutes before the loading of Product D. Administration takes 20 minutes before loading and offloading Products A, B and C.
- Coupling of locomotives to Product A, B C and D RTCs take a minimum of 1 minute and a maximum of 6 minutes. On average this takes 3 minutes. The coupling of RTCs takes place at Shunting yard 3. The RTCs will then be transported to different loading and offloading zones in sets of ten RTCs.
- Detaching locomotives (decoupling) from RTCs for all the products takes 1 minute to 5 minutes. On average detaching of locomotives from the RTCs takes 2 minutes for all the products. The time it takes to detach locomotives is the same in all the loading zones.
- Post-loading administration (paperwork) takes 2 minutes minimum; 2.5 minutes average, and 4 minutes maximum. This takes place at Products A and Product B, C and D loading and off-loading zones (Figure 3).
- Weighing of RTCs takes a minimum of 2.5 minutes; and 4 minutes maximum, and on average 3 minutes. Weighing RTCs takes an extra 20 minutes after all the RTCs have been loaded. Product A is only product that is weighed the RTCs which carries other products are not weighed.

Additional information

- There is no delay associated with the changing of shifts. Working hours for each shift at Company X are from 6:00 to 18:00 Sun-Sun.
- Shunting yard 1 is considered to operate 24/7 because the Transnet Freight Rail (TFR) driver placing trains in the yard should be at the shunting yard every day of the week.
- The distance travelled by the locomotives with the Block Train RTCs from Shunting yard 1 to shunting yard 3 and to Products B, C loading and offloading zones is 8.7 km, and to Product A and D loading and offloading zone it is 8.5 km.
- The Block Train weighs 2000 tons, and has 40 RTCs, each weighing 50 tons.
- The locomotive minimum speed in the primary area is 15 km/h. Maximum speed allowed in the primary area is 20km/h. for the purpose of the study 15 km/h speed has been used in the model.

- Company X uses two 2 locomotives to transport the Block Train RTCs from Shunting yard 3 to the Products A, B, C and D loading and off-loading zones in Plant K (figure 3).
- Product A is the only product that is weighed. It is only weighed at the loading zone.
- The locomotives will drop off the RTCs close to the pump tanks and the Car-pullers will then be used to move the RTCs in the loading zone from one point to another. The pump tanks are the tanks used to store products. These tanks have pumps that are used to fill up the RTCs with the products.
- The loading zones can only take one set of 10 RTCs at a time.

Figure 9 shows observed data for one Product E trains with 30, 35, 38 and 50 RTCs respectively. Ten Product E trains with 40 RTCs were counted a total of 14 Product E trains were observed.

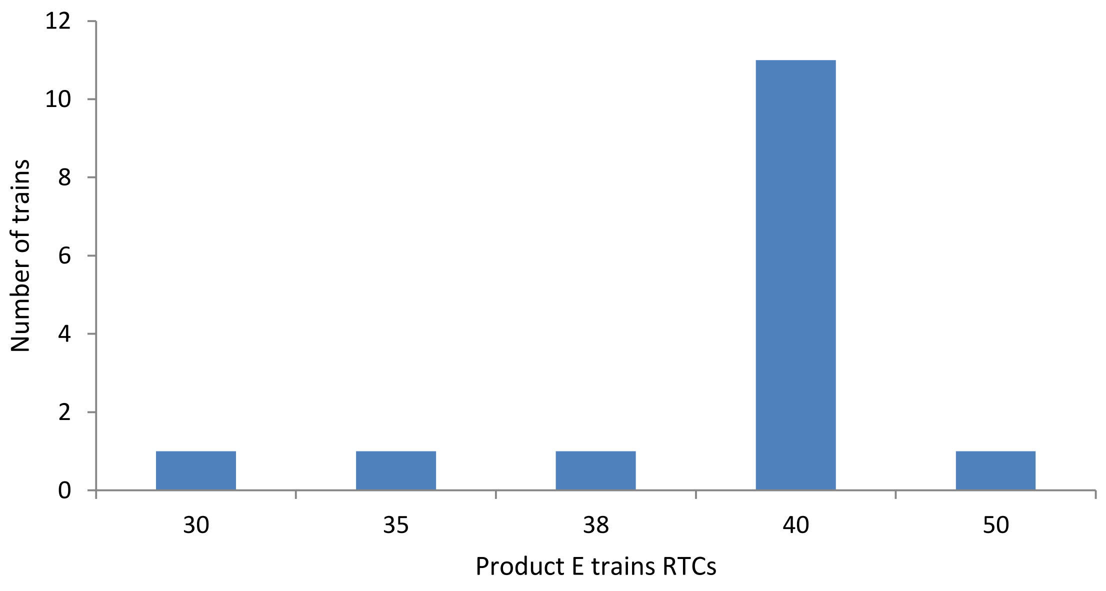


Figure 9: Arrival rate of Local Product E trains monthly

Figure 10 shows observed frequency of Product E train arrival. Out of a total of 7 observations number of Product E train inter arrival times of 4, 5 and 7 days were observed.

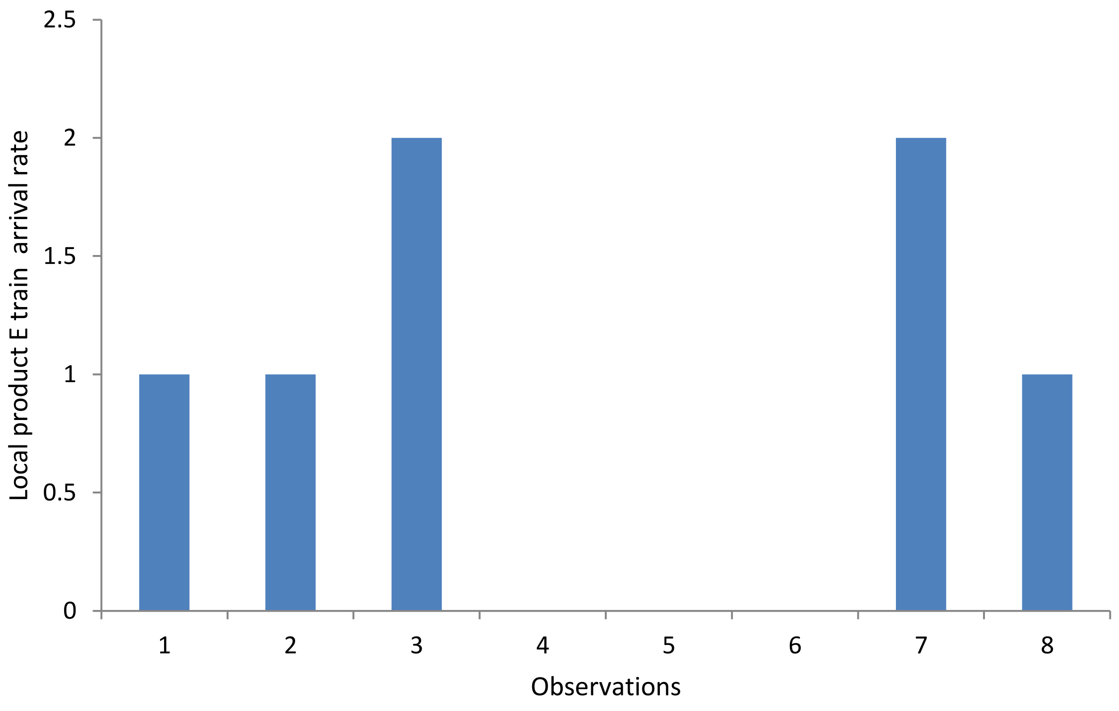


Figure 10: Inter arrival time (in days) of Local Product E trains

Figure 11 shows the frequency of Export Product E arrival. In this graph there is a higher likelihood that an Export Product E train will arrive after the first one has arrived between two days in Town M. If there are 4 to 6 days then the chances of an Export Product E train arriving diminishes. There other product E of a certain quality will be exported. The product E that is been exported is from brought in by local product E Trains from different mines nationally.

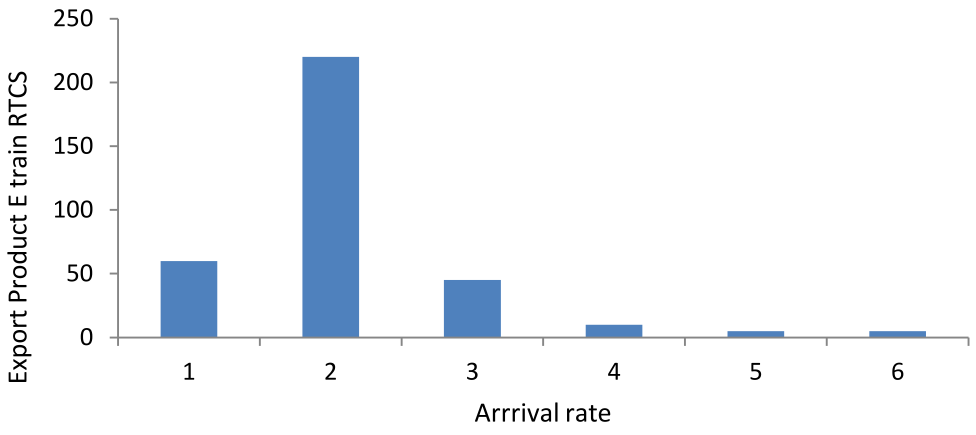


Figure 11: Export Product E trains' arrival probability

Figure 12 states that Block Train arrives on Mondays and Thursday and leaves. One Block Train will arrive and leave plant K weekly. Meaning 4 Block Train loads will arrive every Monday of each month and 4 Block trains will leave every week Thursday of each month. The other 4 Block trains that arrive and leave each month to bring the number to 8 are explained in figure 16.

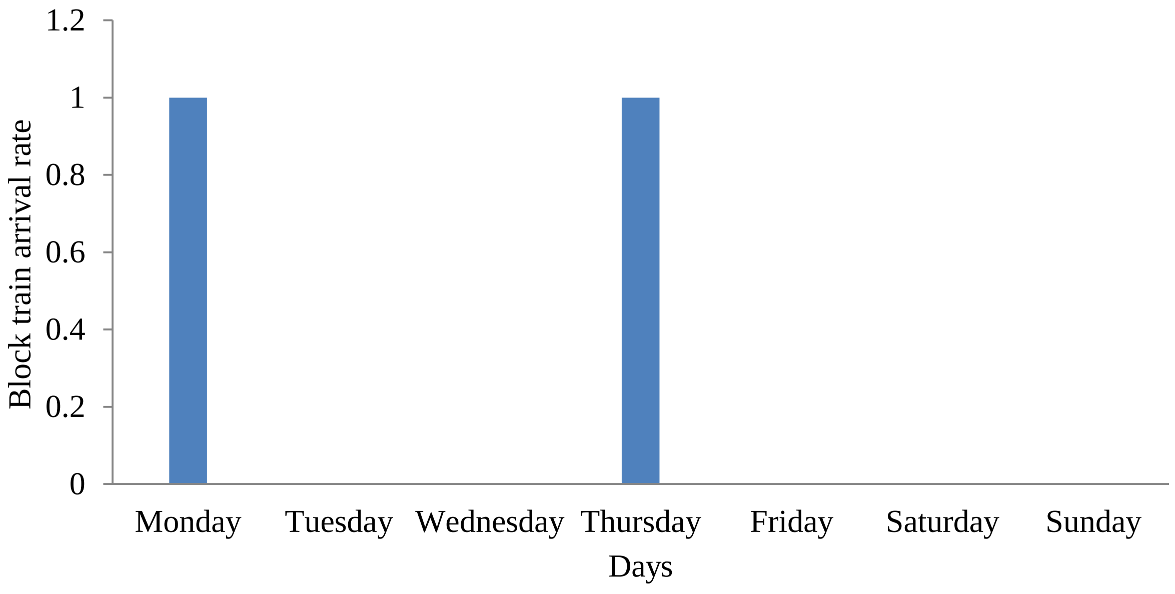


Figure 12: Block Train arrival

Figure 13: the Block Train leaves Company X plant situated in Town M on Wednesdays and Sundays. Each load of the Block Train has 40 RTCs. Two Block Train loads will leave every week.

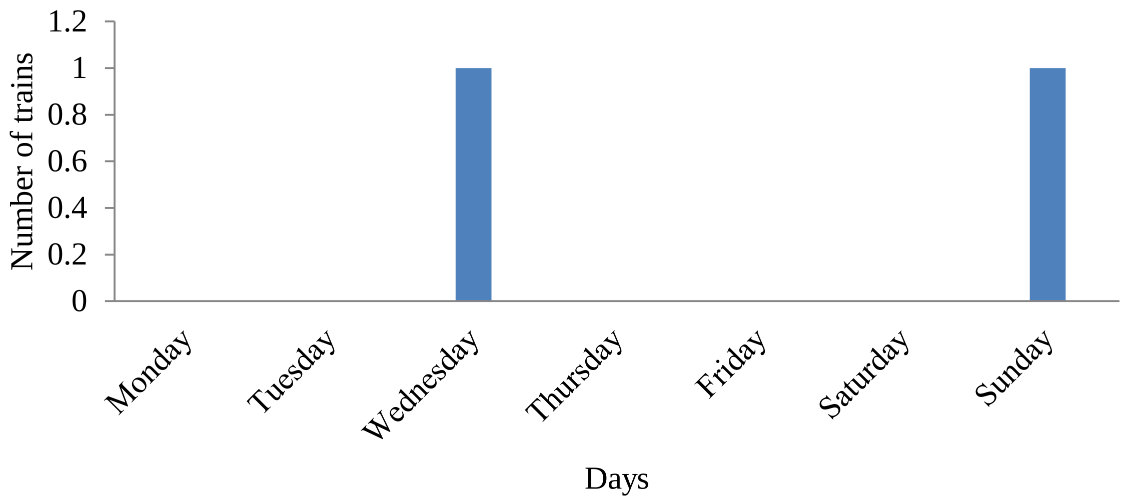


Figure 13: Block Train departures

Block train arrives on Monday and Thursday and leaves plant K on Wednesday and Sunday.

6. SIMULATION

6.1. Description of the model

The network was developed defining RTCs as entities which move through nodes, links and other SIMIO objects which define the network. RTCs in the model are represented as entities.
In the SIMIO objects, events are defined using properties and add-on processes, e.g. how long the locomotive is going to take before it can collect the RTCs, as well as defining how long the RTCs are going to take before they can be connected to the locomotives at the shunting areas.
The simulation model included the site where the locomotives would be parked when the loading and the offloading took place. The simulation developed evaluated the performance of the model and its effectiveness.

The model developed followed the process in figure 14, beginning with the freight trains' arrival at plant K, and Shunting yard 1. Figure 40 in page 50 shows a layout of the model under Model validation.

The Block Train arrivals were generated using entities arriving at Shunting yard 1 shown as Source 1 at the arrival point. The entities enter Shunting yard 1 through this source (Figure 40).

These entities represent the Block trains' arrivals at Shunting yard 1 and are according to the arrival table (Figure 15). Trains arrive on Monday and Thursday and the trains arrive in the morning around 07:00. The source represents the entrance to the shunting yards. A full train or load will arrive in Shunting yard 1 with a Transnet locomotive.
Bidirectional paths were used to represent railway lines. They were connected by basic nodes.

As soon as the entities which represent the Block Train arrive at Shunting yard 1, the Company X locomotive parked at the locomotive parking area located in Shunting yard 3 will collect the Block Train, at Shunting yard 1. The locomotives have been depicted by vehicles which were changed to represent the real locomotives in the model.

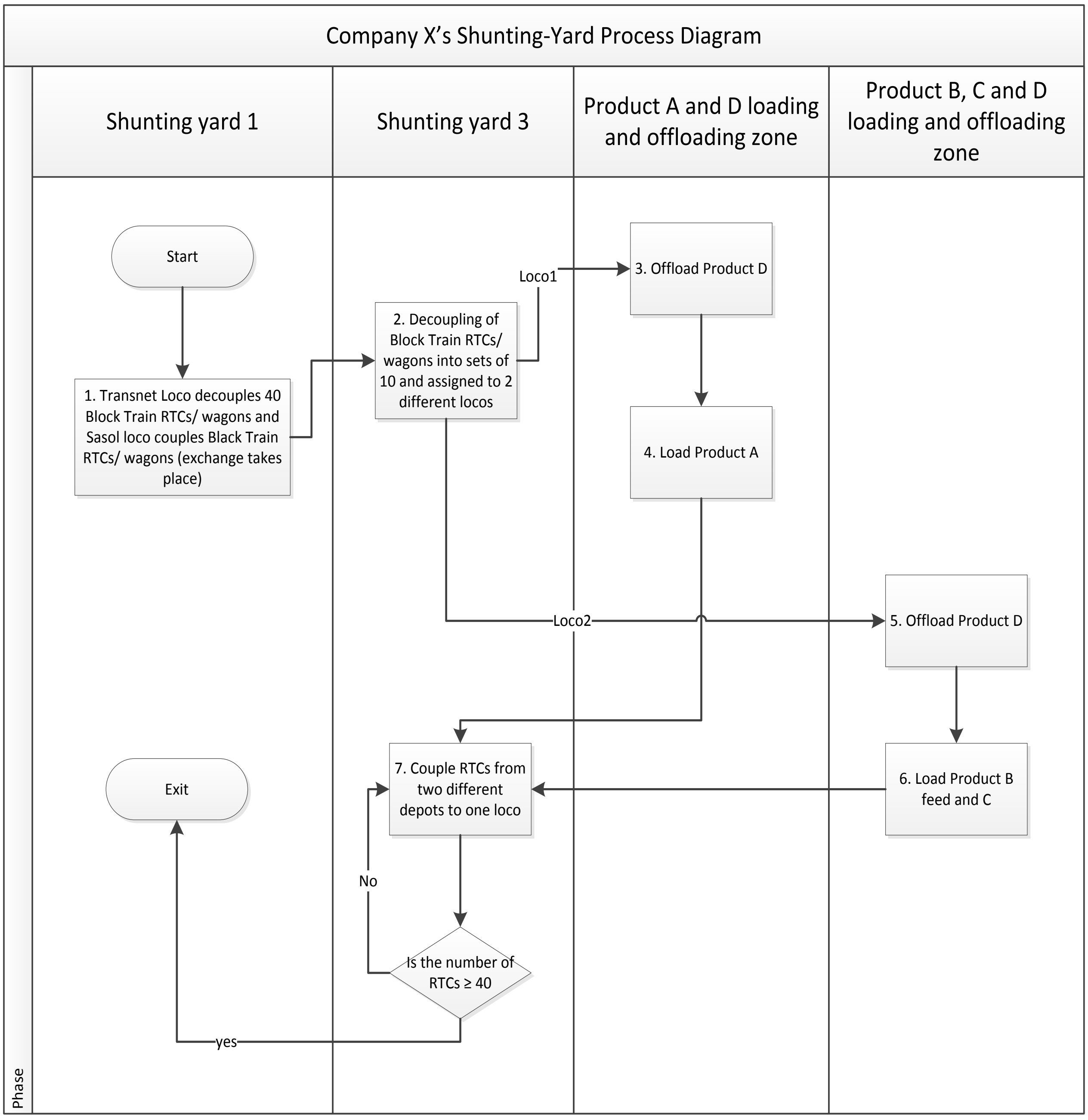
The rail line used by Product E trains meets the rail line used by the Block Train at basic node 22 in plant K (figure 40). All the lines represented in the shunting yards are used for shunting. Product E trains enter the plant through Source 2 and proceed to Server 1 which represents the Product E offloading area at plant K. After unloading, the Product E trains will leave the plant through Sink 2.

Restrictions in the model were represented by means of resources. These allow the trains to use the line in the rail network without colliding (Figure 40). These resources serve as control systems and control the movement of the locomotives on the single line. The resources ensure that once the train is already on the line, no other train will be allowed to enter the single line. The single track starts at Basic Node 22 which serves as an intersection, and ends at Basic Node 23 a node immediately after basic node 22 (Figure 40). All the railway lines in the model are bidirectional; i.e. they allow movement in either direction.

Server 2 is the loading and offloading zone for the other products which are not being transported by the Block train. The products offloaded and loaded at server 2 are products transported by other trains. The depots in the diagram represent offloading and loading zones.

Server 5 represents the loading and offloading zones used by other trains. These trains are transport other products within plant K. Shunting yard 3 has inbound lines and outbound lines for locomotives. This is where locomotives are divided, and taken to the different off-loading and loading zones. The locomotive base is represented by a basic node (Loco Base). This is where the locomotives will park while they are idling (Figure 40).

Servers 7 and 8 represent loading and offloading zones used for other products which are not transported by Block train. Server 13 represents the loading and offloading zones for both Products A and D. The transfer nodes in the model are used to indicate locomotives directions and destinations. Processes are used to show how the movement and the model logic should take place (Appendix A).



Company X's Shunting-Yard Process Diagram
Shunting yard 1
Shunting yard 3
Product A and D loading and offloading zone
Product B, C and D loading and offloading zone
Phase
Start
1. Transnet Loco decouples 40 Block Train RTCs/ wagons and Sasol loco couples Black Train RTCs/ wagons (exchange takes place)
2. Decoupling of Block Train RTCs/ wagons into sets of 10 and assigned to 2 different locos
Loco1
3. Offload Product D
4. Load Product A
Loco2
5. Offload Product D
6. Load Product B feed and C
7. Couple RTCs from two different depots to one loco
No
Is the number of RTCs ≥ 40
yes
Exit

Figure 14: Company X shunting yard process

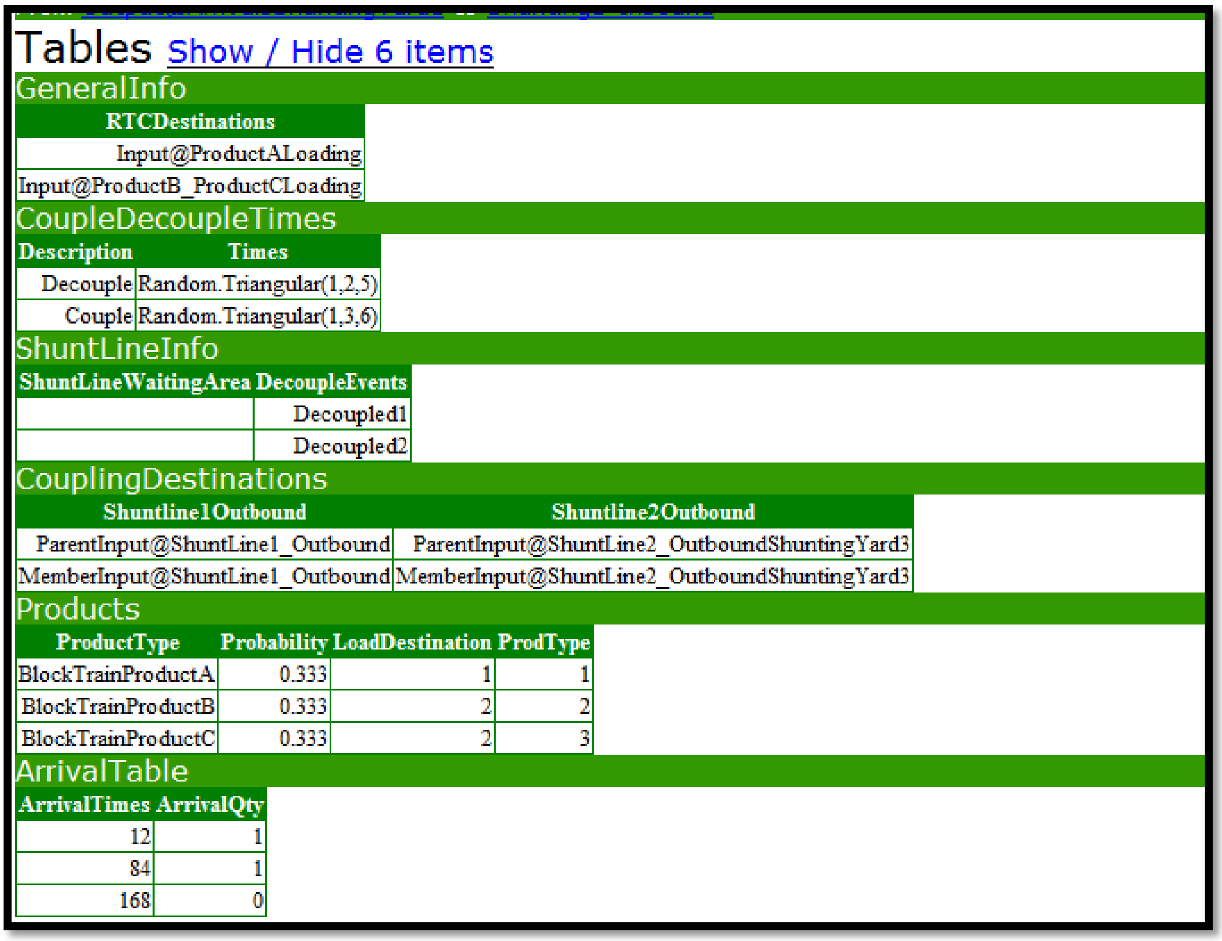
6.2. Important setup parameters for each object.

Figure 15 shows RTC destinations and refers to the locations where loading and offloading takes place. Input@ProductA loading refers to the location where product A is loaded. Input@ProductA loading is a server located at Product A loading zone. Input @ProductsB and ProductC loading refers to the area where loading of products B and C take place. Input@ProductsB and Product C loading is achieved using a server located at Product B and C loading zone.

Under coupling destinations in Figure 15, ParentInput@ShuntLine1 Outbound and ParentInput@Shuntline2 ShuntLine2 Outbound Shunting Yard 3 shows the places where coupling takes place after the products have been loaded in shunting yard 3. Triangular distribution has been used in the study in order to control the coupling and decoupling of entities in the shunting yard 3.

Inbounds at Shunting yard 3 depict a place where decoupling of RTCs will take place so that each set of RTCs can be moved to the different loading zones. The shunting of the locomotives takes place at this point in the rail network. The RTCs will be taken to different loading and offloading zones from shunting yard 3 at the inbounds and outbound locations.

Figure 14 shows the arrival table which indicates how the Block train will be arriving for the six month period in which the simulation is run. This is done taking into consideration the number of days in a week in a month. Under products in Figure 15, different products transported by the Block train are shown. These are Products A, B and C. All the products have an equal probability of 0.333 to reach the loading zones and the arrival table figures allow products to arrive as expected during the period when the model will run. Product A load destination is 1, and its product type is 1. Product B load destination is 2, and its product type is 2. Product B load destination is 2 and its product type is captured as 3.



Tables Show / Hide 6 items

GeneralInfo

RTCDestinations
Input@ProductALoading
Input@ProductB_ProductCLoading

CoupleDecoupleTimes

Description	Times
Decouple	Random.Triangular(1,2,5)
Couple	Random.Triangular(1,3,6)

ShuntLineInfo

ShuntLineWaitingArea	DecoupleEvents
	Decoupled1
	Decoupled2

CouplingDestinations

Shuntline1Outbound	Shuntline2Outbound
ParentInput@ShuntLine1_Outbound	ParentInput@ShuntLine2_OutboundShuntingYard3
MemberInput@ShuntLine1_Outbound	MemberInput@ShuntLine2_OutboundShuntingYard3

Products

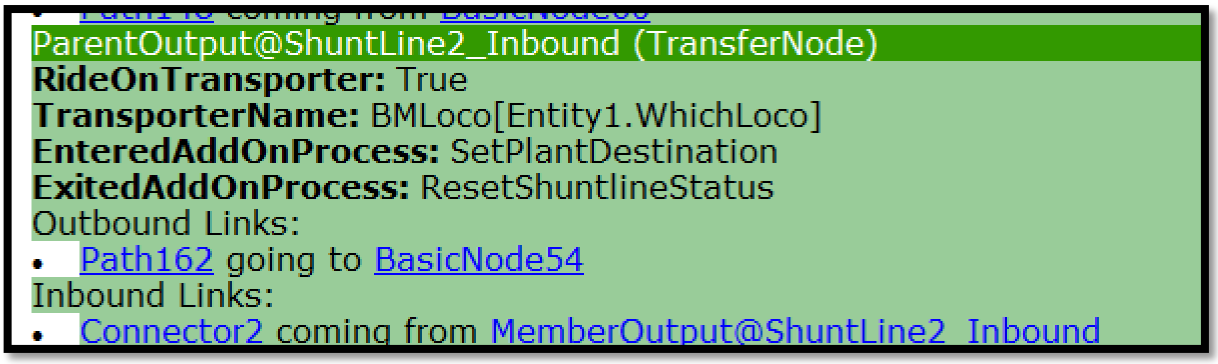
ProductType	Probability	LoadDestination	ProdType
BlockTrainProductA	0.333	1	1
BlockTrainProductB	0.333	2	2
BlockTrainProductC	0.333	2	3

ArrivalTable

ArrivalTimes	ArrivalQty
12	1
84	1
168	0

Figure 15: Simulation model general information

In figure 16 a transfer node setup is shown. BM Loco [Entity1.Which loco] refers to the locomotive to be used at the point when the locomotive is required to transport the load into the primary area. The parameter RideOnTransporter mean the RTCS are pulled by a locomotive which is set to (True) to allow this to happen. EnteredAddOnProcess mean that the RTCs exiting the shunting yard are pulled by a locomotive. This will enable the locomotive to go to the correct destination. ExitedAddOnProcess is the destination in the simulation model where the locomotive will exit the Shunting yard 1 plant K. Path 162 is a path the locomotives use to move to a destination, being basic node 52. Connectors and nodes are used to direct the movements of the locomotive.


ParentOutput@ShuntLine2_Inbound (TransferNode)
RideOnTransporter: True
TransporterName: BMLoco[Entity1.WhichLoco]
EnteredAddOnProcess: SetPlantDestination
ExitedAddOnProcess: ResetShuntlineStatus
Outbound Links:

- Path162 going to BasicNode54

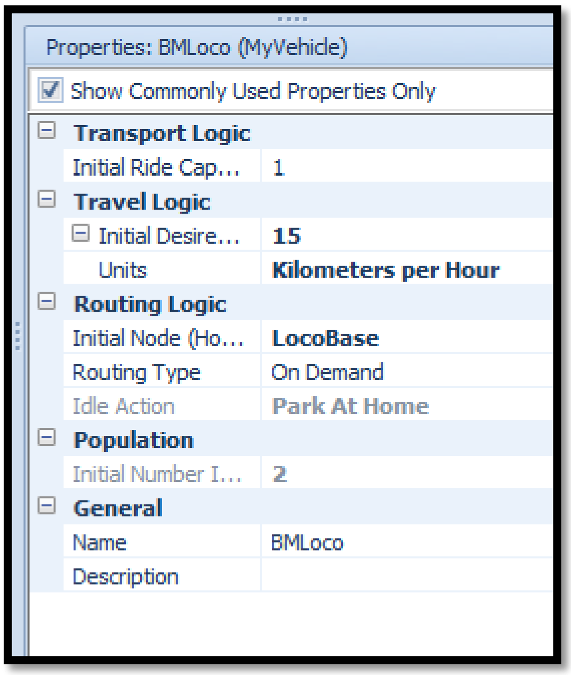
Inbound Links:

- Connector2 coming from MemberOutput@ShuntLine2_Inbound

Figure 16: Locomotives

6.3. Programmed logic.

Figure 17 shows the properties of the Company X locomotives. The entities in the simulations represent the Block train, and the products the train transports. The transport logic has been set at 1, the loading capacity of the locomotive. This is done in to allow the locomotive to carry one train at a time. The travel speed has been set at 15 kilometres per hour. Routing logic indicates how the locomotives should move. In case the locomotive is not needed, it will park at the Loco Base. The population set is 2, meaning two locomotives have been used for the simulation.

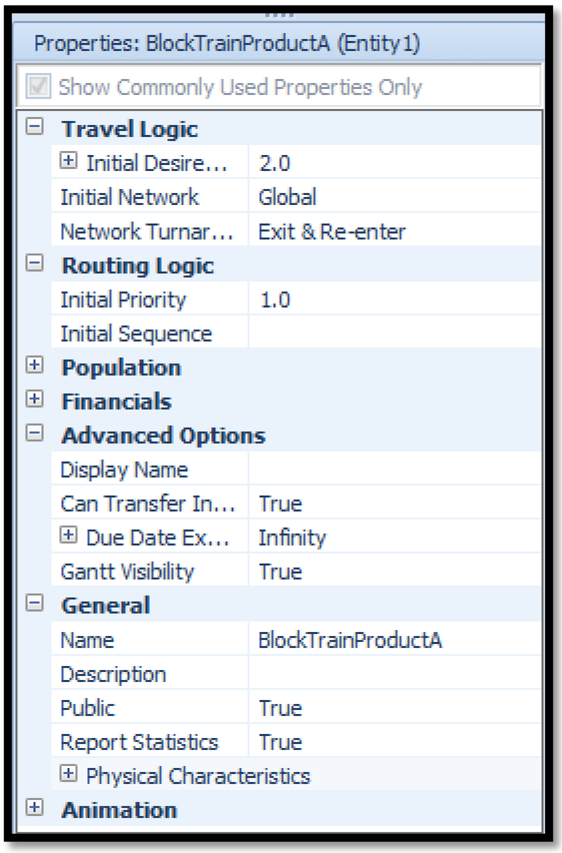

Properties: BMLoco (MyVehicle)

☑ Show Commonly Used Properties Only

Transport Logic	
Initial Ride Cap...	1
Travel Logic	
Initial Desire...	**15**
Units	**Kilometers per Hour**
Routing Logic	
Initial Node (Ho...	**LocoBase**
Routing Type	On Demand
Idle Action	**Park At Home**
Population	
Initial Number I...	**2**
General	
Name	BMLoco
Description	

Figure 17: Properties of the locomotives

Figure 18 shows the properties of entity 1(Product A). The travel logic has been set to allow the entities to be able to enter the rail network, and exit the network. The entities are set up to ride on the locomotive to the different destinations in the plant.

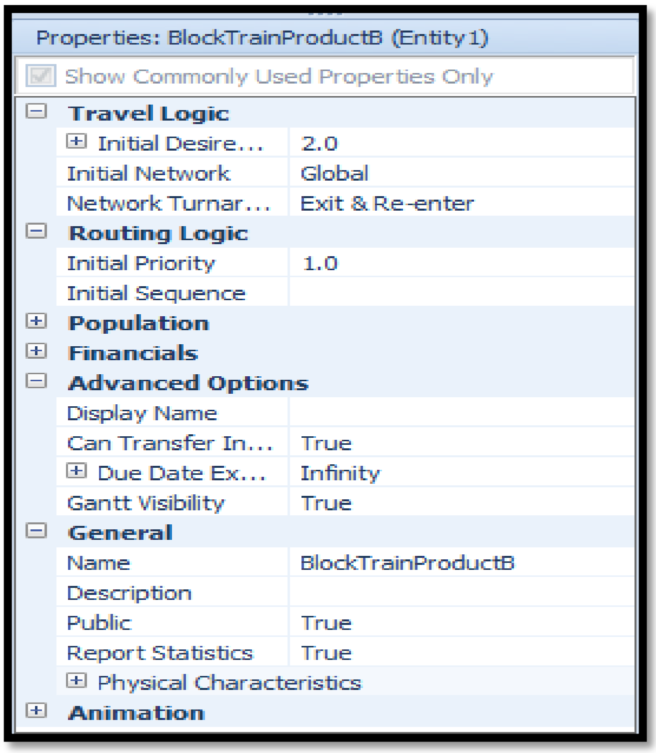

Properties: BlockTrainProductA (Entity1)

Show Commonly Used Properties Only

Travel Logic	
Initial Desire...	2.0
Initial Network	Global
Network Turnar...	Exit & Re-enter
Routing Logic	
Initial Priority	1.0
Initial Sequence	
Population	
Financials	
Advanced Options	
Display Name	
Can Transfer In...	True
Due Date Ex...	Infinity
Gantt Visibility	True
General	
Name	BlockTrainProductA
Description	
Public	True
Report Statistics	True
Physical Characteristics	
Animation	

Figure 18: Block Train Product A (Entity 1)

Figure 19 shows the properties of another entity 1(Product B).

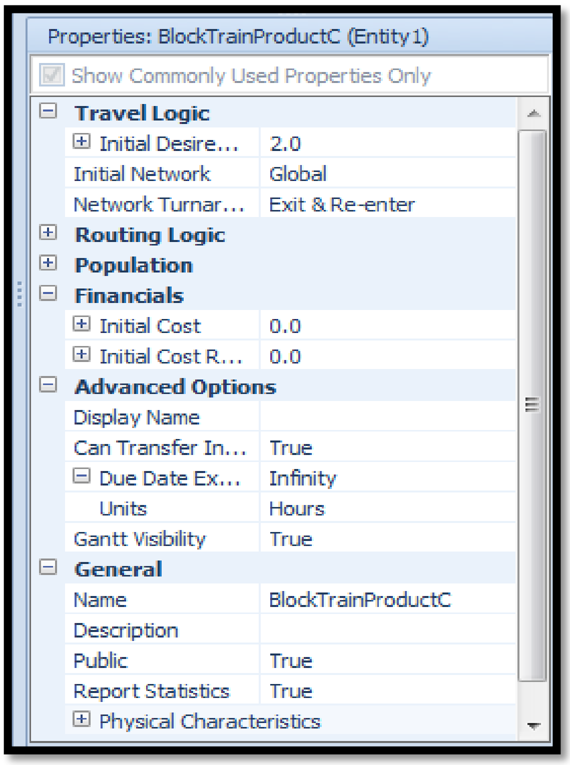

Properties: BlockTrainProductB (Entity 1)

Show Commonly Used Properties Only

Travel Logic	
Initial Desire...	2.0
Initial Network	Global
Network Turnar...	Exit & Re-enter
Routing Logic	
Initial Priority	1.0
Initial Sequence	
Population	
Financials	
Advanced Options	
Display Name	
Can Transfer In...	True
Due Date Ex...	Infinity
Gantt Visibility	True
General	
Name	BlockTrainProductB
Description	
Public	True
Report Statistics	True
Physical Characteristics	
Animation	

Figure 19: Block Train Product B (Entity 1)

Figure 20 shows the properties of another entity 1(Product C).

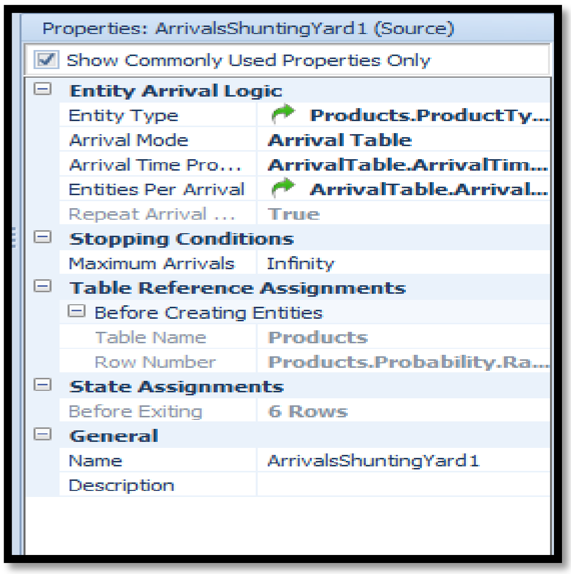

Properties: BlockTrainProductC (Entity 1)

Show Commonly Used Properties Only

Travel Logic	
Initial Desire...	2.0
Initial Network	Global
Network Turnar...	Exit & Re-enter
Routing Logic	
Population	
Financials	
Initial Cost	0.0
Initial Cost R...	0.0
Advanced Options	
Display Name	
Can Transfer In...	True
Due Date Ex...	Infinity
Units	Hours
Gantt Visibility	True
General	
Name	BlockTrainProductC
Description	
Public	True
Report Statistics	True
Physical Characteristics	

Figure 20: Block Train Product C (Entity 1)

Figure 21 shows the entity arrival logic where the Block train will arrive according to the arrival table at Shunting yard 1 with the different products. The repeated arrival has been included so that the arrival of the entities might be repeated depending how long the simulation will run. The entities arrive at Shunting yard 1. An explanation of this is captured under products in figure 15 where two Block train arrive in Plant K per week. A total 8 trains arrives in Plant K with expected number of products in a month.

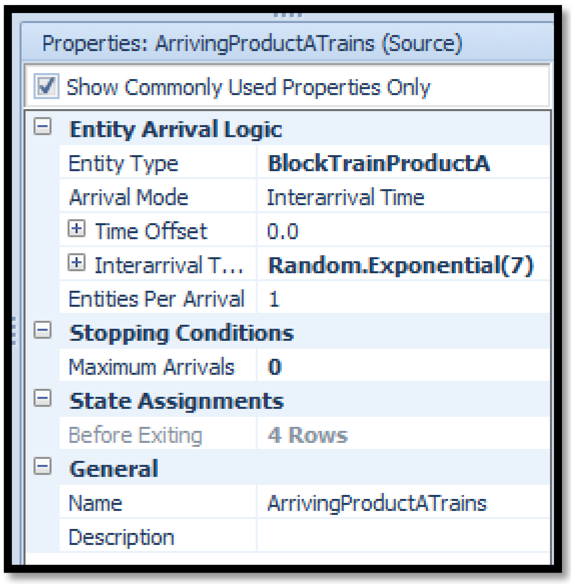

Properties: ArrivalsShuntingYard1 (Source)

Show Commonly Used Properties Only

Entity Arrival Logic	
Entity Type	Products.ProductTy...
Arrival Mode	Arrival Table
Arrival Time Pro...	ArrivalTable.ArrivalTim...
Entities Per Arrival	ArrivalTable.Arrival...
Repeat Arrival ...	True
Stopping Conditions	
Maximum Arrivals	Infinity
Table Reference Assignments	
Before Creating Entities	
Table Name	Products
Row Number	Products.Probability.Ra...
State Assignments	
Before Exiting	6 Rows
General	
Name	ArrivalsShuntingYard1
Description	

Figure 21: Arrivals at Shunting Yard 1

Figure 22 shows the arrivals of the block train with the different products, in this case the logic concerns Product A. It is set up to allow for the arrival of the Block train with Product A and inter arrival has been set up to be random and exponential 7, given the number of days in a week. Entity arrival (the number of products arriving by Block train) is 1. The model has been setup to cater for 24 Hours in day and a seven day week.

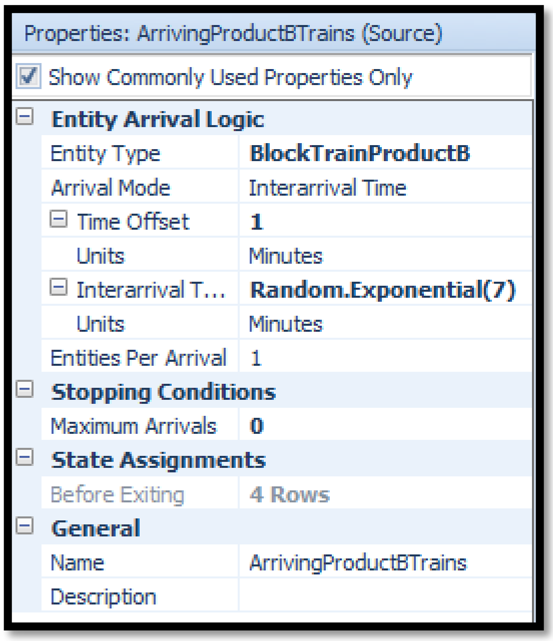

Properties: ArrivingProductATrains (Source)

☑ Show Commonly Used Properties Only

Entity Arrival Logic	
Entity Type	**BlockTrainProductA**
Arrival Mode	Interarrival Time
⊞ Time Offset	0.0
⊞ Interarrival T...	**Random.Exponential(7)**
Entities Per Arrival	1
Stopping Conditions	
Maximum Arrivals	**0**
State Assignments	
Before Exiting	**4 Rows**
General	
Name	ArrivingProductATrains
Description	

Figure 22: Arriving Product A by train at the Source 1

Figure 23 shows Product B logic. The source is set up to allow the arrival of the Block train with Product B and inter arrival has been set up to be random and exponentially set at 7 days, given the number of days in a week. Entity arrival: the number of products to arrive by Block train is 1.

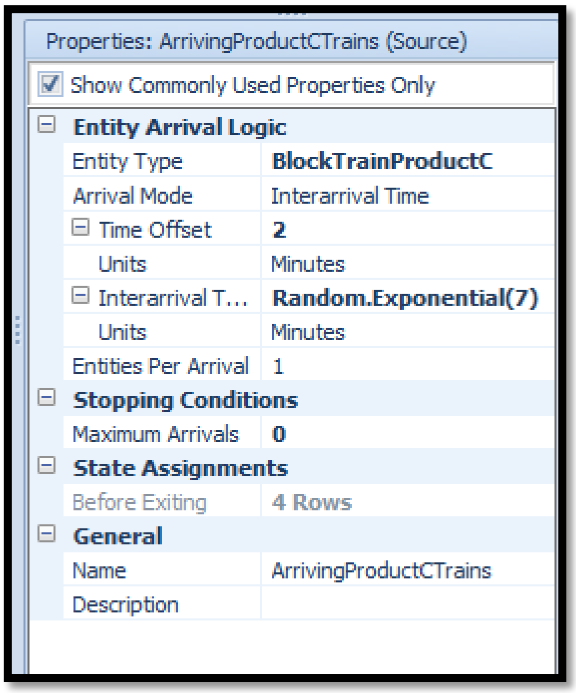

Properties: ArrivingProductBTrains (Source)

☑ Show Commonly Used Properties Only

Entity Arrival Logic	
Entity Type	**BlockTrainProductB**
Arrival Mode	Interarrival Time
⊟ Time Offset	**1**
Units	Minutes
⊟ Interarrival T...	**Random.Exponential(7)**
Units	Minutes
Entities Per Arrival	1
Stopping Conditions	
Maximum Arrivals	**0**
State Assignments	
Before Exiting	**4 Rows**
General	
Name	ArrivingProductBTrains
Description	

Figure 23: Arriving Product B by train at Source 2

Figure 24 shows Product C logic. The source is set up to allow the arrival of the Block train with Product C, and inter arrival has been set up to be random and exponentially at 7 given the number of days in a week.



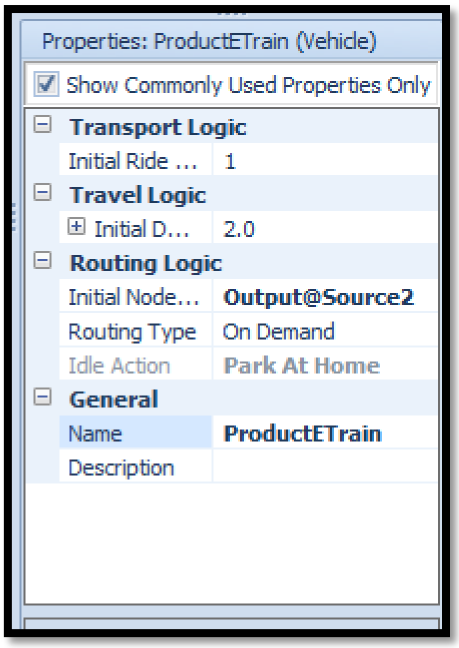
Properties: ArrivingProductCTrains (Source)

Show Commonly Used Properties Only

Entity Arrival Logic	
Entity Type	**BlockTrainProductC**
Arrival Mode	Interarrival Time
Time Offset	**2**
Units	Minutes
Interarrival T...	**Random.Exponential(7)**
Units	Minutes
Entities Per Arrival	1
Stopping Conditions	
Maximum Arrivals	**0**
State Assignments	
Before Exiting	**4 Rows**
General	
Name	ArrivingProductCTrains
Description	

Figure 24: Arriving Product B by train at Source 2

Figure 25 shows the properties of the Product E train that is, the logic. Initial ride capacity is set up to allow one load of Product E to be transported by the Product E train. Product E Locomotive parks at output source node when it is not in demand. Product E trains are transported by TFR locomotives.



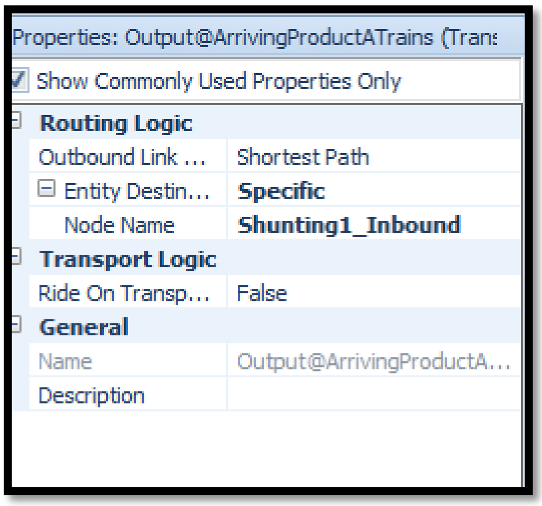
Properties: ProductETrain (Vehicle)

☑ Show Commonly Used Properties Only

Transport Logic	
Initial Ride ...	1
Travel Logic	
⊞ Initial D...	2.0
Routing Logic	
Initial Node...	**Output@Source2**
Routing Type	On Demand
Idle Action	**Park At Home**
General	
Name	**ProductETrain**
Description	

Figure 25: Properties of the Product E train

Figure 23 shows the properties of the transfer node at the arrival source at Shunting yard 1 (figure 40). The entity destination has been set up to be specific to allow for the travelling time of the locomotive to a specific destination, that is shunting yard 1 inbound. The entity concerns Product A.



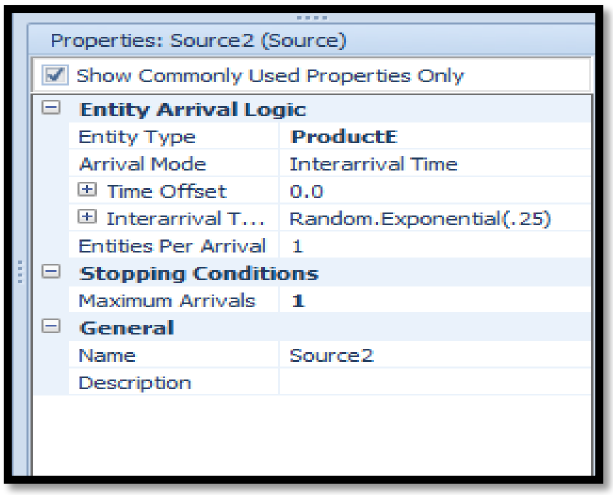
Properties: Output@ArrivingProductATrains (Trans

☑ Show Commonly Used Properties Only

Routing Logic	
Outbound Link ...	Shortest Path
⊟ Entity Destin...	**Specific**
Node Name	**Shunting1_Inbound**
Transport Logic	
Ride On Transp...	False
General	
Name	Output@ArrivingProductA...
Description	

Figure 26: Properties of the transfer nodes

Figure 27 shows the properties of source 2. Product E train enters the plant to deliver product E, at Product E loading zone. The arrival has been set up to be random exponentially distribution of 0.25. The number of entities to arrive at the source is 1, and the maximum arrival is set at 1, meaning not more than one product type can arrive at a time.



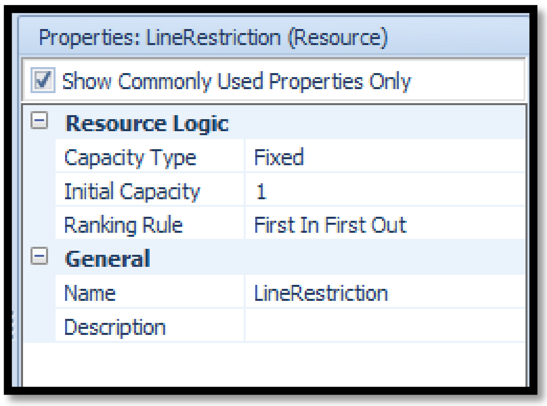
Properties: Source2 (Source)

☑ Show Commonly Used Properties Only

Entity Arrival Logic	
Entity Type	**ProductE**
Arrival Mode	Interarrival Time
⊞ Time Offset	0.0
⊞ Interarrival T...	Random.Exponential(.25)
Entities Per Arrival	1
Stopping Conditions	
Maximum Arrivals	**1**
General	
Name	Source2
Description	

Figure 27 : Properties of Source 2

Figure 28 shows the line restriction source. The resource in this case is used to restrict the movement of the trains on the single track, where only one train is allowed to use the track at a time. This resembles the automated signals in the rail network.



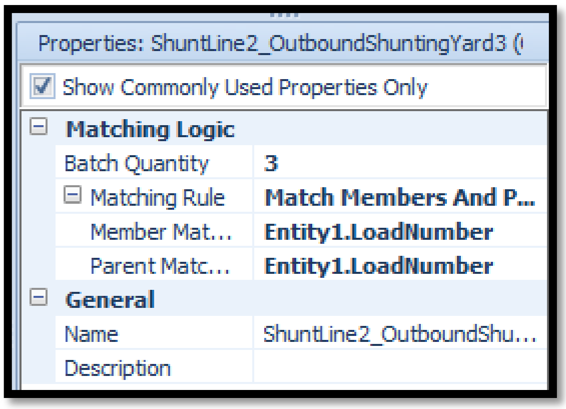
Properties: LineRestriction (Resource)

☑ Show Commonly Used Properties Only

Resource Logic	
Capacity Type	Fixed
Initial Capacity	1
Ranking Rule	First In First Out
General	
Name	LineRestriction
Description	

Figure 28: Line restriction at single track

Figure 29 shows the properties of the combiner at the Shunting yard 3. The combiner is set up in such a way that it will couple entities in this case the RTCs with the different products at Shunting yard 3. The RTCs will be combined until they form a complete load with 40 RTCs. The full load will then be taken to shunting yard 1 by a Company X locomotive. The restriction on the single track follow a first in first out principle, which means only one locomotive entered the single track first will be allowed to use the track at that time no other train will enter.

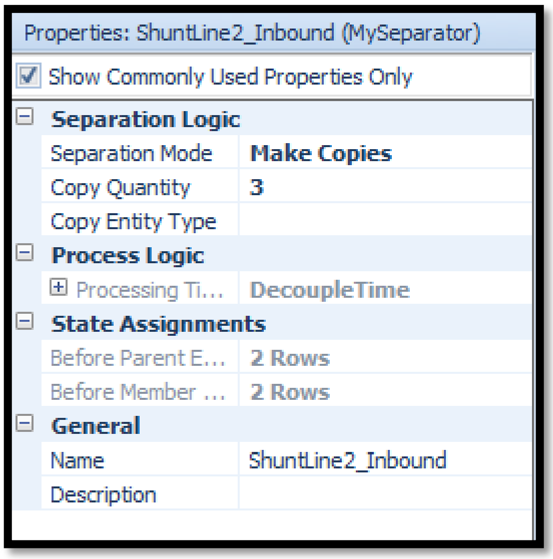

Properties: ShuntLine2_OutboundShuntingYard3 (

☑ Show Commonly Used Properties Only

Matching Logic	
Batch Quantity	**3**
Matching Rule	**Match Members And P...**
Member Mat...	**Entity1.LoadNumber**
Parent Matc...	**Entity1.LoadNumber**
General	
Name	ShuntLine2_OutboundShu...
Description	

Figure 29 Matching of products (Coupling) at shunting yard 3: combiner

Figure 30 shows the properties of the separator. The separator has been set up to make copies to enable the train RTCs to be divided into sets of ten RTCs. The RTCs are transported in sets of ten RTCs because of the limited number of RTCs the loading zone can handle at a time. Decoupling the Block train takes place at Shunting yard 3 and this is made possible by the parameters set up in the separator. 3 copies of each entity are formed at the separator which means products A, B and C are formed at each separator (Figure 40).

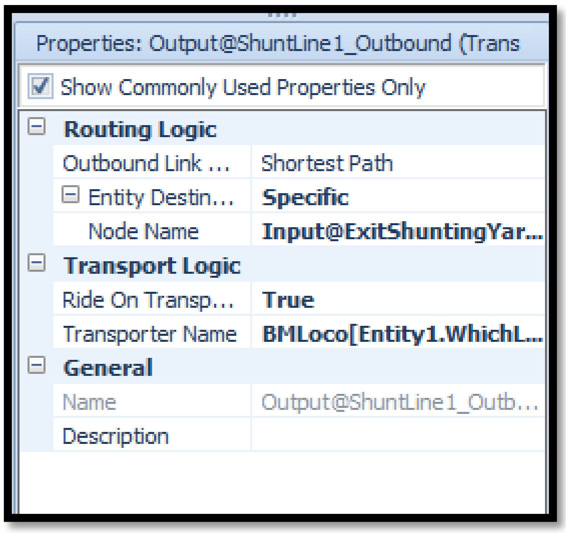

Properties: ShuntLine2_Inbound (MySeparator)

☑ Show Commonly Used Properties Only

Separation Logic	
Separation Mode	**Make Copies**
Copy Quantity	**3**
Copy Entity Type	
Process Logic	
Processing Ti...	**DecoupleTime**
State Assignments	
Before Parent E...	**2 Rows**
Before Member ...	**2 Rows**
General	
Name	ShuntLine2_Inbound
Description	

Figure 30: Properties of the separator at Shunting yard 3 (decoupling)

Figure 31 shows the properties of the transfer node at the separator. The node has been set up to allow the movement of the RTCs and the train to the different loading zones in the plant. The nodes are setup to allow the movement of the locomotives and RTCs to the correct destination together with the RTCs.



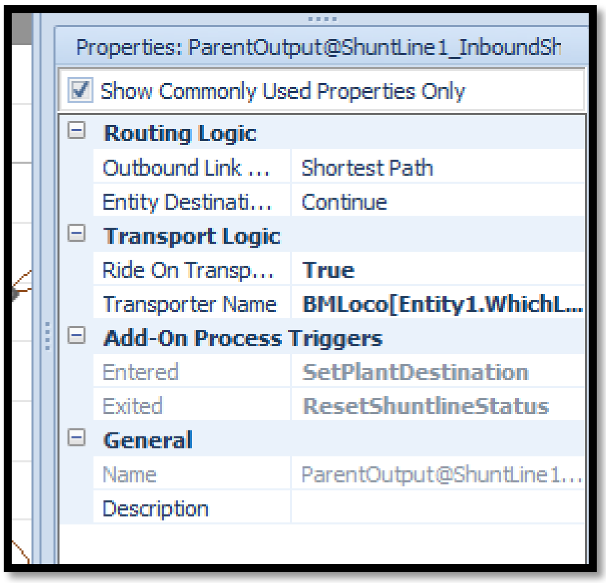
Properties: Output@ShuntLine1_Outbound (Trans

Show Commonly Used Properties Only

Routing Logic	
Outbound Link ...	Shortest Path
Entity Destin...	**Specific**
Node Name	**Input@ExitShuntingYar...**
Transport Logic	
Ride On Transp...	**True**
Transporter Name	**BMLoco[Entity1.WhichL...**
General	
Name	Output@ShuntLine1_Outb...
Description	

Figure 31: Properties of a transfer node in Shunting yard 3

Figure 32 shows the properties of the transfer node at the separator. The node has been set up to allow different RTCs with different products to be transferred to different loading zones in the plant. The destination where the products should go is set up in the transfer node parameters.



Properties: ParentOutput@ShuntLine1_InboundSh

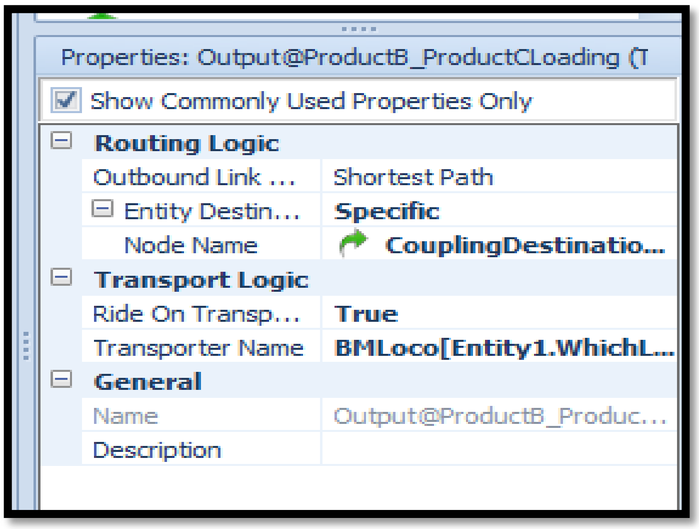
Show Commonly Used Properties Only

Routing Logic	
Outbound Link ...	Shortest Path
Entity Destinati...	Continue
Transport Logic	
Ride On Transp...	**True**
Transporter Name	**BMLoco[Entity1.WhichL...**
Add-On Process Triggers	
Entered	**SetPlantDestination**
Exited	**ResetShuntlineStatus**
General	
Name	ParentOutput@ShuntLine1...
Description	

Figure 32: Properties of the transfer node in Shunting yard 3: inbound

Figure 33 shows the properties of the transfer node at the product B and C loading zone. It is set in such a way that the locomotives go to a specific location. It also allows the coupling of RTCs to the locomotives to take place at the loading zone. The transfer node stated in figure 31 is set up as a location where the locomotive couples RTCs. This happens after the loading of products has taken place at the loading zone. The (True) parameter allows entities to ride on a locomotive. The

RTCs will then be taken to Shunting yard 3 where the full train will be put together and then taken away by the Company X locomotives to Shunting yard 1.

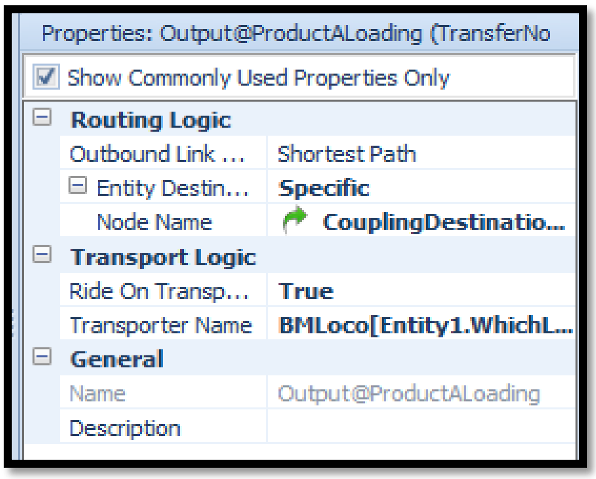

Properties: Output@ProductB_ProductCLoading (T

☑ Show Commonly Used Properties Only

Routing Logic	
Outbound Link ...	Shortest Path
Entity Destin...	**Specific**
Node Name	**CouplingDestinatio...**
Transport Logic	
Ride On Transp...	**True**
Transporter Name	**BMLoco[Entity1.WhichL...**
General	
Name	Output@ProductB_Produc...
Description	

Figure 33: Properties of the transfer node at Product B and C loading zones

Figure 34 shows the properties of the transfer node at the combiner. The node enables the locomotives to go to the specific destination required. The destination is Product A loading zone. It is set up to allow coupling of the RTCs to the locomotives.

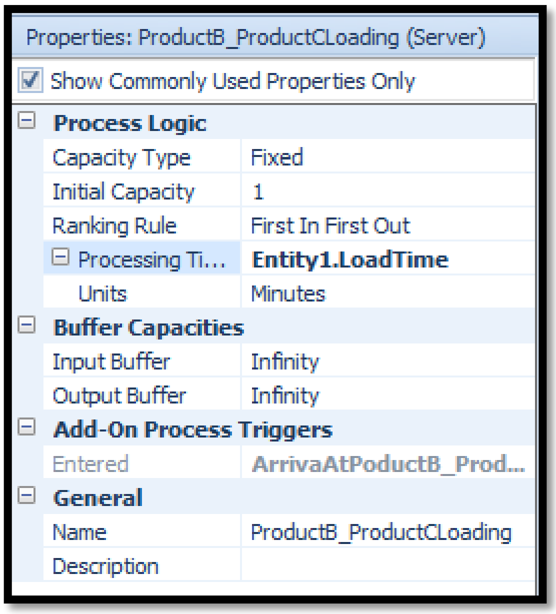

Properties: Output@ProductALoading (TransferNo

☑ Show Commonly Used Properties Only

Routing Logic	
Outbound Link ...	Shortest Path
Entity Destin...	**Specific**
Node Name	**CouplingDestinatio...**
Transport Logic	
Ride On Transp...	**True**
Transporter Name	**BMLoco[Entity1.WhichL...**
General	
Name	Output@ProductALoading
Description	

Figure 34 : Properties of the transfer node at Product A loading zone

Figure 35 shows the properties of the transfer node in the combiner. The node enables the locomotives to go to the specific destination required. The destination is in this case Product B and C loading zone. It is set up to allow coupling of the RTCs to the locomotives.

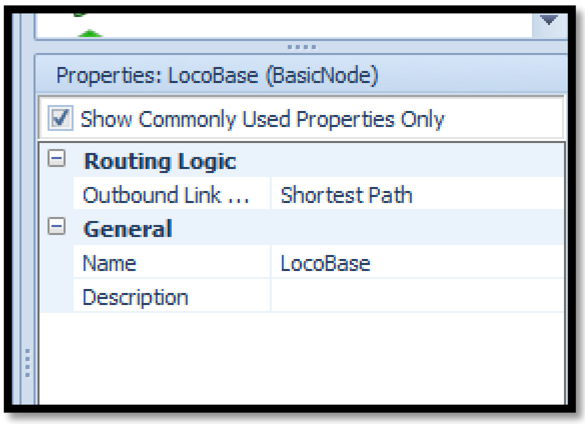

Properties: ProductB_ProductCLoading (Server)

☑ Show Commonly Used Properties Only

Process Logic	
Capacity Type	Fixed
Initial Capacity	1
Ranking Rule	First In First Out
Processing Ti...	**Entity1.LoadTime**
Units	Minutes
Buffer Capacities	
Input Buffer	Infinity
Output Buffer	Infinity
Add-On Process Triggers	
Entered	**ArrivaAtPoductB_Prod...**
General	
Name	ProductB_ProductCLoading
Description	

Figure 35 : Properties of a server at Product B and C loading zones

Figure 36 shows the properties of the basic node where the Company A locomotives park when they are not in demand.

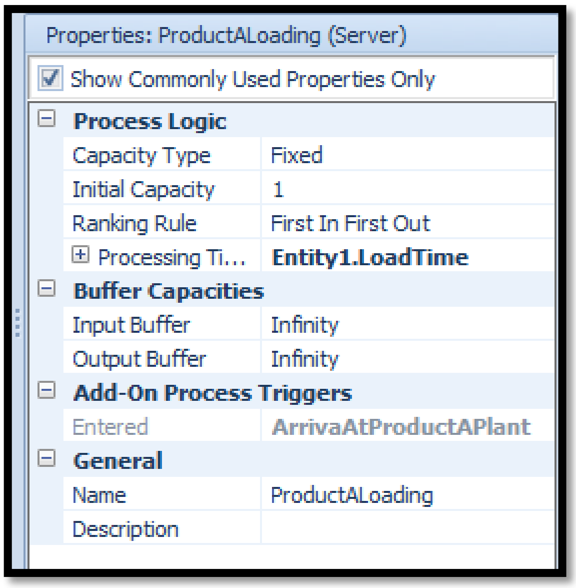

Properties: LocoBase (BasicNode)

☑ Show Commonly Used Properties Only

Routing Logic	
Outbound Link ...	Shortest Path
General	
Name	LocoBase
Description	

Figure 36: Properties of the basic node at the locomotive base

Figure 37 shows the properties of the server at the Product A loading zone. The processing time of the entity load has been set at 20 minutes. It takes 20 minutes to complete the loading at this point. The server has been enabled to allow Product A RTCs to enter the loading zone as expected.



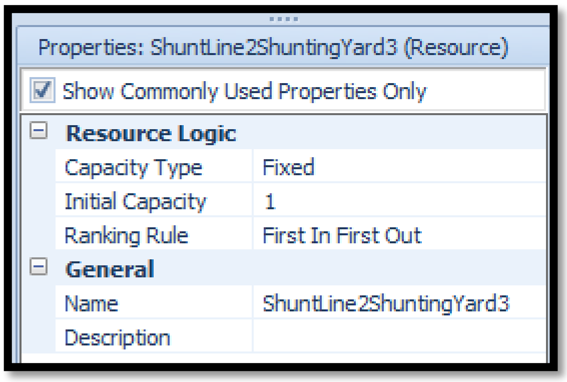
Properties: ProductALoading (Server)

☑ Show Commonly Used Properties Only

Process Logic	
Capacity Type	Fixed
Initial Capacity	1
Ranking Rule	First In First Out
⊞ Processing Ti...	**Entity1.LoadTime**
Buffer Capacities	
Input Buffer	Infinity
Output Buffer	Infinity
Add-On Process Triggers	
Entered	**ArrivaAtProductAPlant**
General	
Name	ProductALoading
Description	

Figure 37: Properties of a server at the Product A loading zone

Figure 3 and 39 shows the properties of the resource at the shunt line 2 in Shunting yard 3. The resource helps in allowing the movement of the entities or RTCs to take place in a particular sequence. A first in, first out principle takes place.



Properties: ShuntLine2ShuntingYard3 (Resource)

☑ Show Commonly Used Properties Only

Resource Logic	
Capacity Type	Fixed
Initial Capacity	1
Ranking Rule	First In First Out
General	
Name	ShuntLine2ShuntingYard3
Description	

Figure 38: Properties of the resources at Shunting yard 3, Shunt line 2

6.3. Explanation of the model

6.3.1. Entities

a) Non Permanent entities:

- Block Train RTCs
- Product E trains
- Transnet Locomotives

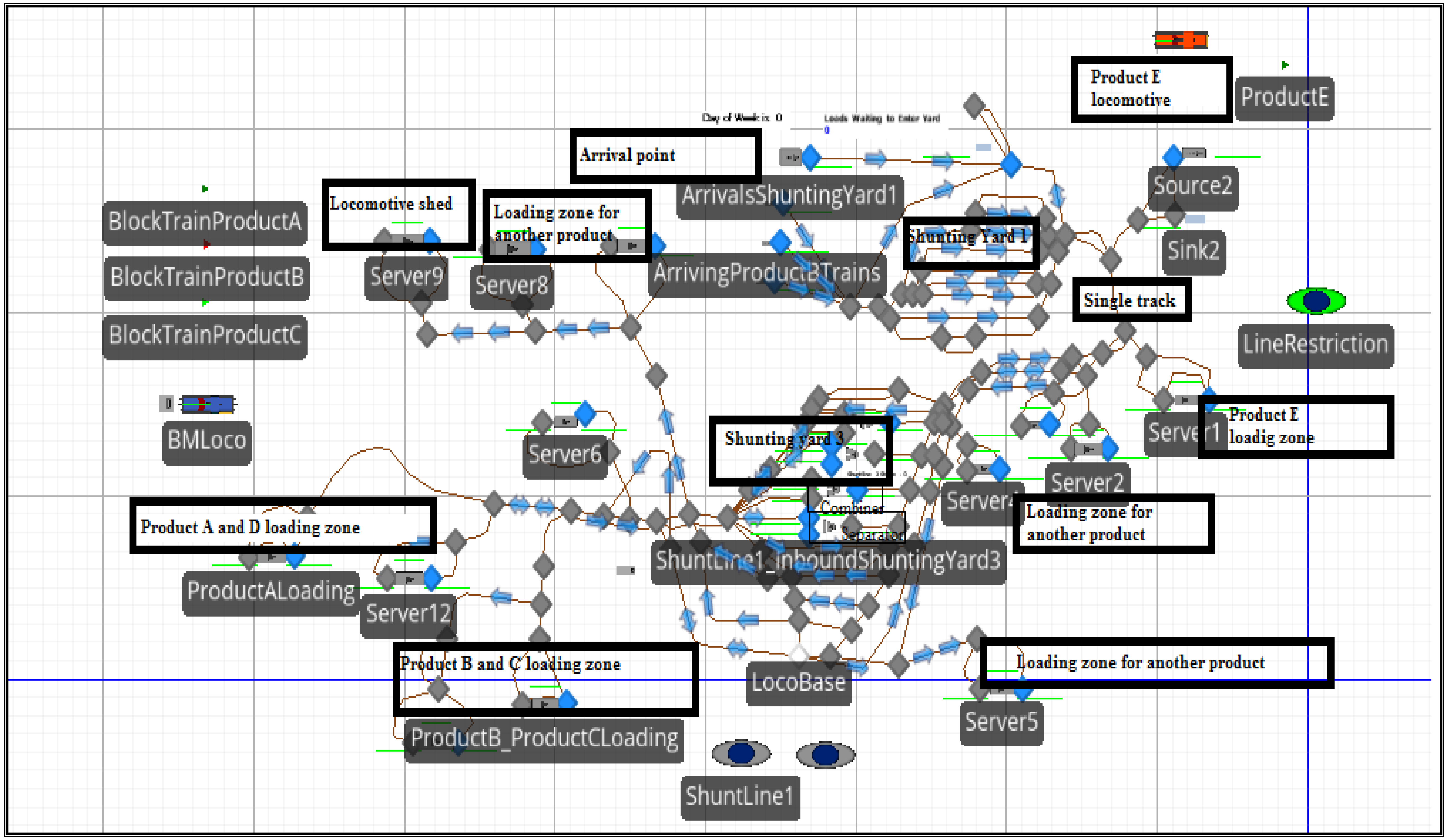
b) Permanent entities

- Company X locomotives
- Loading and offloading zones
- Locomotive shed

6.3.2. Model

The model developed simulates the Block trains' activities. Two shunting locomotives are used in the model (figure 39).

Figure 39: Company X shunting Process model



7. EXPERIMENT.

The model was run for a six month period. Running the model for this time meant that the simulation output was consistent and accurate.

8. RESULTS

8.1. Locomotive Transit Times

Results are shown in table 2. For example, it was found that the RTCs on Block train take 1.27 hours minimum, 1.69 hours maximum and 1.48 hours on average to arrive at the Product A loading and offloading zone, and back to shunting yard 1. The Block train takes 1.3 Hours minimum, 1.59 Hours average 1.89 Hours maximum to travel from Shunting yard 1 to the Product B and C loading zone, and back and back to shunting yard 1.

The times indicated in table 2 include the shunting and waiting time for locomotives to pick up the wagons, as well as the time taken by the train to exit. The time includes the offloading and administration time.

Data Source	**Statistic Type**	**Value**	**Explanation**
Time from arrival to Product A plant K	Average	1.48h	Average Block train travel time from arrival to Product A plant
Time from arrival to Product A plant	Maximum	1.69h	Maximum time from arrival to Product A plant
Time from arrival to Product A plant	Minimum	1.27h	Minimum time from arrival to Product A plant
Time from arrival to Product A plant	Observations	**60**	**Total loads of sets of ten RTCs (60 x 10 RTCs)**
Time from arrival to Product B and C plants	Average	1.59h	Average time from arrival to Product B and C plants.
Time from arrival to Product B and C plants	Maximum	1.89h	Maximum time from arrival to Product B and C plants.
Time from arrival to Product B and C plants	Minimum	1.3h	Minimum time from arrival to Product B and C plants.
Time from arrival to Product B and C plants	Observations	**132**	**Total loads of sets of ten RTCs (132 x 10 RTCs)**

Table 2: The time RTCs

8.2. Total number of loads entering and exiting the plants in six months

Table 3 illustrates the number of full trains per product which were offloaded in each loading and offloading zone.

Data Source	**Statistic Type**	**Value**	**Explanation**
Loads entered: Product A	Final value	15	Number of Product A full trains
Loads entered: Product C	Final value	15	Number of Product C full trains
Loads entered: Product B	Final value	18	Number of Product B full trains
Loads entered: Total	Final value	**48**	**Total number of** full trains
Loads exited: Product A	Final value	15	Number of Product A full trains
Loads exited: Product C	Final value	15	Number of Product C full trains
Loads exited: Product B	Final value	18	Number of Product B full trains
Loads exited: Total	Final value	**48**	**Total number of** full trains

Table 3: Total number of loads entering and exiting the plants in six months

8.3. Utilisation of locomotives

In table 4 the utilisation of the two locomotives is shown for the 24 weeks (6 months).
The total utilisation of locomotive 1 for Product A was 1.06 % of the total time when the locomotive was available. The total utilisation of locomotive 2 for Products A, B, C and D was 2.66 % of the total time when the locomotive was available. The total utilisation of both locomotives was 1.86% of the total time when both locomotives were available which added up to (1.06+2.66)/2=1.86%. The total idle time of locomotive 1 was 98.94 % while the total idle time of locomotive 2 was 97.34 % when they were available (See table 4).

Object Type	Object Name	Data Item	Statistic Type	Value
MyVehicle	BMLoco	Scheduled Utilization	Percent	1.86%
MyVehicle	BMLoco[1]	Scheduled Utilization	Percent	1.06%
MyVehicle	BMLoco[1]	Idle Time	Percent	98.94%
MyVehicle	BMLoco[1]	Transporting Time	Percent	1.06% (42.78h)
MyVehicle	BMLoco[2]	Scheduled Utilization	Percent	2.66%
MyVehicle	BMLoco[2]	Idle Time	Percent	97.34%
MyVehicle	BMLoco[2]	Transporting Time	Percent	2.66% (107.18h)

Table 4: Utilisation of locomotives

9. VALIDATION.

Limited historical data was available for validation. Therefore validation primarily consisted of examining each simulated process individually, and considering whether it was a true reflection of the real-world process, based on what has been observed on-site, as well as practical considerations.

The Block train arrives twice on a weekly basis in Town M and leaves twice from Company X plant situated in Town M to Town L, and the Block train in the model does the same. These results were captured over 24 weeks (6 months) and confirm that in that period 48 Block train trains entered Company X plant K, and 48 Block train trains exited the plant K (Figure 44). This confirms that the Block train arrives twice weekly in six months (24 weeks).

10 sets of RTCs can be loaded or offloaded in each plant at a time, given the limited capacity of the loading and off-loading zones which resulted in 60 loads of Product A sets of ten, and 132 sets of Products B and C transported. The model depicts the decoupling and coupling of ten sets of RTCs in Shunting yard 3. The speed of locomotives to different locations is set at 15km/h as is the case in the real life situation. The Product E trains have also been included in the model because they share the single line in the network rail with the Block Train when they go to a Product E offloading zone. The Product E trains and Block Train use single line at the rail

network and this line is controlled and only allows one train at a time to occupy the section, which is what occurs in the real life situation.

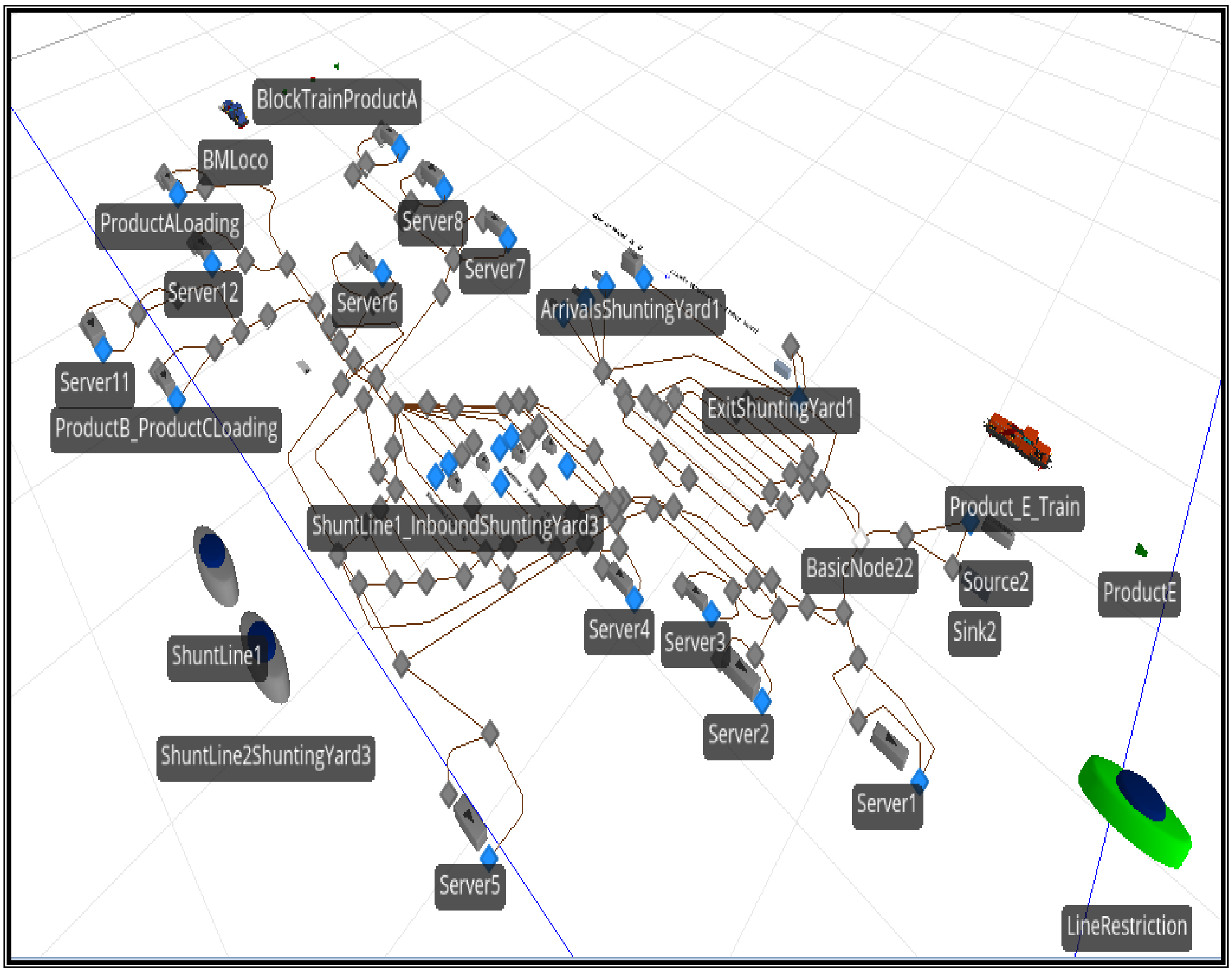


Figure 40: A 3D model of the rail network in the plant

In figure 41 Product E train enters the Product E loading zone. There is no other train on the track except the coal train. There is no exchange of RTCs which confirms what happens in the real situation.

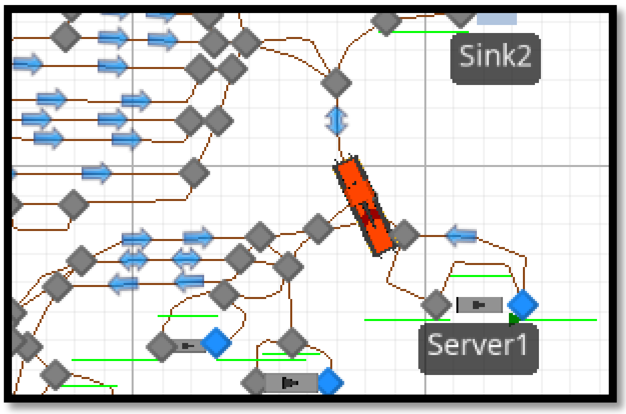


Figure 41: Product E train enters the loading zone

In figure 42 Product E train offloads Product E in the loading zone. The offloading takes place at this point. The loading of Product E in this case confirms what happens in the real situation.

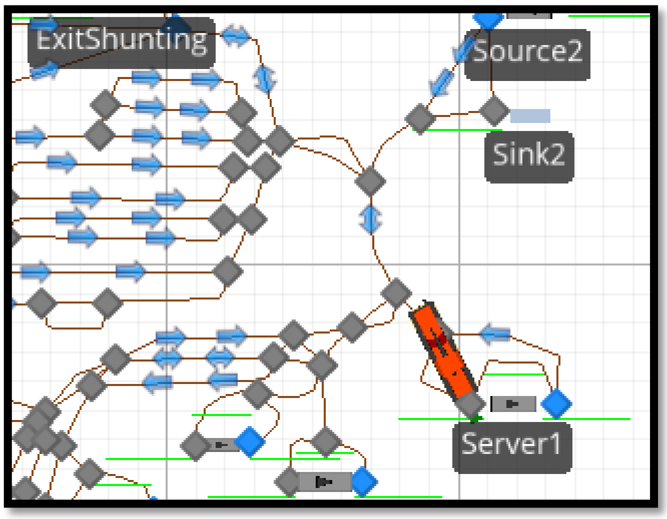


Figure 42: Product E train offloads Product E at the Product E loading zone

In figure 43 Product E train has offloaded Product E at the loading zone. The offloading has taken place and the train is going back. The movement of the Product E train confirms what happens in the real situation.

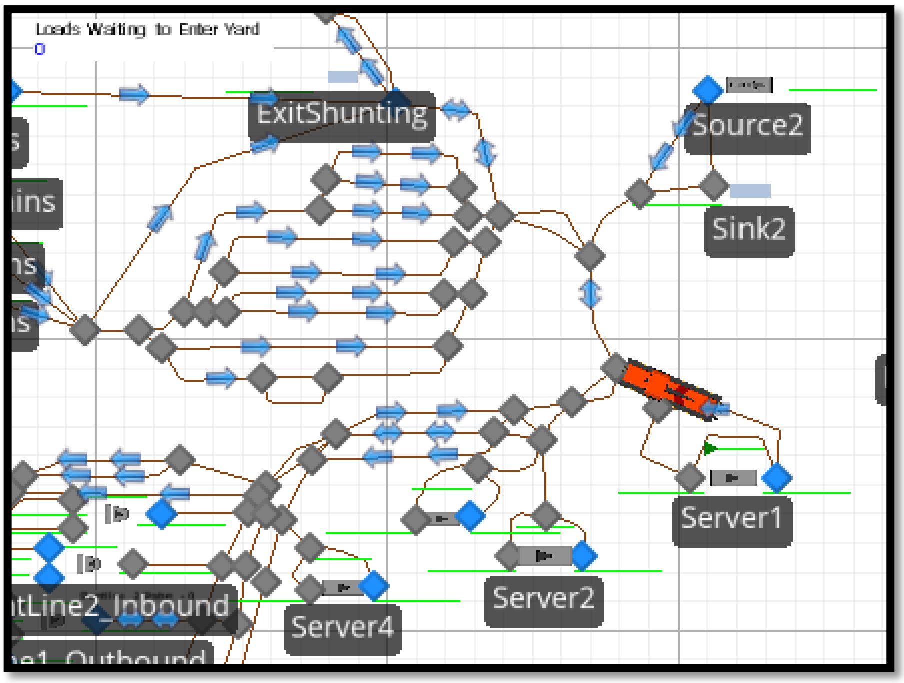


Figure 43: Product E train exits the Product E loading zone

In figure 44 Company X locomotives goes to Shunting yard 1 to pick up the Block train from the locomotive base. As in the real situation, the locomotive movement will take place as simulated.

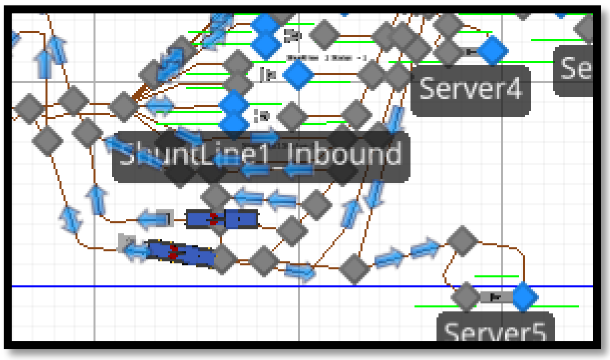


Figure 44: The locomotive from the plant going to pick up the full train at Shunting yard 1

In figure 45 shows a locomotive is on its way to the Shunting yard 1 to pick up the Block train from the locomotive base. The base is where the locomotives park when they are idling.

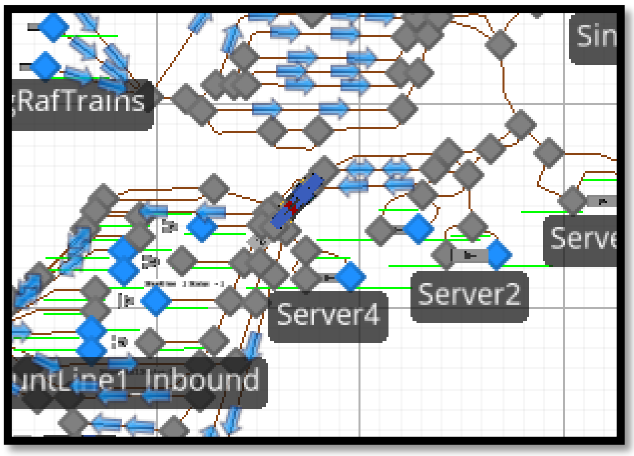


Figure 45: The locomotive passes shunting yard 2 to pick up the full train at shunting yard 1

Figure 46 shows a situation where a Product E locomotive has stopped because the Company X locomotive has already occupied the single track section in the rail network.

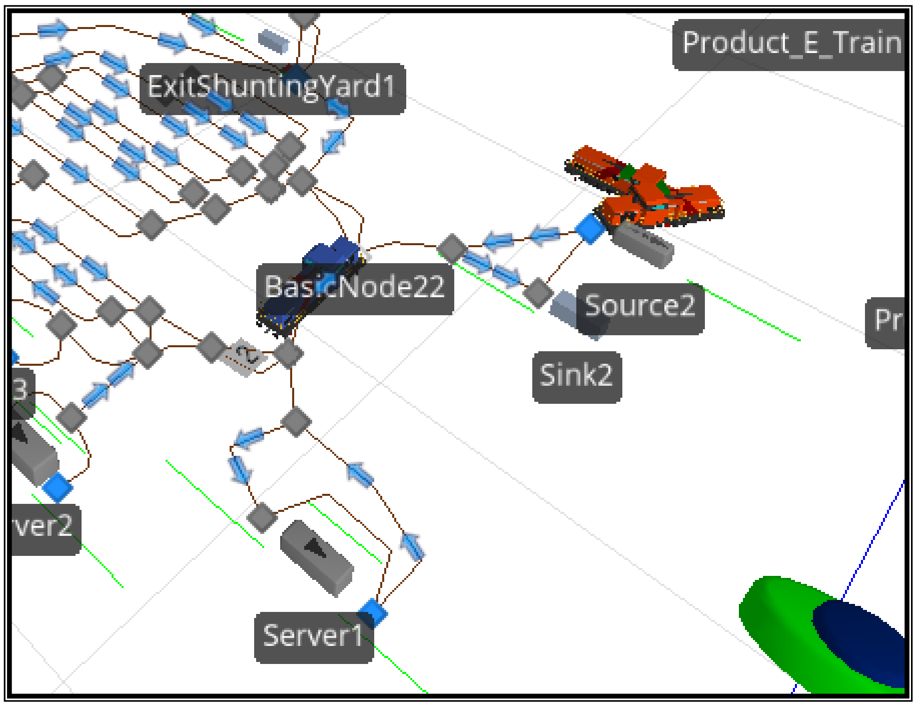


Figure 46: A locomotive has stopped due to single track being occupied

In figure 47 a locomotive collects the Block train at Shunting yard 1.

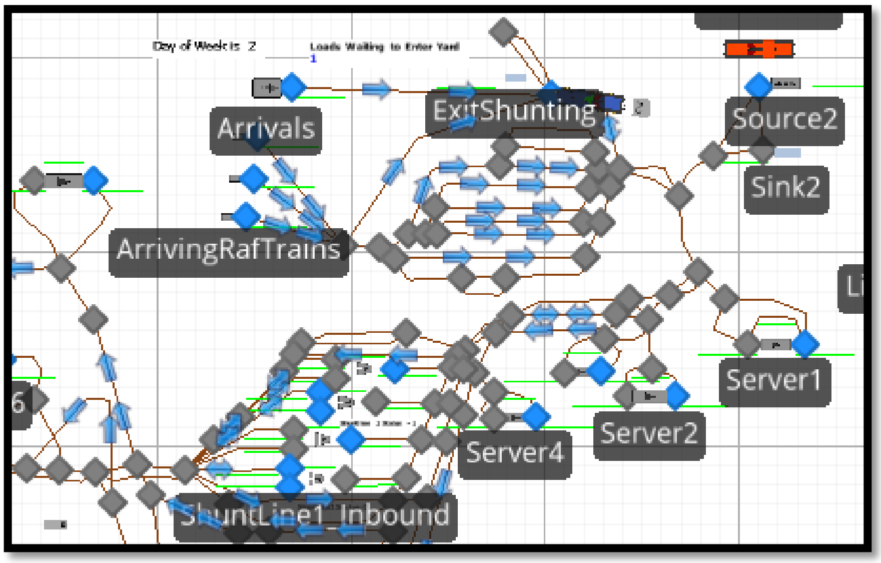


Figure 47: The locomotive collects the full train at Shunting yard 1

In figure 48 a locomotive passes the single track to Shunting yard 3.

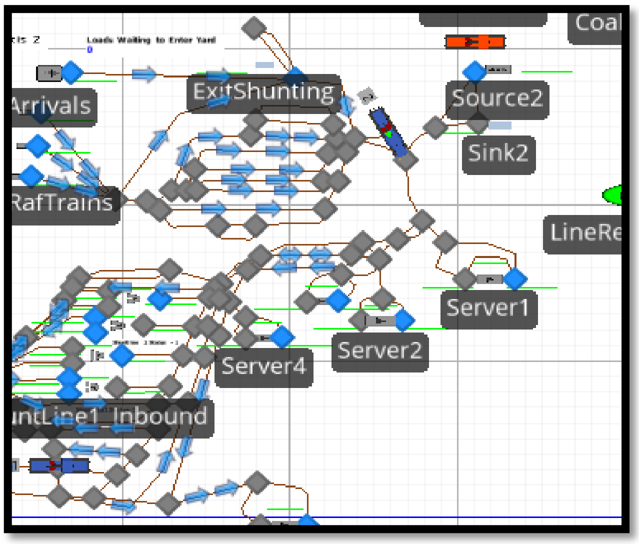


Figure 48: The locomotive has moved the train from Shunting yard 1 to Shunting yard 3

In figure 49 Company X locomotives pass the single track with the load to the Shunting yard 3. This shows what happens in the real situation.

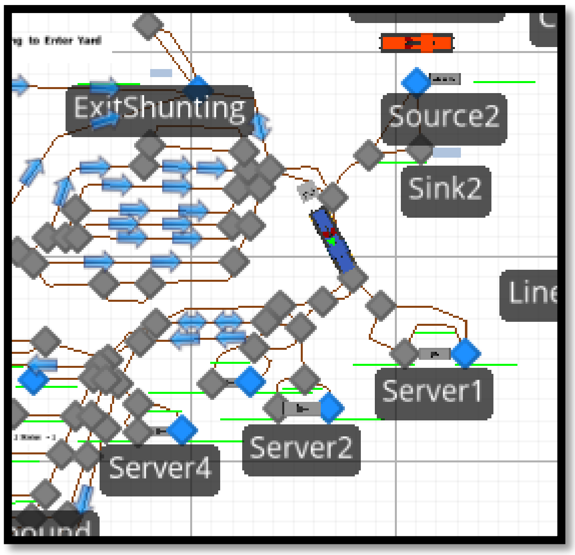


Figure 49: The locomotive passes the single track with the full load to Shunting yard 3

In figure 50 RTCs are taken to the loading zones in sets of tens after the train has been divided in Shunting yard 3. They will decouple and then move to the front to take the load to the loading zone.

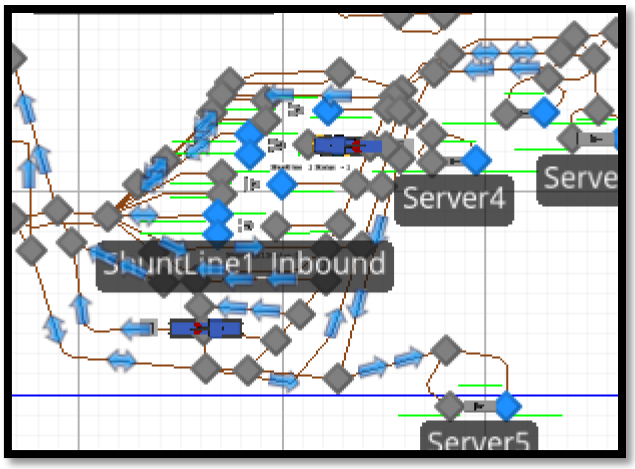


Figure 50: Decoupling of RTCs is takes place at Shunting yard 3

In figure 51 a locomotive takes a set of ten RTCs to the loading zone.

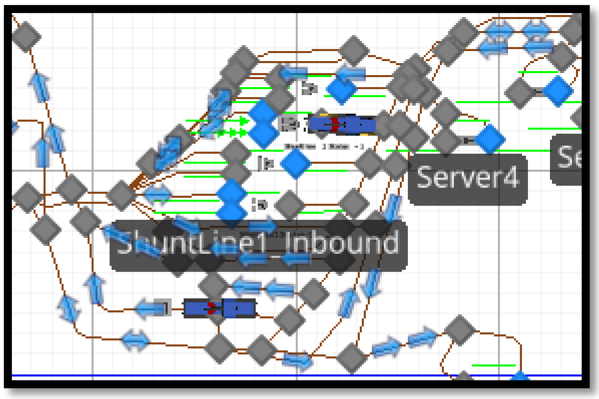


Figure 51: The locomotive is taking RTCs to the loading zone

In figure 52 a locomotive goes to the loading zone with RTCs from Shunting yard 3.

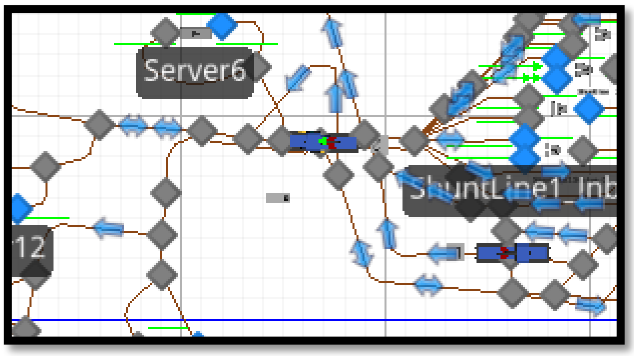


Figure 52: The locomotive is taking RTCs to the loading zone.

In figure 53 a locomotive has dropped off the load in the Product B and C loading zones. This confirms what happens in the real situation where the locomotive will take the loads to the loading zones as expected.

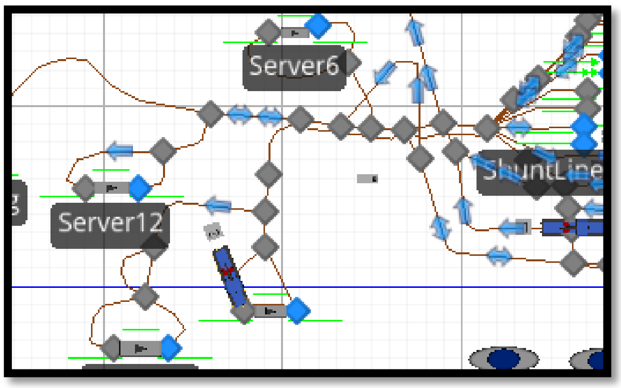


Figure 53: The locomotive drops off the RTCs at the loading zone.

In figure 54 Company X the locomotive returns to Shunting yard 3 to collect more loads to be dropped off at the Product B and C loading zones. This shows what happens in the real situation where the locomotive after dropping off the load will go back to Shunting yard 3 to get more loads. At same time the dropping off the loaded loads to Shunting yard 3 takes place confirming the real situation.

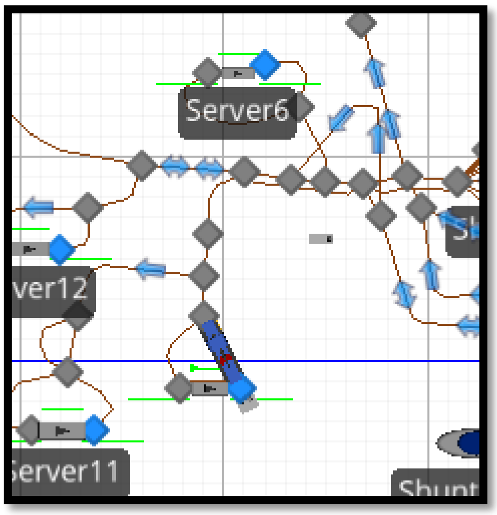


Figure 54: The locomotive collect more sets of RTCs at shunting yard 3 to the loading zone in the plant

In figure 55 a locomotive from the loading zone to Shunting yard 3 to collect more loads and at the same time drop off the loaded RTCs at Shunting yard 3. This reflects what happens in the real situation where the locomotive will take loads to Shunting yard 3 after loading and transport more RTCs to the loading zone as expected.

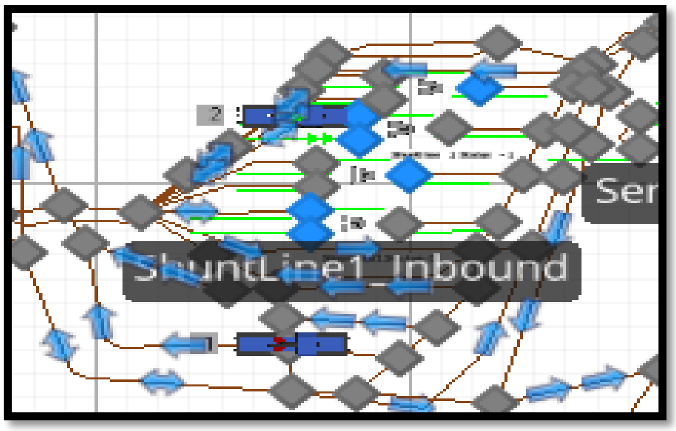


Figure 55: The locomotive collects more sets of RTCs at Shunting yard 3 to drops them off at the loading zone

In figure 56 a locomotive drop off another load of Product B and C loading zones. This mirrors what happens in the real situation.

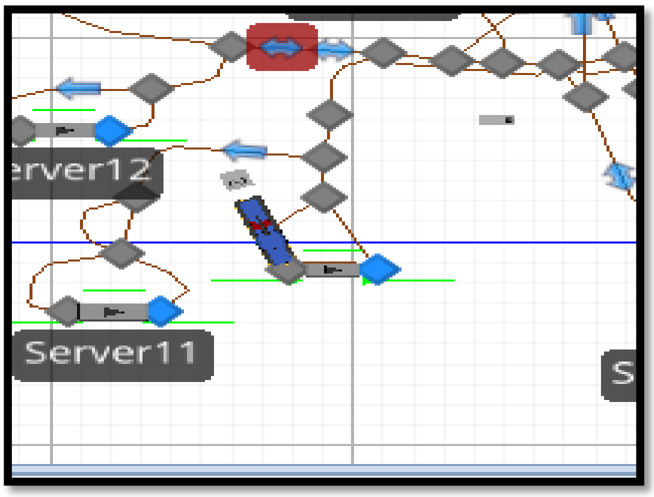


Figure 56: The locomotive drops off the RTCs at the loading zone

In figure 57 a locomotive transport the full train after loading has taken place to Shunting yard 1.

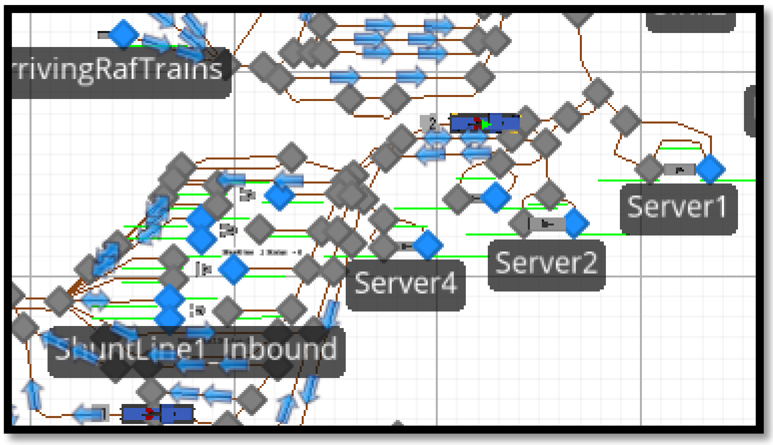


Figure 57: The full train is taken back to Shunting yard 1 after loading coupling has taken place

In figure 58 a locomotive passes the single track with the full load to Shunting yard 1.

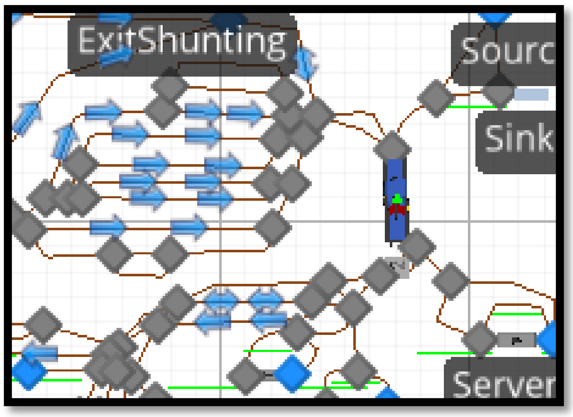


Figure 58: The locomotive with full train goes to shunting yard 1 passes a single track section

In figure 59 a locomotive drop off the full train at Shunting yard 1.

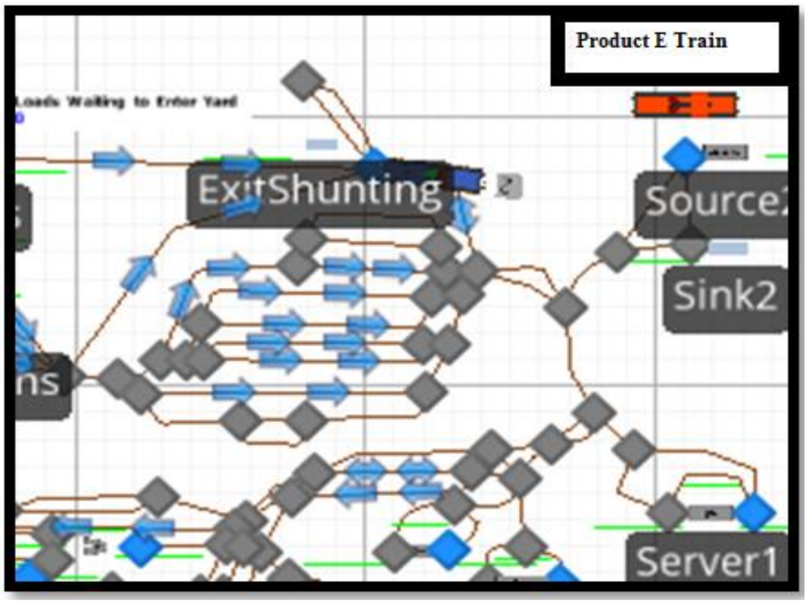


Figure 59: The locomotive has dropped off the full train at Shunting yard 1

In figure 60 shows a locomotives dropping off a set of ten RTCs at the Product A loading zone.

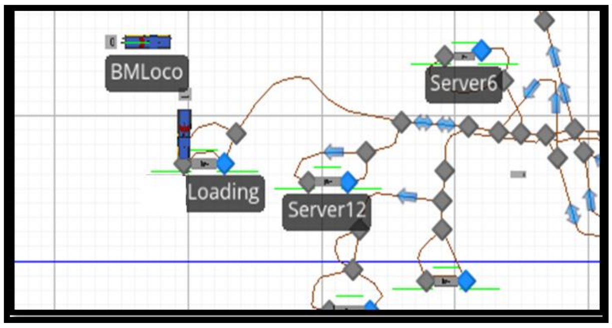


Figure 60: The locomotive makes a drop off at Product A loading zone

In figure 61 a locomotive goes to Shunting yard 3 to collect more sets of RTCs. At the same time a locomotive takes the loaded RTCS to Shunting yard 3 to be jointed to the other loaded RTCs.

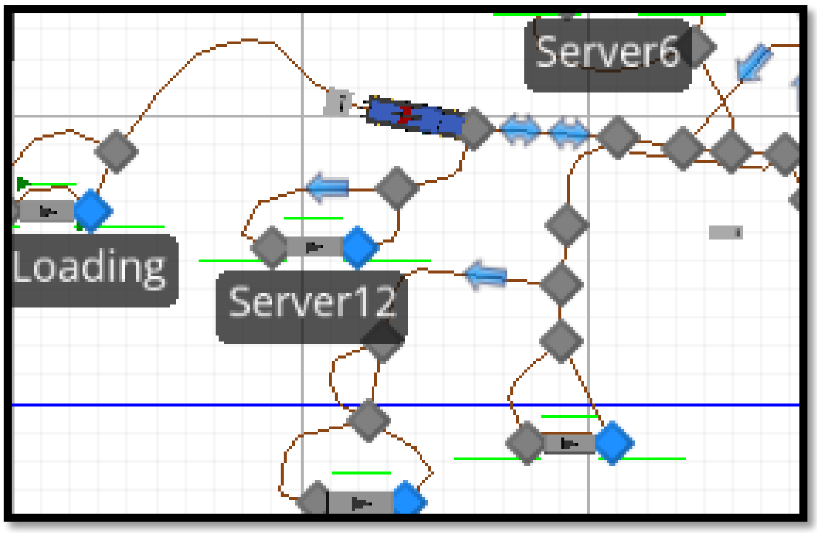


Figure 61: Locomotive goes to pick drop more RTCs from Shunting yard 3 to the loading zone

10. DISCUSSION

The objective of the study was to discover whether a simulation model of the Company X, Plant K rail network system can be developed and used to compare system design changes. The model has been developed successfully. It has been shown to accurately simulate activities occurring on-site.

Taking the results into account, Company X could increase productivity by increasing the speed at which the locomotives travel from the Shunting yard 1 to the offloading and loading zones in the primary area. Instead of travelling at 15km/h, the minimum speed could be increased to 20km/h. The train would then reach its destination more quickly than it does currently. One locomotive could also be used instead of using two to transport the Block Train RTCs, provided that the current schedule does not alter the arrival and departure of the Block Train twice weekly.

Improvement of delivery will also depend on increasing the speed at which the Company X locomotives travel from Shunting yard 1 to the loading and offloading zones. The decrease in the time it takes for the Car-puller to take a set of RTC to the loading zones could also contribute to improving service delivery within the plant.

Adding more days in Block Train schedule will increase productivity. Instead of the train coming only twice a week this could be increased to 3 days. It will be a challenge to change processing time as under normal circumstances it takes 20 minutes to load and offload the products at the

loading zones. Therefore the waiting time of locomotives would not be improved because of the processing time.
The total time of the locomotives’ availability could be used for other work, or the locomotives could be serviced in terms of maintenance and repairs. Given the capacity of the locomotives available, the shunting yard could handle more trains. The speed at which the trains travel could be increased in order to improve the service delivery. As a result of the availability of locomotives, the number of loads can be increased per months.

11. CONCLUSION

The focus of the study was to simulate the Company X plant K rail networks and how shunting takes place from Shunting yard 1 to Shunting yard 3, to the offloading and loading zones and back. In conclusion the Company X rail network can be modelled successfully, and this model can be used for evaluating proposed improvements to the rail network.

12. RECOMMENDATIONS

Delivery of quality service requires company X to be efficient in all sectors of its operations. In order to achieve the quality service delivery and economies of scale, the focus should be on cost containment and on increasing production. Cost containment can be achieved by efficient utilisation of the locomotives. Increasing the speed of the locomotive to 20 km/h will increase the travel time of the locomotives from shunting yard 1 to loading zone and back to the shunting yard 1. Decreasing the time it takes for the Car-puller to take a set of RTC to the loading zones could also assist to improving service delivery within the plant.

Increase in customers could also lead to increase in production. The more a product is delivered on time in different loading zones this will lead to increase in production and more volumes can be produced and this could lead to increase in revenue and more customers should be acquired. By adding more days in the Block Train schedule can also assist in increasing the number of loads transported to Plant K in a month. Efficient controlling of signals will lead to safe environment, free of accident and incidents in the rail network. It is therefore imperative that the controllers should be well trained in order to perform their duties properly by managing control rail signals systems efficiently.

Based on the results it is evident that the locomotives are being under-used. The locomotives' idling time is high. This could be reduced if more trains were added to the schedule. The company could then consider using these locomotives for other purposes, transporting other RTCs with other products within the primary area. One locomotive can be used to transport Block Train.

The Block train can be allowed to come 3 days per week to plant K instead of only two days per week. Processing time in the loading and offloading of the products at the loading zones can be decreased by uplifting employee morale and close supervision at this point. Therefore decrease of processing time could assist in to reduce the time the locomotives spend at the locomotive base. The locomotives that are available can be used for other work in plant K. Once the speed is improved and the number of Block Trains coming to plant K in a week is increased the output in production can also be increased per month. Shunting yards can be used to handle more trains as there will be more space available.

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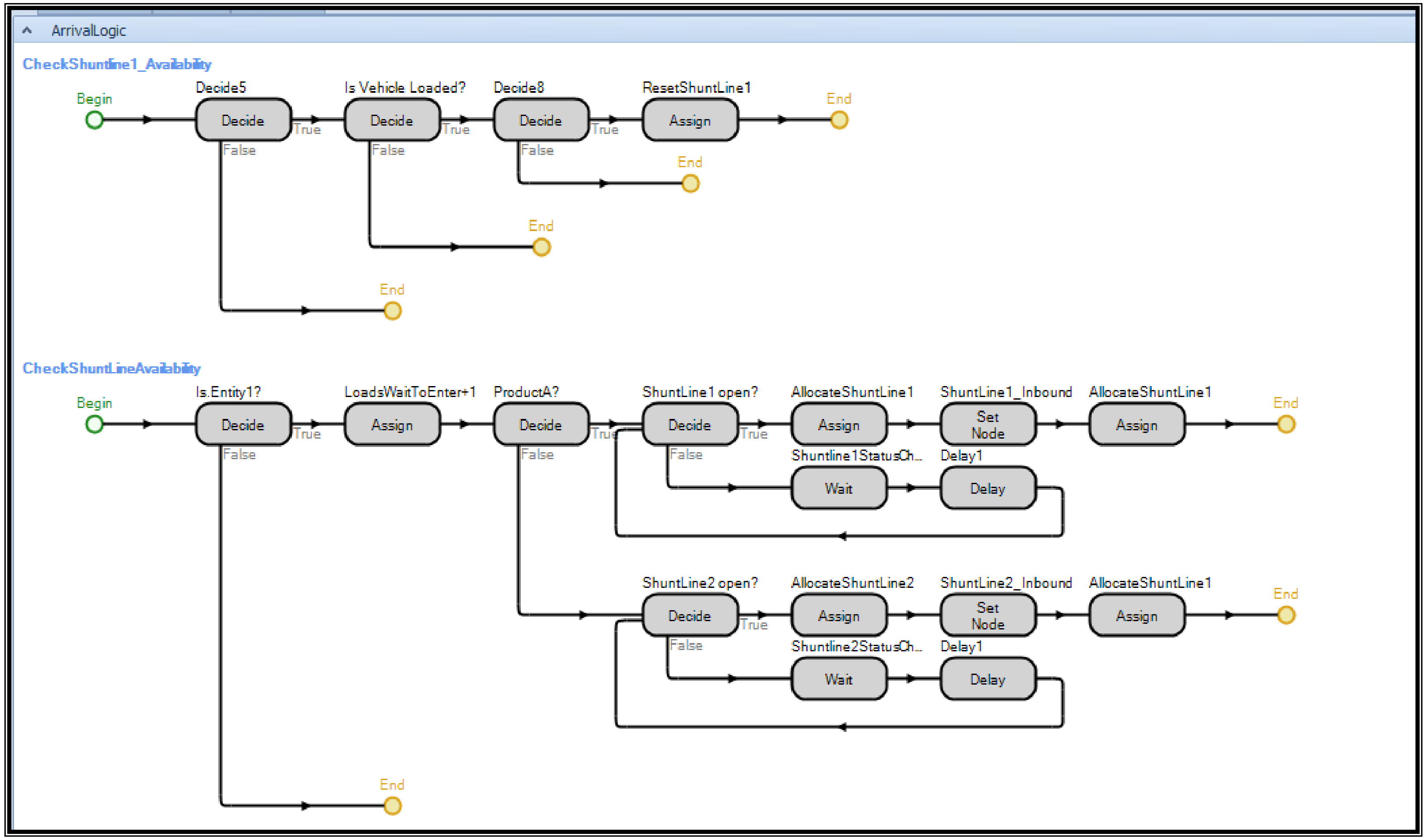
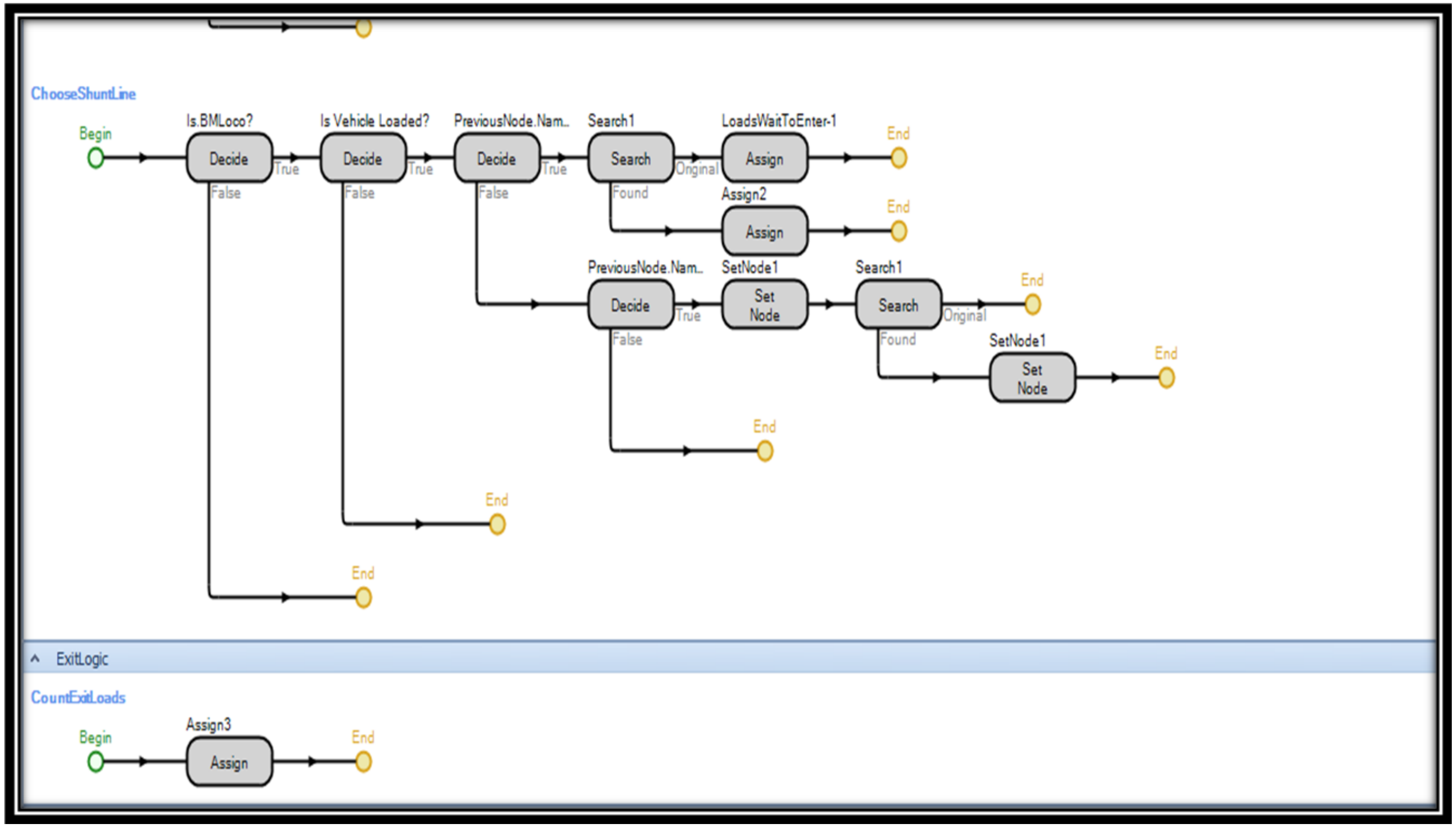
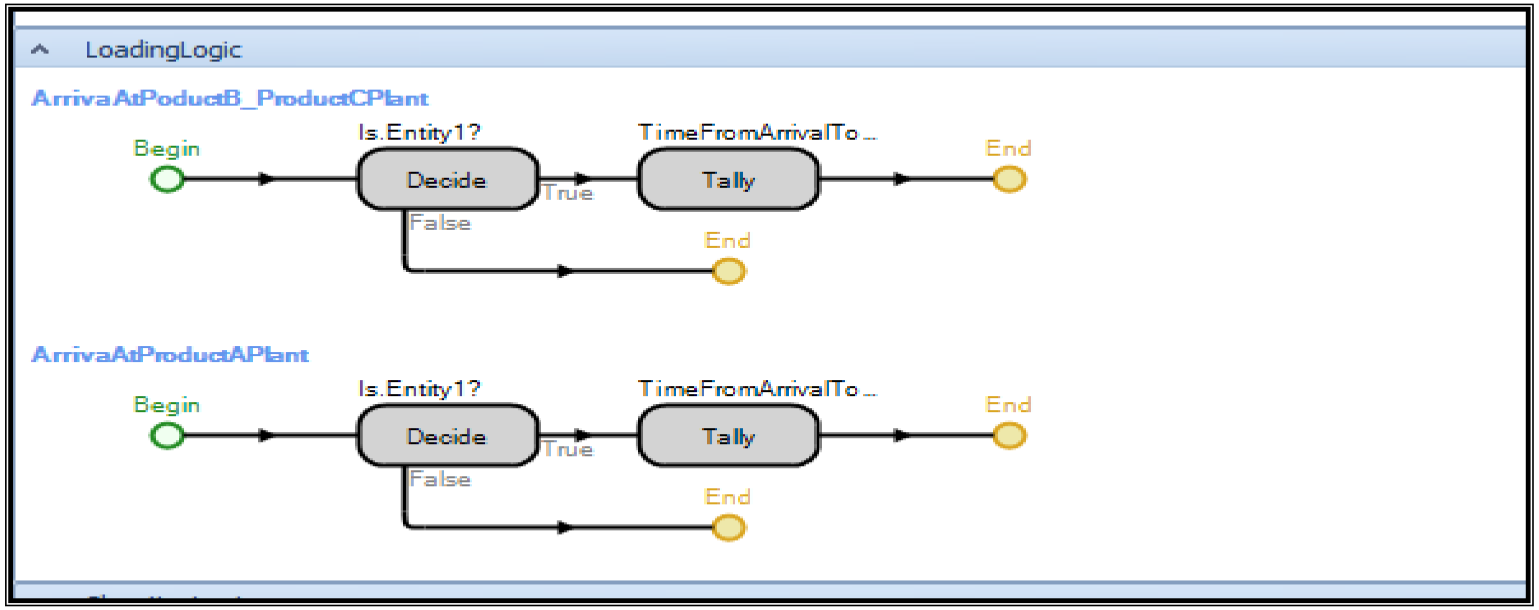
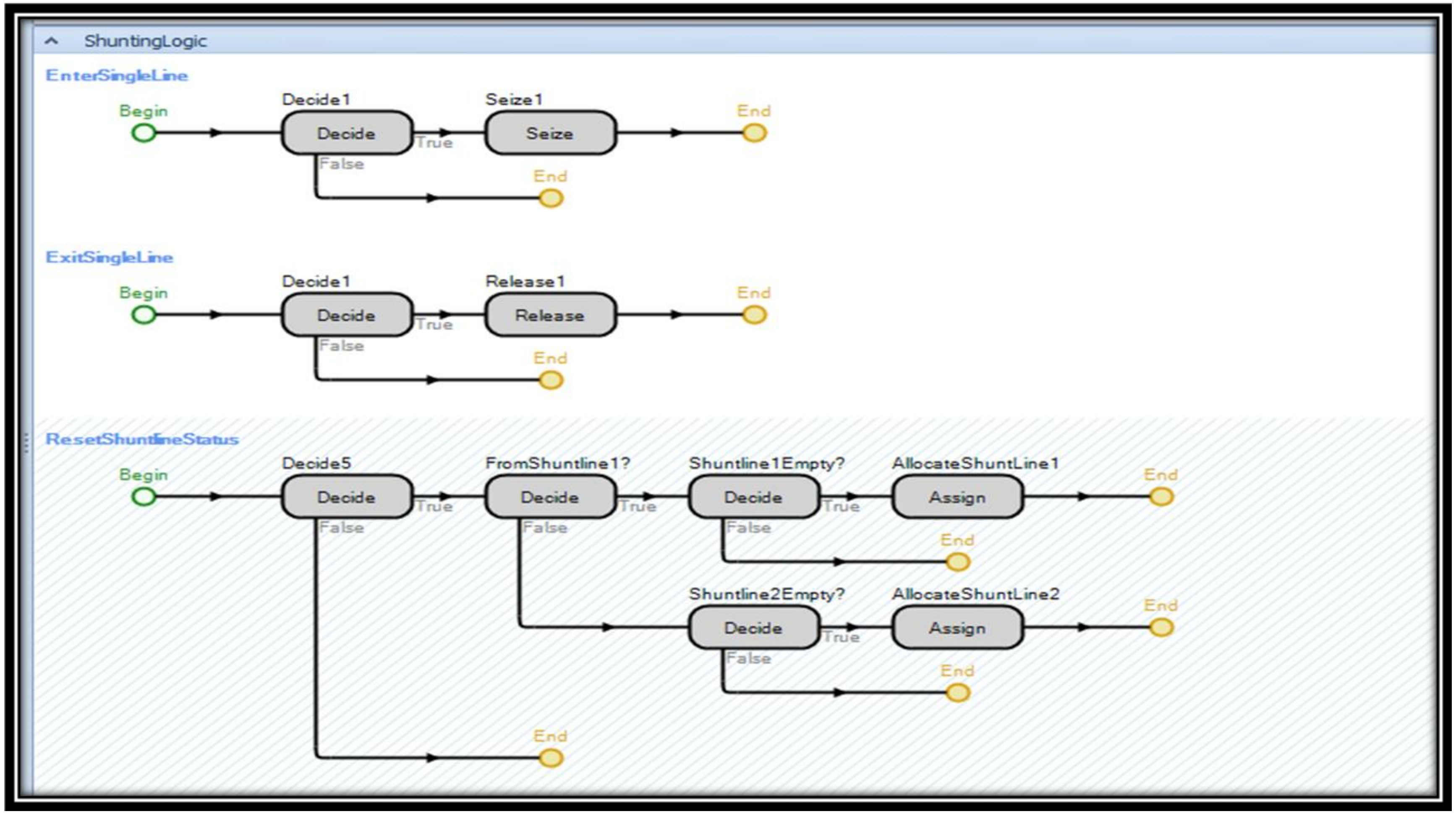
14. APPENDICES

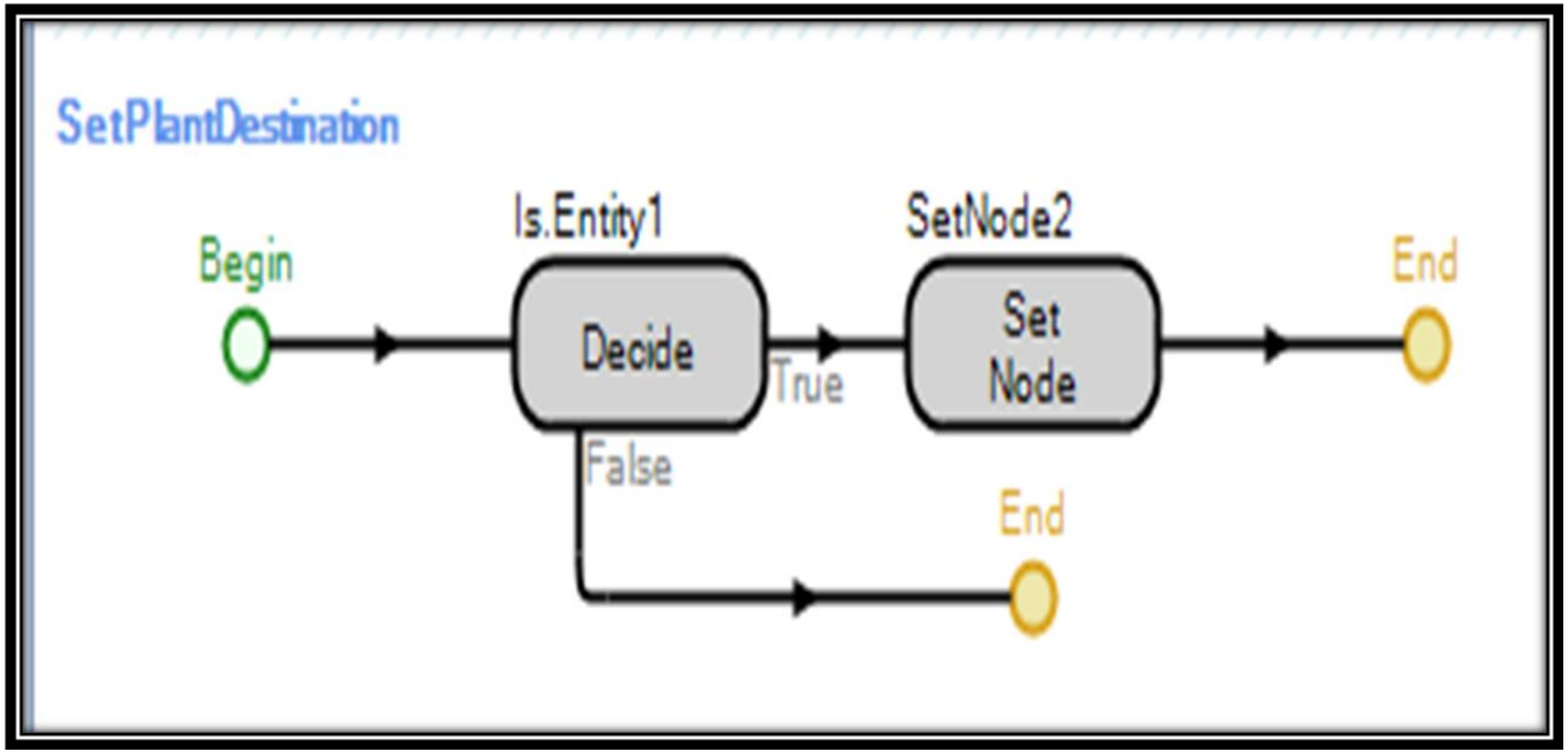
14.2. Appendix A: Model processes




ChooseShuntLine
Begin
Is.BMLoco?
Decide
True
False
Is Vehicle Loaded?
Decide
True
False
PreviousNode.Nam...
Decide
True
False
Search1
Search
Original
Found
LoadsWaitToEnter-1
Assign
End
Assign2
Assign
End
PreviousNode.Nam...
Decide
True
False
SetNode1
Set Node
Search1
Search
Original
Found
End
SetNode1
Set Node
End
End
End
End
ExitLogic
CountExitLoads
Begin
Assign3
Assign
End


LoadingLogic
ArrivaAtPoductB_ProductCPlant
Begin
Is.Entity1?
Decide
True
False
TimeFromArrivalTo...
Tally
End
End
ArrivaAtProductAPlant
Begin
Is.Entity1?
Decide
True
False
TimeFromArrivalTo...
Tally
End
End


ShuntingLogic
EnterSingleLine
Begin
Decide1
Decide
True
False
Seize1
Seize
End
End
ExitSingleLine
Begin
Decide1
Decide
True
False
Release1
Release
End
End
ResetShuntlineStatus
Begin
Decide5
Decide
True
False
FromShuntline1?
Decide
True
False
Shuntline1Empty?
Decide
True
False
AllocateShuntLine1
Assign
End
End
Shuntline2Empty?
Decide
True
False
AllocateShuntLine2
Assign
End
End
End


SetPlantDestination
Begin
Is.Entity1
Decide
True
False
SetNode2
Set Node
End
End

14.2. Appendix B: Standard Library Documentation

Heading: Town M Rail Simulation Model.

Standard Library
Model10
Author: Thabiso

Property Overrides Show / Hide 14 items

Override (ResourceIdleCostRate)
Visible: False
Override (ResourceCostPerUse)
Visible: False
Override (ResourceUsageCostRate)
Visible: False
Override (LogResourceUsage)
Visible: False
Override (DisplayCategory)
Visible: False
Override (DisplayColor)
Visible: False
Override (CapacityType)
Visible: False
Override (WorkSchedule)
Visible: False
Override (WorkDayExceptions)
Visible: False
Override (WorkPeriodExceptions)
Visible: False
Override (InitialCapacity)
Visible: False
Override (RankingRule)
Visible: False
Override (RankingExpression)
Visible: False
Override (DynamicSelectionRule)
Visible: False

States Show / Hide 7 items

IntegerState (ShuntLines)
Dimensions: 2
IntegerState (LoadNumberOverall)
RealState (DecoupleTime)
InitialValue: 1
RealState (CoupleTime)
InitialValue: 1

IntegerState (LoadsWaitToEnter)
IntegerState (LoadsEnterCount)
Description: R1=ProductA R2=ProductB R3=ProductC R4 =Total
Dimensions: 4
IntegerState (LoadsExitCount)
Description: R1=PoductA R2=ProductB R3=ProductC R4=Total
Dimensions: 4

Events Show / Hide 2 items

Event (Decoupled1)
Event (Decoupled2)

Elements Show / Hide 14 items

ShuntLine1Waiting (Storage)
RankingRule: SmallestValueFirst
RankingExpression: Entity1.LoadNumber
ShuntLine2Waiting (Storage)
RankingRule: SmallestValueFirst
RankingExpression: Entity1.LoadNumber
Shuntline1Status (Monitor)
StateVariableName: ShuntLines
Shuntline2Status (Monitor)
StateVariableName: ShuntLines
LoadsEnteredTotal (OutputStatistic)
Expression: LoadsEnterCount[4]
LoadsEnteredProductA (OutputStatistic)
Expression: LoadsEnterCount[1]
LoadsEnteredProductB (OutputStatistic)
Expression: LoadsEnterCount[2]
LoadsEnteredProductC (OutputStatistic)
Expression: LoadsEnterCount[3]
LoadsExitTotal (OutputStatistic)
Expression: LoadsExitCount[4]
LoadsExitProductA (OutputStatistic)
Expression: LoadsExitCount[1]
LoadsExitProductB (OutputStatistic)
Expression: LoadsExitCount[2]
LoadsExitProductC (OutputStatistic)
Expression: LoadsExitCount[3]
TimeFromArrivalToProductAPlant (TallyStatistic)
UnitType: Time
TimeFromArrivalToProductA_ProductBPlant (TallyStatistic)
UnitType: Time

Processes Show / Hide 10 items

EnterSingleLine
TokenActionOnAssociatedObjectDestroyed: EndProcess

Steps

Decide1 (Decide)
DecideType: ConditionBased
Expression: Is.Vehicle
Seize1 (Seize)
ResourceSeizes:
ObjectName: LineRestriction
ExitSingleLine
TokenActionOnAssociatedObjectDestroyed: EndProcess
Steps
Decide1 (Decide)
DecideType: ConditionBased
Expression: Is.Vehicle
Release1 (Release)
ResourceReleases:
ObjectName: LineRestriction
ChooseShuntLine
Steps
Is Vehicle Loaded? (Decide)
DecideType: ConditionBased
Expression: MyVehicle.RideStation.Contents>0
Is.BMLoco? (Decide)
DecideType: ConditionBased
Expression: Is.BMLoco
Search1 (Search)
CollectionType: QueueState
QueueStateName: Vehicle.RideStation.Contents
SearchExpression:
EndingIndex: Vehicle.RideStation.Contents.NumberWaiting
Limit: Infinity
Assign2 (Assign)
StateVariableName: Entity1.WhichLoco
NewValue: Entity1.CurrentTransporter.Population.Index
PreviousNode.Name=="Shunting1_Inbound"? (Decide)
DecideType: ConditionBased
Expression: Vehicle.PreviousNode.Name=="Shunting1_Inbound"
PreviousNode.Name=="Shunting1_Outbound"? (Decide)
DecideType: ConditionBased
Expression: Vehicle.PreviousNode.Name=="Shunting1_Outbound"
SetNode1 (SetNode)
NodeName: Input@ExitShuntingYard1
Search1 (Search)
CollectionType: QueueState
QueueStateName: MyVehicle.RideStation.Contents
Limit: Infinity
SetNode1 (SetNode)
NodeName: Input@ExitShuntingYard1

LoadsWaitToEnter-1 (Assign)
StateVariableName: LoadsWaitToEnter
NewValue: LoadsWaitToEnter-1
SetPlantDestination
Steps
SetNode2 (SetNode)
NodeName: GeneralInfo[Entity1.Destination].RTCDestinations
Is.Entity1 (Decide)
DecideType: ConditionBased
Expression: Is.Entity1
CheckShuntline1_Availability
Steps
Decide5 (Decide)
DecideType: ConditionBased
Expression: Is.Vehicle
Is Vehicle Loaded? (Decide)
DecideType: ConditionBased
Expression: MyVehicle.RideStation.Contents>0
Decide8 (Decide)
DecideType: ConditionBased
Expression:
(ShuntLine1_InboundShuntingYard3.ParentOutputBuffer.Contents ==
0) &&
(ShuntLine1_InboundShuntingYard3.MemberOutputBuffer.Contents ==
0)
ResetShuntLine1 (Assign)
StateVariableName: ShuntLines
NewValue: 0
CheckShuntLineAvailability
Steps
ShuntLine1 open? (Decide)
DecideType: ConditionBased
Expression: ShuntLines[1]==0
AllocateShuntLine1 (Assign)
StateVariableName: ShuntLines
NewValue: 1
Assignments:
AssignmentsStateVariableName: Entity1.WhichShuntLine
AssignmentsNewValue: 1
ShuntLine1_Inbound (SetNode)
NodeName: Input@ShuntLine1_InboundShuntingYard3
AllocateShuntLine1 (Assign)
NewValue:
Assignments:
AssignmentsStateVariableName: Entity1.WhichShuntLine
AssignmentsNewValue: 1

Is.Entity1? (Decide)
DecideType: ConditionBased
Expression: Is.Entity1
ProductA? (Decide)
DecideType: ConditionBased
Expression: Entity1.Destination==1
ShuntLine2 open? (Decide)
DecideType: ConditionBased
Expression: ShuntLines[2]==0
AllocateShuntLine2 (Assign)
StateVariableName: ShuntLines
NewValue: 1
Assignments:
AssignmentsStateVariableName: Entity1.WhichShuntLine
AssignmentsNewValue: 2
ShuntLine2_Inbound (SetNode)
NodeName: Input@ShuntLine2_Inbound
AllocateShuntLine1 (Assign)
NewValue:
Assignments:
AssignmentsStateVariableName: Entity1.WhichShuntLine
AssignmentsNewValue: 2
Shuntline1StatusChange (Wait)
EventName: Shuntline1Status.Event
Delay1 (Delay)
DelayTime: Math.EPSILON
Shuntline2StatusChange (Wait)
EventName: Shuntline2Status.Event
Delay1 (Delay)
DelayTime: Math.EPSILON
LoadsWaitToEnter+1 (Assign)
StateVariableName: LoadsWaitToEnter
NewValue: LoadsWaitToEnter+1
Assignments:
AssignmentsStateVariableName: Entity1.ArrivalTime
AssignmentsNewValue: Timenow
ResetShuntlineStatus

Steps

Decide5 (Decide)
DecideType: ConditionBased
Expression: Is.Vehicle
Shuntline1Empty? (Decide)
DecideType: ConditionBased
Expression:
(ShuntLine1_InboundShuntingYard3.ParentOutputBuffer.Contents ==
0) &&

(ShuntLine1_InboundShuntingYard3.MemberOutputBuffer.Contents == 0)

FromShuntline1? (Decide)

DecideType: ConditionBased
Expression: Vehicle.PreviousNode.Name=="ParentOutput@ShuntLine1_InboundShuntingYard3"

Shuntline2Empty? (Decide)

DecideType: ConditionBased
Expression: (ShuntLine2_Inbound.ParentOutputBuffer.Contents==0)&&(ShuntLine2_Inbound.MemberOutputBuffer.Contents==0)

AllocateShuntLine1 (Assign)

StateVariableName: ShuntLines
NewValue: 0

AllocateShuntLine2 (Assign)

StateVariableName: ShuntLines
NewValue: 0

CountExitLoads

Steps

Assign3 (Assign)

StateVariableName: LoadsExitCount
NewValue: LoadsExitCount[MyVehicle.RideStation.Contents.FirstItem.Entity1.ProdType]+1
Assignments:
AssignmentsStateVariableName: LoadsExitCount
AssignmentsNewValue: LoadsExitCount[4]+1

ArrivaAtProductAPlant

Steps

Is.Entity1? (Decide)

DecideType: ConditionBased
Expression: Is.Entity1

TimeFromArrivalToProductAPlant (Tally)

TallyStatisticName: TimeFromArrivalToProductAPlant
Value: TimeNow-Entity1.ArrivalTime

ArrivaAtPoductB_ProductCPlant

Steps

Is.Entity1? (Decide)

DecideType: ConditionBased
Expression: Is.Entity1

TimeFromArrivalToProductB_ProductCPlant (Tally)

TallyStatisticName: TimeFromArrivalToProductA_ProductBPlant
Value: TimeNow-Entity1.ArrivalTime

Objects Show / Hide 295 items

ArrivingProductATrains (Source)

EntityType: BlockTrainProductA
InterarrivalTime: Random.Exponential(7)
ArrivalNoShowProbability: 0
MaximumArrivals: 0
AssignmentsBeforeExiting:
AssignmentsBeforeExitingStateVariableName: Entity1.Destination
AssignmentsBeforeExitingNewValue: 1
AssignmentsBeforeExitingStateVariableName: Entity1.NumberWagons
AssignmentsBeforeExitingNewValue: 40
AssignmentsBeforeExitingStateVariableName: LoadNumberOverall
AssignmentsBeforeExitingNewValue: LoadNumberOverall+1
AssignmentsBeforeExitingStateVariableName: Entity1.LoadNumber
AssignmentsBeforeExitingNewValue: LoadNumberOverall

Associated Nodes

Output@ArrivingProductATrains (TransferNode)

FlowSplitAllocationRule: Proportional Based On Link Weights
DestinationType: Specific
DestinationNodeName: Shunting1_Inbound
DestinationSelectionExpression: Candidate.Node.InputLocation.Overload
TransporterSelectionExpression: Candidate.Transporter.RideCapacityRemaining
Outbound Links:

- Path1 going to BasicNode1

ExitShuntingYard1 (Sink)

Associated Nodes

Input@ExitShuntingYard1 (BasicNode)

FlowSplitAllocationRule: Proportional Based On Link Weights
Outbound Links:

- Path170 going to Shunting1_Inbound

Inbound Links:

- Path2 coming from Shunting1_Inbound

Source2 (Source)

EntityType: ProductE
ArrivalNoShowProbability: 0
MaximumArrivals: 1

Associated Nodes

Output@Source2 (TransferNode)
FlowSplitAllocationRule: Proportional Based On Link Weights
DestinationType: Specific
DestinationNodeName: Input@Server1
DestinationSelectionExpression:
Candidate.Node.InputLocation.Overload
RideOnTransporter: True
TransporterName: MineTrain
TransporterSelectionExpression:
Candidate.Transporter.RideCapacityRemaining
Outbound Links:

- Path30 going to BasicNode21

Inbound Links:

- Path155 coming from Input@Sink2

Sink2 (Sink)

Associated Nodes

Input@Sink2 (BasicNode)
FlowSplitAllocationRule: Proportional Based On Link Weights
Outbound Links:

- Path155 going to Output@Source2

Inbound Links:

- Path31 coming from BasicNode21

Server2 (Server)

Associated Nodes

Input@Server2 (BasicNode)
FlowSplitAllocationRule: Proportional Based On Link Weights
Inbound Links:

- Path43 coming from BasicNode29

Output@Server2 (TransferNode)
FlowSplitAllocationRule: Proportional Based On Link Weights
DestinationNodeName:
DestinationSelectionExpression:
Candidate.Node.InputLocation.Overload
TransporterSelectionExpression:
Candidate.Transporter.RideCapacityRemaining
Outbound Links:

- Path44 going to BasicNode29

Server3 (Server)

Associated Nodes

Input@Server3 (BasicNode)

FlowSplitAllocationRule: Proportional Based On Link Weights
Inbound Links:

- Path46 coming from BasicNode28

Output@Server3 (TransferNode)

FlowSplitAllocationRule: Proportional Based On Link Weights
DestinationNodeName:
DestinationSelectionExpression:
Candidate.Node.InputLocation.Overload
TransporterSelectionExpression:
Candidate.Transporter.RideCapacityRemaining
Outbound Links:

- Path47 going to BasicNode28

Server4 (Server)

Associated Nodes

Input@Server4 (BasicNode)

FlowSplitAllocationRule: Proportional Based On Link Weights
Inbound Links:

- Path55 coming from BasicNode34

Output@Server4 (TransferNode)

FlowSplitAllocationRule: Proportional Based On Link Weights
DestinationNodeName:
DestinationSelectionExpression:
Candidate.Node.InputLocation.Overload
TransporterSelectionExpression:
Candidate.Transporter.RideCapacityRemaining
Outbound Links:

- Path56 going to BasicNode34

Server5 (Server)

Associated Nodes

Input@Server5 (BasicNode)

FlowSplitAllocationRule: Proportional Based On Link Weights
Inbound Links:

- Path60 coming from BasicNode37

Output@Server5 (TransferNode)
FlowSplitAllocationRule: Proportional Based On Link Weights
DestinationNodeName:
DestinationSelectionExpression:
Candidate.Node.InputLocation.Overload
TransporterSelectionExpression:
Candidate.Transporter.RideCapacityRemaining
Outbound Links:

- Path61 going to BasicNode37

Server6 (Server)

Associated Nodes

Input@Server6 (BasicNode)
FlowSplitAllocationRule: Proportional Based On Link Weights
Inbound Links:

- Path107 coming from BasicNode67

Output@Server6 (TransferNode)
FlowSplitAllocationRule: Proportional Based On Link Weights
DestinationNodeName:
DestinationSelectionExpression:
Candidate.Node.InputLocation.Overload
TransporterSelectionExpression:
Candidate.Transporter.RideCapacityRemaining
Inbound Links:

- Path108 coming from BasicNode67

Server7 (Server)

Associated Nodes

Input@Server7 (BasicNode)
FlowSplitAllocationRule: Proportional Based On Link Weights
Inbound Links:

- Path112 coming from BasicNode70

Output@Server7 (TransferNode)
FlowSplitAllocationRule: Proportional Based On Link Weights
DestinationNodeName:
DestinationSelectionExpression:
Candidate.Node.InputLocation.Overload
TransporterSelectionExpression:
Candidate.Transporter.RideCapacityRemaining

Outbound Links:

- Path113 going to BasicNode70

Server8 (Server)

Associated Nodes

Input@Server8 (BasicNode)
FlowSplitAllocationRule: Proportional Based On Link Weights
Inbound Links:

- Path117 coming from BasicNode73

Output@Server8 (TransferNode)
FlowSplitAllocationRule: Proportional Based On Link Weights
DestinationNodeName:
DestinationSelectionExpression:
Candidate.Node.InputLocation.Overload
TransporterSelectionExpression:
Candidate.Transporter.RideCapacityRemaining
Outbound Links:

- Path118 going to BasicNode73

Server9 (Server)

Associated Nodes

Input@Server9 (BasicNode)
FlowSplitAllocationRule: Proportional Based On Link Weights
Inbound Links:

- Path120 coming from BasicNode74

Output@Server9 (TransferNode)
FlowSplitAllocationRule: Proportional Based On Link Weights
DestinationNodeName:
DestinationSelectionExpression:
Candidate.Node.InputLocation.Overload
TransporterSelectionExpression:
Candidate.Transporter.RideCapacityRemaining
Outbound Links:

- Path121 going to BasicNode74

ProductB_ProductCLoading (Server)
ProcessingTime: Entity1.LoadTime
EnteredAddOnProcess: ArrivaAtPoductB_ProductCPlant

Associated Nodes

Input@ProductB_ProductCLoading (BasicNode)
FlowSplitAllocationRule: Proportional Based On Link Weights
Outbound Links:

- Path126 going to Output@ProductB_ProductCLoading

Inbound Links:

- Path125 coming from BasicNode78

Output@ProductB_ProductCLoading (TransferNode)
FlowSplitAllocationRule: Proportional Based On Link Weights
DestinationType: Specific
DestinationNodeName:
CouplingDestinations[Entity1.ParentOrMember].Shuntline2Outbound
DestinationSelectionExpression:
Candidate.Node.InputLocation.Overload
RideOnTransporter: True
TransporterName: BMLoco[Entity1.WhichLoco]
TransporterSelectionExpression:
Candidate.Transporter.RideCapacityRemaining
Outbound Links:

- Path142 going to BasicNode78

Inbound Links:

- Path126 coming from Input@ProductB_ProductCLoading

Server11 (Server)

Associated Nodes

Input@Server11 (BasicNode)
FlowSplitAllocationRule: Proportional Based On Link Weights
Inbound Links:

- Path129 coming from BasicNode79

Output@Server11 (TransferNode)
FlowSplitAllocationRule: Proportional Based On Link Weights
DestinationNodeName:
DestinationSelectionExpression:
Candidate.Node.InputLocation.Overload
TransporterSelectionExpression:
Candidate.Transporter.RideCapacityRemaining
Outbound Links:

- Path130 going to BasicNode79

Server12 (Server)

Associated Nodes

Input@Server12 (BasicNode)

FlowSplitAllocationRule: Proportional Based On Link Weights
Inbound Links:

- Path134 coming from BasicNode81

Output@Server12 (TransferNode)

FlowSplitAllocationRule: Proportional Based On Link Weights
DestinationNodeName:
DestinationSelectionExpression:
Candidate.Node.InputLocation.Overload
TransporterSelectionExpression:
Candidate.Transporter.RideCapacityRemaining
Outbound Links:

- Path135 going to BasicNode81

ProductALoading (Server)

ProcessingTime: Entity1.LoadTime
EnteredAddOnProcess: ArrivaAtProductAPlant

Associated Nodes

Input@ProductALoading (BasicNode)

FlowSplitAllocationRule: Proportional Based On Link Weights
Outbound Links:

- Path141 going to Output@ProductALoading

Inbound Links:

- Path137 coming from BasicNode82

Output@ProductALoading (TransferNode)

FlowSplitAllocationRule: Proportional Based On Link Weights
DestinationType: Specific
DestinationNodeName:
CouplingDestinations[Entity1.ParentOrMember].Shuntline1Outbound
DestinationSelectionExpression:
Candidate.Node.InputLocation.Overload
RideOnTransporter: True
TransporterName: BMLoco[Entity1.WhichLoco]
TransporterSelectionExpression:
Candidate.Transporter.RideCapacityRemaining
Outbound Links:

- Path138 going to BasicNode82

Inbound Links:

- Path141 coming from Input@ProductALoading

BlockTrainProductA (Entity1)
BlockTrainProductB (Entity1)
BlockTrainProductC (Entity1)
ArrivingProductBTrains (Source)

EntityType: BlockTrainProductB
TimeOffset: 1
InterarrivalTime: Random.Exponential(7)
ArrivalNoShowProbability: 0
MaximumArrivals: 0
AssignmentsBeforeExiting:
AssignmentsBeforeExitingStateVariableName: Entity1.Destination
AssignmentsBeforeExitingNewValue: 2
AssignmentsBeforeExitingStateVariableName: Entity1.NumberWagons
AssignmentsBeforeExitingNewValue: 40
AssignmentsBeforeExitingStateVariableName: LoadNumberOverall
AssignmentsBeforeExitingNewValue: LoadNumberOverall+1
AssignmentsBeforeExitingStateVariableName: Entity1.LoadNumber
AssignmentsBeforeExitingNewValue: LoadNumberOverall

Associated Nodes

Output@ArrivingProductBTrains (TransferNode)

FlowSplitAllocationRule: Proportional Based On Link Weights
DestinationType: Specific
DestinationNodeName: Shunting1_Inbound
DestinationSelectionExpression: Candidate.Node.InputLocation.Overload
TransporterSelectionExpression: Candidate.Transporter.RideCapacityRemaining
Outbound Links:

- Path139 going to BasicNode1

ArrivingProductCTrains (Source)

EntityType: BlockTrainProductC
TimeOffset: 2
InterarrivalTime: Random.Exponential(7)
ArrivalNoShowProbability: 0
MaximumArrivals: 0
AssignmentsBeforeExiting:
AssignmentsBeforeExitingStateVariableName: Entity1.Destination
AssignmentsBeforeExitingNewValue: 2

AssignmentsBeforeExitingStateVariableName: Entity1.NumberWagons
AssignmentsBeforeExitingNewValue: 40
AssignmentsBeforeExitingStateVariableName: LoadNumberOverall
AssignmentsBeforeExitingNewValue: LoadNumberOverall+1
AssignmentsBeforeExitingStateVariableName: Entity1.LoadNumber
AssignmentsBeforeExitingNewValue: LoadNumberOverall

Associated Nodes

Output@ArrivingProductCTrains (TransferNode)

FlowSplitAllocationRule: Proportional Based On Link Weights
DestinationType: Specific
DestinationNodeName: Shunting1_Inbound
DestinationSelectionExpression: Candidate.Node.InputLocation.Overload
TransporterSelectionExpression: Candidate.Transporter.RideCapacityRemaining
Outbound Links:

- Path140 going to BasicNode1

LineRestriction (Resource)
Server1 (Server)

Associated Nodes

Input@Server1 (BasicNode)

FlowSplitAllocationRule: Proportional Based On Link Weights
Outbound Links:

- Path37 going to Output@Server1

Inbound Links:

- Path36 coming from BasicNode24

Output@Server1 (TransferNode)

FlowSplitAllocationRule: Proportional Based On Link Weights
DestinationType: Specific
DestinationNodeName: Input@Sink2
DestinationSelectionExpression: Candidate.Node.InputLocation.Overload
RideOnTransporter: True
TransporterName: MineTrain
TransporterSelectionExpression: Candidate.Transporter.RideCapacityRemaining
ExitedAddOnProcess: EnterSingleLine
Outbound Links:

- Path154 going to BasicNode24

Inbound Links:

- Path37 coming from Input@Server1

MineTrain (Vehicle)
InitialNode: Output@Source2
IdleAction: Park At Home
ProductE (Entity1)
ShuntLine1 (Resource)
ShuntLine2ShuntingYard3 (Resource)
BMLoco (MyVehicle)
InitialDesiredSpeed: 15
InitialNumberInSystem: 2
InitialNode: LocoBase
IdleAction: Park At Home
ShuntLine1_Outbound (Combiner)
BatchQuantity: 3
MatchingRule: Match Members And Parent
MemberMatchExpression: Entity1.LoadNumber
ParentMatchExpression: Entity1.LoadNumber

Associated Nodes

ParentInput@ShuntLine1_Outbound (BasicNode)
Inbound Links:

- Path156 coming from BasicNode54

MemberInput@ShuntLine1_Outbound (BasicNode)
Inbound Links:

- Path158 coming from BasicNode54

Output@ShuntLine1_Outbound (TransferNode)
DestinationType: Specific
DestinationNodeName: Input@ExitShuntingYard1
RideOnTransporter: True
TransporterName: BMLoco[Entity1.WhichLoco]
Outbound Links:

- Path159 going to BasicNode46

ShuntLine1_InboundShuntingYard3 (MySeparator)
SeparationMode: Make Copies
CopyQuantity: 3
ProcessingTime: DecoupleTime
AssignmentsBeforeParentExiting:

AssignmentsBeforeParentExitingStateVariableName: Entity1.ParentOrMember
AssignmentsBeforeParentExitingNewValue: 1
AssignmentsBeforeParentExitingStateVariableName: Entity1.LoadTime
AssignmentsBeforeParentExitingNewValue: Random.Triangular(17,20,23)
AssignmentsBeforeMemberExiting:
AssignmentsBeforeMemberExitingStateVariableName: Entity1.ParentOrMember
AssignmentsBeforeMemberExitingNewValue: 2
AssignmentsBeforeMemberExitingStateVariableName: Entity1.LoadTime
AssignmentsBeforeMemberExitingNewValue: Random.Triangular(4,5,6)

Associated Nodes

Input@ShuntLine1_InboundShuntingYard3 (BasicNode)

Inbound Links:

- Path147 coming from BasicNode48

ParentOutput@ShuntLine1_InboundShuntingYard3 (TransferNode)

RideOnTransporter: True
TransporterName: BMLoco[Entity1.WhichLoco]
EnteredAddOnProcess: SetPlantDestination
ExitedAddOnProcess: ResetShuntlineStatus
Outbound Links:

- Path82 going to BasicNode54

Inbound Links:

- Connector1 coming from MemberOutput@ShuntLine1_InboundShuntingYard3

MemberOutput@ShuntLine1_InboundShuntingYard3 (TransferNode)

Outbound Links:

- Connector1 going to ParentOutput@ShuntLine1_InboundShuntingYard3

ShuntLine2_Inbound (MySeparator)

SeparationMode: Make Copies
CopyQuantity: 3
ProcessingTime: DecoupleTime
AssignmentsBeforeParentExiting:

AssignmentsBeforeParentExitingStateVariableName: Entity1.ParentOrMember
AssignmentsBeforeParentExitingNewValue: 1
AssignmentsBeforeParentExitingStateVariableName: Entity1.LoadTime
AssignmentsBeforeParentExitingNewValue: Random.Triangular(13,15,17)
AssignmentsBeforeMemberExiting:
AssignmentsBeforeMemberExitingStateVariableName: Entity1.ParentOrMember
AssignmentsBeforeMemberExitingNewValue: 2
AssignmentsBeforeMemberExitingStateVariableName: Entity1.LoadTime
AssignmentsBeforeMemberExitingNewValue: Random.Triangular(4,5,6)

Associated Nodes

Input@ShuntLine2_Inbound (BasicNode)
Inbound Links:

- Path148 coming from BasicNode60

ParentOutput@ShuntLine2_Inbound (TransferNode)
RideOnTransporter: True
TransporterName: BMLoco[Entity1.WhichLoco]
EnteredAddOnProcess: SetPlantDestination
ExitedAddOnProcess: ResetShuntlineStatus
Outbound Links:

- Path162 going to BasicNode54

Inbound Links:

- Connector2 coming from MemberOutput@ShuntLine2_Inbound

MemberOutput@ShuntLine2_Inbound (TransferNode)
Outbound Links:

- Connector2 going to ParentOutput@ShuntLine2_Inbound

ShuntLine2_OutboundShuntingYard3 (Combiner)
BatchQuantity: 3
MatchingRule: Match Members And Parent
MemberMatchExpression: Entity1.LoadNumber
ParentMatchExpression: Entity1.LoadNumber

Associated Nodes

ParentInput@ShuntLine2_OutboundShuntingYard3 (BasicNode)
Inbound Links:

- Path150 coming from BasicNode54

MemberInput@ShuntLine2_OutboundShuntingYard3 (BasicNode)
Inbound Links:

- Path146 coming from BasicNode54

Output@ShuntLine2_OutboundShuntingYard3 (TransferNode)
DestinationType: Specific
DestinationNodeName: Input@ExitShuntingYard1
RideOnTransporter: True
TransporterName: BMLoco[Entity1.WhichLoco]
Outbound Links:

- Path71 going to BasicNode44

ArrivalsShuntingYard1 (Source)
EntityType: Products.ProductType
ArrivalMode: Arrival Table
ArrivalTimeProperty: ArrivalTable.ArrivalTimes
EntitiesPerArrival: ArrivalTable.ArrivalQty
RepeatArrivalPattern: True
AssignmentsBeforeExiting:
AssignmentsBeforeExitingStateVariableName: Entity1.Destination
AssignmentsBeforeExitingNewValue: Products.LoadDestination
AssignmentsBeforeExitingStateVariableName: LoadNumberOverall
AssignmentsBeforeExitingNewValue: LoadNumberOverall+1
AssignmentsBeforeExitingStateVariableName: Entity1.LoadNumber
AssignmentsBeforeExitingNewValue: LoadNumberOverall
AssignmentsBeforeExitingStateVariableName: Entity1.ProdType
AssignmentsBeforeExitingNewValue: Products.ProdType
AssignmentsBeforeExitingStateVariableName: LoadsEnterCount
AssignmentsBeforeExitingNewValue: LoadsEnterCount[Entity1.ProdType] + 1
AssignmentsBeforeExitingStateVariableName: LoadsEnterCount
AssignmentsBeforeExitingNewValue: LoadsEnterCount[4]+1
AssignmentBeforeCreatingEntitiesTableName: Products
AssignmentBeforeCreatingEntitiesTableRow: Products.Probability.RandomRow

Associated Nodes

Output@ArrivalsShuntingYard1 (TransferNode)
DestinationType: Specific
DestinationNodeName: Shunting1_Inbound
Outbound Links:

- Path172 going to Shunting1_Inbound

BasicNode1 (BasicNode)
FlowSplitAllocationRule: Proportional Based On Link Weights
Outbound Links:

- Path3 going to BasicNode3
- Path143 going to Shunting1_Inbound

Inbound Links:

- Path1 coming from Output@ArrivingProductATrains
- Path139 coming from Output@ArrivingProductBTrains
- Path140 coming from Output@ArrivingProductCTrains

BasicNode2 (BasicNode)
FlowSplitAllocationRule: Proportional Based On Link Weights
BasicNode3 (BasicNode)
FlowSplitAllocationRule: Proportional Based On Link Weights
Outbound Links:

- Path4 going to BasicNode4
- Path5 going to BasicNode5

Inbound Links:

- Path3 coming from BasicNode1

BasicNode4 (BasicNode)
FlowSplitAllocationRule: Proportional Based On Link Weights
Outbound Links:

- Path11 going to BasicNode9
- Path27 going to BasicNode19

Inbound Links:

- Path4 coming from BasicNode3

BasicNode5 (BasicNode)
FlowSplitAllocationRule: Proportional Based On Link Weights
Outbound Links:

- Path6 going to BasicNode6
- Path10 going to BasicNode8

Inbound Links:

- Path5 coming from BasicNode3

BasicNode6 (BasicNode)
FlowSplitAllocationRule: Proportional Based On Link Weights
Outbound Links:

- Path7 going to BasicNode7
- Path8 going to BasicNode7

Inbound Links:

- Path6 coming from BasicNode5

BasicNode7 (BasicNode)
FlowSplitAllocationRule: Proportional Based On Link Weights
Outbound Links:

- Path9 going to BasicNode8

Inbound Links:

- Path7 coming from BasicNode6
- Path8 coming from BasicNode6

BasicNode8 (BasicNode)
FlowSplitAllocationRule: Proportional Based On Link Weights
Outbound Links:

- Path14 going to BasicNode12

Inbound Links:

- Path9 coming from BasicNode7
- Path10 coming from BasicNode5

BasicNode9 (BasicNode)
FlowSplitAllocationRule: Proportional Based On Link Weights
Outbound Links:

- Path12 going to BasicNode10
- Path17 going to BasicNode13

Inbound Links:

- Path11 coming from BasicNode4

BasicNode10 (BasicNode)
FlowSplitAllocationRule: Proportional Based On Link Weights
Outbound Links:

- Path13 going to BasicNode11
- Path15 going to BasicNode11

Inbound Links:

- Path12 coming from BasicNode9

BasicNode11 (BasicNode)
FlowSplitAllocationRule: Proportional Based On Link Weights
Outbound Links:

- Path16 going to BasicNode12

Inbound Links:

- Path13 coming from BasicNode10
- Path15 coming from BasicNode10

BasicNode12 (BasicNode)
FlowSplitAllocationRule: Proportional Based On Link Weights
Outbound Links:

- Path21 going to BasicNode15

Inbound Links:

- Path14 coming from BasicNode8
- Path16 coming from BasicNode11

BasicNode13 (BasicNode)
FlowSplitAllocationRule: Proportional Based On Link Weights
Outbound Links:

- Path18 going to BasicNode14
- Path19 going to BasicNode14

Inbound Links:

- Path17 coming from BasicNode9

BasicNode14 (BasicNode)
FlowSplitAllocationRule: Proportional Based On Link Weights
Outbound Links:

- Path20 going to BasicNode15

Inbound Links:

- Path18 coming from BasicNode13
- Path19 coming from BasicNode13

BasicNode15 (BasicNode)

FlowSplitAllocationRule: Proportional Based On Link Weights
Outbound Links:

- Path26 going to Shunting1_Outbound

Inbound Links:

- Path20 coming from BasicNode14
- Path21 coming from BasicNode12

BasicNode16 (BasicNode)

FlowSplitAllocationRule: Proportional Based On Link Weights
Outbound Links:

- Path25 going to Shunting1_Outbound

Inbound Links:

- Path24 coming from BasicNode19
- Path28 coming from BasicNode18

Shunting1_Outbound (BasicNode)

FlowSplitAllocationRule: Proportional Based On Link Weights
Outbound Links:

- Path32 going to BasicNode22

Inbound Links:

- Path25 coming from BasicNode16
- Path26 coming from BasicNode15
- Path144 coming from Shunting1_Inbound
- Path168 coming from BasicNode22

BasicNode18 (BasicNode)

FlowSplitAllocationRule: Proportional Based On Link Weights
Outbound Links:

- Path28 going to BasicNode16

Inbound Links:

- Path23 coming from BasicNode20
- Path29 coming from BasicNode20

BasicNode19 (BasicNode)
FlowSplitAllocationRule: Proportional Based On Link Weights
Outbound Links:

- Path24 going to BasicNode16
- Path22 going to BasicNode20

Inbound Links:

- Path27 coming from BasicNode4

BasicNode20 (BasicNode)
FlowSplitAllocationRule: Proportional Based On Link Weights
Outbound Links:

- Path23 going to BasicNode18
- Path29 going to BasicNode18

Inbound Links:

- Path22 coming from BasicNode19

BasicNode21 (BasicNode)
FlowSplitAllocationRule: Proportional Based On Link Weights
Outbound Links:

- Path33 going to BasicNode22
- Path31 going to Input@Sink2

Inbound Links:

- Path30 coming from Output@Source2

BasicNode22 (BasicNode)
FlowSplitAllocationRule: Proportional Based On Link Weights
Outbound Links:

- Path34 going to BasicNode23
- Path168 going to Shunting1_Outbound

Inbound Links:

- Path32 coming from Shunting1_Outbound
- Path33 coming from BasicNode21

BasicNode23 (BasicNode)
FlowSplitAllocationRule: Proportional Based On Link Weights
Outbound Links:

- Path35 going to BasicNode24
- Path38 going to BasicNode25

Inbound Links:

- Path34 coming from BasicNode22
- Path169 coming from BasicNode25

BasicNode24 (BasicNode)
FlowSplitAllocationRule: Proportional Based On Link Weights
Outbound Links:

- Path36 going to Input@Server1

Inbound Links:

- Path35 coming from BasicNode23
- Path154 coming from Output@Server1

BasicNode25 (BasicNode)
FlowSplitAllocationRule: Proportional Based On Link Weights
Outbound Links:

- Path39 going to BasicNode27
- Path169 going to BasicNode23

Inbound Links:

- Path38 coming from BasicNode23
- Path40 coming from ShuntingYard2

ShuntingYard2 (BasicNode)
FlowSplitAllocationRule: Proportional Based On Link Weights
Outbound Links:

- Path40 going to BasicNode25
- Path48 going to BasicNode30

Inbound Links:

- Path41 coming from BasicNode27
- Path51 coming from BasicNode31

BasicNode27 (BasicNode)
FlowSplitAllocationRule: Proportional Based On Link Weights
Outbound Links:

- Path41 going to ShuntingYard2

- Path171 going to BasicNode30

Inbound Links:

- Path39 coming from BasicNode25
- Path42 coming from BasicNode29
- Path45 coming from BasicNode28

BasicNode28 (BasicNode)
FlowSplitAllocationRule: Proportional Based On Link Weights
Outbound Links:

- Path45 going to BasicNode27
- Path46 going to Input@Server3

Inbound Links:

- Path47 coming from Output@Server3

BasicNode29 (BasicNode)
FlowSplitAllocationRule: Proportional Based On Link Weights
Outbound Links:

- Path42 going to BasicNode27
- Path43 going to Input@Server2

Inbound Links:

- Path44 coming from Output@Server2

BasicNode30 (BasicNode)
FlowSplitAllocationRule: Proportional Based On Link Weights
Outbound Links:

- Path49 going to BasicNode32
- Path50 going to BasicNode31

Inbound Links:

- Path48 coming from ShuntingYard2
- Path171 coming from BasicNode27

BasicNode31 (BasicNode)
FlowSplitAllocationRule: Proportional Based On Link Weights
Outbound Links:

- Path52 going to BasicNode32
- Path63 going to BasicNode39

- Path51 going to ShuntingYard2

Inbound Links:

- Path50 coming from BasicNode30
- Path152 coming from BasicNode39

BasicNode32 (BasicNode)
FlowSplitAllocationRule: Proportional Based On Link Weights
Outbound Links:

- Path53 going to BasicNode33

Inbound Links:

- Path49 coming from BasicNode30
- Path52 coming from BasicNode31

BasicNode33 (BasicNode)
FlowSplitAllocationRule: Proportional Based On Link Weights
Outbound Links:

- Path54 going to BasicNode34
- Path57 going to BasicNode35

Inbound Links:

- Path53 coming from BasicNode32

BasicNode34 (BasicNode)
FlowSplitAllocationRule: Proportional Based On Link Weights
Outbound Links:

- Path55 going to Input@Server4

Inbound Links:

- Path54 coming from BasicNode33
- Path56 coming from Output@Server4

BasicNode35 (BasicNode)
FlowSplitAllocationRule: Proportional Based On Link Weights
Outbound Links:

- Path58 going to BasicNode36

Inbound Links:

- Path57 coming from BasicNode33

BasicNode36 (BasicNode)
FlowSplitAllocationRule: Proportional Based On Link Weights
Outbound Links:

- Path59 going to BasicNode37
- Path62 going to BasicNode38

Inbound Links:

- Path58 coming from BasicNode35

BasicNode37 (BasicNode)
FlowSplitAllocationRule: Proportional Based On Link Weights
Outbound Links:

- Path60 going to Input@Server5

Inbound Links:

- Path59 coming from BasicNode36
- Path61 coming from Output@Server5

BasicNode38 (BasicNode)
FlowSplitAllocationRule: Proportional Based On Link Weights
Outbound Links:

- Path92 going to LocoBase

Inbound Links:

- Path62 coming from BasicNode36
- Path81 coming from BasicNode52

BasicNode39 (BasicNode)
FlowSplitAllocationRule: Proportional Based On Link Weights
Outbound Links:

- Path64 going to BasicNode42
- Path66 going to BasicNode40
- Path152 going to BasicNode31

Inbound Links:

- Path63 coming from BasicNode31
- Path149 coming from BasicNode59

BasicNode40 (BasicNode)
FlowSplitAllocationRule: Proportional Based On Link Weights
Outbound Links:

- Path65 going to BasicNode41
- Path67 going to BasicNode41

Inbound Links:

- Path66 coming from BasicNode39

BasicNode41 (BasicNode)
FlowSplitAllocationRule: Proportional Based On Link Weights
Outbound Links:

- Path69 going to BasicNode43

Inbound Links:

- Path65 coming from BasicNode40
- Path67 coming from BasicNode40

BasicNode42 (BasicNode)
FlowSplitAllocationRule: Proportional Based On Link Weights
Outbound Links:

- Path68 going to BasicNode43
- Path70 going to BasicNode44

Inbound Links:

- Path64 coming from BasicNode39

BasicNode43 (BasicNode)
FlowSplitAllocationRule: Proportional Based On Link Weights
Outbound Links:

- Path73 going to BasicNode45

Inbound Links:

- Path68 coming from BasicNode42
- Path69 coming from BasicNode41

BasicNode44 (BasicNode)
FlowSplitAllocationRule: Proportional Based On Link Weights
Outbound Links:

- Path145 going to BasicNode59
- Path151 going to BasicNode60

Inbound Links:

- Path70 coming from BasicNode42
- Path71 coming from Output@ShuntLine2_OutboundShuntingYard3

BasicNode45 (BasicNode)
FlowSplitAllocationRule: Proportional Based On Link Weights
Outbound Links:

- Path74 going to BasicNode47

Inbound Links:

- Path73 coming from BasicNode43

BasicNode46 (BasicNode)
FlowSplitAllocationRule: Proportional Based On Link Weights
Outbound Links:

- Path76 going to BasicNode48

Inbound Links:

- Path159 coming from Output@ShuntLine1_Outbound
- Path153 coming from BasicNode17
- Path157 coming from BasicNode60

BasicNode47 (BasicNode)
FlowSplitAllocationRule: Proportional Based On Link Weights
Outbound Links:

- Path83 going to BasicNode53

Inbound Links:

- Path74 coming from BasicNode45

BasicNode48 (BasicNode)
FlowSplitAllocationRule: Proportional Based On Link Weights
Outbound Links:

- Path77 going to BasicNode49
- Path147 going to Input@ShuntLine1_InboundShuntingYard3

Inbound Links:

- Path76 coming from BasicNode46

BasicNode49 (BasicNode)
FlowSplitAllocationRule: Proportional Based On Link Weights
Outbound Links:

- Path78 going to BasicNode50
- Path87 going to BasicNode55
- Path165 going to BasicNode84

Inbound Links:

- Path77 coming from BasicNode48
- Path164 coming from BasicNode54

BasicNode50 (BasicNode)
FlowSplitAllocationRule: Proportional Based On Link Weights
Outbound Links:

- Path79 going to BasicNode51
- Path89 going to BasicNode57

Inbound Links:

- Path78 coming from BasicNode49

BasicNode51 (BasicNode)
FlowSplitAllocationRule: Proportional Based On Link Weights
Outbound Links:

- Path80 going to BasicNode52
- Path90 going to BasicNode58

Inbound Links:

- Path79 coming from BasicNode50

BasicNode52 (BasicNode)
FlowSplitAllocationRule: Proportional Based On Link Weights
Outbound Links:

- Path81 going to BasicNode38
- Path91 going to Loco2Base

Inbound Links:

- Path80 coming from BasicNode51

BasicNode53 (BasicNode)
FlowSplitAllocationRule: Proportional Based On Link Weights
Outbound Links:

- Path84 going to BasicNode54

Inbound Links:

- Path83 coming from BasicNode47

BasicNode54 (BasicNode)
FlowSplitAllocationRule: Proportional Based On Link Weights
Outbound Links:

- Path99 going to BasicNode62
- Path156 going to ParentInput@ShuntLine1_Outbound
- Path158 going to MemberInput@ShuntLine1_Outbound
- Path146 going to MemberInput@ShuntLine2_OutboundShuntingYard3
- Path150 going to ParentInput@ShuntLine2_OutboundShuntingYard3
- Path164 going to BasicNode49

Inbound Links:

- Path84 coming from BasicNode53
- Path86 coming from BasicNode55
- Path82 coming from ParentOutput@ShuntLine1_InboundShuntingYard3
- Path162 coming from ParentOutput@ShuntLine2_Inbound
- Path167 coming from BasicNode64

BasicNode55 (BasicNode)
FlowSplitAllocationRule: Proportional Based On Link Weights
Outbound Links:

- Path86 going to BasicNode54

Inbound Links:

- Path85 coming from BasicNode56
- Path87 coming from BasicNode49

BasicNode56 (BasicNode)
FlowSplitAllocationRule: Proportional Based On Link Weights
Outbound Links:

- Path85 going to BasicNode55
- Path97 going to BasicNode61

Inbound Links:

- Path88 coming from BasicNode57

BasicNode57 (BasicNode)
FlowSplitAllocationRule: Proportional Based On Link Weights
Outbound Links:

- Path88 going to BasicNode56

Inbound Links:

- Path89 coming from BasicNode50
- Path95 coming from BasicNode58

BasicNode58 (BasicNode)
FlowSplitAllocationRule: Proportional Based On Link Weights
Outbound Links:

- Path95 going to BasicNode57

Inbound Links:

- Path90 coming from BasicNode51
- Path94 coming from Loco2Base

Loco2Base (BasicNode)
FlowSplitAllocationRule: Proportional Based On Link Weights
Outbound Links:

- Path94 going to BasicNode58
- Path96 going to BasicNode61

Inbound Links:

- Path91 coming from BasicNode52
- Path93 coming from LocoBase

LocoBase (BasicNode)
FlowSplitAllocationRule: Proportional Based On Link Weights
Outbound Links:

- Path93 going to Loco2Base
- Path100 going to BasicNode63
- Path72 going to BasicNode84

Inbound Links:

- Path92 coming from BasicNode38

BasicNode61 (BasicNode)
FlowSplitAllocationRule: Proportional Based On Link Weights
Outbound Links:

- Path98 going to BasicNode62

Inbound Links:

- Path96 coming from Loco2Base
- Path97 coming from BasicNode56

BasicNode62 (BasicNode)
FlowSplitAllocationRule: Proportional Based On Link Weights
Outbound Links:

- Path102 going to BasicNode64
- Path109 going to BasicNode68

Inbound Links:

- Path98 coming from BasicNode61
- Path99 coming from BasicNode54

BasicNode63 (BasicNode)
FlowSplitAllocationRule: Proportional Based On Link Weights
Outbound Links:

- Path101 going to BasicNode64
- Path103 going to BasicNode65

Inbound Links:

- Path100 coming from LocoBase

BasicNode64 (BasicNode)
FlowSplitAllocationRule: Proportional Based On Link Weights
Outbound Links:

- Path104 going to BasicNode66
- Path167 going to BasicNode54

Inbound Links:

- Path101 coming from BasicNode63

- Path102 coming from BasicNode62
- Path166 coming from BasicNode69

BasicNode65 (BasicNode)
FlowSplitAllocationRule: Proportional Based On Link Weights
Outbound Links:

- Path111 going to BasicNode69

Inbound Links:

- Path103 coming from BasicNode63
- Path105 coming from BasicNode66

BasicNode66 (BasicNode)
FlowSplitAllocationRule: Proportional Based On Link Weights
Outbound Links:

- Path105 going to BasicNode65
- Path106 going to BasicNode67

Inbound Links:

- Path104 coming from BasicNode64

BasicNode67 (BasicNode)
FlowSplitAllocationRule: Proportional Based On Link Weights
Outbound Links:

- Path107 going to Input@Server6
- Path108 going to Output@Server6

Inbound Links:

- Path106 coming from BasicNode66

BasicNode68 (BasicNode)
FlowSplitAllocationRule: Proportional Based On Link Weights
Outbound Links:

- Path110 going to BasicNode70

Inbound Links:

- Path109 coming from BasicNode62

BasicNode70 (BasicNode)
FlowSplitAllocationRule: Proportional Based On Link Weights

Outbound Links:

- Path112 going to Input@Server7
- Path114 going to BasicNode71

Inbound Links:

- Path113 coming from Output@Server7
- Path110 coming from BasicNode68

BasicNode71 (BasicNode)
FlowSplitAllocationRule: Proportional Based On Link Weights
Outbound Links:

- Path115 going to BasicNode72
- Path116 going to BasicNode73

Inbound Links:

- Path114 coming from BasicNode70

BasicNode72 (BasicNode)
FlowSplitAllocationRule: Proportional Based On Link Weights
Outbound Links:

- Path119 going to BasicNode74

Inbound Links:

- Path115 coming from BasicNode71

BasicNode73 (BasicNode)
FlowSplitAllocationRule: Proportional Based On Link Weights
Outbound Links:

- Path117 going to Input@Server8

Inbound Links:

- Path116 coming from BasicNode71
- Path118 coming from Output@Server8

BasicNode74 (BasicNode)
FlowSplitAllocationRule: Proportional Based On Link Weights
Outbound Links:

- Path120 going to Input@Server9

Inbound Links:

- Path119 coming from BasicNode72
- Path121 coming from Output@Server9

BasicNode69 (BasicNode)
FlowSplitAllocationRule: Proportional Based On Link Weights
Outbound Links:

- Path122 going to BasicNode75
- Path132 going to BasicNode80
- Path166 going to BasicNode64

Inbound Links:

- Path111 coming from BasicNode65

BasicNode75 (BasicNode)
FlowSplitAllocationRule: Proportional Based On Link Weights
Outbound Links:

- Path123 going to BasicNode76

Inbound Links:

- Path122 coming from BasicNode69

BasicNode76 (BasicNode)
FlowSplitAllocationRule: Proportional Based On Link Weights
Outbound Links:

- Path124 going to BasicNode78
- Path127 going to BasicNode77

Inbound Links:

- Path123 coming from BasicNode75

BasicNode77 (BasicNode)
FlowSplitAllocationRule: Proportional Based On Link Weights
Outbound Links:

- Path128 going to BasicNode79

Inbound Links:

- Path127 coming from BasicNode76
- Path131 coming from BasicNode79

BasicNode78 (BasicNode)
FlowSplitAllocationRule: Proportional Based On Link Weights
Outbound Links:

- Path125 going to Input@ProductB_ProductCLoading

Inbound Links:

- Path124 coming from BasicNode76
- Path142 coming from Output@ProductB_ProductCLoading

BasicNode79 (BasicNode)
FlowSplitAllocationRule: Proportional Based On Link Weights
Outbound Links:

- Path129 going to Input@Server11
- Path131 going to BasicNode77

Inbound Links:

- Path128 coming from BasicNode77
- Path130 coming from Output@Server11

BasicNode80 (BasicNode)
FlowSplitAllocationRule: Proportional Based On Link Weights
Outbound Links:

- Path133 going to BasicNode81
- Path136 going to BasicNode82

Inbound Links:

- Path132 coming from BasicNode69

BasicNode81 (BasicNode)
FlowSplitAllocationRule: Proportional Based On Link Weights
Outbound Links:

- Path134 going to Input@Server12

Inbound Links:

- Path133 coming from BasicNode80
- Path135 coming from Output@Server12

BasicNode82 (BasicNode)
FlowSplitAllocationRule: Proportional Based On Link Weights
Outbound Links:

- Path137 going to Input@ProductALoading

Inbound Links:

- Path136 coming from BasicNode80
- Path138 coming from Output@ProductALoading

Shunting1_Inbound (TransferNode)
FlowSplitAllocationRule: Proportional Based On Link Weights
DestinationNodeName:
GeneralInfo[Entity1.Destination].RTCDestinations
DestinationSelectionExpression:
Candidate.Node.InputLocation.Overload
RideOnTransporter: True
TransporterName: BMLoco[Entity1.WhichShuntLine]
TransporterSelectionExpression:
Candidate.Transporter.RideCapacityRemaining
EnteredAddOnProcess: CheckShuntLineAvailability
Outbound Links:

- Path144 going to Shunting1_Outbound
- Path2 going to Input@ExitShuntingYard1

Inbound Links:

- Path143 coming from BasicNode1
- Path170 coming from Input@ExitShuntingYard1
- Path172 coming from Output@ArrivalsShuntingYard1

BasicNode17 (BasicNode)
Outbound Links:

- Path153 going to BasicNode46
- Path160 going to BasicNode83

Inbound Links:

- Path163 coming from BasicNode84

BasicNode59 (BasicNode)
Outbound Links:

- Path149 going to BasicNode39

Inbound Links:

- Path145 coming from BasicNode44
- Path161 coming from BasicNode83

BasicNode60 (BasicNode)
Outbound Links:

- Path148 going to Input@ShuntLine2_Inbound
- Path157 going to BasicNode46

Inbound Links:

- Path75 coming from BasicNode83
- Path151 coming from BasicNode44

BasicNode83 (BasicNode)
Outbound Links:

- Path75 going to BasicNode60
- Path161 going to BasicNode59

Inbound Links:

- Path160 coming from BasicNode17

BasicNode84 (BasicNode)
Outbound Links:

- Path163 going to BasicNode17

Inbound Links:

- Path72 coming from LocoBase
- Path165 coming from BasicNode49

Path1 (Path)
From Output@ArrivingProductATrains to BasicNode1
AllowPassing: False
Path3 (Path)
From BasicNode1 to BasicNode3
Type: Bidirectional
Path4 (Path)
From BasicNode3 to BasicNode4
Path5 (Path)
From BasicNode3 to BasicNode5
Path6 (Path)
From BasicNode5 to BasicNode6
Path7 (Path)
From BasicNode6 to BasicNode7
Path8 (Path)
From BasicNode6 to BasicNode7
Path9 (Path)
From BasicNode7 to BasicNode8

Path10 (Path)
From BasicNode5 to BasicNode8
Path11 (Path)
From BasicNode4 to BasicNode9
Path12 (Path)
From BasicNode9 to BasicNode10
Path13 (Path)
From BasicNode10 to BasicNode11
Path14 (Path)
From BasicNode8 to BasicNode12
Path15 (Path)
From BasicNode10 to BasicNode11
Path16 (Path)
From BasicNode11 to BasicNode12
Path18 (Path)
From BasicNode13 to BasicNode14
Path20 (Path)
From BasicNode14 to BasicNode15
Path21 (Path)
From BasicNode12 to BasicNode15
Path24 (Path)
From BasicNode19 to BasicNode16
Path25 (Path)
From BasicNode16 to Shunting1_Outbound
Path26 (Path)
From BasicNode15 to Shunting1_Outbound
Path17 (Path)
From BasicNode9 to BasicNode13
Path27 (Path)
From BasicNode4 to BasicNode19
Path19 (Path)
From BasicNode13 to BasicNode14
Path22 (Path)
From BasicNode19 to BasicNode20
Path23 (Path)
From BasicNode20 to BasicNode18
Path28 (Path)
From BasicNode18 to BasicNode16
Path29 (Path)
From BasicNode20 to BasicNode18
Path30 (Path)
From Output@Source2 to BasicNode21

EnteredAddOnProcess: EnterSingleLine

Path32 (Path)
From Shunting1_Outbound to BasicNode22

DrawnToScale: False
LogicalLength: 300

Path33 (Path)
From BasicNode21 to BasicNode22

Type: Bidirectional

Path34 (Path)

From BasicNode22 to BasicNode23
Type: Bidirectional
DrawnToScale: False
LogicalLength: 4.5
Path35 (Path)
From BasicNode23 to BasicNode24
Type: Bidirectional
Path38 (Path)
From BasicNode23 to BasicNode25
DrawnToScale: False
LogicalLength: 500
Path39 (Path)
From BasicNode25 to BasicNode27
DrawnToScale: False
LogicalLength: 250
Path41 (Path)
From BasicNode27 to ShuntingYard2
DrawnToScale: False
LogicalLength: 250
Path42 (Path)
From BasicNode29 to BasicNode27
Path43 (Path)
From BasicNode29 to Input@Server2
Path44 (Path)
From Output@Server2 to BasicNode29
Path45 (Path)
From BasicNode28 to BasicNode27
Path46 (Path)
From BasicNode28 to Input@Server3
Path47 (Path)
From Output@Server3 to BasicNode28
Path49 (Path)
From BasicNode30 to BasicNode32
DrawnToScale: False
LogicalLength: 2
Path50 (Path)
From BasicNode30 to BasicNode31
Type: Bidirectional
DrawnToScale: False
LogicalLength: 2
Path52 (Path)
From BasicNode31 to BasicNode32
Type: Bidirectional
Path53 (Path)
From BasicNode32 to BasicNode33
DrawnToScale: False
LogicalLength: 20
Path54 (Path)
From BasicNode33 to BasicNode34
Path55 (Path)

From BasicNode34 to Input@Server4
Path56 (Path)
From Output@Server4 to BasicNode34
Path57 (Path)
From BasicNode33 to BasicNode35
DrawnToScale: False
LogicalLength: 20
Path58 (Path)
From BasicNode35 to BasicNode36
DrawnToScale: False
LogicalLength: 80
Path59 (Path)
From BasicNode36 to BasicNode37
Path60 (Path)
From BasicNode37 to Input@Server5
Path61 (Path)
From Output@Server5 to BasicNode37
Path62 (Path)
From BasicNode36 to BasicNode38
Path64 (Path)
From BasicNode39 to BasicNode42
Path66 (Path)
From BasicNode39 to BasicNode40
Path65 (Path)
From BasicNode40 to BasicNode41
Path67 (Path)
From BasicNode40 to BasicNode41
Path68 (Path)
From BasicNode42 to BasicNode43
Path69 (Path)
From BasicNode41 to BasicNode43
Path70 (Path)
From BasicNode42 to BasicNode44
Path73 (Path)
From BasicNode43 to BasicNode45
Path74 (Path)
From BasicNode45 to BasicNode47
Path76 (Path)
From BasicNode46 to BasicNode48
DrawnToScale: False
LogicalLength: 20
Path77 (Path)
From BasicNode48 to BasicNode49
Path78 (Path)
From BasicNode49 to BasicNode50
Path79 (Path)
From BasicNode50 to BasicNode51
Path80 (Path)
From BasicNode51 to BasicNode52
Path81 (Path)
From BasicNode52 to BasicNode38

Path83 (Path)
From BasicNode47 to BasicNode53
Path84 (Path)
From BasicNode53 to BasicNode54
Path85 (Path)
From BasicNode56 to BasicNode55
Path86 (Path)
From BasicNode55 to BasicNode54
Path87 (Path)
From BasicNode49 to BasicNode55
DrawnToScale: False
LogicalLength: 700
Path88 (Path)
From BasicNode57 to BasicNode56
Path89 (Path)
From BasicNode50 to BasicNode57
DrawnToScale: False
LogicalLength: 700
Path90 (Path)
From BasicNode51 to BasicNode58
Path91 (Path)
From BasicNode52 to Loco2Base
Path92 (Path)
From BasicNode38 to LocoBase
Path93 (Path)
From LocoBase to Loco2Base
Path94 (Path)
From Loco2Base to BasicNode58
Path95 (Path)
From BasicNode58 to BasicNode57
Path96 (Path)
From Loco2Base to BasicNode61
Path97 (Path)
From BasicNode56 to BasicNode61
Path98 (Path)
From BasicNode61 to BasicNode62
Path99 (Path)
From BasicNode54 to BasicNode62
DrawnToScale: False
LogicalLength: 20
Path100 (Path)
From LocoBase to BasicNode63
Type: Bidirectional
Path101 (Path)
From BasicNode63 to BasicNode64
Path102 (Path)
From BasicNode62 to BasicNode64
DrawnToScale: False
LogicalLength: 20
Path103 (Path)
From BasicNode63 to BasicNode65

Path104 (Path)
From BasicNode64 to BasicNode66
Path105 (Path)
From BasicNode66 to BasicNode65
DrawnToScale: False
LogicalLength: 20
Path106 (Path)
From BasicNode66 to BasicNode67
Path107 (Path)
From BasicNode67 to Input@Server6
Path108 (Path)
From BasicNode67 to Output@Server6
Path109 (Path)
From BasicNode62 to BasicNode68
Path112 (Path)
From BasicNode70 to Input@Server7
Path113 (Path)
From Output@Server7 to BasicNode70
Path114 (Path)
From BasicNode70 to BasicNode71
Path115 (Path)
From BasicNode71 to BasicNode72
Path116 (Path)
From BasicNode71 to BasicNode73
Path117 (Path)
From BasicNode73 to Input@Server8
Path118 (Path)
From Output@Server8 to BasicNode73
Path119 (Path)
From BasicNode72 to BasicNode74
Path120 (Path)
From BasicNode74 to Input@Server9
Path121 (Path)
From Output@Server9 to BasicNode74
Path110 (Path)
From BasicNode68 to BasicNode70
Path111 (Path)
From BasicNode65 to BasicNode69
DrawnToScale: False
LogicalLength: 20
Path122 (Path)
From BasicNode69 to BasicNode75
Type: Bidirectional
DrawnToScale: False
LogicalLength: 200
Path123 (Path)
From BasicNode75 to BasicNode76
Type: Bidirectional
DrawnToScale: False
LogicalLength: 200
Path124 (Path)

From BasicNode76 to BasicNode78
Type: Bidirectional
DrawnToScale: False
LogicalLength: 200
Path125 (Path)
From BasicNode78 to Input@ProductB_ProductCLoading
DrawnToScale: False
LogicalLength: 240
Path127 (Path)
From BasicNode76 to BasicNode77
Path128 (Path)
From BasicNode77 to BasicNode79
Path129 (Path)
From BasicNode79 to Input@Server11
Path130 (Path)
From Output@Server11 to BasicNode79
Path131 (Path)
From BasicNode79 to BasicNode77
Path132 (Path)
From BasicNode69 to BasicNode80
Type: Bidirectional
DrawnToScale: False
LogicalLength: 100
Path133 (Path)
From BasicNode80 to BasicNode81
Type: Bidirectional
Path134 (Path)
From BasicNode81 to Input@Server12
Path135 (Path)
From Output@Server12 to BasicNode81
Path136 (Path)
From BasicNode80 to BasicNode82
Type: Bidirectional
DrawnToScale: False
LogicalLength: 300
Path137 (Path)
From BasicNode82 to Input@ProductALoading
DrawnToScale: False
LogicalLength: 130
Path139 (Path)
From Output@ArrivingProductBTrains to BasicNode1
AllowPassing: False
Path140 (Path)
From Output@ArrivingProductCTrains to BasicNode1
AllowPassing: False
Path138 (Path)
From Output@ProductALoading to BasicNode82
DrawnToScale: False
LogicalLength: 130
Path141 (Path)

From Input@ProductALoading to Output@ProductALoading
DrawnToScale: False
LogicalLength: 50
Path126 (Path)
From Input@ProductB_ProductCLoading to Output@ProductB_ProductCLoading
DrawnToScale: False
LogicalLength: 50
Path142 (Path)
From Output@ProductB_ProductCLoading to BasicNode78
DrawnToScale: False
LogicalLength: 240
Path143 (Path)
From BasicNode1 to Shunting1_Inbound
Path144 (Path)
From Shunting1_Inbound to Shunting1_Outbound
Type: Bidirectional
DrawnToScale: False
LogicalLength: 700
AllowPassing: False
EnteredAddOnProcess: ChooseShuntLine
Path63 (Path)
From BasicNode31 to BasicNode39
Path152 (Path)
From BasicNode39 to BasicNode31
Path31 (Path)
From BasicNode21 to Input@Sink2
EnteredAddOnProcess: ExitSingleLine
Path36 (Path)
From BasicNode24 to Input@Server1
EnteredAddOnProcess: ExitSingleLine
Path37 (Path)
From Input@Server1 to Output@Server1
Path154 (Path)
From Output@Server1 to BasicNode24
Path155 (Path)
From Input@Sink2 to Output@Source2
Path82 (Path)
From ParentOutput@ShuntLine1_InboundShuntingYard3 to BasicNode54
Type: Bidirectional
InitialTravelerCapacity: 1
DrawnToScale: False
LogicalLength: 400
Connector1 (Connector)
From MemberOutput@ShuntLine1_InboundShuntingYard3 to ParentOutput@ShuntLine1_InboundShuntingYard3
Path147 (Path)
From BasicNode48 to Input@ShuntLine1_InboundShuntingYard3
Type: Bidirectional
InitialTravelerCapacity: 1
DrawnToScale: False

LogicalLength: 340

Path156 (Path)
From BasicNode54 to ParentInput@ShuntLine1_Outbound

Type: Bidirectional
InitialTravelerCapacity: 1
DrawnToScale: False
LogicalLength: 400

Path158 (Path)
From BasicNode54 to MemberInput@ShuntLine1_Outbound

Type: Bidirectional
InitialTravelerCapacity: 1
DrawnToScale: False
LogicalLength: 400

Path159 (Path)
From Output@ShuntLine1_Outbound to BasicNode46

Type: Bidirectional
InitialTravelerCapacity: 1
DrawnToScale: False
LogicalLength: 340

Path2 (Path)
From Shunting1_Inbound to Input@ExitShuntingYard1

DrawnToScale: False
EnteredAddOnProcess: CountExitLoads

Path149 (Path)
From BasicNode59 to BasicNode39

Path153 (Path)
From BasicNode17 to BasicNode46

Type: Bidirectional
InitialTravelerCapacity: 1

Connector2 (Connector)
From MemberOutput@ShuntLine2_Inbound to ParentOutput@ShuntLine2_Inbound

Path71 (Path)
From Output@ShuntLine2_OutboundShuntingYard3 to BasicNode44

Type: Bidirectional
InitialTravelerCapacity: 1
DrawnToScale: False
LogicalLength: 340

Path145 (Path)
From BasicNode44 to BasicNode59

Type: Bidirectional

Path146 (Path)
From BasicNode54 to MemberInput@ShuntLine2_OutboundShuntingYard3

Type: Bidirectional
InitialTravelerCapacity: 1
DrawnToScale: False
LogicalLength: 500

Path150 (Path)
From BasicNode54 to ParentInput@ShuntLine2_OutboundShuntingYard3

Type: Bidirectional

InitialTravelerCapacity: 1
DrawnToScale: False
LogicalLength: 500

Path75 (Path)
From BasicNode83 to BasicNode60

Type: Bidirectional
InitialTravelerCapacity: 1

Path148 (Path)
From BasicNode60 to Input@ShuntLine2_Inbound

Type: Bidirectional
InitialTravelerCapacity: 1
DrawnToScale: False
LogicalLength: 340

Path151 (Path)
From BasicNode44 to BasicNode60

DrawnToScale: False
LogicalLength: 20

Path157 (Path)
From BasicNode60 to BasicNode46

DrawnToScale: False
LogicalLength: 20

Path160 (Path)
From BasicNode17 to BasicNode83

DrawnToScale: False
LogicalLength: 20

Path161 (Path)
From BasicNode83 to BasicNode59

DrawnToScale: False
LogicalLength: 20

Path162 (Path)
From ParentOutput@ShuntLine2_Inbound to BasicNode54

Type: Bidirectional
InitialTravelerCapacity: 1
DrawnToScale: False
LogicalLength: 500

Path72 (Path)
From LocoBase to BasicNode84

DrawnToScale: False
LogicalLength: 60

Path163 (Path)
From BasicNode84 to BasicNode17

DrawnToScale: False
LogicalLength: 20

Path164 (Path)
From BasicNode54 to BasicNode49

DrawnToScale: False
LogicalLength: 700

Path165 (Path)
From BasicNode49 to BasicNode84

Type: Bidirectional
InitialTravelerCapacity: 1

Path166 (Path)
From BasicNode69 to BasicNode64

DrawnToScale: False
LogicalLength: 60

Path167 (Path)
From BasicNode64 to BasicNode54

DrawnToScale: False
LogicalLength: 40

Path168 (Path)
From BasicNode22 to Shunting1_Outbound

DrawnToScale: False
LogicalLength: 300

Path169 (Path)
From BasicNode25 to BasicNode23

DrawnToScale: False
LogicalLength: 500

Path170 (Path)
From Input@ExitShuntingYard1 to Shunting1_Inbound

DrawnToScale: False

Path40 (Path)
From ShuntingYard2 to BasicNode25

DrawnToScale: False
LogicalLength: 500

Path51 (Path)
From BasicNode31 to ShuntingYard2

DrawnToScale: False
LogicalLength: 2

Path48 (Path)
From ShuntingYard2 to BasicNode30

DrawnToScale: False

Path171 (Path)
From BasicNode27 to BasicNode30

DrawnToScale: False

Path172 (Path)
From Output@ArrivalsShuntingYard1 to Shunting1_Inbound

Tables Show / Hide 6 items

GeneralInfo

RTCDestinations
Input@ProductALoading
Input@ProductB_ProductCLoading

CoupleDecoupleTimes

Description	Times
Decouple	Random.Triangular(1,2,5)
Couple	Random.Triangular(1,3,6)

ShuntLineInfo

ShuntLineWaitingArea	DecoupleEvents
	Decoupled1

	Decoupled2

CouplingDestinations

Shuntline1Outbound	Shuntline2Outbound
ParentInput@ShuntLine1_Outbound	ParentInput@ShuntLine2_OutboundShuntingYard3
MemberInput@ShuntLine1_Outbound	MemberInput@ShuntLine2_OutboundShuntingYard3

Products

ProductType	Probability	LoadDestination	ProdType
BlockTrainProductA	0.333	1	1
BlockTrainProductB	0.333	2	2
BlockTrainProductC	0.333	2	3

ArrivalTable

ArrivalTimes	ArrivalQty
12	1
84	1
168	0

Schedules Show / Hide 1 items

StandardWeek

Days: 7
Start Date: 2011-01-03T00:00:00

Entity1

Author: Thabiso

Property Overrides Show / Hide 14 items

Override (ResourceIdleCostRate)
Visible: False

Override (ResourceCostPerUse)
Visible: False

Override (ResourceUsageCostRate)
Visible: False

Override (LogResourceUsage)
Visible: False

Override (DisplayCategory)
Visible: False

Override (DisplayColor)
Visible: False

Override (CapacityType)
Visible: False

Override (WorkSchedule)
Visible: False

Override (WorkDayExceptions)
Visible: False

Override (WorkPeriodExceptions)
Visible: False

Override (InitialCapacity)
Visible: False

Override (RankingRule)
Visible: False

Override (RankingExpression)
Visible: False
Override (DynamicSelectionRule)
Visible: False

States Show / Hide 9 items

IntegerState (Destination)
IntegerState (NumberWagons)
IntegerState (WhichShuntLine)
IntegerState (LoadNumber)
IntegerState (WhichLoco)
IntegerState (ParentOrMember)
Description: 1=Parent 2=Member
RealState (LoadTime)
IntegerState (ProdType)
RealState (ArrivalTime)
InitialValueUnits: Hours
UnitType: Time

Processor

Author: Thabiso

Property Overrides Show / Hide 14 items

Override (ResourceIdleCostRate)
Visible: True
Override (ResourceCostPerUse)
Visible: True
Override (ResourceUsageCostRate)
Visible: True
Override (LogResourceUsage)
Visible: True
Override (DisplayCategory)
Visible: True
Override (DisplayColor)
Visible: True
Override (CapacityType)
Visible: True
Override (WorkSchedule)
Visible: True
Override (WorkDayExceptions)
Visible: True
Override (WorkPeriodExceptions)
Visible: True
Override (InitialCapacity)
Visible: True
Override (RankingRule)
Visible: True
Override (RankingExpression)

Visible: True

Override (DynamicSelectionRule)

Visible: True

Elements Show / Hide 1 items

Processing (Station)

Processes Show / Hide 1 items

MainProcess

TriggeringEventName: Processing.Entered

TokenActionOnAssociatedObjectDestroyed: EndProcess

Steps

IntoProcessing (EndTransfer)

ToOutput (Transfer)

FromType: CurrentStation

ToType: ParentExternalNode

ExternalNodeName: Output

Transfer Points Show / Hide 2 items

Input

NodeClassName: BasicNode

InputLocationType: Station

StationName: Processing

Output

NodeClassName: TransferNode

MyVehicle

Base: Vehicle

Author: Thabiso

States Show / Hide 2 items

IntegerState (WhichShuntLine)

IntegerState (Direction)

Description: 1=Inbound 2=Outbound

MySeparator

Base: Separator

Author: Thabiso