Demerara Harbour Bridge Corporations

Feasibility Study and Design for the New
Demerara River Crossing

FINAL REPORT
FEASIBILITY STUDY AND DESIGN NEW DEMERARA RIVER CROSSING
FINAL REPORT
DOC NO.: GGFD-R-014 REV 0 | AUGUST 17TH, 2017

Authorization

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Doc number: GGFD-R-014
Revision: 0
Date: August 17th, 2017
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1 Executive summary

1.1 Introduction

The Demerara Harbour Bridge has been in operation for 40 years and has long passed its technical lifetime. The bridge is no longer able to service the present and future traffic demand. The long retraction time causes major traffic congestion. A total overhaul would be costly and the limited capacity does not provide a solution for the growing traffic.

A pre-feasibility study carried out in 2013 proposes three alternative locations, Houston, Peters Hall (the existing location) and New Hope, to realize a new bridge.

Figure 1 Demerara Harbour Bridge 2017

Figure 2 Traffic congestion approach to bridge

Figure 3 Three alternative bridge locations
Currently there is an urgent need for a final conclusion on the configuration and location of the new river crossing. A detailed feasibility and design study is needed to address all aspects of the Project and present a basis for decision-making and the further steps into realisation.

The Government of Guyana has commissioned LievenseCSO to execute a feasibility and design study. This study includes site investigations, traffic and river studies, designs, environmental impact study, socio economic cost benefit analysis, financial analysis and financing and funding plan. The aim of the study is to support the decision making by the government on the location and configuration of the river crossing.

The Demerara Harbour Bridge Corporation has acted as the Employer and has supervised the Consultants together with the Department of Transportation Planning of the Ministry of Public Infrastructure. Consultants very much appreciate the efforts of the Demerara Harbour Bridge Corporation and the Ministry of Public Infrastructure for all timely data collection as well as the excellent organisation of the stakeholder meetings and feed backs given. The study has been carried out between January 1, 2017 and August 17, 2017.

This Final Report summarizes the findings and conclusions of the study. For more detailed information on the subjects studied reference is made to the Annexes of this Report comprising the detailed study reports on the various subjects.

1.2 Main conclusions

A low bridge at Houston with three lanes and a movable section to transit seagoing vessels is found to be the best solution.

- Present bridge is unreliable and lacks the capacity to serve the traffic demand hence a new bridge is required.
- Traffic is estimated to continue to grow at 5% per annum.
- The road network in greater Georgetown area is saturated. The road network adjacent to the present bridge is not able to serve the present and future traffic demand. New linking roads are required to fully use the new bridge capacity.
- The best location is at Houston – Versailles.
- A three lane bridge with an opening section to allow river traffic to pass is the best configuration.
- Investment costs, traffic demand, economic impact, urban development aspects, environmental impacts and financial feasibility have all been considered in the equation to arrive at the above choice of location and configuration.
1.3 Recommended bridge location

The Houston – Versailles location is the recommended location for the following reasons:

- The highest socio economic cost benefit (highest benefits for invested money).
- Much lower urban and environmental impacts than other locations.
- The best solution to improve traffic.
- The lowest investment cost and thus the most viable from funding viewpoint.

Some issues to be resolved are the resettlement of some houses, and efforts to minimize the impact to the Muneshwer terminal as well as to the PSI Fishing terminal adjacent to the bridge.
On the West Bank attention should be paid to mangrove fringe crossing, the current drainage channel and a timber company.

There is impact to the harbour as well as the navigation in the river. Procedures for navigation have to be reconsidered and new lead lines to be developed.

All these challenges are manageable.

1.4 Recommended bridge configuration

The recommended configuration is a low bridge with movable section. The bridge shall be designed with a minimum clearance of 17,5 m above Chart Datum (CD) to allow uninterrupted passing of trawlers, tugs and barges and smaller coastal and service vessels.

A low bridge is about 20 % less expensive than a high bridge (with a reduced height of 43,5 m CD). Compared to the high bridge, the low bridge has also an estimated 15% higher lane capacity and less risk on the breakdown of trucks and cargo fallen off.

Disadvantage of the low bridge remains the bridge openings at high tide but these shall be mitigated by building a fast movable bridge to be opened only for the larger vessels, allowing day and night openings outside rush hours.

As the road traffic has a directional imbalance, a three-lane configuration with the middle lane reversible provides the best ratio between investment costs and capacity to service the traffic demand. A two-lane configuration does provide more capacity than the present bridge and will suffice only short term as traffic growth continues. A four-lane bridge is much more expensive and will have a large imbalance as one direction will not be used to capacity. Optimal is three lanes where all lanes will be used to capacity.
1.5 Additional road capacity by the Links

To reduce the traffic congestion the bridge is only a part of the problem. The city road network has to be improved and extended to serve the present and future traffic demand. The existing bank roads need to be relieved. New links from the bridge to town as well as from the bridge to the west bypassing Vreed-en-Hoop to relieve the East and West Bank Public Roads from traffic are required. In addition, the East Bank Public Road shall be relieved from the traffic from Diamond and more south by realizing the by-pass road now under preparation between Diamond and Ogle.

1.6 Alternative transport modalities

According to the traffic forecast, the proposed measures will suffice to mitigate the traffic until about the year 2030. At that time the road system is expected to become saturated again. New investments will be required, like a second bridge as well as extension of the city road network. It is recommended to shift this moment backwards in time by promoting alternative transport modalities (speed-boats and public transport) in order to reduce the traffic demand for the road system.
1.7 Financial feasibility and financing of the Project

A business case of the Project has been developed for the Project. In principle the conclusions hold for each type of financing. The Revenues from toll and the expenses have been projected. The debt service (repayment of principal and interest) to pay back bonds/loans and interest) is the most important cost factor and is very dominant in the financial projections.

Government wishes as much as possible private involvement (PPP) to reduce the claim on Government funding and liabilities. A funding plan has been developed taking into account lowest government contribution i.e. maximise non-governmental financial institutions and funding, swift arranging and a sustainable structure which fits the Project. A keen appetite has been found in the national and regional financial markets to fund the Project.

From the financial projections it was concluded that the business case of the Project is financially not viable assuming similar toll rates and no contribution from Government. The main reason is the high debt service caused by the short loan periods and high interests in the market.

1.8 Investment costs, Toll rates and Business Case

Project costs of the low three lane bridge at Houston - Versailles are estimated at USD 150 million, including contractors cost and additional costs for services, land acquisition for the approach roads, and limited budget for a first phase of link roads.

Total required funding is USD 170 million including interest for pre-financing cost during construction.

In the business model the required Government contribution was calculated as function of toll increase at the moment of commissioning of the new crossing. In all cases the toll rises 3 % per annum to compensate escalation. Assumption was made that traffic grows on the forecasted values. The following table gives the indicative relation between toll increase and Government contribution (summed over the indicated period).

<table>
<thead>
<tr>
<th>No</th>
<th>Toll rates (2017 =100%)</th>
<th>Government contribution</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>100%</td>
<td>US$ 140,113.167 over the first 12 years</td>
</tr>
<tr>
<td>2</td>
<td>200%</td>
<td>US$ 67,555.591 over the first 10 years</td>
</tr>
<tr>
<td>3</td>
<td>250%</td>
<td>US$ 39,392.604 over the first 5 years</td>
</tr>
<tr>
<td>4</td>
<td>300%</td>
<td>US$ 27,349.203 over the first 5 years</td>
</tr>
</tbody>
</table>

Table 1 Indicative relation between toll increase and Government contribution

Toll tariff rates are advised to be increased to 250 % of the present 2017 road toll rates. Toll for river vessels to be increased to 700 % of the present rates (which have not been increased recently). In this way the Government contribution will be limited to about US $ 39 million to be paid in 5 years after commissioning of the Project and the Project becomes viable.

The proposed financial structure is by Project Finance. The structure is realized by a Government owned Special Purpose Company (SPC) being the owner and arranging the funding.
The SPC is supported and guaranteed by Government through:

- A guarantee on the pay back on bonds, loans and interest.
- Some SPC equity or similar long term financing not requiring interest.
- Annual yearly government contribution for the first 5-10 years to cover the negative cash flow as indicated above.

An alternative structure is to seek private parties willing to engage themselves in a BOOT Project (built, operate, own and transfer). These parties will take care of the financing which may be better than can be funded by Government. However Project costs are higher and the BOOT business case must result in sufficient risk coverage and profit for the private partner and as a result may require higher toll rates or more Government contribution. It is expected that similar guarantees from Government will be required as in the case of Project Finance.

DBFM (Design, Built, Finance and Maintain) or similar is a mixed option combining the SPC structure with possibly better financing by the private party.

1.9 Risk Management

The recommended project has from an financial point of view limited safety margin and many factors are still uncertain. This include among others, the contract costs of the D&C contractor, the final funding costs and interest, the uncertainty in the traffic forecast and thus the revenues, claims and force majeure.

Therefore, it is recommended to adopt a flexible development strategy to control risks in cost and revenues by scope management, as this is the only way to influence the costs of the project. This includes minor items like the link roads and viaducts over the bank roads, but even the consideration to accept two lanes if such is the only way to realize the project. Another recommendation is early contractor involvement.

1.10 Communication

Make investments in careful communication to the public to generate the willingness to pay the considerable higher toll rates; use for this also the Final Environmental and Social Impact Assessment (ESIA) process as required by the Environment Protection Agency (EPA) as a tool to create public support for the project.
2 Why a new bridge?

2.1 The condition of the current floating bridge

The current two-lane steel floating bridge connects the East Bank at Peters Hall with the West Bank at Meer Zorgen. Some 40,000-45,000 people (10,000 vehicles per direction) use the bridge each day. The market share of the bridge for the passenger segment is about 85% (the other 15% use speedboats).

The current bridge has already passed its technical life and requires fundamental overhaul, replacement, maintenance and repair. Road capacity is limited due to the retraction system. Opening times are long due to the slow retraction process. The structure is vulnerable for incidents from vehicles and vessels as well as river forces. As the bridge is the only connection, the West Bank economy and population will suffer significantly in case the bridge cannot be used over longer time; there is no good alternative.

In addition, the long and frequent bridge openings impact traffic. Bridge opening time depends on water levels and flow velocities (tide). When appropriate tidal conditions for opening coincide with (road) rush hours, large traffic jams occur. The retraction time to open the bridge allowing river traffic pass is long and the mechanism sometimes fails resulting in either river or road traffic cannot pass. This causes unnecessary delays and demurrage for the ships and congestion for road traffic.

The new bridge will replace the existing bridge. As soon as the new bridge is in operation the old bridge will be closed and demolished.

2.2 Historic growth of traffic

In the last decade the traffic grew with 5% per year. The limitations of the road system to cope with such growth has been reached.

Reference is made to the situation in 1988 when the bridge was out of operation for a few weeks.

Figure 7 Exceedance curve closure times existing bridge
2.3 Traffic congestion in general

The bridge is not the only cause of traffic congestion: the capacity of particularly East Bank Public Road and its junctions is insufficient during rush hours.

Congestion starts here, and affects the flow of traffic on the bridge. Also, the traffic through Vreed-en-Hoop as well as Goed Fortuin on the West Bank is slow and is causing many delays.

Essentially, apart from the retractions and possibly accidents, the present 2 lane bridge, in principle, has sufficient theoretical capacity for the present traffic. Congestion emerges where the East Bank Public Road enters the city center. Then it extends from the bank roads to the bridge.
3 Road traffic: forecast

3.1 Drivers for growth

The growth of traffic on the bridge is strongly related to the macro economic growth. According to the IMF, ‘Guyana’s macroeconomic outlook is generally positive for 2016 and the medium-term’.

International studies indicate that there are several factors that explain the volume of motorized vehicles. Rand/Institute for Mobility Research identifies nine factors that explain motorized transportation in developing countries: 1) good car infrastructure; 2) inexpensive fuel; 3) pro-car policies; 4) lack of alternative to driving; 5) active population; 6) existence of domestic oil; 7) strength of the domestic car industry; 8) spatial dispersion; 9) favourability of car culture.

For Guyana three out of these nine factors are expected to drive the increase of traffic demand in the future: good car culture, inexpensive fuel and existence of domestic oil. The conclusion is that a further increase in motorized transportation is to be excepted. This is in line with historical data. Car registration in Guyana shows a steep increase of over 7% per annum (2010-2015). Worldwide, people are using cars more and more. The percentage of commuters that are able to use individual transportation modes will increase over time.

Momentarily, car-pooling is widely used for the bridge crossing. The public transport by speedboats and minibuses seems flexible and rather efficient. Improvements can still be made and may reduce the additional traffic pressure on the bridge in the future.

A large share of demand for transportation services consists of commuting distances to schools, administration and utilities. Regarding trade corridors the bridge plays an important role. Georgetown is considered the marketplace of Guyana. The bridge provides Regions 1, 2, 4 and 7 with market access. The Port of Georgetown plays a key role in Guyana’s international trade.

Urbanisation has resulted in a long series of housing schemes, following the lines of the shore of the ocean, the riverbanks and the larger roads. When there is a road, housing schemes and commercial developments follow. Demerara West Bank and West Coast also show a strong increase in housing. However, Region 3 has a relatively low level (even slight reduction) of employment opportunities. People have to cross the Demerara River to go to work, for administrative issues, access to markets, schools and hospitals. The crossings are strongly related to a structural imbalance. At present there is a ratio of 1:2 between the West Bank and the East Bank population. We assume a continuation of the ratio of 1:2 for the number of inhabitants on the West and East Bank respectively which means that population growth is assumed to be equal on both sides.

There is no recent integral transportation plan, neither at a regional level nor at national level. The general traffic projection will be influenced by the plans for urban development in the regions. Due to a strong decrease of average household size, the number of houses shows a structural increase. Although Government follows a decentralisation policy, it is not
believed that this policy will significantly influence (or even turn) the degree of urbanisation, which is observed all over the world. These factors, together with an increase of the commercial activities, lead to the structural growth of the larger Georgetown area.

3.2 Models predicting impacts of growth on traffic

In our traffic models we have taken a time horizon of 30 years for traffic forecast projections. The technical lifetime of a fixed bridge exceeds 50 years. Effects of bridge type and location on traffic growth have been estimated.

The effect of a price increase on the volume of demand (price elasticity of demand) has been analysed and identified. Effects of pricing policies on volumes were found to be low. It has also been evidenced by a recent doubling of the toll rates. After 5 months the 100% price increase led run to a slight volume decrease (-6%) compared to the situation that was expected when the fee would not have been changed. Ferry traffic however increased significantly and some overflow to the alternative mode occurred. It is expected that the traffic volumes soon will return to 5% per annum growth pattern, that was followed before the price increase. The demand for bridge crossings seems to be ‘relatively inelastic’ also because the alternative is not attractive for various reasons.

3.3 Prognosis on traffic volumes

The prognosis of the traffic volumes crossing the bridge is based on historical volumes, a base growth rate and several incremental changes (jumps). Impact of toll increase is assumed to be zero. With 5% per annum, the base growth rate is positioned in between GDP growth (4%) and growth in registration of vehicles (7%). The availability of the new bridge in 2020 is expected to result in an instantaneous 10% jump in traffic due to reduced interruptions.

A second jump, of 25% is expected in 2025 when the additional road infrastructure will be fully effective. A third jump might occur in 2030, supposing that the Demerara West Bank becomes urban, offering more employment, commerce and utilities, and thus the need for people to use the bridge might change and even decrease. The number of river crossings might stabilize or even slow down.
3.4 Impact of bridge location and bridge capacity on traffic forecast

Bridge capacity is related to bridge type and number of lanes. The number of lanes is the most important factor, however capacity is further influenced by:

- The steepness and length of slopes. A high bridge has an estimated 15% reduced capacity as well as risk for failing trucks on the slope. A low bridge has no reduction.
- The width of the lanes and shoulders.
- Opening times: a low bridge will open for river traffic and will cause twice per day waiting queues on the bridge. Opening times for the movable bridge shall be limited to about 15 minutes.

We do not expect that the new bridge capacity has an impact on the traffic forecast. Only when the maximum capacity is reached of the road system, there will be a reduction of the growth and ultimately a cap. Generally what is observed is that the traffic will spread more to the quiet hours and the road system is congested during the whole day. The hindrance is larger, the traffic volumes hardly change.

The location of the bridge is important from various points of view. After all the location impacts the travel time and cost (mileage) for people crossing the river. Also the investment costs are impacted by the location. The width of the river is an important denominator for the costs of construction as are the costs of necessary links and the costs of project resettlement and land acquisition. The Peters Hall location has been taken as base case to compare Houston and New Hope locations.

New Hope is the most southern location and leads to additional travel kilometres (18 kilometres for a return trip between Vreed-en-Hoop and town centre). A similar number of kilometres of linking roads are to be built to connect to destinations and origins and/or improved to ensure smooth traffic flow. Even without traffic congestion traffic forecast may be slightly lower due to the larger traffic distances to be driven with resulting longer travel times and particularly vehicle operating costs (VOC).

The Houston location results in the least kilometres and minimizes the length of the critical section of East Bank Public Road (from Houston to the V-junction 500 m north) where the congestion generally disappears. As a result the shorter travel times and lesser VOC may result in some higher traffic numbers due to lower cost and less travel time.
3.5 Impact of speedboat ferry system on traffic forecast bridge

The service route of the speedboat ferry services and the general comfort for the passengers could be improved; the general travel experience is low. The bridge is perceived as a much better way to cross the river. But if service level could be improved and more locations for landing could be developed including pre and post transport, the ferry could become a more significant alternative for the bridge crossing.

In our forecast we assume a constant ratio between the bridge and the ferry, hence also ferry transport shall grow with 5% annually.

At present in terms of passengers the ferries only take 15% of the total demand. If it has to become a more serious alternative, the capacity has to be tripled or more also to cope with the growth. In that case the pre and post transport in Vreed-en-Hoop and Stabroek Market as well as the terminals become a limiting factor.

If cost ratios remain as at present we do not expect a change in the market share. A new bridge with higher toll rates (negative) but with lower travel times and VOC (positive) will have an impact which can be negative or positive. However, we do not expect the changes to be significant compared to the forecasted annual demand of 5% growth.

Figure 10 Passengers disembarking a ferry
4 River transport: present situation and forecast

4.1 Nature and number of ships

The number of ships crossing the present bridge at Peters Hall is summarized in the table below.

<table>
<thead>
<tr>
<th>Category ships</th>
<th>2009</th>
<th>2012</th>
<th>2016</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trawlers</td>
<td>530</td>
<td>205</td>
<td>431</td>
</tr>
<tr>
<td>Coastal vessels</td>
<td>16</td>
<td>7</td>
<td>48</td>
</tr>
<tr>
<td>Tug/barge</td>
<td>216</td>
<td>226</td>
<td>136</td>
</tr>
<tr>
<td>Ocean Going Vessels (OGV)</td>
<td>449</td>
<td>691</td>
<td>524</td>
</tr>
<tr>
<td>Total</td>
<td>1,211</td>
<td>1,219</td>
<td>1,139</td>
</tr>
</tbody>
</table>

*Table 2 Transits through Demerara Harbour Bridge*

The origins/destinations for river transport *south of the existing bridge* are as follows:

- Oil products terminals just south of the existing bridge and at Linden. Generally the load per vessel is around 5,000 t as more cargo is not possible due to limited depth of the river. Tugs are not used. The pilots navigate the vessel using the tidal currents and water levels.
- Bauxite export from Linden to sea.
- Coastal vessels and special purpose vessels serving terminals between the bridge and Linden. This is a small category serving smaller industries along the river as well as Linden. It includes dredgers, marine construction equipment, smaller general cargo vessels, etc.
- Trawlers going to their terminals just south of the bridge as well as between New Hope and Grove. The trawlers based in Georgetown are fishing in coastal waters for shrimps as well as deep-sea fishing.
- Tug-barage operations contain generally bulk goods. Air draft is small (4 m). For nautical reasons they pass the bridge through the wide retractable opening to avoid incidents.

4.2 Trends

The trends in river traffic are as follows: the number of transits by trawlers have been reduced significantly, the number of transits by Ocean Going Vessels (OGVs) is constant over the years and coastal/tug combinations are without a significant change over time. This is surprising as fish production was constant over the years and significant economic growth occurred over the years.

![Figure 11 Trends in shipping](image)

For many categories of ships the future trend is difficult to determine. It is considered that the existence of a bridge has a negative impact to the port development of the riverbank captured by the bridge.
4.3 Bridge impact on navigation in the present situation

It is not the bridge that is causing the limitations in passing the river section between Grove and Houston, it is the limited water depth of 3 m between Grove and Houston that requires vessels to pass at high tide. The bridge is only an extra complicating factor. The bridge has to be opened to allow river traffic to pass at the right window around high water. If efficient, the bridge should hardly have an impact on river traffic.

However, the present bridge is slow and there is always the risk of breakdown. Vessels start manoeuvring only when the bridge is open, lengthening the opening time for road traffic.

Crossing the Houston-Grove river section in the present situation is a time consuming activity, waiting for appropriate tide conditions with optimum water depth and water current conditions. Generally vessels enter the port at high tide over the bar in the river mouth and if destined to transit the south of the harbour beyond Peters Hall, will go for anchor until the next high tide.

The bridge opens at the appropriate moment to have optimal nautical conditions such as low currents and high tide. The vessels pass in a small opposing ebb current and continue to the oil terminals or to Linden.

When returning to sea, a vessel has to wait for high water at the anchorage in Grove just north of New Hope as the river depth is limiting between Grove and Houston. At high water the bridge opens, and the vessels pass the bridge in a small opposing flood current and continue their journey to sea.

River transport is suffering from the shallowness limiting the time-window to pass Houston-Grove river section to high water only. The bridge opening complicates matters due to the time it takes to open the bridge and the vessel to pass.

Fishing trawlers are not hindered by the tide, but by the bridge only. The number of trawlers to transit the bridge depends on the location of the bridge. Below a table is given with the number per location based on the present transits. The fishing industry is said to have additional major damages: loss of value of perishable cargo of trawlers, uncertainty of delivery and consequently quality certificates may be lost.
### 4.4 Air draft of ships influences bridge height

Air draft (the height above water) of the ships is a very important parameter and of major influence in deciding bridge type and height and consequently investment. Analysis show that smaller vessels are the largest in number (56% at present). Most of these vessels are trawlers with an air draft of 13.5 m. It will be logical to build a passage allowing these vessels to transit the bridge without opening. With high tide of 3.1 m above Chart Datum (CD) and a safety margin of 0.9 m, the required height to allow all trawlers to pass is 17.5 m above CD.

For Ocean Going Vessels the largest measured air draft in 2016 is 43.5 m. The required clearance including safety margin of 0.9 m is 47.5 m above CD. However, this concerns only chartered tankers. There is limited room to reduce the required air draft without significant economic losses (charter a vessel with lower air draft) to 43.5 (99 % to pass).

### 4.5 Impact of bridge location on river navigation

The main conclusion regarding river traffic is that the location strongly influences the river transit numbers. If the bridge would be positioned at Houston, the number of trawlers passing would be high. If giving unrestricted access to sea, a clearance of 17.5 m above CD would be needed. The number of oil tankers to pass a new bridge would increase, as two terminals are located between Peters Hall and Houston. With a bridge at New Hope the number of oil tankers would be minimised and no trawlers at all would pass the bridge.

In the table below the estimated numbers of OGVs are given for the various alternative locations of the bridge.
### Table 4 Number of Ocean Going Vessels per category on different bridge locations (year 2017)

<table>
<thead>
<tr>
<th>Type of cargo</th>
<th>Number of OGVs</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Peters Hall</td>
</tr>
<tr>
<td>Oil Products</td>
<td>99</td>
</tr>
<tr>
<td>Bauxite</td>
<td>62</td>
</tr>
<tr>
<td>General cargo</td>
<td>101</td>
</tr>
<tr>
<td>Total</td>
<td>262</td>
</tr>
</tbody>
</table>

4.6 **How to reduce the navigation time of vessel passage**

Considering that a movable bridge can open fast (4 min for opening or closing), further improvements in navigating the bridge would have to be found in the nautical procedures. The present nautical procedures have been developed for the present location and bridge type. In case of another location, other procedures would be required.

In case the bridge would be positioned at Houston, the bridge would affect the nautical procedures between the present harbour limit and the existing bridge alignment. It may also require repositioning of the anchor locations. Houston would require on average one opening per day, New Hope only one opening per two days.

![Figure 14 Caland bridge, Rotterdam the Netherlands](image-url)
For the new bridge location it is advised to train pilots in a simulator in a reputed marine research institute who will also design this procedure. In case of a bridge at Houston, the nautical procedures and lead lines in the harbour area shall also have to be redesigned to ensure safe shipping. Another measure is the compelling use of tugs increasing safety of manoeuvring. The use of tugs is already a measure considered by MARAD to cope with the port congestion and safety of manoeuvring.

As a result it is expected that with sufficient measures opening times of about average 15 minutes can be reached in case only one vessel is passing. Most likely passing of more vessels is less efficient due to the fast opening/closure procedures of the bridge. Day and night retractions are required with preference at outside rush hours to avoid the impact to the road traffic during rush hours. Note that the procedure of opening a modern bridge with good navigational means is much less complicated than the retraction of the present floating bridge with all its limitations.

4.7 Feasibility from a navigation point of view

Houston location will affect most vessels, but is the best option taking into account the water depth. New Hope location has to serve the lowest number of vessels and has deep water but its location in a bend in the river makes manoeuvring more difficult. Peters Hall location is a median in terms of number of vessels to serve and but has limitations in water depth.

From a shipping and port point of view New Hope is the favourite location, but the differences between the three locations are not significant. Shippers however prefer a high bridge ensuring unlimited access.

For the bridge at Houston a fixed minimum elevation of 17.5 m CD is recommended to allow trawlers and smaller vessels to transit without opening the movable part. In New Hope this minimum air draft is less relevant. The elevation of a high or movable bridge shall be at least 47.5 m to allow all recorded traffic of OGVs to pass the bridge or a minimum of 43.5 m CD to let 99% pass.

In case of a movable bridge the number of transits of OGVs at Houston is twice the In case of a movable bridge the number of transits of OGVs at Houston is twice the number of transits at New Hope, with a double impact to the road traffic. Opening times must be reduced to an average of about 15 minutes.

Figure 15 Botlek double lift bridge Rotterdam The Netherlands 2015 length 92 m, height 45 m
5 Road traffic: present situation

5.1 Current bridge

The current bridge has two lanes (one in each direction). During rush hours a double lane opening is used. One direction is closed in order to provide traffic from two lanes in the opposite direction. Trucks are not allowed during rush hours. Retractions during high tide at rush hour and incidents result in significant delays and stationary traffic. As a result, Demerara Harbour Bridge is felt by the public to be an unreliable link in the road network: traffic jams occur in the morning peak (eastbound direction) and in the evening peak (westbound direction), but as said apart from retractions and incidents, the low capacity of public roads are the main reason.

5.2 Origin and destination of bridge users

Origin-destination analyses have been carried out using two methods: roadside interviews at both approaches to the bridge and interviews at the Stabroek and Vreed-en-Hoop ferry terminals.

The roadside interviews involved enumerators interviewing drivers of all motor vehicle types as they approached the bridge.

Daily commuters are estimated to represent about 80% of the bridge crossing traffic. The main volume of commuters is between the coastal region of the West Bank and the North West of Georgetown. Trade and transport of products to markets is estimated to represent 10% of bridge crossing traffic and predominantly uses heavy trucks. Both flows are closely related to economic growth. The last 10% consists of traffic flows in the opposite direction: commercial and administrative visits to Region 3.
5.3 Present situation road system

The traffic volumes on East Bank Public Road northbound show a maximum of 1,600 passenger car equivalent (pce) during morning rush hour on several days in the week (three lanes northbound opened). The traffic volumes southbound shows 1,500 pce in the evening rush hour, the morning rush hour, when one lane is available, shows 900 pce.

Traffic volumes on the West Bank Public Road show a peak in the morning rush hour with a maximum of 1,900 pce. During the rest of the day traffic volumes vary between 1,000 and 1,500 pce. On the West Bank the morning rush hour is similar to the evening rush hour. On the bridge the traffic volumes during morning rush hours are slightly higher than the traffic volumes during evening rush hours (without the double lane opening).
The traffic on the bridge is in the rush hour maximum 1,000 pce with two directional lanes. With a double lane opening the traffic increases to about 1,500 pce in the direction of opening.

The current roads on both banks have no alternatives other than the speedboat ferry. Any capacity related problem that occurs has a direct effect on travel time.

**Figure 20** Eastbound traffic on Demerara Harbour Bridge

**Figure 21** Summary of current traffic problems West Bank
5.4 Accidents

Existing traffic problems also arise from capacity reducing factors such as the slopes due to the retractor spans, and road incidents on the bridge (average over 3 year: 37 incidents per year) causing major congestion. No fatal incidents were reported (due to low speed). Maximum allowed speed is 35 km/hr. Retractions also cause hindrance as waiting traffic has a problem to start due to lack of gasoline or an engine problem. Generally the incident costs are expected to be low, the cost to society is roughly estimated at USD 1,0 million per year.

5.5 Conclusions existing situation

The main cause of the low capacity of the system is the limited capacity of the East Bank Public Road, not because of the number of lanes, but because of the many intersections, turning vehicles, stopping minibuses to pick up passengers and the mix of traffic (including horse drawn vehicles and other slow moving road users). Compared to an ideal situation of a 2x2 lane road, the present capacity is only 50%. Other reasons for sub-optimal performance are retractions of the bridge during peak hours, and lack of alternative routes in case of accidents. Small disturbances cause significant traffic delays.
6 Road traffic: expected impacts of a new bridge

A new bridge should not only connect both riverbanks but also result in undisturbed traffic. In the traffic study impacts of height and number of lanes of a new bridge on general traffic flow have been assessed.

6.1 Effect of height of (new) bridge on traffic

A high bridge has the advance that it does not close for road traffic. However in the case of an elevation difference of about 46 m the ramps are very long to reach the required clearance height. With a maximum possible slope of 6% there is more than 750 m of slope required to overcome 46 m. This results on the East Bank in not being at the road level west of the East Bank Public Road and significant ramps and road works are required at the east of East Bank Public Road.

Another impact of a high bridge is the impact to truck traffic: Trucks have generally modified differentials to cope with long haul distances. They are vulnerable on long steep slopes not reaching the top. Major hindrance will occur due to trucks blocking the road. Cargo may fall off from not properly loaded trucks, resulting in accidents and major traffic delays. The road system is reduced in capacity by slow trucks climbing the hill. Assuming 10% trucks, the road capacity is reduced by 15% on 750 m long slopes of 6%. This value is based on non-modified trucks and will be more in case of modified trucks.

The navigation channel is not in the centre of the river but close to the east bank in case of Peters Hall. As a result the long slopes of the high bridge will first cross the East Bank Public Road and then return to the bank road making the intersection.
This solution will have significant urban impact in the locations Houston and Eccles-Peters Hall-Nandy Park. A low bridge does not have this problem and the intersection is directly between the approach road and the bank road.

The abovementioned impact can be overcome in case of Houston by reducing the maximum clearance with 4 m (which would be acceptable) and shifting the bridge opening more to the west in the mid of the river as water depth is sufficient. In that case a design is possible that allows a direct intersection with East Bank Public Road. This is not possible for the region Eccles-Peters Hall-Nandy Park as the channel is too close to the east bank.

The low bridge has a height difference of about 15 m between land level and maximum bridge level. This will give much shorter slopes and allows more gentle slopes. The shorter slopes will have no impact to capacity and will allow modified trucks to reach the top easily. In all locations a direct intersection with the East Bank Public Road is possible.

6.2 Effect of number of lanes

The lane layout of the bridge has been investigated in a two-lane, a three-lane and a four-lane option. In terms of investment, the cost of the bridge is related to the number of lanes. Viewing the fact that financing of the bridge is difficult and has to be paid out of toll revenues, a lane layout has to be selected with the best quality/price ratio.

Important is the imbalance in the traffic in morning and evening rush hour. This imbalance is so large that one direction is closed for a period without significant problems arising.

Two-lane low bridge

In case of a two-lane bridge without using the two-lane opening in rush hours, the single lane has a capacity of maximum 1,300 pce. This estimate is close to the measured capacity during double opening of the floating bridge (1,500 pce). In case of an efficient two-lane bridge it is expected that in the first years the bridge without double opening system is not a limiting factor.

If then the double opening system is to be applied, the critical moment is shifted backwards at the expense of opposing traffic (which is expected to remain marginal also in future).

The two-lane bridge is vulnerable in case of incidents: significant traffic congestion will be the result as traffic cannot move. Frequency and severity of consequences is expected to be similar to the existing harbour bridge.

Conclusion: a two lane bridge with efficient lane structure is an option and not critical for the first years of operation, but vulnerable to incidents. On mid-term the bridge will be the limiting factor in the traffic system.

Three-lane low bridge

A three-lane bridge is designed to have a double lane in the direction of most traffic, and one lane in the other direction. This design fits the best with the present imbalanced traffic flows and will suffice until 2030. It is less vulnerable
to incidents as traffic can use the other two lanes (unless the case of a major incident). On long term one directional opening during rush hour may be an option.

Conclusion: a three-lane bridge is the design which matches best the traffic demand and has the best price-quality ratio. Investment costs are still within amounts for which financing can be obtained.

Four lanes low bridge
A four lanes bridge with median is not critical regarding capacity not even after the first 10 years. A disadvantage is the low demand on two lanes making the investment not very efficient. Other disadvantage is that a high capacity bridge will exceed the capacity of the linking roads. Viewing the fine mesh road network of Guyana, the realization of a high capacity link will require major investments in the adjacent infrastructure.

Conclusion: a four-lane bridge is a good traffic solution. It requires additional investment which is not paid back on the short and medium term, and will be extremely difficult to finance.

In the medium term future an estimated annual growth of 5% means additional measures: expansion of the bridge or an additional bridge. A second bridge boosts reliability and redundancy of the total network and is therefore favoured.

If the annual growth of traffic by 5% could be slowed down (by measures and policies), the capacity of the bridge remains sufficient for a longer time. The growth could be tempered by improving alternative ways of transport, for example by improving ferry services by raising comfort (easy access and safety) and capacity of pre and post transport.
Recommended lane design
If funding can be found a three-lane bridge is recommended as most suitable to serve the traffic demand in the coming decade.
If funding can only be found for a two-lane bridge, selecting a two-lane configuration implies higher vulnerability for accidents and traffic congestion. Intersections and linking road should higher capacity to serve traffic demand than the bridge; the bridge is the highest investment and should therefore be used most efficiently.

In the far future a second bridge is advised above over-dimensioning the first bridge, giving more redundancy, allowing better distribution of the traffic over the region and spread economic developments.
We also recommend to implement measures to reduce traffic growth by public transport as speedboat ferries and minibuses.

6.3 Effect Impacts bypass roads and links
The traffic forecast assumes that the existing road network is kept on the present level. If not extended or improved, the new bridge may give a slight improvement but traffic congestion will not be resolved on mid and long term.

Government is preparing the Project of the eastern bypass road on the East Bank, connecting Diamond with Ogle. This bypass will reduce traffic from the East Bank Public Road. It is considered that the existing east and west bank roads including Vreed-en-Hoop cannot be significantly improved further.

As a result links are needed to better connect the bridge to town centre and the west bank connections. The figure below indicates the required connections for each of the three locations. The blue line is the planned eastern bypass; the red lines are the proposed new links.
7 Alternatives considered

The purpose of the study is to advise on alternative investment options within reasonable (affordable) budget. Preferable options are characterized by a high benefit/cost ratio, positive impacts on social and environmental elements, and most appropriate to river navigation and support (road) mobility between East Bank and West Bank. Variables are bridge location and bridge type (floating, low and high bridge).

7.1 Location

A pre-feasibility study has been carried out in 2013 proposing three main alternatives for the location of the new connection: from Houston to Versailles, from Peters Hall to Meer Zorga (the location of the present bridge), and from New Hope to Laurentia Catherina.

Figure 25 Alignment Studied
Some sub-alternatives north and south of Peters Hall and Meer Zorgen have also been evaluated. Links to a planned bypass east of Georgetown and bypasses to Georgetown central district have been considered as well. The table below indicates the investigated combinations. Reference is made to Annex 5.

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*Table 5 Alternative bridge locations with already planned bypass and recommended links*
8 Design Considerations

8.1 Bridge type
The alternatives considered are: a bridge similar to the current floating bridge, a low bridge with a movable part and a high bridge. A tunnel has not been considered because of the high investment and maintenance costs and the importance of non-interrupted connectivity between the East and the West Bank.

8.2 Number of lanes
A main consideration of the bridge Project is the cost level. Taking into account the length of the river crossing (the bridge is approximately 1.5 km in length) it is estimated that additional width of the bridge cost about 4 million USD each meter, independent of its purpose. This means that the cross sections have to be optimal arranged and as much as possible designed as fit for purpose of servicing the traffic coming of and going on to the bridge. Parameters are number of lanes, width of lanes, width of shoulders, barriers, pedestrian and/or cycle path.

8.3 Intersections
Traffic analysis recommends east-west links to deviate traffic to other parts of the road network. The intersections at both the roads will be controlled by traffic lights. It is proposed to plan flyovers to connect the bridge to the links located further down south. The flyovers may be built in a phased way, as the traffic light will manage the traffic during the first phase of operation. Intersections and linking roads shall have a larger capacity than the bridge from an economical reason: the bridge is by far the most expensive component of the system and shall be used to a maximum.

8.4 Ancillary facilities
The following ancillary facilities are required:
- a toll plaza with four covered gates for manual collection and preparation for automatic toll collection;
- an office building 1.000 m$^2$ with premises for staff, administration and management. It also comprises a control room for handling the traffic around the bridge (the bridge traffic lights, the intersection traffic lights), and space for security staff and police;

Figure 26 Examples of low and high bridge (left: St. Maarten and right: Suriname)
• a garage of 200 m² for company cars, rescue trucks and a small workshop and spare parts;
• the movable bridge has spares and workshop in the bridge foundation. It has two parking places and a bridge operating room on road level, with a staircase to the machine room and workshop;
• portals above the three lanes of the bridge every 250 m indicating the direction of the reversible lane.
9 Reference Design and Cost Estimate

9.1 Rules for horizontal alignments

In working out the horizontal alignments the following rules were applied:

- For the alignments Peters Hall to Meer Zorgen, the existing retractable part of the current bridge is in the deepest water (3.2 m CD) and the most suitable as streamlines are straight.
- At the Houston Versailles location the opening can be located over a large stretch of the river. However, much deviating from the present fairway would require a redesign of the fairways in the port.
- In New Hope the depth is much larger than at other locations. Main concerns are the curved river flows, particularly the flood current, which could lead to nautical hazards.
- In order to reduce costs, it is preferred to have the opening of the high bridge as much as possible in the middle of the river to avoid that the bridge proceeds over land.
- The intersections shall be perpendicular crossings. Gradual bends have been applied on the horizontal alignment to fit the alignment at the bank roads as well as the preferred nautical transit opening of the bridge. This results in a curved bridge at most locations.
- The length of the bridge is to be minimized for cost reasons.

9.2 Rules for vertical alignments

- For a high bridge: The highest road level of the bridge is + 50 m CD, and a clearance of 47,5 m CD to allow the highest vessel recorded in 2016 (43,5 m air draft).
- For a low bridge: a minimum clearance of + 17,5 m CD to allow trawlers to transit the bridge without opening. The movable part shall have a clearance of + 47,5 m CD, high enough for all OGVs.
- Abutments of high and low bridge are set on + 6,2 m CD. The slopes shall not be steeper than 6% and preferably be 4% or lower.

9.3 Impacts on land

With a high bridge the elevation difference is about 43,8 m. Utilising a maximum slope of 6 % the length of the bridge slopes is about 750 m at both sides of the navigable opening. The nautical passage at Peters Hall and New Hope is more or less on 1/3 of the width of the river at the east side. As a result the high bridge shall slope hundreds of meters over land and will also cross the East Bank Public Road. At Houston the navigable opening can be in the middle but even here the length is not sufficient for reaching the land surface levels before the intersection. The low bridge generally needs 375 m to reach land level and has ample space to do so. On the west side there is enough length to reach the elevations required for the intersection levels.
9.4 Construction methods

A considerable part of the required construction material should be imported from outside Guyana since there is no steel industry and no possibility of the production of large concrete pre-stressed structures. Most of the construction will be done on the river, therefore in the reference design, it is tried to use mostly pre-fab elements and only chosen for in-situ production if necessary.

9.5 Low bridge design

In the design the structure has been kept as light and simple as possible. The low bridge is a fixed bridge with spans of 20 m and a movable section with a span of 95 m and a nautical width of 70 m. Main longitudinal girders are pre-fab made of pre-stressed concrete in the shape of a reverse T, with an in-situ reinforced concrete layer on top. These beams are then placed on a crossbeam. The cross beam is a reinforced prefab concrete beam.

The cross beam is founded on two steel piles for normal sections and 4 steel piles at strong points which are located every 123 m. The cross beam and the piles are connected by a reinforced concrete pile plug. The weight of the structure is calculated and the piles are designed based on the calculated dead weight and the live loads.

The movable section is a lift bridge with the deck and the towers designed in steel in order to keep the weight of the bridge low in view of the poor soil conditions. Bascule and swing bridges have been considered but are more costly for this Project.

9.6 High bridge design

In the design of the high bridge the structure should be designed as steep as possible in order to keep the bridge short and avoid building it longer than necessary over land.

Figure 27 Lift Bridge Pont Jacques Chaban Delmas, Bordeaux, France 2012 (long 110 m, height 77 m)
The nautical opening is at least 75 m from the side lines of the ship collision barriers. This is slightly larger than the width of the current bridge since for the high bridge no tide restrictions will apply and therefore vessels will pass the bridge with larger current velocities. The length of the bridge span is taken to be 95 m (10 m free space from the axis for the width of the pier foundation and for protection against collision).

Height of the deck in this span is estimated to vary from 7,0 m to 1,8 m. All the other span lengths are either 52 m (large spans over deep water with less foundations) or 30 m (smaller spans on shore and shallow water). Height of the girders is determined to be around 1,8 m (box-girder).

Figure 28 Fixed high bridge Suriname River
Cost estimate

The costs of the various alternatives were developed in the conceptual design based on quantities and unit rates. Price level is 2017. The cost estimate concerns the contract price for design and construct the river crossing, not the total employers costs. Costs are assumed with exemption of import taxes and VAT to contractor and prime subcontractors.

![Figure 29 Estimated contract costs for several bridge alternatives (low bridge left and high bridge right)](image)

*Figure 29 Estimated contract costs for several bridge alternatives (low bridge left and high bridge right)*
10 Environmental and social impacts

10.1 Scope
This initial impact assessment has been carried out to support decision-making and present information on the potential impacts and the possibilities and need to mitigate or compensate negative impacts (and costs related to both). Construction phase as well as operation phase is taken into account. A full socio-environmental impact assessment study have to be performed at a later stage to satisfy the Guyana rules and legislation on this issue and before the bridge construction starts.

10.2 Traffic-related impacts
Predicted traffic growth has been used to assess impacts on traffic-related items as noise, air quality, safety, nuisance and health. Traffic growth obligates to look after links and bypasses on the west and the east side, they are considered inevitable to mitigate the expected traffic related impacts.

The impact compared to the present situation is large in case of a new bridge between New Hope and Laurentia Catherina. Significant traffic increase will occur on roads south of the current bridge location on the East and West Bank, where traffic is rather quiet at present. Existing roads are not appropriate to receive much more vehicles and residents live close to the existing roads, consequently serious resettlement challenges have to be dealt with. This bridge location is considered to be undesirable due to impacts on residents related to noise, air quality and safety. A bridge at New Hope-Laurentia Catherina (daily two times 9 km additional driving) is also not considered to be a very sustainable alternative regarding carbon footprint.

10.3 Biodiversity
All bridges impact mangroves on the West Bank, mangroves on the East Bank are already more impacted by man (and in worse condition) and the mangrove fringe on the East Bank is considerably smaller than on the West Bank. Special attention on these mangroves is recommended. Technical solutions with low impact on biodiversity are feasible from technical and financial points of view.

Figure 30 Mangroves and one of its typical species; the Scarlet Ibis
In the IESIA many other environmental and social items (not mentioned above) have been taken into consideration, like waste, safety, landscape and cultural heritage, mineral resources, water quality among others. Many of these items are important but not distinctive, others are, considering the Project in the construction and operation phase, insignificant.

10.4 Overall impacts

The overall social impact of the Project will be positive, because it will benefit many, especially if links and bypasses are constructed simultaneously with bridge construction. Shorter traffic time and economic development is beneficial for everybody. Nevertheless some residents may suffer from the impacts due to more noise, unsafe situations and contaminated air. The challenge is to mitigate these negative effects in an appropriate way and reduce exposure of persons involved to an acceptable level.

Resettlement is an issue of major (and decisive) importance on the East Bank in the different sub-alternatives of Eccles, Peters Hall and Nandy Park. In New Hope no resettlement will take place. In Houston Versailles it concerns 4 houses to be demolished as well as some impact to river terminals adjacent to the selected alignment.

The overall environmental impacts of this Project are considered to be low to moderate and manageable from a technical, social and financial point of view.

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Figure 31 Summary of the impacts on the alternatives considered

10.5 Recommendations from environmental and social point of view

Within this scope a new bridge at New Hope to Laurentia Catherina is the least attractive option. Longer distances mean longer travel times, increased emissions of greenhouse gases, more residents impacted by noise, safety and contaminated air. Houston-Versailles is considered to be the best alternative from an environmental and social point of view, due to the proximity of the destination of most of the bridge-users and only a limited resettlement challenge compared to other nearby locations as Eccles, Peters Hall and Nandy Park.

A broader challenge is to improve mobility, and a new bridge alone is not sufficient to solve this effectively. Some bypasses are already planned and others should be considered. Links to these bypasses are of utmost importance to solve the mobility problem. New links and bypasses shall also alleviate impacts by noise, safety and air contamination.
11 Economic feasibility

11.1 Scope

A socio-economic cost benefit analysis provides input for investment and financing decisions that have to be made. The analysis is a supportive tool for alternative selection and for Project justification.

A Project is feasible in an economic sense when the benefits outweigh the costs. Benefits and costs are measured from a national (or public) point of view. The cost-benefit analysis (CBA) shows which of the alternatives create the highest value, but it is more about identifying differences between Project alternatives, than about predicting absolute monetary values.

This analysis includes construction costs, operation costs and maintenance costs, rehabilitation costs and revenues. It also includes the socio-economic effects: travel time for both passengers and cargo and for river and road traffic, environmental and social and economic effects. Improved travel time will lead to an improved business climate, improved competitive positioning, and new opportunities in the field of land development and real estate development. Direct as well as indirect effects have been considered.

11.2 Assumptions on economic feasibility

A time horizon of 30 years is taken for our Projections, the technical lifetime of the bridge exceeds 50 years. Projections longer than 30 years involve high uncertainty and their predictive value becomes low. At the same time it is probable that this bridge will be followed by other river-crossing infrastructure. A newly built copy of the present floating bridge, on the same location, with an identical layout, and without any change to the surrounding road infrastructure, is taken as reference case.

The Inter-American Development Bank recommends that a 12% real discount rate to be used in Projects. In addition we have performed the calculation with a 9% and with a 6% rate in the sensitivity analysis. This rate is a good reflection of the social cost of capital (representing the investors’ positions) as inflation at the moment is 0%, and domestic interest rates are 10-12% per annum.

11.3 Revenues from toll

The bridge generates revenues from two sources: road traffic and river traffic. For road traffic the toll rates are assumed to be constant. For river traffic the toll rates are assumed to increase over time. The traffic volumes are based on the traffic forecast.

Annual revenues from toll are estimated to be at 5,4 million USD in year 1, and growing over the years to 8,4 million USD in year 10. The growth of revenues is the consequence of a growth in traffic volumes. Location and configuration of
the bridge has some impact: it determines whether river traffic can pass without restriction. We assumed that all river traffic, passing the bridge, keeps paying the toll, even in case of a high bridge where the river traffic can pass unrestricted. In the sensitivity analysis we make calculations for higher toll rates.

11.4 Investment costs

Constructions costs are summarized earlier in this report. Other investment costs are land acquisition (2 to 5 million USD depending on alternative) and reinvestments after 10, 20 and 30 years (2,9 million USD in all alternatives for 10 year period). Initial construction costs make the difference.

11.5 Operational costs

We calculated the operation and maintenance costs of the bridge, including directly connected infrastructure to range between 0,9 million USD and 2,1 million USD for the different alternatives. The difference between alternatives is very limited: all alternatives have lower operational expenses than the reference case (the floating bridge).

![Figure 32 Revenues from toll](image)

![Figure 33 Operations and maintenance costs](image)

**Value of time and vehicle operating costs**

The road traffic travel time effects have been calculated per location to range between 6,0 million USD and 22 million USD in year 1, compared to the reference case, and growing to an annual 47 million USD in some cases. When the infrastructure becomes saturated, the effect drops down to zero, as the traffic situation will become equal to the present situation.

In order to be able to calculate travel distance and travel time in a way that all Project alternatives can be compared in an objective way, we defined a common point of departure (Mandela Avenue in Georgetown) and arrival (Vreed en Hoop). We applied the concept of value of time (1 USD per passenger per hour).

The impact on vehicle operating costs has also been analysed by relating to the distance. VOC (vehicle operating cost) are assumed to be USD 0,2/km. The result can be seen in the figure below.
We applied the concept of value of time: 9,000 USD for Ocean Going Vessels, 1,500 USD for trawlers and 3,000 USD for tugs, barges and coastal vessels, per ship per day.

11.7 Results and conclusions

The table on next page presents the results. The Present situation has a negative net present value of -25 million USD, and thus it is a cost to society. Nine out have a positive outcome, and thus they represent a value to society.

Location proofs to be of decisive importance: bridges at Houston-Versailles show positive and high benefit values, bridges located around Peters Hall show lower but still positive values and bridges located at New Hope-Laurentia Catherina show negative values.

Three-lane bridges result in higher benefit compared to two-lane bridges.

Investing in a 3 lane low bridge at the Houston Versailles location is far more advantageous to society than not investing.
Figure 35 Summary of results of socio-economic cost benefit analysis
12 Basic Design: Low 3 lane bridge Houston - Versailles

The selected alternative was worked out into a detailed design. This includes the links as well as the bridge.

The map below indicates the logical alignments for the bridge in Houston-Versailles.

*Figure 36 Links Houston-Versailles (red). Y-pass road East in yellow*
The links consist in West of a N-S link connecting the road beyond Vreed-en-Hoop with the road to Schoonord. A junction connects to the W-E road connecting to the approach road of the bridge and the West Bank Public Road. In the east also a 4 lane E-W road connects to two N—S links to town to connect to Mandela Avenue.

Details of the approach roads are given in the plan views below:
Figure 39 East Bank Approach roads and junction

Figure 40 Junction East Bank

Figure 41 Junction West Bank including toll and premises
A impression of the basic design is given in the following visuals. Note that these visuals not necessarily are fully correct in details, main purpose is to give an impression.

Figure 42 View link roads from West Bank to East

Figure 43 Approach to bridge
Figure 44 Plan junction West Bank and toll plaza

Figure 45 Flyover West Bank junction

Figure 46 Toll Plaza
Figure 47 View on bridge

Figure 48 Movable bridge section
Figure 49 From river East Bank

Figure 50 Approach road East Bank
The East Bank approach road requires land acquisition of 4 houses as well as land acquisition and a narrow corridor to align the bridge between the PSI Fish processing plant and the Muneshwer Terminal under construction.

The West Bank junction will require land acquisition at the river side as well as the acquisition of the timber shed on the west side of the junction.
Figure 53 Location of new bridge in drainage canal Houston between PSI and Muneshwer terminal, 2017

Figure 54 Timber shed, Versailles
The houses to be demolished are on the East Bank and indicated in figure 55.

*Figure 55 Houses to be demolished, East Bank*
Financial feasibility, Financing and Funding

The Project is financially not viable without support from the government. Revenues from toll make up for the operation expenditures but cannot support the debt service. The toll rates can be increased but there is a limit to that. A too large increase would make the toll unaffordable for many of the people who have to use the bridge.

There seems to be strong appetite and sufficient liquidity in the financial markets of Guyana and the region to fund the Project. Loans or bonds and preferred cumulative shares issues provide for the required funds. This so-called Project Financing Structure requires a Government supported Special Purpose Company (SPC).

A PPP structure like BOOT (Built, Own, Operate and Transfer) whereby an investor signs a concession agreement with the government to build and operate the bridge and in which the concessionaire has to arrange the financing can only be successful if the government provides support in case contribution and certain guarantees.

PPP Strategy

The government expressed the wish to maximise funding from the non-government sector in order at to limit the government contribution to the funding of the Project as much as possible. That means that the Project has to be structured in a Public Private Partnership (PPP), i.e. a Built, Own, Operate and Transfer (BOOT) type of arrangement or a Project Finance structure whereby the commercial banks and (institutional) investors are involved, or an intermediate structures like DBFM (Design, Built, Finance and Maintain).

The overall objective is a sound and sustainable funding of the Project whereby the government contribution is minimised and at the same time an affordable toll rate is charged.

Organisational structure; SPC

For the new bridge a Special Purpose Company (SPC) is assumed. The SPC holds the assets and operates and maintains the bridge. In case of a Project Finance structure the government will be the sole owner/shareholder of the SPC. The Ministry of Public Infrastructure and the Ministry of Finance will be the two governing bodies. The SPC will be a legal entity with limited liability under the laws of the Co-operative Republic of Guyana.

Possible Partners

As part of the study Public Private Partnership (PPP) structures are identified. Two types of PPP are considered: BOOT and Project Finance. The most likely partners are the international contractor and/or the financial institutions in Guyana and the region.

The Financial Model

The investment is budgeted at approximately USD 150 million of which approximately 20% will be denominated in Guyana dollar (G$). The national Guyanese portion has been maximised as
much as possible to allow maximum application of the liquidity and appetite available in Guyana and to optimise the natural hedge (revenues in G$ versus Opex and debt service in G$).

In case of a BOOT the financing is arranged by the owner/sponsor of the Project. He drafts his own model and arranges the funding. The government only sets out rules and terms in a concession which define amongst others the required capacities of the river crossing facilities, the toll rates and the term of the concession. Government may need to provide guarantees and provide a yearly contribution or subsidy if needed.

In a Project Finance structure the Government/SPC raises the required funding. The EBITDA (revenues minus operational cost) shall be sufficient to cover the debt service (repayment of loans and bonds as well as interest). If not sufficient, Government has to contribute by paying a yearly contribution to cover the negative cash flow until revenues have increased and or loans and bonds are paid back.

13.5 Revenues

The business case of the bridge is based on revenues from collected toll from the vehicles as well as from marine traffic passing the bridge.

The numbers of road traffic have been taken from the outcome of the traffic forecast study. A cap on the traffic demand has been applied. The road network will become saturated at a certain point in time. Toll rates applied are at present rates (scenario 1). In scenarios 2 and 3 rates have been increased with 100% and 200%. In all scenarios a general increase of 9% at the end of each consecutive third year has been applied to follow the increase of cost in time.

There is though a good case to make for increasing the rates. After all the people will benefit on travel costs and time. The majority will have a shorter distance to travel and they save time since congestion decreases. There are voices stating that increasing the rates even further to triple (increase of 200%) would still be acceptable.

The existing toll categories and tariffs for ships are applied, increased with a part of the amount that will be saved on demurrage costs as the bridge can open any time except for rush hours. These rates are increased charging a toll for the Ocean Going Vessels in the amount of USD 1625 (in 2017 USD 250). The tariffs for marine traffic also grow with steps of 9% every fourth year. As the second category (smaller vessels like tugs, trawlers and coastal vessels) basically have no demurrage cost, the tariff for this category (trawlers and coastal vessels) has not been changed.

The limits for increasing the toll rates are set by affordability, social responsibility, willingness to pay and what is political acceptable. There are no alternatives for crossing Demerara River safely except for the ferryboats. Raising the tariffs may imply that the poorer people cannot afford to use the bridge. From the very beginning of this Project the government
has put emphasise on the fact that the rates should remain affordable.

13.6 Tax and Dividends

In this Funding Plan it is assumed that the Project is exempted from paying import and VAT taxes and that dividend is only paid out if the Project makes a profit i.e. positive Net Profit After Tax (NPAT).
14 Financial feasibility; toll rate impact

A business case of the Project has been developed for Scenario 1 (no increase of toll except for the compensation of cost increase). The operational result (revenues minus operational expenses) shows strong positive figures. The debt service (repayment of principal and interest) is dominant in the financial projections. The business case of the Project is financially not viable and cannot be sustained without Government contribution. To be able to attract funding for the investments to be made long term financing is required. The market cannot provide such long term funding, but only medium term funding resulting in high debt services over the medium term.

A funding plan has been developed taking into account lowest government contribution i.e. maximise non-governmental financial institutions and funding, swift arranging and a sustainable structure which fits the project.

Project costs of the low three lane bridge at Houston - Versailles are estimated at USD 150 million, including contractors cost and additional costs for services, land acquisition for the approach roads, and limited budget for a first phase of link roads. As also pre-financing cost due to interest during construction have to be financed, total required funding is assumed upon USD 170 million.

14.1 Cash available for debt service

In Annex 8 (Financial Feasibility) it is concluded that the required Debt Service weighs heavy on the financials of the Project and are high in comparison with the Operational Expenditures. Debt service includes interest and repayments of loans or bonds. Generally the loans/bonds are medium term (10-15 year) and require yearly repayment and together with the interest the yearly cash needed for debt service is considerable. As a result of the high debt service it was concluded that the Project is not financially viable without a contribution from Government to support the cash shortfall.

14.2 Increase of toll; effect business case and government contribution

The Financial Model has been run with the data of four scenarios for road toll. It was concluded that they are not nearly enough to cover for the Debt Service as well, even with the highest increase of toll rates of 200% on top of the existing toll rate.

As a result the Government shall arrange a contribution (subvention) on an annual basis to cover the gap between the revenues and the cost. The amounts are given in table 7.
Scenario no. | Toll rates against 2017 rates | Government contribution |
--- | --- | --- |
1 | 100% | USD 140.113.167 over the first 12 years |
2 | 200% | USD 67.555.591 over the first 10 years |
3 | 250% | USD 39.392.604 over the first 5 years |
4 | 300% | USD 27.349.203 over the first 5 years |

Table 7 Government contribution on an annual basis (input data Annex 10)

The main reasons for the need for significant Government contribution are the short period of the financing in combination with the high interest rates. This can be mitigated through two options:

- Guyana long-term government bond issue in US and/or G$. This will reduce the repayment and need for contribution. For this a country credit rating is required. There are some successful examples of such facilities in the region.
- Increase of equity in the SPC as equity does not require repayment neither interest. An example is to raise the equity by selling existing DHB premises.

As a result the toll should be increased substantially but there is a limit to that. Willingness and affordability are to be reckoned with. There is though a good case to make for increasing the present road toll rates provided that the traffic congestion is improved significantly and travel times are brought to acceptable values. In that case people will safe on travel time. Many of them will safe on vehicle operating costs as travel distance reduces with maximum 8 km per day and also the use of fuel in traffic jams.

Toll tariff rates are advised to be increased to 250% of the present 2017 road toll rates. Toll for river vessels to be increased to 700% of the present rates (which have not been increased recently). In this way the Government contribution will be limited to about US $ 39 million to be paid in 5 years after commissioning of the project, and the project becomes viable.

14.3 Project structure

The proposed structure is a Government owned Special Purpose Company (SPC) being the owner of the project and arranging the funding supported by Government through:

- A guarantee on the pay back on bonds, loans and interest.
- Some SPC equity or similar long term financing not requiring interest.
- Annual government contribution for the first 5-10 years to cover the negative cash flow.

In the Project Finance structure the national and regional financial institutions provide for the required funds under a loan of bond type of structure. In a Project Finance structure the Government (through a 100% Government owned special purpose company (SPC) is the owner of the
Project (bridge facilities) and takes out the financing. The bridge is operated by the SPC.

The Financial Feasibility has concluded that in the Project Finance option the funding could very well be arranged by the financial markets in Guyana and the region. There seems to be sufficient liquidity and appetite with the financial institutions to provide the required funding for the Project against commercial terms and conditions. For the foreign currency a borrowing sovereign guarantee is required. On Guyana currency borrowing softer collateral may be arranged.

An alternative structure is to seek private parties willing to engage themselves in a BOOT project. These parties will take care of the financing which may be better than can be funded by Government. However project costs are higher and the BOOT business case must result in sufficient risk coverage and profit for the private partner and as a result may require higher toll rates or Government contribution. It is expected that similar guarantees from Government will be required as in the case of Project Finance.

The BOOT requires ad investor to execute the project arranging the financing himself. The Government provides a concession for the bridge and may be required to provide some additional support and/or financial contribution. It is difficult to say if private partners are willing to do so, also viewing the history of previous BOOT projects as well as the country risk related to long term commitment in local infrastructure. Full government guarantees will be required on revenues. In the procurement parties with attractive BOOT solutions may be selected.

In a concessional structure development institutions or governments provide funding against soft terms. This option was not further considered due to the long time it will take to arrange. The government seeks a swift implementation of the project.

14.4 Impact of bridge locations and configurations on the financial modelling

Revenue differences between the different bridge locations are rather small, as well as different configurations as traffic is compelling. Purely from a financial point of view the alternative which has the lowest investment cost, requires the smallest government subsidy and would be the preferred alternative.
15 Risk management

In order to find the best solution, Consultants have made best efforts in estimating the investment costs as well as the market conditions for finance. Both are estimated as median values, meaning that final numbers may spread and be higher or lower. There is no safety margin in the cost as well as the revenue numbers, as else the decision making process is influenced by the safety margin taken. The expected spread needs to be managed in the development process.

The following most important risks include in the development stage:

- Changes in interest in the market, resulting to increase of debt service before bonds are issued.
- Higher construction cost than estimated, due to market developments, market approach, scope changes, risks division and unexpected events.

After commissioning the main risks are:

- Acceptance by the public of the increase in toll.
- Stagnating growth of traffic, providing lower revenues than forecasted.

Generally the risks in the development stage are to be managed by a flexible approach in what can be realized at the moment of contractual and financial close. Scope management must be performed together with the private partner to reduce costs if needed by scope management. Such also include links and viaducts to be developed in a phased way and if possible alternative funding sources to be looked for. Positive developments in costs or revenues can be used to reduce the Government contribution.

Risk management during construction requires a sufficient budget for unforeseen. It is advised to shift most of the risks to the contractor at possibly higher cost as measures to reduce costs in this stage are marginal.

To manage risks after commissioning a good communication strategy to the public is essential. The moment construction is visible toll rates to be increased gradually to the required level during may help to accept the new rates. It also may assist in reducing the pre-financing costs.

Traffic always will grow, but the pace may be much lower. Growth rate under the forecast is a cash flow problem the positive side is that future investments will be delayed. Government has a large influence on bridge traffic by its policies regarding housing, locations of schools and hospitals as well as employment generation on the West Bank.

As a result it is recommended to adopt a flexible approach in the development of the Project, a careful monitoring of the process and timely steering, as well a budget for unforeseen.
DISCLAIMER

Traffic forecasts, cost and schedule estimates as well as the assessments of the reaction of the market and public included in this report and its annexes are based on the Consultant’s interpretation of data collected and investigated as at the date hereof, and are susceptible to change for a variety of reasons including but not limited to economic conditions, government actions or inactions, unforeseen physical conditions, world financial market, construction market developments, public attitudes, etc.

Users of this report are deemed to be aware of the foregoing limitations, and shall therefore use the content of this report at their own responsibility.
Annexes

Annex 1. Traffic Projections Demand
Annex 2. Site Investigation
Annex 3. Analysis Road System
Annex 4. Shipping Analysis
Annex 5. Conceptual Design River crossing
Annex 7. Economic Feasibility
Annex 8. Financial Feasibility
Annex 9. Basic Design
Annex 10. Financing and Funding Plan
Annex 11. Basic Design Drawings
Annex 12. Basic Design Cost Estimation