Analysing London Gateway using event-based simulation modelling

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Abstract

The scope of this paper is to give an insight into one of the main deep-sea ports in the United Kingdom, the London Gateway, which is a part of the Thames Gateway project and to indicate how, through becoming more rail focussed, it is possible for both output and efficiency to increase. The aim of this study is ultimately to highlight how gradually shifting the reliance of moving freight to rail from road can enhance the overall throughput and output of a port, while also improving the nation's overall carbon emissions. However, as the results from this simulation show, there is not always the option to solely rely upon rail freight, this is because an over dependency upon one form instead of the other can ultimately have detrimental consequences upon both throughput and output, as well as questions over whether the current rail infrastructure of the United Kingdom has the capacity and ability to handle longer freight trains.

1. Background (Introduction)

In the aftermath of Brexit and COVID–19 there has been real pressure on road hauliers with driver shortages and it will be argued that, through increasing the number of containers transported by rail, this pressure can be relieved while also reducing overall carbon emissions emitted by road transport, with rail being a more environmentally form of transport.
Following recent global agreements and ambitions set by the Government of United Kingdom (UK), such as becoming Net – Zero by 2050, it is pivotal that a modal shift from road to rail occurs significantly but to the extent whereby it is one hundred percent. With every tonne that is moved by rail-freight over road, carbon emissions can fall even by around 76% (Network Rail, 2021). It is vital, environmentally, that carbon emissions fall to reach Net – Zero targets, but also socially because of the negative impacts of air pollution from road transport which can have the potential to create negative affects upon city centre populations.

In recent years, rail ports within the UK, most notably Freightliner's Southampton Terminal, have undergone extensive extension work, which has enabled freight trains to operate at increased capacity to carry an additional 20% more freight (around an extra 84 containers per day) [1]. Through rail freight services, having increased capacity to carry more freight, this presents an opportunity for hauliers and businesses utilising rail freight to transport more goods at once, and in a shorter turnaround time, as well as better utilisation of assets i.e. one locomotive and one locomotive driver, instead of over 50 trucks and 50 truck drivers. There are not only health benefits of reducing carbon emissions through switching from road to rail, it also presents an economical gain for freight hauliers who can better utilise assets by using rail freight as a means to transport goods in one service rather than use multiple trucks and drivers to transport the same containers.

Modal Shift does not just involve promoting the use of rail freight, but other forms of freight transport such as maritime, where it would be more environmentally beneficial to remove road from the supply chain. Therefore, there is a plethora of potential in investigating which types of freight transport is best suited to carrying freight over long distances globally, or are specifically best suited to carrying containers, bulk freight (biomass, sand etc.).

Furthermore, little is known about how a reduction in congestion on major UK routes, or motorways from a reduction in HGV's on the road is impacting upon people's cost of living. For example, through having additional HGV's travelling by road, the average speed of the road will naturally decrease (less road space and travelling commuters prevented to go above 60mph), thus, through cars being prevented from travelling at faster average speeds, and as a result of varying constant speeds, this would result in a possibly adverse impact on fuel consumption for drivers, resulting in a higher fuel costs [2]. Moreover, especially in the UK's current climate, with a recession looming, and the price of fuel rising by over 42% in 2022 [3], a modal shift to rail or maritime would potentially enable people to increase their fuel economy, thus lowering their expenditure, either monthly or weekly, spent on fuel to travel, for either leisure or work purposes.

Therefore, from this it is exhibited that there is not just the environmental benefits being derived from modal shift, there is some degree of economic benefit to be gained, not just from freight hauliers and their customers, but also to a significant proportion of UK society who own and drive a road car, of which in the current cost of living crisis, a reduction in the amount spent on fuel would be a significant benefit in most households. Additionally, it is possible that other economic benefits, not just for businesses, potentially could be derived and be made aware to the UK population.

The efficiency of a port does not just concern how quickly a ship can be loaded and unloaded, but it is equally of significance of how fast these goods can be moved off quayside and onto national transport systems [4]. Moreover, at some deep sea ports such as London Gateway, where there is increased rail line capacity for longer trains, whereby a single rail service can take over 70 trucks off the road [5] . Through having a rail connection on site, it enables an 'efficient' port operation to take place, as the movement of containers will not be limited to just local and port road infrastructure. In case that local road infrastructure is stagnated, there is an alternative option by rail to increase output. Consequently, rail presents an opportunity to relieve pressure off local and national road transport systems.

For purposes of this study, London Gateway has been chosen to examine how operations at the rail terminal can be improved, in terms of shifting the reliance off road to rail, especially following the aftermath of the HGV driver shortage crisis in late 2021, the increasing fuel prices which are having detrimental monetary and time costs upon both customers and businesses. Through, seeing how the rail terminal reacts to increases in the amount of throughput it receives (i.e. gradual increases from 25% up to 40% and eventually 60%) an event – based simulation modelling can help to identify if the port is feasible to work with a stronger commitment to rail freight, which will enable more freight to run via rail and meet on – going climate change ambitions. It has been found that "each tonne of freight transport by rail produced 76% less carbon emissions compared to road" [6], as a result of these facts, it would enable the UK to significantly reduce its carbon emissions through putting more reliance on rail freight, and meet the objective set out in the Government's 'Net Zero Strategy: Build

Back Greener report', of which "plans to deliver a net zero rail network by 2050" (Department for Business, Energy and Industrial Strategy, 2021, p. 25). Through putting more freight on rail vice road [7], the need for road can be focussed elsewhere, such as for 'Last Mile' delivery. Such a move will reduce the number of HGV's on national roads. It will also present a feasible opportunity for the use of battery or electric HGV's to be implemented for 'Last Mile' delivery because of the short distance required to/from the point of delivery.

2. Systems and Processes at London Gateway:

London Gateway is one of many deep sea ports situated in the UK, along with other major ports such as Southampton and Felixstowe. It has a capacity for over 2.4 million containers to pass through the port each year [5] highlighting how important the port is in transporting goods such as food, clothing and other essential products to people not just in the UK but around the world. Moreover, the port also has a key rail terminal located within its facility where up to "12 rail freight services run five times per week" [8] with the capacity to have 6 rail – freight services in at one time, as well 180 bays for road haulage [5]. Around 25% of all shipping containers which move through the port is moved via rail [9], leaving the other ¾ (75%) of throughput containers moving via road haulage.

For a basic layout of a port with road and rail transportation sites [10], the process from getting containers off the ship and onto either rail or road and then onwards to retailers / consumers involves 4 key steps:

1. Ship – Land (through quay cranes);
2. Automated Stacking Yard (focussing on the 30 for landside operations);
3. Automated truck handling process;
4. The rail terminal.

1. Ship – Land

Stage one of the process involves transporting the containers off the maritime vessel and into the port grounds, to later be moved via the 'Automated Stacking Cranes' (ASCs). Currently at the Port of London Gateway there are "12 quayside cranes each being able to carry up to four containers at one time" [11]. For this case study, the model is basing the number of containers to arrive per ship to be in the figure of around 5,700, which is based on ships such as the 'E.R. Denmark' berthing at the London Gateway whereby it carried approximately 5,762 TEU [12], as well as on average per hour (60 minutes), 40 containers being unloaded [13].

2. Automated Stacking Yard

Stage two of the process is the automated stacking yard, whereby this simulation is focussing on the use of the 30 landside automated stacking cranes (ASCs) which manage the movement of containers from quayside to delivery on road transport (trucks) or to the rail terminal.

3. Automated Truck Handling Process

This process involves a truck with a wagon attached to pull into a bay and wait for the automated crane to come into position and 'place' the container on to the truck, and once this has been safely completed the truck will be ready for dispatch. Next it can be driven off to its destination. The average time a truck enters and departs this stage is around 35 minutes, as well as over 1300 trucks per day [5].

4. The Rail Terminal

The fourth and final stage of this process is the rail terminal, which has on average 11 departures per day [14] to destinations such as Birmingham, Liverpool, Manchester and Scotland. A ¼ of all containers which are unloaded off the ship will end up being distributed in – land via rail [5]. The rail terminal at London Gateway has 6 'roads', with there being a growing need to reduce carbon emissions and become 'net – zero' by 2050, increasing the % of containers and freight by rail can play a significant role in helping to achieve this objective as a freight train emits 0.04 kg CO_2 / km, in comparison to a HGV emitting 0.26 kg CO_2 / km [15].

For the purposes of this study an event-based simulation model implemented using Simul8 is set up to study the performances of London Gateway.

3. Event – based Simulation Modelling

3.1. Literature review

Event-based simulation modelling has been used successfully to study the performances of different types of rail freight systems, terminals, stations and yards included. A simulation model using Simul8 is developed in [16] to study the potential for increasing the utilisation levels of a rail line by introducing more rail freight services. an event based simulation model using ARENA is presented in [17] to study and evaluate the design of a rail interchange yard, which provides service to both high speed and conventional railways. Contribution to the same field is reported in [18] , looking at an intermodal terminal with gateway function in particular.

Event-based simulation modelling techniques are used in [19] to design a collection point for baggage transfer services at a railway station.

Event-based simulation models using Simul8 are implemented in [20], [21] and [22] to analyse and evaluate rail freight yard performances. The models presented there are extended in [23] to include a network of rail freight yards, showing the clear potential of the tool.

The intention behind this study is to use event-based simulation modelling to analyse the performances of London Gateway Intermodal Terminal. Specifically, as key element that goes through intermodal terminals, intermodal traffic can be defined as "a system of transport whereby two or more modes of transport are used to transport the same loading unit or truck in an integrated manner" [24]. There is a range of factors which contribute to the efficiency and overall success of an intermodal terminal. Factors that can influence the timeliness of loading, unloading and the throughput which an intermodal terminal such as London Gateway, and intermodal terminals experience across the UK, and Europe. Further reference is made in [25] to the timeliness factor within the simulation model of an intermodal terminal presented there, stating that the higher the efficiency of the loading and unloading process of the freight train, the higher the capacity each track within the terminal. An efficient loading/unloading process, as stated in [26], reduces the likelihood of going over the cut – off time (cut – off time being an agreed time for loading to be completed or ceased to ensure a timely departure from the terminal) as loading would likely be completed prior to the designated cut off time. The reduced risk of going over the cut – off time also reduces the need for compromise, in regards to prioritising getting a fully loaded train to departure, however, with a delay, or a partially loaded train incurring no departure delays, but incurring costs through reduced revenue because of transporting less containers per service.

This is applicable to all aspects of the intermodal terminal, not just the rail terminal, but also the unloading/loading of shipping vessels, and HGVs to improve the overall throughput an intermodal terminal can handle. It could be further argued that through an intermodal terminal focussing on improving efficiency of the loading/unloading process will in theory enable the intermodal terminal to increase its throughput regardless of what form of transport is used to distribute containers to/from the terminal. However, through the use of the London Gateway simulation it is hoped that highlighting rail as a more attractive form of transportation for containers, not only because of its environmental benefits, but with its increased capacity (more containers moved per train versus road transport) can also enable an intermodal terminal to become more efficient through distributing more containers at one time, and not having to store large numbers of containers on sight awaiting transportation, of which could be inefficient as it requires more trips to/from the storage site, compared with going directly from ship to train.

The external environment in [27] is defined as being something that organizations have no control over, can have severe impact on terminal throughput, especially during pandemics suchlike "Coronavirus" and phenomena associated with them, e.g. lockdowns, stagnate the movement of containers through ports globally which could see a "reduction in throughput of between 25 – 30%" [28] because of countries halting their exports. With the external environment being one factor, industrial action can have an influence upon the throughput and efficiency of ports and intermodal terminals [29] and and upon the supply chains they serve and are part of .

However, there are many more factors which have been found and stated in simulations studies of intermodal terminals which can impact significantly upon the efficiency of intermodal terminals. In [30] a reference is made to the human aspect of rail operations with the requirement to have well qualified personnel, like rail shunters and ground staff, who can execute the shunting operations in a timely and professional manner. Without the input of ground – staff it could pose a risk to the arrival/departure time of a freight service, thus having later consequences on the amount of time to load / unload the train, as well as the overall time for train preparation, which, if not done correctly can have even more devastating consequences on timeliness for the customers of the freight service, as well as for other customers on the rail network because of possible unsafe loads or damaged goods during transit.

The simulation model in [30] suggested that the use of rail freight in intermodal terminals does indeed have the potential to increase its share of container based freight movements. Hence, this suggestion is very promising in relation to the objectives and motivations set out for the London Gateway simulation model, in that the main rationale for the London Gateway simulation model is to investigate whether London Gateway can increase its reliance upon rail freight to distribute containers.

In [31] a further reference is made that is relevant to the motivation of the simulation model for London Gateway through describing terminals such as this as being a facilitator and as enabling a link between origin and destination within the wider supply chain, with a potential opportunity to understand how and where it is possible to increase the throughput of the 'nodes' in the network. Moreover, the layout of the simulation executed there is similarly mirrored in the London Gateway model, i.e. split into four areas: road and rail gates, a buffer area (temporary storage of containers) and a storage area (higher storage time compared to the buffer area). In contrast to [31], the London Gateway model entry gates differ. This is because of the London Gateway queueing network being comprised of arrival by maritime (boat), and departure by *both* road (trucks) and rail, whereas in [30] it just includes the input of road transport (inland container terminal) then to rail (and vice – versa), rather than an input from maritime. However, it is interesting to note that through simulating an inland container terminal it provides further insight into the other end of the supply chain, and how there is further room for efficiency in the meeting point between road and rail.

Overall, previous relevant simulation studies highlight just how many factors (human, technological and the wider external environment of which it is virtually impossible to control) impact or can affect the process of moving a container from A to B, as well as how many "influencing" interaction points there is in creating many opportunities or threats to the timeliness of service delivery. A one train service departing a port such as London Gateway can be delayed or underutilised through a handful of factors: shipping delay, rail network delay, road network delay, a locomotive failure or a plant breakdown (reach stackers or overhead crane failures). This can more specifically result in a truck not arriving on time to pick up a container, or drop off a container needing to be transported via rail, a train being underutilised (not at its full operational capacity), or a customer (business or individual) not having their order or demands fulfilled. The consequences of one or more of these failures occurring, is likely to have a domino effect upon the ports throughput for days, as well its impacts upon other freight transport facilities and networks across the country and the rest of the supply chain.

3.2 Modelling of London Gateway using SIMUL8

For simulation modelling purposes, the main objective is looking at whether or not the rail freight terminal at London Gateway has the capacity and efficiency-level to handle increased traffic if switched from a reliance on truck / road haulage. This study looks at opportunities for "shift to rail" with the three scenarios being:
Scenario 1: A benchmark – to be used as a control, and whether or not the current system is fit for purpose.
Scenario 2: Increase % of containers to rail from 25% to 40% (road being at 60%)
Scenario 3: Increase % of containers going via rail to 60% (road being at 40%).

All three scenarios are modelled using Simul8 over a 24 hour period (00:00 – 23:59) to represent a 24 hour day at London Gateway, whereby a ship arrives with an average TEU load of 5,700 and then be unloaded through the duration of the day. From being unloaded off the ship, containers move from the Quayside Cranes, into the Automated Stacking Cranes, then to either the Automated Truck Handling Process (i.e. 30 modules each with a capacity of 6 bays i.e. 180 bays per hour) or the Rail Freight Terminal, which has 3 cranes that can load containers onto 6 trains at any one time (as it is a 24 hour simulation, there is scheduled to be 11 departures per day, with each train averaging 50 – 60 containers per train).

From Figure 1, which shows the layout of terminal implemented in the Simul8 model, for Scenario 1, the parameters of the simulation are as follows:

- Number of Containers arriving off the ship: 5,700
- 12 Quayside Cranes: each with an average service time of a container every 2 minutes.
- 30 Automated Stacking Cranes (Land): each with an average service time of a container every minute.
- Automated Truck Handling Process: each of the 30 ‘modules’ having 6 bays, with an average service time of 35 minutes per truck.
- Rail Freight Terminal: within which the rail terminal cranes servicing a container every 2 minutes.

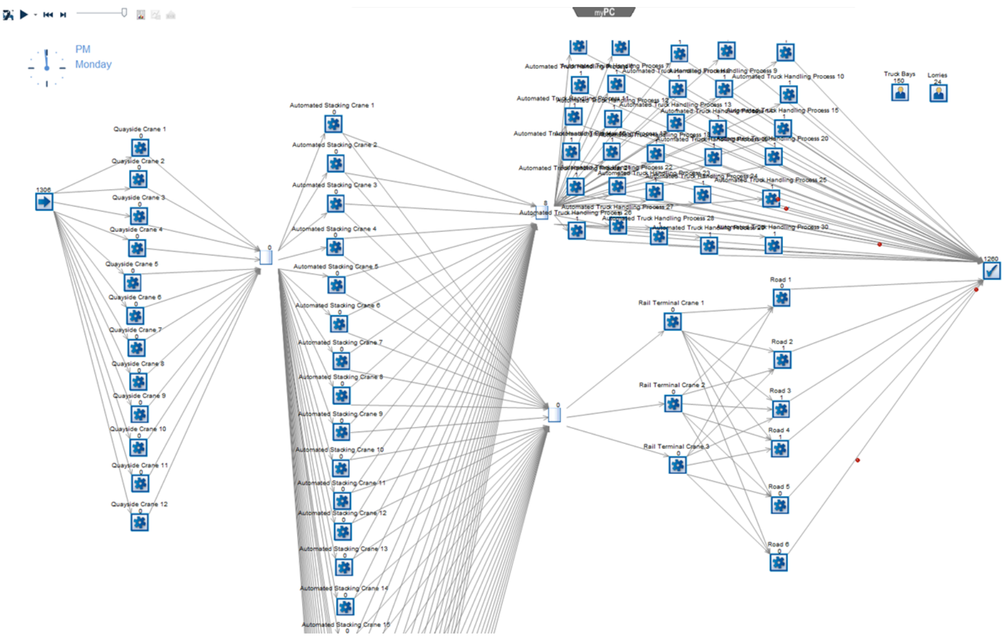


Figure 1 – Screenshot of Simul8 ‘London Gateway Model’

Scenario 1 ‘Benchmark’:

The first scenario using the Simul8 Model set to simulate a benchmark run was ‘Do Nothing'. It enabled comparison to the current system performance of London Gateway, in relation to the Measures of System Performance (MoPs) such as: Number of trucks removed (which were compared across all three scenarios), the number of containers in the system and their throughput, and utilisation levels (of Automated Truck Handling System and Rail Terminal).

Table 1 Completed Work Items for Truck handling process, Scenario 1

Automated Truck Handling Process	No. of Completed Work Items
1	38
2	41
3	38
3	37
4	38
5	39
6	39
7	38
8	41
9	39
10	37
11	40
12	38
13	37
14	38
15	35
16	38
17	39
18	39
19	37
20	39
21	37
22	40
23	38
24	38
25	37
26	38
27	35
28	38
29	35
30	39
Total	1,180
Average	39.3

Table 2 Completed Work Items for Rail Terminal, Scenario 1

Rail Road	No. of Completed Work Items
1	64
2	66
3	68
4	66
5	65
6	63
Total:	392
Average:	65.3

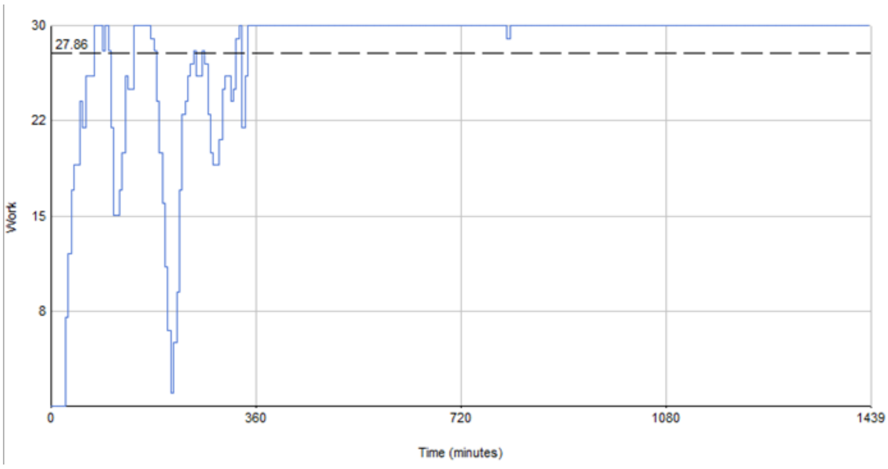


Figure 2 Lorries *52% Utilization, Scenario 1

From 'Scenario 1' a total of 1,622 containers went through the simulation, with 1,526 containers being executed (outputted). This output was split between Road / Rail with a ratio of 60:40, 1,180: 392 containers. Rail had a higher average output of containers in comparison to Road (see Table 1 and Table 2), with Road having 39 and Rail having 65. The main reasoning for this output being the utilisation of lorries being 52%, with an average number of lorries per hour being 27.86 (see Figure 2).

In comparison of Road and Rail utilization, Road has little room to increase its capacity/input with around 6% spare capacity (see Figure 3), and if the percentage of containers via road was to increase then it would be limited to how efficient containers would move through the system before the system incurs delays.

In comparison to Rail, whereby there is a waiting capacity of over 51% (see Figure 4), which would enable a higher percentage of containers to go via Rail and ultimately more containers to go through the Port within a 24 hour period.

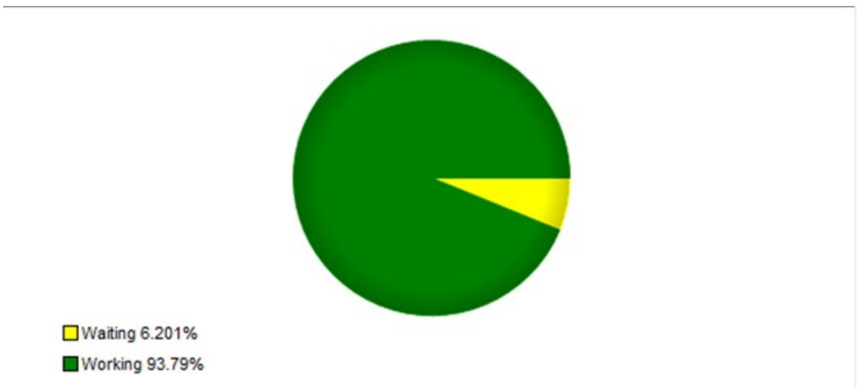


Figure 3 Road Utilisation, Scenario 1

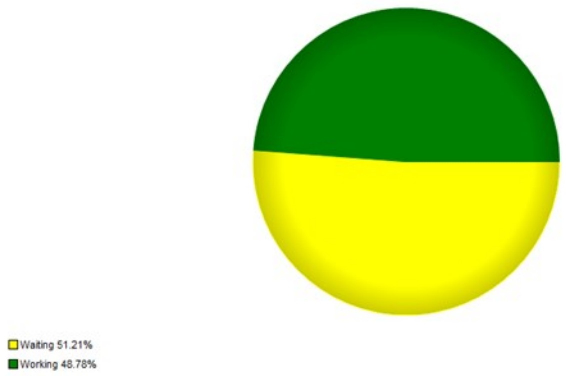


Figure 4 Rail Utilisation, Scenario 1

There is on average 35 containers per train (*18 freight wagons-platform*), which is accurate as not every train each day is continually expected to have a train load of 50 – 60 containers due to varying levels of demand and shipping rates. Moreover, each train is expected to have a varying wagon set type and length, ranging from IFA wagons (IFA being a carrying capacity of a single container per wagon), to IKA wagons (IKA being a carrying capacity of two containers per wagon) which will influence a train's carrying capacity. Moreover, as the model is only taking into consideration the unloading of one ship, not the maximum capacity of three, the throughput of containers would be higher if the number of containers inputted into the system was higher. It should also be taken into account that not all containers within a ship would be unloaded, as each would likely have a different destination globally, thus inputs into the system are expected to vary.

Scenario 2 'Increase % of containers to rail from 25% to 40% (road being at 60%)':

For Scenario 2, it was envisaged to study how much additional capacity can be utilised from the rail cranes. It was seen that all 6 spending over 50% of the time 'waiting' in Scenario 1. There is potential opportunity to exploit this spare capacity to shift container traffic from road to rail. Therefore for Scenario 2, an increase in the percentage of containers going to rail was increased from 25% to 40%, with road being at 60% (see Figure 5).

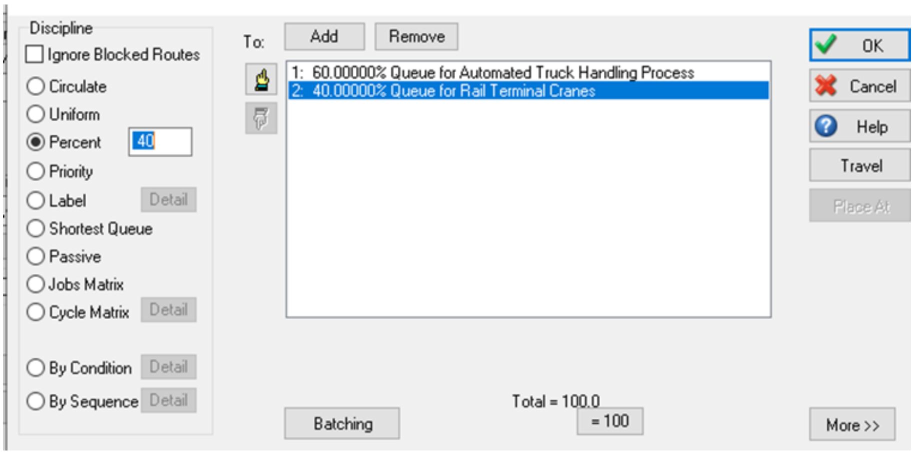


Figure 5: Routing Out in Simul8, Scenario 2

Table 3 Completed Work Items for Truck handling process, Scenario 2

Automated Truck Handling Process	No. of Completed Work Items
1	32
2	35
3	31
3	31
4	31
5	33
6	33
7	32
8	35
9	33
10	30
11	34
12	31
13	31
14	33
15	29
16	32
17	31
18	32
19	32
20	33
21	32
22	35
23	30
24	33
25	32
26	33
27	31
28	31
29	31
30	32
Total	994
Average	33.1

Table 4 Completed Work Items for Rail Terminal, Scenario 2

Rail Road	No. of Completed Work Items
1	98
2	96
3	101
4	105
5	105
6	100
Total:	605
Average:	100.8

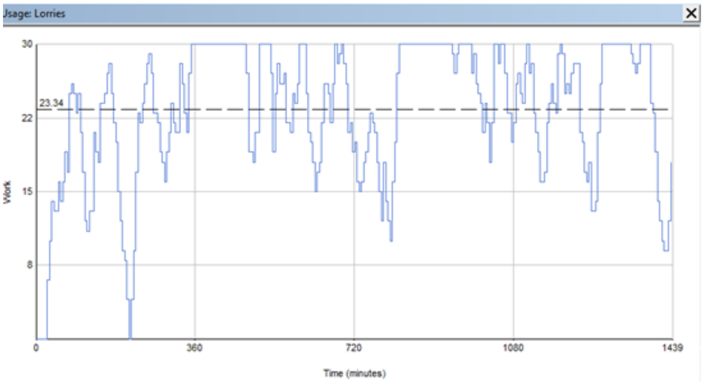


Figure 6 Lorries *43% Utilization, Scenario 2

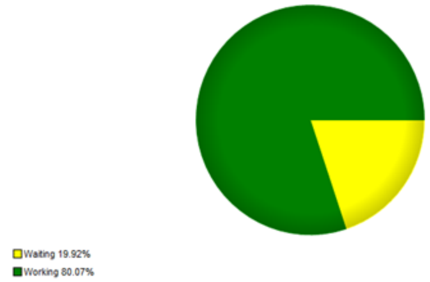


Figure 7 Road Utilisation, Scenario 2

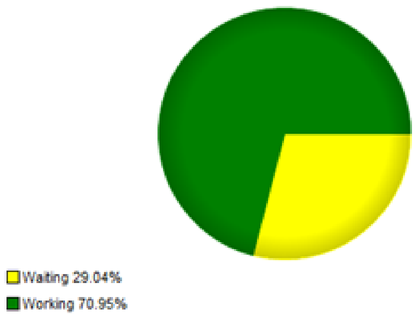


Figure 8 Rail Utilisation, Scenario 2

First observations show an increase in total output through the Simul8 model, with Scenario 1 executing 1,572 containers compared to Scenario 2 (see Table 3 and Table 4) executing 1,599 containers (1.72% increase for a 15% modal shift). Furthermore, as a result of this 15% modal shift change, this would lead to 186 lorries being removed of the road (1,180 – 994); reducing Congestion on London roads. A reduction in the utilization of lorries (Figure 6) and road (Figure 7) , any ‘wastage’ i.e. unused truck bays could be converted into new areas to stack containers or implement new cranes (servers) to load/unload lorries, making the process more efficient. Due to the shift to Rail in this scenario, an increase of over 20% in the utilisation of rail is observed as shown in Figure 8. It would enable a stronger commitment to rail freight, through having more Rail Terminal cranes in comparison to the truck handling cranes because trains can become longer, and be turned around quicker rather than road, as well as potentially (depending upon rail network capacity and the availability of Network Rail paths) increasing the frequency of trains departing the terminal per day.

Scenario 3 'Increase % of containers going via rail to 60% (road being at 40%)':

For Scenario 3, the percentage of containers going via rail was increased to 60%, with road being at 40% (see Figure 9) as a result of rail still having a 1/3 (around 30%) operational capacity left.

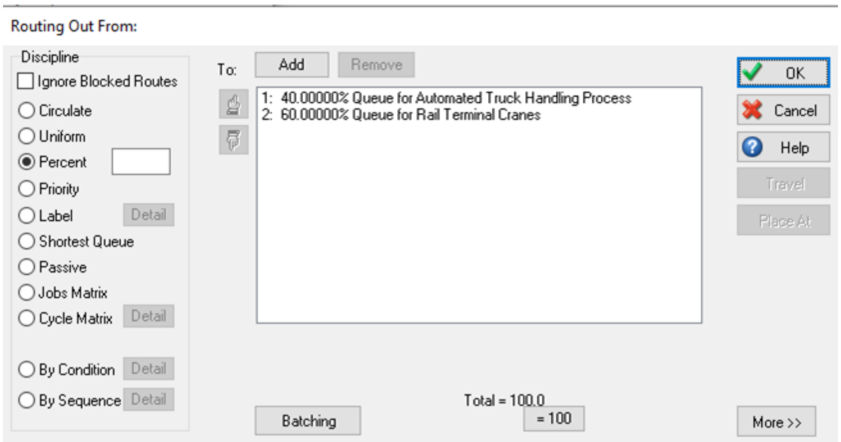


Figure 9 Routing Out in Simul8, Scenario 3

Table 5 Completed Work Items for Truck handling process, Scenario 3

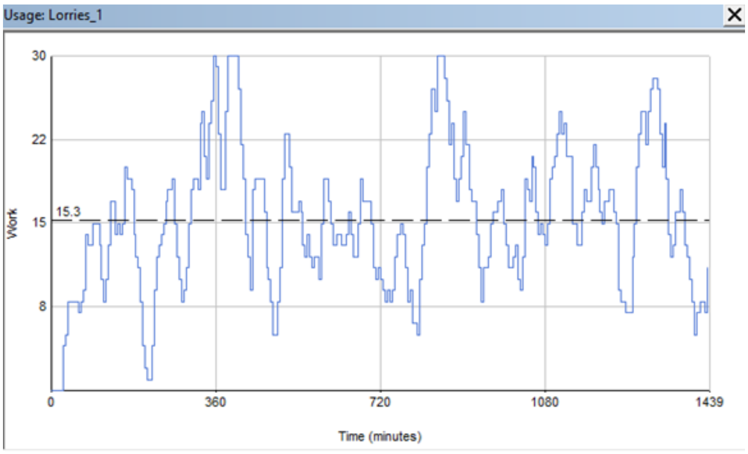
Automated Truck Handling Process	No. of Completed Work Items
1	21
2	23
3	21
4	20
5	22
6	21
7	21
8	23
9	22
10	20
11	22
12	21
13	21
14	22
15	20
16	21
17	20
18	21
19	20
20	22
21	20
22	23
23	20
24	21
25	20
26	22
27	20
28	20
29	21
30	20
Total	631
Average	21

Table 6 Completed Work Items for Rail Terminal, Scenario 3

Table 8 - 'Completed Work Items for Rail Terminal'

Rail Road	No. of Completed Work Items
1	135
2	135
3	139
4	136
5	134
6	135
Total:	814
Average:	135.7

Figure 10 Lorries *28% Utilization



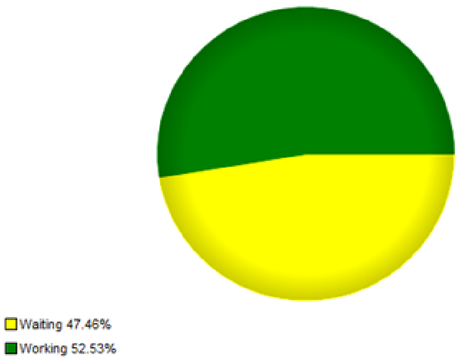


Figure 11 Road Utilisation, Scenario 3

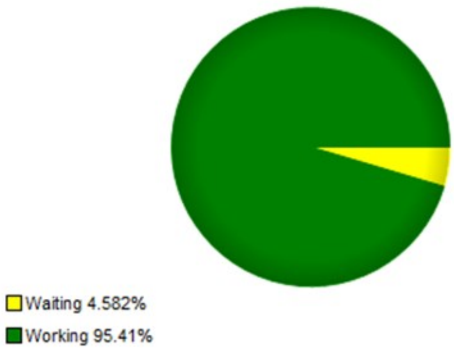


Figure 12 Rail Utilisation, Scenario 3

However, a 20% increase in containers going via rail, meant total output of Scenario 3 (see Table 5 and Table 6) was 1,445 containers a -10.7% decrease in comparison to Scenario 2, and a -8.8% decrease in comparison to Scenario 1. Therefore, from Scenario 3, with abnormally high utilisation of rail and unrealistically low utilisation of lorries and road (see Figure 10, Figure 11 and Figure 12), it could be concluded that a shift to rail in excess of 55% reduces the Port's total output, and puts an unsustainable amount of pressure upon the rail terminal, with the total output per train being on average an extra 14 containers (average of 60 in Scenario 1). Moreover, as the Simul8 model suggested, see Figure 13, there is a significant queue forming for the rail terminal, with currently over 100 containers in the queue waiting to be assigned to the rail terminal.

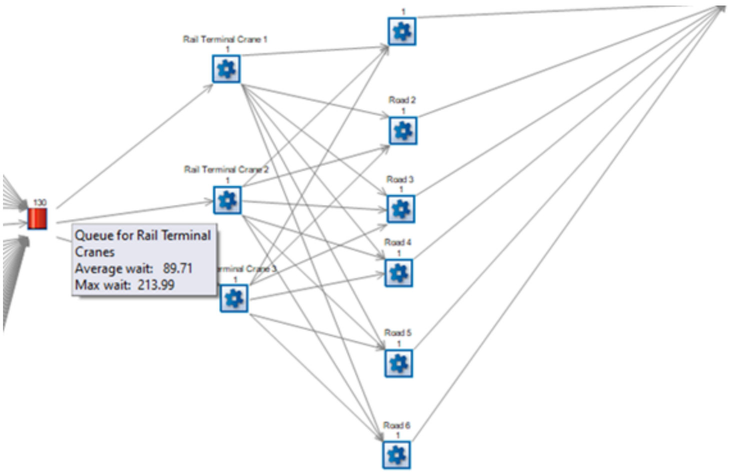


Figure 13: 60% Rail Usage – Queue formation in the Simul8 Model

Increasing Rail throughput to 60% restricts the Port from increasing its throughput per day, although the number of containers going via rail is 814 (in total), with an average train load of 74 per train (814/11), in comparison to Scenario 1 which had an average train load of 35 containers per train (392/11). Thus, there may have to be a compromise here over the number of containers going via rail versus the number of total containers outputted through the Port.

4. Conclusion:

An event-based simulation modelling study of London Gateway has been conducted to investigate and evaluate as to whether or not London Gateway has the potential to increase its reliance on rail freight as a means of increasing the total throughput of containers. The Simul8 model presented in this study suggests that for decision making purposes on sift to rail in the case of London Gateway the best scenario to be implemented is one in-between Scenario 2 and 3, whereby the percentage of containers going through rail has to be increased from 25% to around 50-55%, but no more than 60%. This is because of the queue being too large for the rail terminal and cranes to handle, without having to implement additional cranes to tackle this demand. However, based on the result obtained from the Simul8 model in Scenario 1 in particular, it would be recommended that London Gateway immediately increase the percentage of containers going through the rail terminal, up to 25% , with rail terminals having over 50% spare capacity which is being wasted. Next, from Scenario 2 it has been highlighted that a 15% increase in containers going via rail rather than road, it is expected to increase the total system output by 1.72%, thus, any increase up to 25% of containers going via rail (around a 50/50 split) will exhibit an increase in system output. Scenario 3 would not be recommended to be implemented, this is because overall system output decreases by 8.8%, reducing overall system efficiency, causing a bottleneck in the rail terminal, rather than splitting the pressure put on both Rail and Road .

6. Future Studies

Future studies could look into a range of scenarios regarding intermodal terminals like London Gateway and their use of rail freight, for example such studies could investigate the possible geographical positioning of terminals to enable an efficient relationship between road & rail i.e. using rail as the primary 'facilitator' of moving containers from A to B but then using electric HGVs for 'last mile' delivery. As well as this, it could potentially be looked into what extent factors influencing timeliness within an intermodal terminal, factors such as human resources (ground – staff and shunters), rail and road networks (how any delays incurred could be mitigated by the terminal), as well as the individual processes which occur within an intermodal terminal e.g. storage areas within the terminal and what philosophy they operate i.e. First in First Out (FIFO) or Last in First Out (LIFO), and how this could be improved to ensure the container is moved within the terminal the least amount of times to ensure resources can be utilised more effectively, and containers have travelled the least amount of distance from Ship to Train/Road (and vice – versa).

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