FEASIBILITY STUDY ON TRAFFIC DECONGESTION STRATEGIES AT MASERU BRIDGE BORDER POST

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ABSTRACT

The decongestion strategy of Maseru Bridge was informed by a research exercise investigating different border post decongestion measures and border precinct typologies. Generic design parameters for border post decongestion strategies were compiled. Each measure and typology was evaluated against the generic design parameters. A short list of three decongestion strategies was determined. The capacity requirements of each was determined based on data surveys at the existing border crossing which determined the travel needs for light vehicles, public transport vehicles, freight vehicles and pedestrians. Design years and directional and seasonal peaks were taken into consideration when the patronage forecast was estimated. A spreadsheet based queueing model was developed to determine the number of entry lanes, number of parking bays and queueing capacity required for each decongestion strategy. The model took consideration of a large variety of design related constraints or parameters. The generic design parameters in conjunction with the capacity requirements as provided by the queueing model were taken into account in the conceptual design of the different border precincts.

1. INTRODUCTION

The Feasibility Study on Traffic Decongestion Strategies for Maseru Border Post was informed by a prior study that included a literature review and legal scan, the conceptual development of decongestion strategies and the development of quality and service criteria for the evaluation of the decongestion strategies. The prior study's findings were also supplemented with data survey information. The prior study's findings are reported on in the report "Botes, F, 2014. Feasibility Study on Traffic Decongestion Strategies for Maseru Bridge - Project Charter Report. Hatch Goba MPA".

The evaluation of the proposed decongestion strategies took place during three different stages namely a benchmarking exercise, an economic analysis and a stakeholder impact assessment. This paper presents the process and methodology applied during the benchmarking exercise. During this stage, the outcomes and recommendations of the prior study's literature review and legal scan, conceptual development of four decongestion strategies and identified quality and service criteria as well as the data survey information were applied with a view to refine and then benchmark each proposed strategy against international and local best practice.

2. DECONGESTION STRATEGY OPTIONS

2.1 Decongestion Measures

Case studies were reviewed and the following measures were identified to address the decongestion strategy at Maseru Bridge Border Post:

2.1.1 Measure 1: Expanding the Maseru Bridge Border Post

This option considers expanding the existing border post to accommodate a separation of certain processes or traffic streams. It allows for the redevelopment of the border post for better freight traffic processing enhancing light vehicle traffic, public transport vehicle traffic and pedestrian border processing.

2.1.2 Measure 2: Relocating Selected Functions

This option considers that some processing components present at the existing border post (for example freight processing) could be relocated from the existing border post to another site located some distance away from the actual border post. Once processed remotely, this traffic will proceed to the existing border post. The remaining processing components (for example person processing) would continue to be processed at the existing border post. Ultimately the total number of processed traffic would continue to route across the existing border post.

2.1.3 Measure 3: Separating Trip Types / Border Post Specialisation

Border post specialization involves separating different types of traffic, e.g. freight vehicles, light vehicles, public transport vehicles and pedestrians. Different types of traffic will be dedicated to different border posts.

2.1.4 Measure 4: Relocating the Maseru Bridge Border Post

This measure involves relocating the entire existing border post to a new site along the border. The aim would be to identify a new site with suitable space in order to be able to expand the border post to accommodate a separation of certain processes or traffic streams.

2.2 Border Precinct Typologies

Case studies were reviewed to identify the best practice border post precinct development typologies which could be applied to the border post measures identified above:

2.2.1 Precinct Typology A: Traditional Freight and Person Traffic Border Post

This refers to the traditional processing methodology where outgoing trips are processed in the first country at one facility and incoming trips are processed in the second country at another facility. This methodology requires trip makers to stop and queue twice. Literature has revealed that this layout is in fact able to effectively accommodate large volumes of traffic, if it is well designed, for example in the case of the Blue Water Bridge Plaza Border Post between United States (US) and Canada.

2.2.2 Precinct Typology B: Freight Traffic Only Border Post

This refers to the processing methodology where freight trips are processed separate from person trips. The freight processing facility can either be provided as a traditional all traffic border post, a one-stop border post, or a facility located some distance away from the actual border. Literature has revealed that this layout is highly effective in reducing delays, for example in the case of the freight processing facility at the Otay Mesa Border Post between the United States and Mexico, with the nearby person processing facility at San Ysidro Border Post located approximately 10km away.

2.2.3 Precinct Typology C: One-Stop Border Post (OSBP) (Applicable to Freight and/or Persons)

This refers to the processing methodology where both outgoing trips and incoming trips are processed by both countries at the same facility. This requires trip makers to stop only once. The following typologies exist:

<u>C1 Straddle facility</u>: the joint processing facility for freight and persons in both directions straddles the actual physical border, for example the Nemba-Gasenyi border post between Rwanda and Burundi.

<u>C2 One country facility</u>: the joint processing facility for freight and persons in both directions is located in one country, for example the Malaba border post between Kenya and Uganda which is located in Kenya.

<u>C3 Juxtaposed facility</u>: A joint processing facility for freight and persons in one direction is located in the first country. Another joint processing facility for freight and persons in the other direction is located in the second country, for example the Chirundu border post between Zambia and Zimbabwe. Alternatively a joint processing facility for freight traffic in both directions is located in the first country and another joint processing facility for person traffic is located in the second country, for example the Lebombo-Ressano Garcia border post between South Africa and Mozambique.

Each proposed measure can in theory be implemented by applying any of the border precinct typologies. In total twelve different permutations of options therefore exist as shown in the table below. Five of these options were discarded when evaluating the proposed measure against each border precinct typology, and also against the practical considerations in the context of the existing Maseru Bridge Border Post. In the table, each of the remaining seven options are illustrated by providing a short description of how such an option would practically be implemented to decongest the existing Maseru Bridge Border Post.

- Option 2A is not practically possible since a traditional all traffic border post implies that all processing activities are taking place at the actual border post and no functions are relocated.
- Option 4A would not be considered given that an OSBP is widely regarded as the most effective border precinct design. It is therefore unlikely that the entire functionality of the border post would be redesigned at a different location in the form of a traditional all traffic border post since the current traditional border post is not coping with the current traffic demand.
- Option 1B was not practically considered in the context of the Maseru Bridge Border Post as the expansion of the existing Maseru Bridge Border Post measure was envisaged to encompass all trip types – freight and persons.
- Option 2C was discarded from the point of view that securing and controlling processed freight on the one country's side is difficult enough, and adding the complexity of securing freight cleared by Lesotho some distance into South African territory is likely to be practically unachievable.
- Option 3C was discarded from a practical point of view as it would require the costly investment of creating entirely new OSBP facilities at at least two different locations.
- In terms of OSBP precinct typologies the straddle facility was found not applicable to Maseru Bridge Border Post where the border is defined by the Caledon River as the

agreements to acquire budgets from both countries for building an entire new very wide bridge an processing facilities straddling the river is likely to be complicated.

- The juxtaposed facility was also found not practically applicable to Maseru Bridge Border Post as such a strategy would double the governance and legal issues as the border post would be located in two countries instead of just one country.

Table 1: Decongestion strategy options

OPTIONS	Measure			
	1	2	3	4
Border Precinct Typologies	**Expanding the Maseru Bridge Border Post**	**Relocating Selected Functions**	**Separating Trip Types / Border Specialisation**	**Relocating the Maseru Bridge Border Post**
A. Traditional All Traffic Border Post	Upgraded facility at Maseru Bridge to offer best practice traditional processing of freight and persons.		Person only processing at Maseru Bridge. Freight processing moved to dedicated alternative existing border facility, e.g. Ficksburg Bridge.	
B. Freight Traffic Only Border Post		Freight processing to be accommodated at a nearby new site, e.g. near Ladybrand adjacent to the N8.	Freight only processing at dedicated border facility at Maseru Bridge. Person processing moved to dedicated alternative existing border facility, e.g. Ficksburg Bridge.	Freight processing to be accommodated at an entirely new border facility, e.g. Foso Bridge. Persons continued to be processed at Maseru Bridge.
C. One Stop Border Post (OSBP)	Freight and persons to be accommodated at a new Maseru Bridge border facility.			Freight and persons to be accommodated at an entirely new border facility, e.g. Foso Bridge. Maseru Bridge Border Post to be closed.

3. GENERIC DESIGN PARAMETERS

Benchmarking of the proposed decongestion strategy was required in order to ensure that any particular decongestion strategy or element thereof, conforms to local and international good practice standards in terms of the design parameters applied. Based on the literature review, the most appropriate good practice requirements in terms of concept design parameters were selected.

3.1 Regional Connectivity Parameters

The following three North American case studies were reviewed with respect to regional connectivity:

- US Gateway and Corridors Concept Study.
- Canadian National Policy Framework for Strategic Gateways and Trade Corridors.
- Mexico Multimodal Corridor Master Plan.

The concept design parameters and requirements identified from these studies pertaining to regional connectivity and the improvement of freight corridors and gateways were as follows:

- Border post capacity should be improved by developing multimodal regional or strategic infrastructure.

- Border post operational efficiency should encourage trade.
- Legal and institutional arrangements should promote regional connectivity.
- Improved policy measures such as trade promotion and economic growth should accompany infrastructure and operational improvements. This should include:
    - Integrating the existing freight corridors with other identified freight corridors in the national freight strategy.
    - Improving the reliability of the border post to generate additional demand on the strategic transport network. As a benchmark, the Mamumo Border Post between Namibia and Botswana experienced an immediate increase of 35% - 50% in tonnage processed as a result of improvements implemented.
    - A strategic development plan along approach corridors to respond to this increased demand is required.

Following the completion of this study and the implementation of its recommendations, it could be concluded that all of the criteria pertaining to regional connectivity are adhered to within the mandate of the Department of Transport including improved border post capacity and improved operational efficiency in terms of traffic operations. However, it is recommended that some criteria outside the mandate of the Department of Transport, still needs to be addressed by the relevant authorities, for example improved operational efficiency in terms of border processing by various authorities, improved legal and institutional arrangements, and improved policy measures.

3.2 Congestion Alleviation Strategy Parameters

The primary concept design parameters and requirements pertaining to congestion alleviation strategies were as follows:

- Freight and passenger traffic should be separated.
- Processing and inspection activities should be separated.
- Facilities should be purpose built and staff should be trained for the particular function of a particular facility.
- The long term growth of the border post as a result of economic growth as well as due to improvements implemented should be taken into account. As a benchmark, the Mamumo Border Post between Namibia and Botswana experienced a 9.8% growth per year in vehicle processing between 2005 and 2007 as a result of improvements implemented at the border post.
- Seasonal and directional peak flows should be taken into account.
- The use of existing facilities and road networks should be maximised.
- Road based and rail based freight processing should not be completely separated.
- Established services (logistics, public transport, freight operators) should not be disrupted but accommodated on existing corridors.

The seven options short listed were developed further and evaluated against the criteria set out above. Note that Maseru Bridge Border Post currently has a railway line crossing at the existing border post and offers rail based freight processing services as well as road based freight processing services. The following four options were discarded as a result of this exercise:

- Option 1A: Long term growth as well as seasonal and directional peak flows cannot be adequately accommodated due to space limitations.
- Option 3A: The use of existing facilities would not be maximised, road and rail based freight services would be separated and established services would be disrupted.

- Option 3B: The use of existing facilities would not be maximised, road and rail based freight services would be separated and established services would be disrupted.
- Option 4C: The use of existing facilities would not be maximised, road and rail based freight services would be separated and established services would be disrupted.

3.3 Border Precinct Development Parameters

The following case studies were reviewed with specific reference to border precinct development:

- Blue Water Bridge Plaza Border Post between United States and Canada (Traditional all traffic border post).
- Otay Mesa (freight) and San Ysidro Border (light vehicle) Border Posts between United States and Mexico (Freight traffic only border post).
- Nemba-Gasenyi Border Post between Rwanda and Burundi (OSBP Straddle Facility).
- Malaba Border Post between Kenya and Uganda (OSBP One-Country Facility).
- Cinkase Border Post between Togo and Burkina Faso (OSBP One-Country Facility)
- Chirundu Border Post between Zambia and Zimbabwe (OSBP Juxtaposed Facility).
- Lebombo-Ressano Garcia Border Post between South Africa and Mozambique (OSBP Juxtaposed Facility).
- Mamumo Border Post between Namibia and Botswana (OSBP Juxtaposed Facility).

The concept design parameters and requirements identified from these studies pertaining to border precinct development were grouped and discussed under facilities and circulation or functioning of border post operations:

3.3.1 Facilities

The following facilities should be provided in the border post precinct:

- Adequate vehicle lane capacity.
- Adequate queueing and stacking capacity across bridges and on both approaches.
- Clear and appropriate road signage and process signage.
- Separate processing areas for public transport vehicles, light vehicles, freight vehicles and pedestrians.
- Primary inspection areas (drive-through toll booths and/or docks) for public transport vehicles, light vehicles and freight vehicles
- Secondary inspection areas (drive-through toll booths and/or docks) for public transport vehicles, light vehicles and freight vehicles
- Parking areas for light vehicles, freight vehicles and public transport vehicles.
- Pedestrian pathways.
- Violator processing areas.
- Fast track bypass lanes for pre-cleared vehicles.
- Office space.
- Space for security measures are provided.
- Hygiene (ablution) facilities.
- Social and telecommunication facilities.
- Loading zones for cargo.
- Commercial space for logistics companies, freight operators and public transport operators.

3.3.2 Circulation or Functioning of Border Post Operations

The following criteria or guidelines were obtained regarding the circulation and functioning at the investigated border posts:

- Border management should be integrated and coordinated between various government departments and other agencies.
- All government agencies should be mandated to inspect vehicles, persons and goods.
- Traffic flows should be managed according to a specific processing sequence.
- Freight vehicles, light vehicles, public transport vehicles and pedestrian movements should be limited, reducing conflict and improving safety.
- Adequate circulation should be designed to allow vehicles that cannot be processed to return to their country of origin.
- Processing of light vehicles, freight vehicles, or commercial trips and private trips should be separated.
- Primary inspection of light / public transport vehicles, freight vehicles, or commercial trips and private trips should be separated.
- Secondary inspection of light / public transport vehicles, freight vehicles, or commercial trips and private trips should be separated.
- Parking for light vehicles, freight vehicles and public transport operators should be separated.
- Freight traffic should be segregated according to the type of goods transported, e.g. live animals, perishable food stuffs, etc.
- The violator processing area should be separated from the inspection areas.
- Border management should be integrated and coordinated between the two countries to reduce processing duplication time (One-Stop-Border-Post (OSBP)).
- The number of required stops for travellers should be limited (OSBP).
- The required facilities (e.g. parking, offices, inspection areas, scanners and weighbridges and information etc.) should be limited by sharing them between countries (OSBP).

The remaining three options short listed were developed further and evaluated against the criteria set out above. It was concluded that all required facilities can be provided for in the conceptual designs of the three options. The only exception is clear and appropriate road signage and processing signage which should be addressed as part of the detailed design stage of the chosen option to be implemented. It was further concluded that all circulation and functional design elements within the Department of Transport's mandate can be provided for in the conceptual designs of the three options. It was recommended that the following areas (which do not fall within the Department of Transport's control) be addressed by the relevant authorities:

- Integration and coordination of border management between various government departments and other agencies.
- Mandates of government agencies to inspect vehicles, persons and goods.
- Integration and coordination of border management between the two countries to reduce processing duplication time.

4. INFRASTRUCTURE CAPACITY REQUIREMENTS

4.1 Design Options

The benchmarking exercise concluded that three of the options adhered to international best practice from a practical point of view and could therefore be evaluated further.
In summary, the three options evaluated were:

4.1.1 Option 1C: Expanding the Maseru Bridge Border Post / OSBP (One-country)
This option considers that the existing border post on the South African side would be expanded to accommodate a separation of freight processes from person processes. Both outgoing trips and incoming trips would be processed in one location at the border. In this case, a one country facility is proposed on the South African side due to space limitations on the Lesotho side. The joint processing facility for freight and persons and both directions would be located at the location of the existing Maseru Bridge Border Post.

4.1.2 Option 2B: Relocating Selected Functions / Freight-only border post
This option considers that freight processing components present on the South African side would be relocated from the existing border post to another site located some distance away from the actual border in South Africa to a purpose-built facility located near the intersection of the N8 and the R26 some 20km away. Processed freight would then be escorted in convoy to the Maseru Bridge Border Post where the total number of processed traffic (freight and persons) would merge and would continue to route across the existing border post on the South African side. A one-country OSBP for person processing is proposed at the existing Maseru Bridge Border Post location.

4.1.3 Option 4B: Relocating the Maseru Bridge Border Post / Freight-only border post
This measure involves relocating the freight processing functionality at the existing border post to a new site identified at Foso Bridge along the existing border between South Africa and Lesotho. The new site will provide suitable space to accommodate the freight processing facilities. Both outgoing and incoming freight trips would be processed at this location at Foso Bridge. Person traffic would continue to route across the existing border post on the South African side. A one-country OSBP for person processing is proposed at the existing Maseru Bridge Border Post location.

4.2 Approach

Judging by the three options under consideration, it became apparent that the conceptual design of an OSBP freight processing facility on the one hand and the conceptual design of an OSBP person processing facility on the other hand would address the requirements of all three options. These somewhat generic building blocks can be placed either at the existing Maseru Bridge Border Post location (Option 1C), or at the facility located near the intersection of the N8 and the R26 (Option 2B), or at the new site identified at Foso Bridge (Option 4B) to make up any of the three options discussed above.

The generic conceptual design elements of these OSBP facilities had been determined during the benchmarking process described above. A cost-benefit-analyses comparing all three options from an economic perspective, rather than a design perspective, was now required. In order to inform the cost-benefit-analyses, high level costs had to be determined for each option. The high level costs could only be determined based on practical conceptual designs making provision for adequate infrastructure and capacity taking into consideration the actual demand expected to cross the border.

Traffic count surveys, travel time surveys and road side interview surveys at four border posts along the western border between South Africa and Lesotho (Ficksburg Bridge, Peka Bridge, Maseru Bridge and Van Rooyens Gate) were carried out and processed. From the interviews, information such as type of vehicle, number of occupants, journey purpose, journey frequency, waiting time at border post, preferred route, origin and destinations of trips were obtained. An appropriate growth rate was determined based on economic projections and applied to the demand numbers. The demand for freight vehicles, public transport vehicles, light vehicles and pedestrians was estimated for a 20 year horizon.

4.3 Development of Queueing Model

In assessing border post operations, many operational variables present themselves that potentially will affect the approach to design of such facilities. From a transport infrastructure provision perspective, some of these variables are as follows:

- Traffic profile and composition
- Design horizons and associated projected traffic growth
- Service rates per user per configuration assumed for border control
- Different characteristics of operations per different user type
- Topographical constraints limiting infrastructure development
- Congestion levels and associated levels of service to users as a result of variations in the abovementioned parameters

Given the variety of variable, it is important to be able to undertake sensitivity assessments of the effect of each of the above variables and the impact of such on the infrastructure design process.

This is possible using traditional queueing models. However, given the extent of variables being tested, a spreadsheet model was developed that was able to easily test the effects of changes to parameters as a result of changes to each variable. This approach enabled a large variety of design related constraints to be tested from an operational perspective.
The tool developed enabled a quick assessment to be undertaken of the impacts of, for instance, faster processing times at peak periods on infrastructure needs.

The tool furthermore allowed a quick assessment to be conducted of the implications of various operational decisions on the performance of the border control system. Given a set of peak flows through the border, the tool was able to assess the number of processing points on a One Stop Border Post (OSBP) approach to ensure a policy driven acceptable level of service was maintained throughout the border control process.

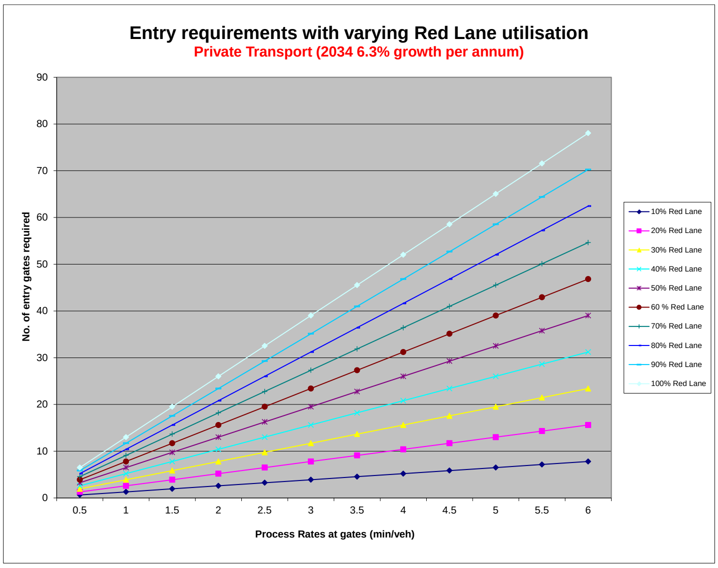
The tool also allowed for testing of variable servicing rates of users for different categories of vehicles using the border post. As such, private, public transport and freight vehicles could be considered separately as each of these categories will generally utilise separate facilities as a benchmark standard for facilities being developed worldwide at present.

In the case of both the Lebombo as well as Maseru Border posts, the spreadsheet toolkit was used to conduct a traffic analysis to specifically assess the implication of the new operational strategies on the design features to be designed into any new facility. The key features considered in any such traffic analysis should include:

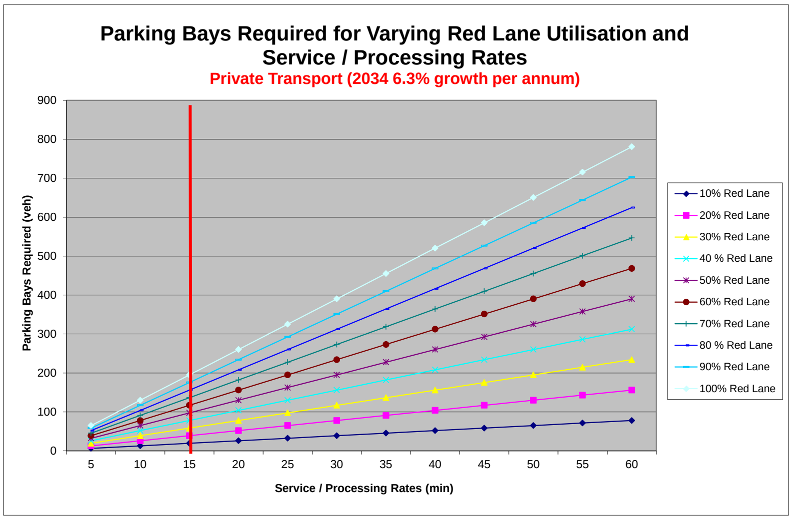
- The expected processing rate at the entry gates to be provided at the facility
- The expected split in utilisation between red and green lane traffic (users targeted for further intervention versus uses allowed to filter further through the system unimpeded)
- The expected interception rate strategy to be adopted by the relevant border post operator
- The expected vehicle category split of approaching traffic broken into 3 primary categories as follows:
    - Private Transport

o Public Transport
o Freight / Commercial vehicles

The graph below indicates the number of entry lanes required. Since it is the first processing gate the red utilisation assumed is 100% which will yield 26 lanes required to process the input peak traffic flow.



The tool was able to highlight the effect on the facility design of considering extreme peak operating conditions endemic to border posts related to specific periods of the year and in particular Easter and Christmas peak flows that place extreme pressure at most large border posts throughout the country. This enabled strategic as well as operational decisions to be considered to mitigate against the effect of such peaks through the possible introduction of remote processing facilities designed to ease operational pressure at the border posts themselves. The graph below illustrates the parking requirements required for various red lane percentage utilisation.



Furthermore, the assessment of acceptable peaking characteristics based on daily flow profiles was possible using the data generated by the analytical tool. Decisions such as the implications of designing for situations where the facility operated below v/c's <1 80% of the time and the implications of such decisions on physical design parameters were possible.

With the functionality of the spreadsheet model developed, the project team was able to ensure that the facilities provided were responsive to practical, operational and policy constraints considerations at all times. Furthermore, the tool was able to be used as an instrument by border post operators to test the effects of operational strategies to assist in determining the cost effectiveness of such strategies.

4.4 Application of Queueing Model

The model was developed to determine the number of entry lanes required at the OSBP and the number of parking bays required at the OSBP. The most important input variable into the model is the assumed service flow rate at the entrance to the OSBP. This assumption was not calibrated to observed service flow rates at other One Stop Border Post partly due to budget constraints and also due to the fact that no other One Stop Border Post of similar scale and functionality currently exists in South Africa. A series of sensitivity tests were performed to ensure a robust outcome of the model's capacity recommendations.

The typical assumptions of the queueing model for light vehicles were as follows:

- Peak hour light vehicle flow of 781vph, with accompanying typical 40 hours of hourly arrivals
- 2 minute light vehicle processing time at the first control point
- 20% red lane assignment, with a processing time of 15 minutes for red lane inspection process

The benchmark one stop border post assumes that passport control processing takes place at the first controlled point of entry to the border post very similar to a toll plaza. The driver stops the vehicle in the entry lane at the first processing window and hands the occupant(s)' passport(s) to the official. The driver then proceeds to a second window. The passports are then processed by the first country's officials whom then pass the passports through a dividing window to the second country's officials, whom then process it and hand it back to the driver. The vehicle is then allocated either a green lane ticket or red lane ticket and is requested to proceed to the correct colour lane.

The design was based on a forecast peak hour flow rate for year 2034. In 2034 a peak hour flow rate of 781 light vehicles per hour was estimated and using the queueing model it was calculated that, assuming a 2 minute processing time for light vehicles, 26 entry lanes are required for the queue to clear satisfactorily.

Sensitivity tests were undertaken to evaluate what would be required if the processing time increased or if traffic flows increased to peak season conditions, which is estimated to be 30% higher than the normal peak hour. The queueing model evaluated the accumulated effect of oversaturated conditions, given the 26 entry lanes and based on an hourly profile of arrivals and departures. The model then predicted lane utilisation and essentially predicted how long the queue will be in order to estimate the space required to accommodate the queue.

If a slower processing time of 3 minutes was assumed, the queue generated would be 325 vehicles of which 232 vehicles could be accommodated in the splay area, which means the queue would extend to 800m beyond the splay area.

If a 30% increase in peak hour flow rate was assumed, (to account for an Easter weekend for instance) the queue generated for the same 26 entry lanes and peak flow of 1015 light vehicles per hour will be 235 vehicles. This queueing will virtually all be accommodated within the approach splay of the border post. This can be seen in the histogram below.

Time		Arrival Rate		Average Queue Length (veh) – No of Channels																										
From	To	Veh/ min	veh/ hr	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
05:00	06:00	1.1	66	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
06:00	07:00	2.9	176	123	87	57	26	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
07:00	08:00	7.9	476	539	473	413	353	296	266	236	206	176	146	116	86	56	26	0	0	0	0	0	0	0	0	0	0	0	0	0
08:00	09:00	16.9	1015	1494	1398	1308	1218	1131	1071	1011	951	891	831	771	711	651	591	535	505	475	445	415	385	355	325	295	265	235	205	175
09:00	10:00	12.6	759	2193	2067	1947	1826	1710	1620	1530	1440	1350	1260	1170	1080	990	900	814	754	694	634	574	514	454	394	334	[illegible]	[illegible]	154	94
10:00	11:00	9.4	565	2697	2541	2391	2241	2095	1975	1855	1735	1615	1495	1375	1255	1135	1015	898	808	718	628	538	448	358	268	178	88	0	0	0
11:00	12:00	9.7	582	3220	3034	2854	2674	2497	2347	2197	2047	1897	1747	1597	1447	1297	1147	1001	881	761	641	521	401	281	161	41	0	0	0	0
12:00	13:00	8.7	521	3680	3464	3254	3044	2838	2658	2478	2298	2118	1938	1758	1578	1398	1218	1041	891	741	591	441	291	141	0	0	0	0	0	0
13:00	14:00	7.0	419	4039	3793	3553	3313	3077	2867	2657	2447	2237	2027	1817	1607	1397	1187	980	800	620	440	260	80	0	0	0	0	0	0	0
14:00	15:00	8.5	512	4491	4215	3945	3675	3408	3168	2928	2688	2448	2208	1968	1728	1488	1248	1012	802	592	382	172	0	0	0	0	0	0	0	0
15:00	16:00	10.1	604	5036	4730	4429	4129	3833	3563	3293	3023	2753	2483	2213	1943	1673	1403	1136	896	656	416	176	0	0	0	0	0	0	0	0
16:00	17:00	8.7	521	5496	5160	4830	4500	4173	3873	3573	3273	2973	2673	2373	2073	1773	1473	1177	907	637	367	97	0	0	0	0	0	0	0	0
17:00	18:00	8.3	499	5935	5569	5209	4848	4492	4162	3832	3502	3172	2842	2512	2182	1852	1522	1196	896	596	296	0	0	0	0	0	0	0	0	0
18:00	19:00	7.4	446	6320	5924	5534	5144	4758	4398	4038	3678	3318	2958	2598	2238	1878	1518	1161	831	501	171	0	0	0	0	0	0	0	0	0
19:00	20:00	7.5	450	6710	6284	5864	5444	5028	4638	4248	3858	3468	3078	2688	2298	1908	1518	1131	771	411	51	0	0	0	0	0	0	0	0	0
20:00	21:00	6.2	371	7021	6565	6115	5665	5218	4798	4378	3958	3538	3118	2698	2278	1858	1438	1022	632	242	0	0	0	0	0	0	0	0	0	0
21:00	22:00	3.9	234	7195	6709	6229	5748	5272	4822	4372	3922	3472	3022	2572	2122	1672	1222	776	356	0	0	0	0	0	0	0	0	0	0	0
22:00	23:00	2.9	172	7307	6791	6281	5771	5264	4784	4304	3824	3344	2864	2384	1904	1424	944	468	18	0	0	0	0	0	0	0	0	0	0	0
23:00	00:00	1.8	110	7357	6811	6271	5731	5194	4684	4174	3664	3154	2644	2134	1624	1114	604	98	0	0	0	0	0	0	0	0	0	0	0	0
00:00	01:00	1.0	57	7354	6778	6208	5638	5072	4532	3992	3452	2912	2372	1832	1292	752	212	0	0	0	0	0	0	0	0	0	0	0	0	0
01:00	02:00	1.1	66	7361	6755	6154	5554	4958	4388	3818	3248	2678	2108	1538	968	398	0	0	0	0	0	0	0	0	0	0	0	0	0	0
02:00	03:00	0.7	40	7340	6704	6074	5444	4818	4218	3618	3018	2418	1818	1218	618	18	0	0	0	0	0	0	0	0	0	0	0	0	0	0
03:00	04:00	0.7	40	7320	6654	5994	5334	4677	4047	3417	2787	2157	1527	897	267	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
04:00	05:00	1.2	71	7331	6635	5944	5254	4568	3908	3248	2588	1928	1268	608	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
05:00	06:00	3.9	234	7504	6778	6058	5338	4622	3932	3242	2552	1862	1172	482	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
06:00	07:00	8.5	507	7952	7196	6446	5696	4949	4229	3509	2789	2069	1349	629	117	87	57	27	0	0	0	0	0	0	0	0	0	0	0	0
07:00	08:00	16.5	988	8880	8094	7314	6534	5757	5007	4257	3507	2757	2007	1257	716	656	596	536	478	448	418	388	358	328	298	268	238	208	178	148
08:00	09:00	10.2	613	9433	8617	7807	6997	6190	5410	4630	3850	3070	2290	1510	939	849	759	669	581	521	461	401	341	281	221	161	101	41	0	0
09:00	10:00	8.8	529	9903	9057	8216	7376	6540	5730	4920	4110	3300	2490	1680	1078	958	838	718	601	511	421	331	241	151	61	0	0	0	0	0
10:00	11:00	7.9	476	10319	9443	8573	7703	6836	5996	5156	4316	3476	2636	1796	1165	1015	865	715	567	447	327	207	87	0	0	0	0	0	0	0
11:00	12:00	7.4	441	10700	9794	8894	7994	7098	6228	5358	4488	3618	2748	1878	1216	1036	856	676	499	349	199	49	0	0	0	0	0	0	0	0
12:00	13:00	8.6	516	11156	10220	9290	8360	7434	6534	5634	4734	3834	2934	2034	1342	1132	922	712	505	325	145	0	0	0	0	0	0	0	0	0
13:00	14:00	9.9	596	11692	10726	9766	8806	7849	6919	5989	5059	4129	3199	2269	1548	1308	1068	828	590	380	170	0	0	0	0	0	0	0	0	0
14:00	15:00	11.4	684	12316	11320	10330	9340	8353	7393	6433	5473	4513	3553	2593	1841	1571	1301	1031	764	524	284	84	54	24	0	0	0	0	0	0
15:00	16:00	10.4	626	12882	11856	10836	9816	8800	7810	6820	5830	4840	3850	2860	2078	1778	1478	1178	881	611	341	110	50	0	0	0	0	0	0	0
16:00	17:00	10.4	622	13444	12388	11338	10288	9242	8222	7202	6182	5162	4142	3122	2310	1980	1650	1320	993	693	393	132	42	0	0	0	0	0	0	0
17:00	18:00	12.2	732	14117	13031	11951	10870	9794	8744	7694	6644	5594	4544	3494	2652	2292	1932	1572	1215	885	555	265	145	72	42	12	0	0	0	0
18:00	19:00	9.8	587	14643	13527	12417	11307	10201	9121	8041	6961	5881	4801	3721	2849	2459	2069	1679	1292	932	572	251	101	0	0	0	0	0	0	0
19:00	20:00	7.8	468	15051	13905	12765	11625	10488	9378	8268	7158	6048	4938	3828	2927	2507	2087	1667	1249	859	469	119	0	0	0	0	0	0	0	0
20:00	21:00	6.5	393	15384	14208	13038	11868	10701	9561	8421	7281	6141	5001	3861	2929	2479	2029	1579	1132	712	292	0	0	0	0	0	0	0	0	0
21:00	22:00	4.4	265	15588	14382	13182	11982	10786	9616	8446	7276	6106	4936	3766	2804	2324	1844	1364	887	437	0	0	0	0	0	0	0	0	0	0
Average Delay Time / vehicle over full peak period (min)				7769	4775	3281	2385	1789	1370	1056	812	617	457	324	224	171	129	94	66	44	26	13	8	5	4	3	2	1	1	1

It was therefore concluded that the number of entry lanes required for the generic one stop border post for light vehicles is 26 entry lanes per direction of flow.

It was assumed that 20% of light vehicles will be selected/allocated to the red lane. Using this assumption and assuming a red lane processing time of 15 minutes per light vehicle, a need to provide at least 40 parking bays for light vehicles was determined.

In the same way the required entry lanes was calculated for public transport passengers and pedestrians. In 2034, the peak direction flow rate is 370 passengers per hour. A processing time of 3 minutes was used to determine the number of immigration processing lanes required. By applying the queueing model, it was determined that the number of processing lanes for passengers/pedestrians would be 15.

The parking requirements of public transport vehicles was calculated for the 370 passengers per hour with the same mix of PT vehicles as was observed at the typical peak at the Maseru Border post. This number of vehicles, their offload/loading time was used to determine the number of stopping bays required. A turnaround loop is proposed to be located separately from the light traffic. This layout is shown in the typical concept layout in Figure 1.

The typical assumptions of the queueing model for freight vehicles were as follows:

- Peak hour heavy vehicle flow of 51vph, with accompanying typical 40 hours of hourly arrivals
- 2.5 minute heavy vehicle processing time at the first control point
- 60% red lane assignment, with a processing time of 45minutes for red lane inspection process

Similarly, the required entry lanes for freight vehicles were determined. In 2034, a peak hour flow rate of 51 freight vehicles per hour was estimated and it was calculated that, assuming a 2.5 minute processing time, 2.5 entry lanes would be required. A sensitivity test with respect to increasing the average processing time of 3.5 minutes was undertaken but the queue formed was found to be negligible. For the freight vehicles, it was therefore assumed that 3 entry lanes are required to allow for more variation around the average processing time.

It was assumed that 60% of freight vehicles will be selected/allocated to the red lane. Using this and assuming at least a 45 minute average processing time per vehicle, it was calculated that 30 freight vehicle parking bays would be needed.

All the above results were utilized to provide the appropriate number of entry lanes, parking provision for red lane processing and separate public transport parking bays for each of the different vehicle type OSBP layouts.

5. CONCEPTUAL DESIGN

5.1 Typical Design Elements

In ***Figure 1,*** a typical conceptual design template of the OSBP person processing facility, taking account of the capacity requirements for the specific demand at the specific location, is provided. In ***Figure 2*** a typical conceptual design template of the OSBP freight processing facility, taking account of the capacity requirements for the specific demand at the specific location, is provided. The design templates can be considered generic in the sense that it does not take into consideration topographical, environmental, and geological or other physical aspects, specific to the location, into account.

Both designs only show the traffic movement in one direction. It is proposed that the mirror image of each will have to be provided in order to accommodate both directions.

The approach road to the westbound border post and the approach road to the eastbound border post would be shared. However, from a safety and security point of view, it is not recommended to combine the internal access roads for the two directions. It is, however, recommended to combine these for the two countries as that would be one of the benefits of the recommended OSBP.

From a safety and security point of view, it is not recommended to combine ancillary facilities such as staff parking, storage, ablution facilities, etc. for the two directions. Rather the idea is to share facilities between the two countries in one direction. It is, however, recommended to combine these for the two countries as that would be one of the benefits of the recommended OSBP.

When the two directions are combined it is required from a safety and security point of view to accommodate pedestrian flow in an under-cover tunnel-like walkway where no interaction between the two directions is possible. This tunnel will emerge at a public transport ranking facility at either end of the tunnel. This ranking facility has been designed to accommodate an effective turnaround circle for public transport vehicles.

The parking for the light vehicle red lane processing has been so arranged that vehicles can easily be called to be processed without waiting too long behind the vehicle in front of them. It was envisaged that 4 processing lanes would be available for police and custom inspection to also minimise the waiting time. Waiting vehicles would be called on a first come first served basis.

It was assumed that in terms of the freight vehicle red lane, processing around 60% of all freight vehicles would be targeted. The parking facility is intended to be utilised by both police and customs officials, so it was decided to be conservative in providing sufficient parking space. Although the parking is linearly arranged, the customs processing facility would also have six lanes with inspection pits and catwalks for each lane. This will allow freight vehicles transporting certain types of goods to queue in a particular parking lane and be processed in that particular inspection lane. This will ensure that freight vehicle waiting time is minimised, in the event that freight vehicles are processed at substantially differing rates.

5.2 Practical Implementation

5.2.1 Option 1C: Expanding the Maseru Bridge Border Post / OSBP (One-country)

Due to the space constraints on the Lesotho side, it is envisaged that a full OSBP One Country Facility could be accommodated in the available space on the South African side. The sharing of facilities between two countries per direction would be appropriate considering the space limitations present at the current location of the existing Maseru Bridge Border Post.

In addition to the construction of an entire new OSBP facility a new section of the N8 needs to be constructed which will pass over the railway line via a bridge to a new roundabout from which will emanate a new road to/from the freight vehicle facility, a new road to/from the light vehicle facility and a new road serving the public transport vehicle facility. New holding areas for public transport will also have to be provided.

5.2.2 Option 2B: Relocating Selected Functions / Freight-only border post

It is proposed to locate the OSBP freight processing facility near the N8/R26 intersection some distance away from the current location of the existing Maseru Bridge Border Post. At the same time it is proposed to locate the OSBP person processing facility on the available space on the South African side at the existing Maseru Bridge Border Post.

Freight vehicles will be escorted in convoy to the border where only a final cursory check will be performed before they are allowed to proceed over the bridge into Lesotho. In addition to the construction of an entire new OSBP facility a bypass road for the accompanied (processed) freight vehicles would be required. Freight vehicles that would normally be destined for other border posts such as Ficksburg Bridge would be discouraged from using the OSBP freight processing facility near the N8/R26 intersection.

In addition a new section of the N8 needs to be constructed which will pass over the railway line via a bridge to a new roundabout from which will emanate a new road to/from the light vehicle facility and a new road serving the public transport vehicle facility. New holding areas for public transport will also have to be provided.

5.2.3 Option 4B: Relocating the Maseru Bridge Border Post / Freight-only border post

A location close to Foso (located approximately 6km from Maseru and 20km from the existing Maseru Bridge Border Post) was identified as an appropriate location to develop such an OSBP freight processing facility. Maseru Bridge Border Post would be closed for freight vehicles and all freight vehicles would be redirected to Foso. At the same time, it is proposed to locate the OSBP person processing facility on the available space on the South African side at the existing Maseru Bridge Border Post.

The construction of a new freight only road from Ladybrand to the new border facility at Foso would be required. This road would be 15.4 km long of which 6km would be completely new in mountainous terrain. A new bridge will have to be constructed over the border and the rehabilitation of 9km of road in Lesotho would also be required to accommodate the additional freight vehicle loading.

The current service times for border processing from one country entry to other country exit (based on actual surveys) and estimated new service times (including 20% red lane for light vehicles and 60% red lane for freight) are shown in the ***Table 2*** below.

Table 2: Total Border Post Processing times

	Current Maseru BP	**Optimized Traditional BP**	**OSBP**
Passengers/Peds	33min	24min	10min
Light vehicles	40min	25min	12min
Freight vehicles	168min	89min	61min

These average processing times were used in the economic evaluation of the Concept Border Post option designs. This is the subject of another SATC paper.

Figure 1: Light Vehicle Processing Facility

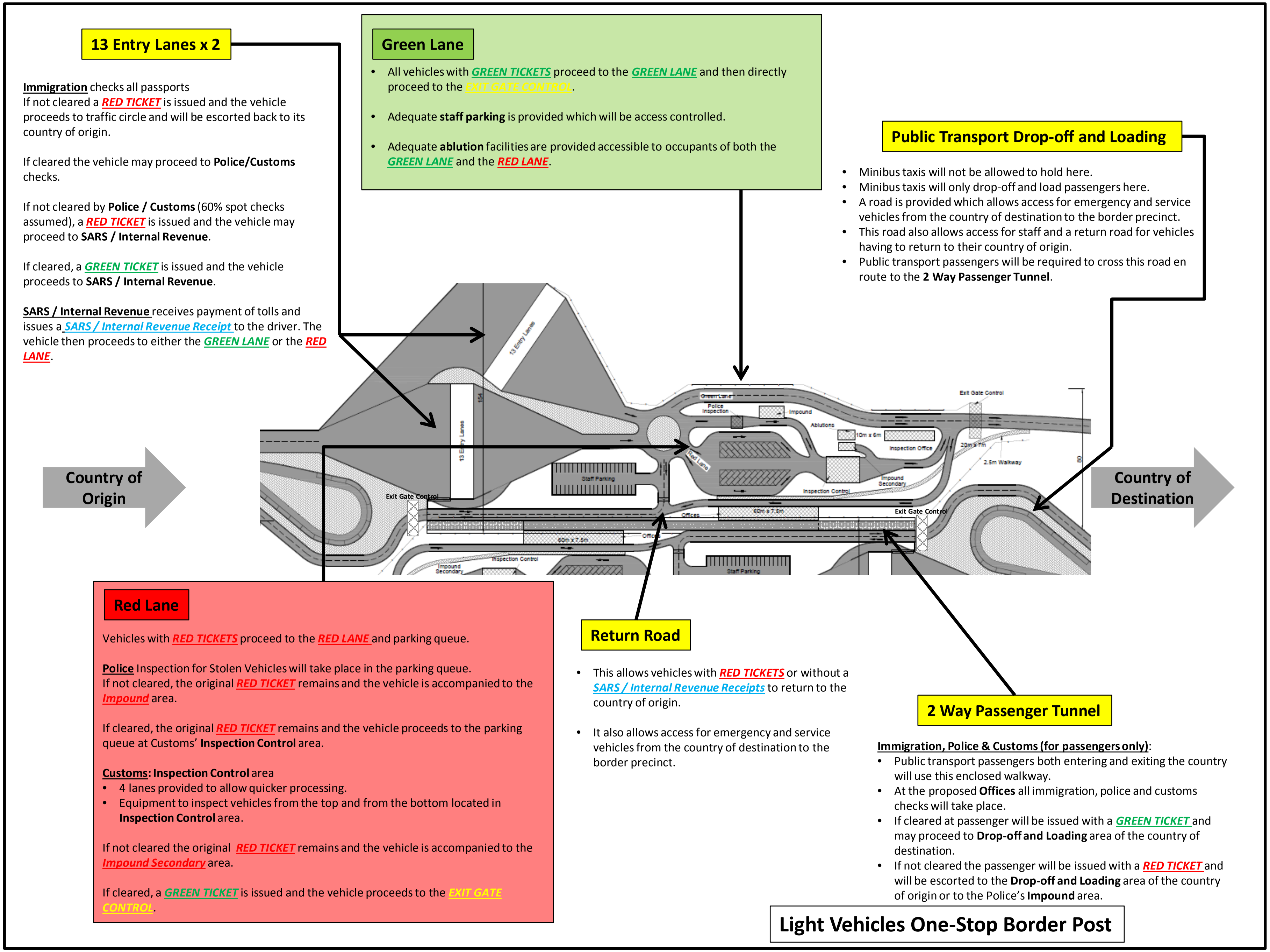
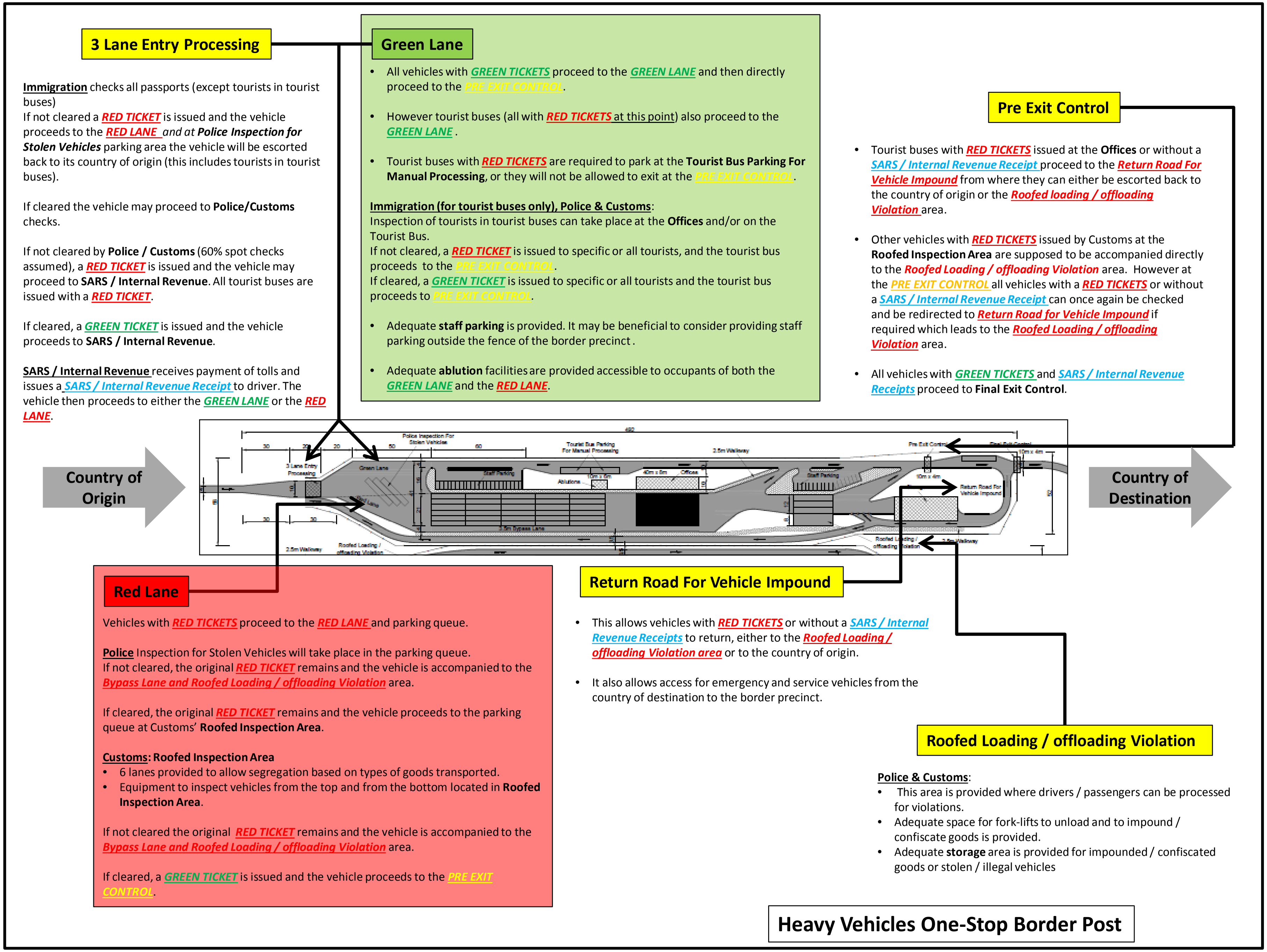


Figure 2: Freight Vehicle Processing Facility



6. CONCLUSIONS

The generic design parameters provided should be utilized to assess the various decongestion strategies for border posts. These generic design parameters can then also be used as a checklist to inform the conceptual design of a particular decongestion strategy in terms of the border precinct development.

The required infrastructure at the border precinct in terms of the capacity of the number of entry lanes, queueing capacity and number of parking for freight vehicles, light vehicles and public transport vehicles needs to be determined by applying an appropriate queueing model and testing the sensitivity to various assumptions.

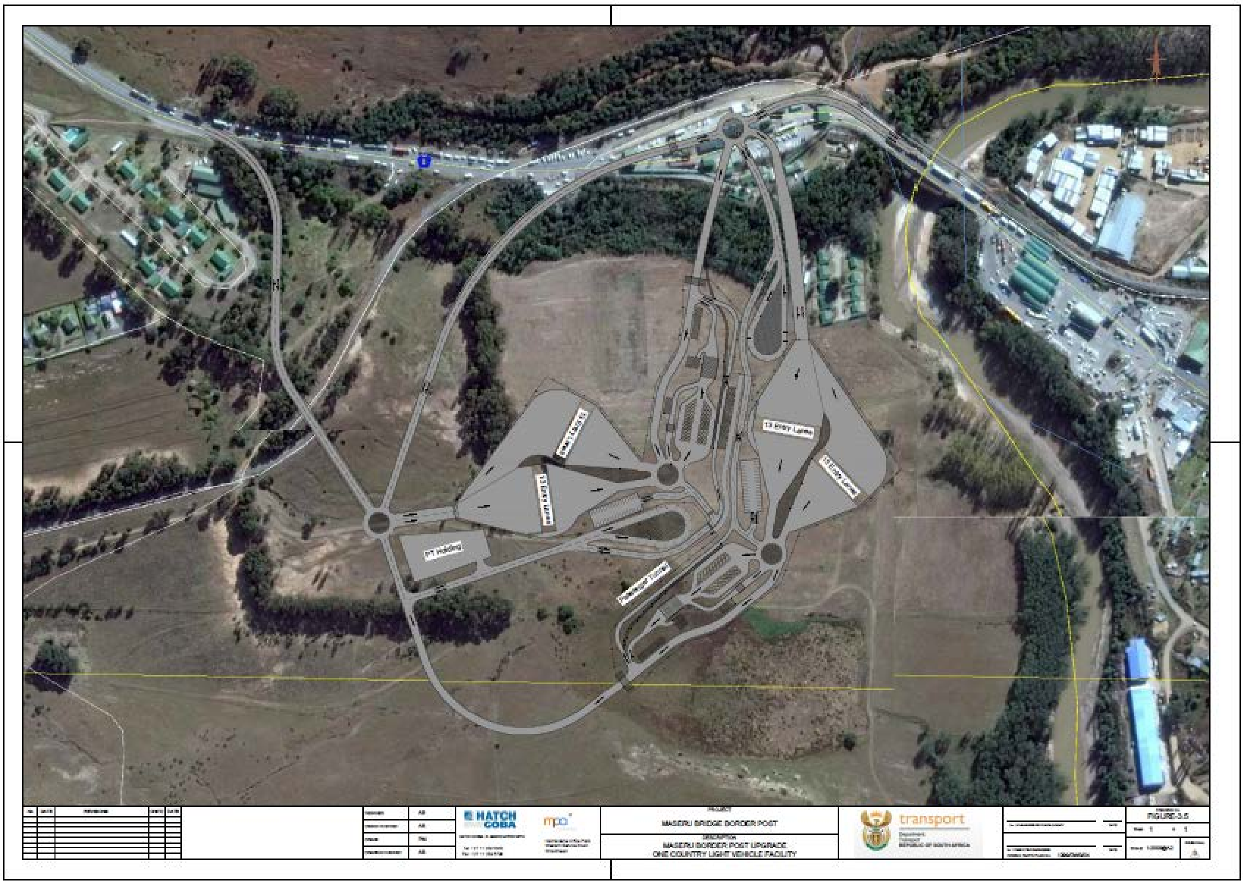
The One Stop Border Post Option 4C which has the new Freight OSBP facility at Foso and upgrades the Maseru Border Post to a one country OSBP for passengers and light vehicles seems to be the most transport economic option. The Maseru Bridge Border Post concept layout is shown in ***Figure 3***.

Should these generic design parameters be followed, case studies have shown that significant improvements in processing time as a result of the decongestion of the border post could be expected as shown in ***Table 3*** below.

Table 3: Total Border Post Processing times

	Current Maseru BP	**Optimized Traditional BP**	**OSBP**
Passengers/Peds	33min	24min	10min
Light vehicles	40min	25min	12min
Freight vehicles	168min	89min	61min

Figure 3: Maseru Bride Border Post Concept Layout



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