THE IMPACT OF THE PORT OF DURBAN ON THE CITY'S ROAD NETWORK

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ABSTRACT

This study answers two key questions i.e. what is the volume of freight traffic generated by the Port of Durban and its overall distribution and what impact does the Port of Durban have on the City's road network. This was achieved by quantifying the road based volumes (specifically heavy vehicle trips) based on Transnet's Freight Demand Forecasts at the Port of Durban.

The freight distribution patterns from the Port of Durban were then investigated. Finally, the impacts and costs the Freight Demand Forecasts from the Port of Durban have on the City's (Durban) road network were investigated. The costs included accidents costs, environmental costs, congestion costs and infrastructure costs.

The complex interaction of freight movement around ports can often be overlooked or misunderstood. This then leads to inefficiencies, inequalities, inadequate funding and unsustainability. It is thus imperative that planning authorities fully understand the multitude of port interactions, movements and impacts so that proper frameworks and policies can be established by all stakeholders to deal with ports.

1. INTRODUCTION

1.1 Background

The role and importance of port cities to the economy is a widely known and studied field. Ports have traditionally been located in close proximity to urban areas and played an important role in the consolidation and growth of many port cities, not only in economic terms, but also with regard to culture, ideas and people (Fenton 2014).

Whilst port operations have enriched – in multiple senses – the quality of life in many urban areas, ports also present challenges for the cities in which they are located, e.g. in terms of issues such as local air pollution from ships or inland transport, traffic and congestion (Fenton 2014).

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Efficient interface and linking the port waterfront services to inland transport corridors is fundamental in trade facilitation as cargo transit between ports and their destination is a critical indicator in attracting more ships and more traffic (Mutonya 2009).

It is thus imperative that planning authorities fully understands the multitude of port interactions, movements and impacts so that proper frameworks and policies can be established to deal with ports.

1.2 Objectives

The objectives of this study were as follows:

- To quantify the road based volumes (specifically heavy vehicle trips) based on Transnet's Freight Demand Forecasts at the Port of Durban. This in essence provides the vehicular trip generation characteristics at the port.
- To investigate the freight distribution patterns from the Port of Durban
- To determine the impacts and costs the Freight Demand Forecasts from the Port of Durban has on the City's (Durban) road network in terms of the following:
    - Accidents Costs
    - Environmental Costs
    - Congestion Costs
    - Infrastructure Costs

1.3 Overall Approach

The overarching approach of this paper is quantitative and is based on freight modelling. The data available to do this modelling was obtained from the Transnet's Freight Demand Forecasts. The paper will describe the modelling of freight transport flows from the Port of Durban i.e. measuring the freight demand. The externality costs of the quantified freight volumes were then estimated. The study was a desktop analysis using available information in order to achieve the desired planning outcomes.

2 LITERATURE REVIEW

The common challenge for cities is that freight transport is growing (Lindholm & Behrends 2012). For cities seeking to compete in the globalized economy, effective freight transport services are a key success factor (Docherty 2004). The movement of freight in the EThekwini Municipal Area is one of the city's most important economic activities and a major reason for the growth and prosperity of the local authority (Royal Haskoning DHV*Imani Development 2013), with the Port of Durban playing a significant role in the local economy. Since it is almost universally recognized that freight transport is important, there needs to be a much greater focus on freight planning (Rodrigue, Comtois & Slack 2006).

Port statistics indicate that a number of ports in Africa continued to record significant growth in traffic both in cargo volumes and containers for the coming years (Mutonya 2009). The three main determinants for competitive ports identified by (Merk & Li 2013) are: extensive maritime forelands, effective port operations and strong hinterland connections. When a port or its hinterland facilities are strongly congested, this then weakens the ports competitive position (OECD/ITF 2008). Thus, the development of ports and increase in port volumes should not only consider advances within the ports itself, but should also consider the landside and hinterland connections.

Trip generation is usually calculated by converting annual commodity tonnage data into daily truck/vehicle trips using a payload conversion factor (Fischer & Han, 2001). The conversion process from commodity flows to vehicle trips to/from establishments (e.g. Port of Durban) takes into consideration variations by time, day and month (Allen, Browne & Cherrett 2012). Al-Deek (2001) further explains that the truck/vehicle flow changes are related to commodities being transported. Observing different approaches to freight modelling (vehicle/commodity based), it may be seen that the choice of approach will depend on data availability (Kulpa, 2013).

Once the freight movements around the Port are appropriately quantified, the social costs of transport (accident costs, environmental costs, congestion costs and infrastructure costs) as a result of port development can be measured and calculated correctly.

3 METHODOLOGY

3.1 Introduction

This section provides an outline of the methodology adopted to achieve the objectives.

3.2 Methodology

3.2.1. Quantify Road Based Vehicle Volumes

The procedure followed to estimate the number of heavy vehicles generated by the Port of Durban is as follows:

a) Transnet Freight Demand Forecasts: The Transnet National Ports Authority of South Africa has developed the Transnet Market Demand Strategy which provides long term estimates on the annual tonnage of various commodities imported and exported at all Ports in South Africa.
b) Estimate Annual Commodity Volumes: Based on the Transnet Freight Demand Forecasts, the various commodities at the Port of Durban are grouped as follows:
    i. Containers – measured in TEU's / annum
    ii. Dry Bulk – measured in Tons / annum
    iii. Liquid Bulk – measured in Kilo Litres / annum
    iv. Ro-Ro Units – measured in Units / annum
    v. Break Bulk – measured in Tons / annum
c) Convert Annual Commodity Volumes to Road Based Volumes: The annual

commodity volumes are converted to road based volumes (Fischer & Han, 2001) based on information provided by Transnet as well as conversion factors (Jong et al. 2004, Tavasszy & Jong, 2014). The assumptions for conversion are given in Table 1.

Table 1: Vehicle Demand Forecast Assumptions

ITEM	DESCRIPTION	VALUE
Annual Volume in peak month	Percentage of annual volume in peak month	10%*
Weeks per month	-	4.5
Weekly volume on peak day	Percentage of weekly volume on peak day	17%*
Daily volume in peak hour	Percentage daily volume in peak hour	To be Calculated using existing traffic count data
Transshipment	Cargo/commodity transfer from one vessel to another (Applies to Containers Only)	17%**
Reverse Haul	Vehicles loaded in both directions, i.e. inbound and outbound	Varies per commodity type**
TEU's per vehicle	Containers (20 Foot) carried per road vehicle	1
Design Road Modal Split	Proportion of commodity transported by road (design only)	Varies per commodity type**
PCE Factor	Factor for conversion of heavy goods vehicles to passenger car units.	4***
Growth in Background Traffic	The yearly growth in background traffic on the road network (per annum)	2%
Vehicle Payloads: Containers: TEU's per vehicle Dry Bulk: Tons per truck Break Bulk: Tons per truck Ro-Ro: Units per vehicle	Containers (20 Foot) carried per road vehicle	1 30 tons 30 tons 6 units

* Per Literature Review Findings
**Per Transnet
*** PCE of 2 generally used on SANRAL roads. A PCE of 4 was used in the study due to the stop/start nature of operations within the Port and CBD environment.

3.2.2. Freight Distribution and Assignment to and from the Port of Durban

Freight to and from the Port of Durban is either distributed internally within the EThekwini Municipality or externally beyond the borders of the Municipality i.e. the hinterland.

For purposes of this study, only the hinterland trips was considered. The proportion of hinterland trips was estimated using the data provided by SANRAL (Yearly Traffic Data).

In relation to the Port of Durban, the key origin and destination points are either to the West, North or South. In essence the key freight routes are:

- Durban-Gauteng Corridor: to the West leaving the Municipality is National Route 3 (N3) which links Durban with Gauteng and beyond the South African borders.
- Northern Corridor: The National Route 2 (N2) services the northern areas which include Richards Bay, Pongola and Mpumalanga.
- Southern Corridor: The N2 South Corridor services the southern EThekwini region, southern KZN as well as the Eastern and Western Cape area.

Trips were assigned onto the road network from each Port Gate in the same proportion of existing freight traffic volumes using existing traffic count data. The traffic count data was provided by the EThekwini Municipality and Arup.

The heavy vehicle trip conversion process, including trip distribution and trip assignment, estimated from Transnet's Freight Demand Model is summarised in the diagram shown in Figure 1.

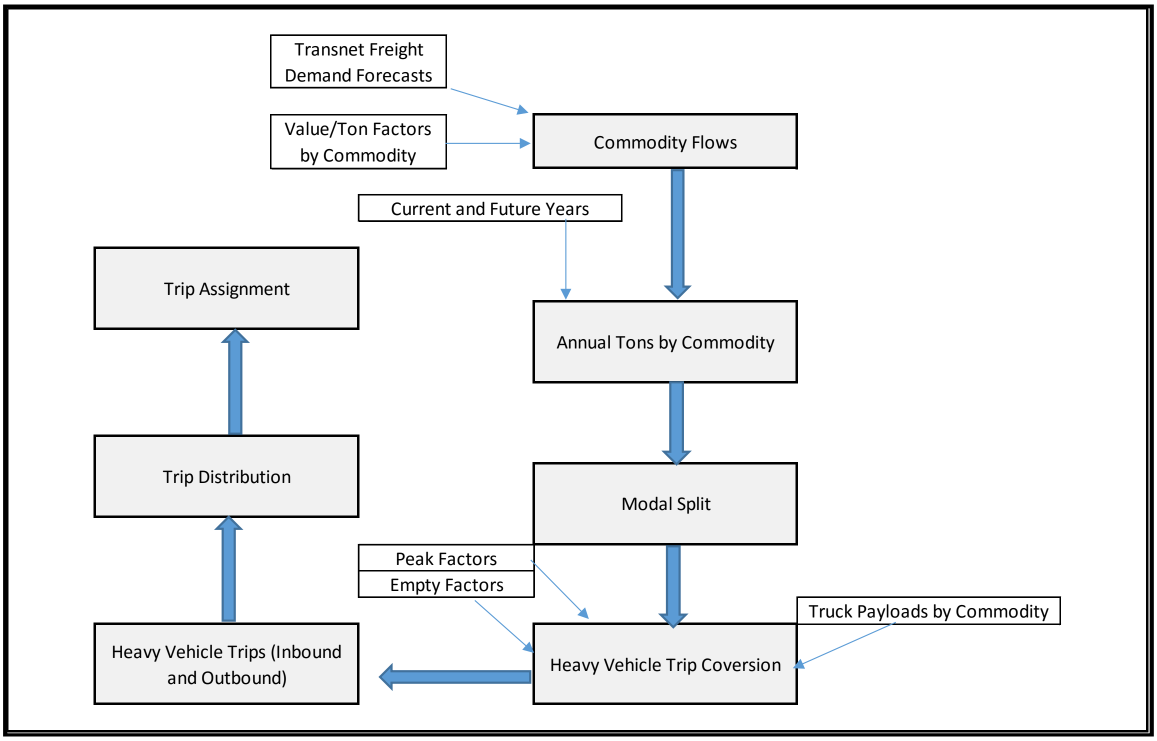

Figure 1: Heavy Vehicle Trip Conversion Process

3.2.3. Impacts and Costs

Once the number of heavy vehicle trips generated by the Port of Durban is known, the impacts and costs of these trips can then be estimated. The method to calculate the various costs and impacts are described in Sections 3.2.3.1 to 3.2.3.4.

3.2.4. Accident Costs

The method to calculate accident costs was as follows:

i. The total number of heavy vehicles on the main road network based on traffic count data was estimated
ii. The proportion of heavy vehicle trips that are port related trips on the main road network can be estimated from the trip distribution results
iii. The EThekwini Municipality's comprehensive accident record on the road network pertaining to this current study was obtained
iv. Using the findings from the literature review, the cost of an accident (de Beer & van Niekerk, 2004) involving heavy vehicles was applied to the port related accidents to estimate the total accident cost associated with the Port of Durban

3.2.5. Environmental Impact

Environmental costs are based on Green House Gas (GHG) Emissions rates. In order to calculate the total GHG emissions, the total vehicle kilometres and volume needs to be estimated. Thus, the method of calculation for environmental costs is as follows:

i. Calculate the total number of heavy vehicle trips from the Port of Durban
ii. Estimate the volume (weight) travelled on the main road networks
iii. Estimate the average distance travelled on each of the main roads by port related traffic

3.2.6. Congestion Costs

The method to calculate congestion costs is as follows:

i. The proportion of heavy vehicles on the main road network was estimated using existing traffic count data and the port related traffic was estimated
ii. The average distance travelled on the main roads was estimated
iii. The unit costs of congestion, based on the findings from the Literature Review, was applied to the above

3.2.7. Infrastructure Costs

Infrastructure costs was based on the cost of a new road as well as the average road wear costs.

4 ANALYSIS AND RESULTS: TRAFFIC VOLUMES

4.1 Commodity Flows

The growth in the demand for each commodity is illustrated in the graph shown in Figure 2.

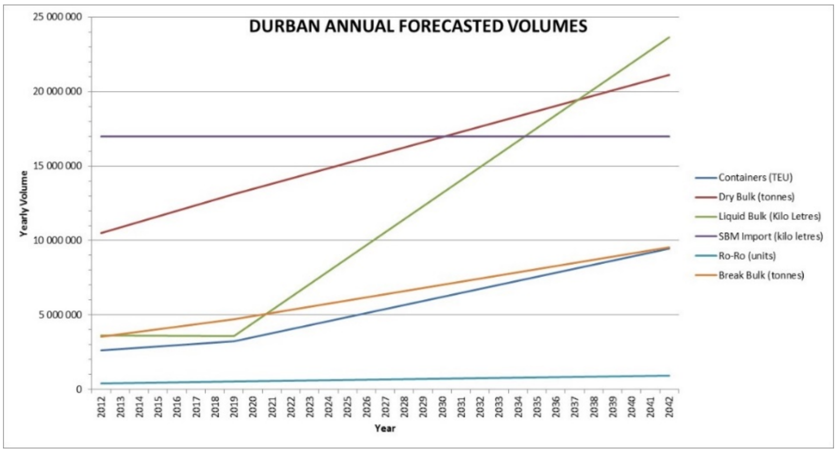

Figure 2: Annual Commodity Volumes

The commodity demand forecast at the Port of Durban shows a general increase from current levels over the next 30 years. The change in slope for the year 2019 signifies the time period when many of the infrastructure upgrades at the Port, including the new Dig-Out Port, would be completed and the sudden take-up is as a result of latent demand. The Transnet forecasted commodity demand volumes are based on prevailing market conditions both locally and on the international markets. Any significant worsening of the market, like the financial crisis of 2008, will have a negative effect on the demand forecasts and consequently, the demand may be adjusted downwards.

4.2 Modal Split

The change in modal split from the year 2012 to the forecast year 2042 is shown graphically in Figure 3.

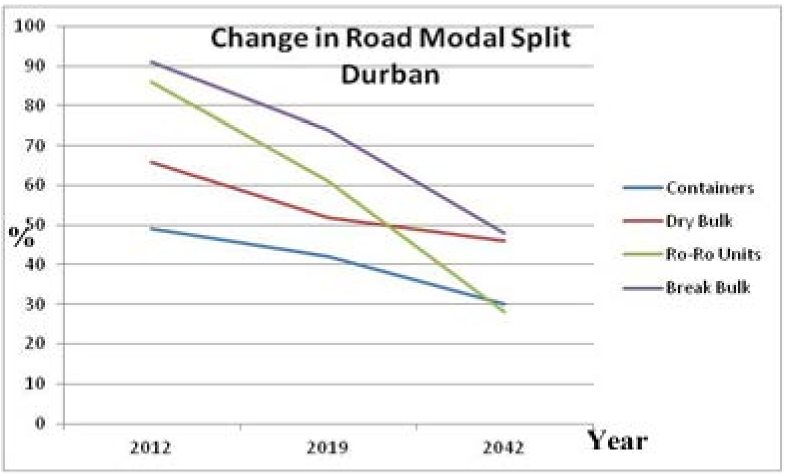

Figure 3: Change in Road Modal Split

The reduction in the road modal split, as shown in Figure 3, is attributed to the fact that rail is envisaged to be the dominant mode of transport in the future as opposed to road from the Port of Durban. This is in line with Transnet's long term strategy to shift the road/rail modal split in favor of rail.

4.3 Vehicle Volumes

Peak Hour

The peak hour vehicle volumes that was calculated using a spreadsheet model is summarized in Table 2.

Table 2: Peak Hour Vehicle Volumes at the Port of Durban

YEAR	TEU's(Tons)/ANNUM	PEAK HOUR VOLUMES (PCE)			
		INBOUND (PCE)	OUTBOUND (PCE)	TOTAL	ADDITIONAL VEHICLES
DURBAN					
CONTAINERS					
2012	2634278	1355	676	2031	
2019	3236578	1480	739	2219	187
2042	9455132	1359	679	2038	6
DIG PORT: Containers		2039	1018	3056	3056
DRY BULK					
2012	10504272	318	159	477	
2019	13104966	313	156	469	-8
2042	21108511	445	222	668	191
RO-RO UNITS					
2012	384231	71	36	107	
2019	517306	68	34	102	-5
2042	908908	55	27	82	-25
BREAK BULK					
2012	3532397	139	69	208	
2019	4711962	150	75	225	18
2042	9528164	197	98	296	88

4.4 Daily Truck Volumes

The daily truck volumes are illustrated in Figure 4.

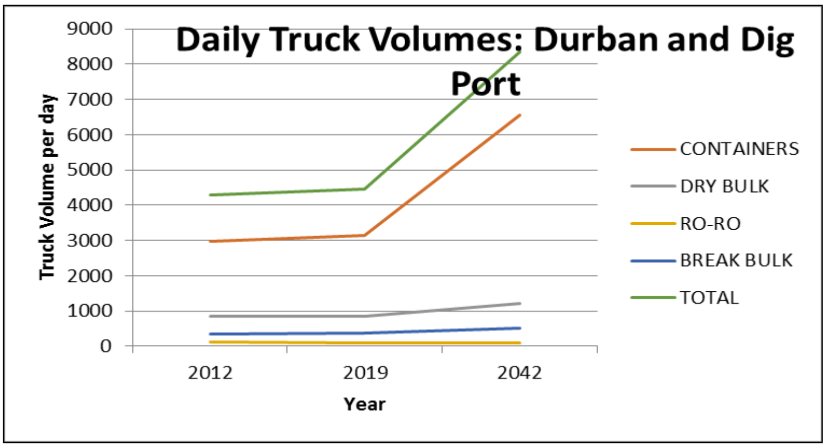

Figure 4: Daily Truck Volumes

As expected, the largest increase to the daily truck volumes from 2012 to 2042 was containers in that by 2042, it is expected that there would be more than double the amount of heavy vehicles on the road network. The positive behind the result is that the movement of goods by container transport is geared towards rail (or rather easily transported by rail), and perhaps greater emphasis needs to be placed on the road:rail modal split for Containers.

4.5 Distribution

The distribution pattern from the Port of Durban is 21% to the North, 61% to the West and 18% to the South.

4.6 Assignment

An assignment model was developed to estimate the number of trips on the strategic freight routes around the Port. The model linked the Gate volumes at the port with the key routes and the results are shown in Figure 5.

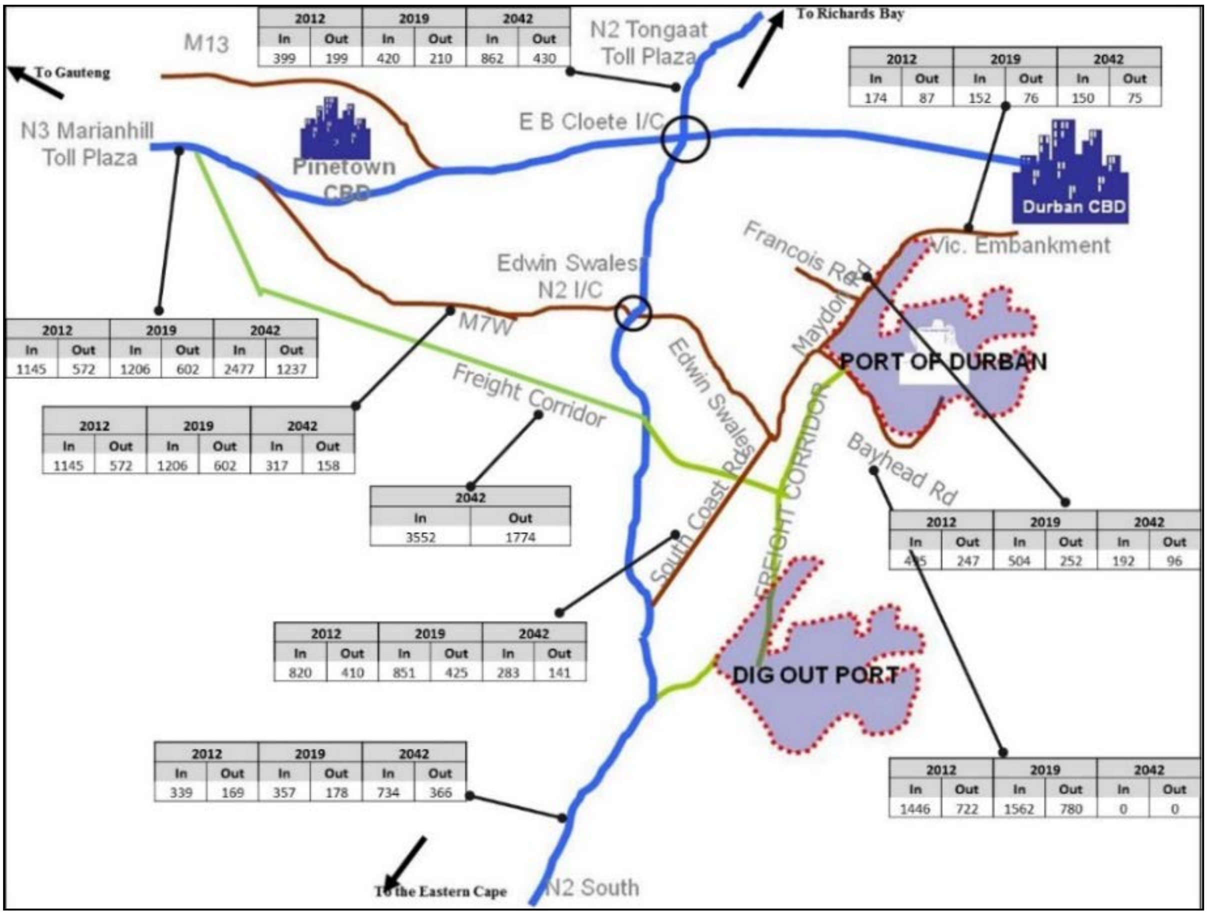

Figure 5: Peak Hour Assignment Volumes (PCE)

5 ANALYSIS AND RESULTS: IMPACTS AND COSTS

The purpose of this Section is to determine the impacts and costs associated with the heavy vehicle demand at the Port of Durban. The results of the assessment undertaken in Section 4 of this study was used as input to calculate the externality costs. While there are various externality costs not discussed in this study (noise, policing, roadway land, inter alia), the four costs assessed are accident, environmental, congestion and infrastructure.

5.1 Environmental Impact

Applying the average CO_2 emission factor of 62g CO_2/ton-km (McKinnon & Piecyk, 2011) to the average distance and volume on each route from the Port of Durban provide the following results:

- 2012: 388 000 tons CO_2 per year
- 2019: 402 960 tons CO_2 per year
- 2042: 1 127 120 tons CO_2 per year

5.2 Congestion Costs

The Texas Transportation Institute has developed a congestion index which is used to calculate congestion costs in Major U.S. cities (Victoria Transport Policy Institute, 2003). Applying an average highway congestion cost of 8.78 cents per vehicle-mile (US Dollar) for trucks on all highway types yields the following results:

The 2012 analysis shows that Port related traffic account for almost 25% of the total congestion costs due to the movement of all heavy vehicles within the city of Durban. The annual cost of congestion for Port related traffic is estimated at R130 Million annually in 2012 and R135 Million annually in 2019.

By 2042, congestion due to Port related traffic is estimated to cost the economy approximately R377 Million annually.

5.3 Accident Costs

The average cost of accidents, as per Table 4, is as follows which has been adjusted to current year (2014) costs:

Fatal	R 1 196 000
Serious	R 296 268
Average	R 91 472

The total cost of accidents on the main roads within the study area costs the economy on average R1.8 Billion per annum which is a substantial cost. Of this cost, on average 23% is related to heavy vehicles. Port related traffic constitutes approximately 30% of all heavy vehicle trips on the roads within the study area

Consequently, heavy vehicles from the Port of Durban, as a function of the total accidents, costs the economy on average R120 Million per annum.

5.4 Infrastructure Costs

The total road infrastructure costs in 2012 was R6.3 Billion, in 2019 would be R6.6 Billion and in 2042 would be approximately R13.8 Billion. Using the above estimates and bearing in mind that the infrastructure in 2012 has already been built (2012 can be considered the base cost), the road infrastructure costs required for the port expansions in 2019 and 2042 is expected to be approximately R300 Million and R7.5 Billion respectively.

6 CONCLUSION

The study outcome are summarized below:

- The peak hourly volumes are expected to increase from approximately 2800veh/h to 6140 veh/h by 2042
- The daily truck volumes are expected to increase from approximately 4200 veh/day to 8500 veh/day by 2042
- The distribution pattern from the Port of Durban is 21% to the North, 61% to the West and 18% to the South.
- The average CO_2 emission factor is expected to increase from approximately 388 000 tons per year to 1 127 120 tons per year by 2042
- The annual cost of congestion for Port related traffic is estimated at R130 Million annually and this figure is expected to increase to R377 Million annually by the year 2042.
- Heavy vehicles from the Port of Durban, as a function of the total accidents, costs the economy on average R120 Million per annum
- The road infrastructure costs required for the port expansions in 2019 and 2042 is expected to be approximately R300 Million and R7.5 Billion respectively.

What the findings are showing is that while the planning authorities at the Port of Durban are emphasising a shift to rail in the future, there would still be a dependancy on heavy vehicles as a mode of transport and given the anticipated future growth in port volumes, heavy vehicles on the City's road network are also expected to increase on certain routes. It was also found that the movement of containers is the major overall contributor to truck volumes on the road network. The research contained in this study provides a tool and mechanism for understanding the freight movement patterns within a port environment. There is a strong need for the Port of Durban and the urban areas of the city to coexist, meaning that this involves planning measures that maintain a livable city while overcoming social and environmental challenges.

Future Research

The research contained in this study could benefit by expanding on some of the following items:

- On site observations to confirm the outputs from this study and to further calibrate the freight spreadsheet model that was developed.

- A more detailed analysis is required on the distributions patterns from the Port of Durban. This can be achieved by interview surveys or by including the private sector.
- Further research is required on the solutions to the impacts identified in this study.

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