

INTERSECTION AND SIGNAL DESIGN FOR BRT: CHALLENGES, LESSONS LEARNED & THE ROAD AHEAD

A Frieslaar, J Jones, L van der Merwe & B Dlamini

HHO Africa Infrastructure Engineers, PO Box 6503, Roggebaai, 8012,
Tel: 021 425 2870, Fax: 021 – 419 4689, E-mail: andre@hho.co.za

ABSTRACT

The National Department of Transport's Vision of the Public Transport Action Plan encourages the utilisation of Bus Rapid Transit (BRT) as part of Integrated Rapid Transport Networks (IPTN's). The roll out of BRT is currently being pursued in all of the major cities in South Africa.

The design and signalisation of intersections needs to comply with the South African Road Traffic Signs Manual (SARTSM) in order to be legal. The SARTSM was drafted prior to BRT being envisaged and as yet has not been modified to adapt to the demands of the road based public transport requirements. The implementation of the SARTSM to active BRT projects is discussed, as are the challenges of conforming to SARTSM and the lessons learned from observations in the field.

Alternative signalisation techniques have been implemented internationally to manage bus and light rail systems in street networks. The paper reviews various good international examples of these techniques with a view to encouraging decision makers within South Africa to update the SARTSM and hopefully improve the legibility of traffic signals at these complex BRT junctions and hence improve the safety of all road users.

1 INTRODUCTION

1.1 Background

HHO Africa have been the lead consultant in the rollout of Phase 1A of the MyCiTi BRT System in Cape Town between Civic Station in the CBD and Atlantis approximately 40km to the north. This part of the BRT system encompasses a portion of the CBD, Paarden Eiland Milnerton, Century City, Montague Gardens, Table View, Melkbos and Atlantis. The projects includes 33km of dedicated busway, 32 trunk stations and approximately 50 signalised intersections all of which required special phasing to accommodate the bus movements through the intersections.

The design and signalisation of intersections needs to comply with the South African Road Traffic Signs Manual (SARTSM) in order to be legal. The SARTSM was drafted prior to BRT being envisaged and as yet has not been modified to adapt to the demands of the road based public transport requirements. The implementation of the SARTSM to active BRT projects is discussed, as are the challenges of conforming to SARTSM and the lessons learned from observations in the field.

Alternative signalisation techniques have been implemented internationally to manage bus and light rail systems in street networks. The paper reviews various good international examples of these techniques with a view to encouraging decision makers within South Africa to update the SARTSM and hopefully improve the legibility of traffic signals at these complex BRT junctions and hence improve the safety of all road users.

1.2 Scope of this paper

This paper presents the current legal framework governing the design and implementation of traffic signal controls for “bus lanes”. It then briefly reviews international precedent for traffic signal treatments for bus, BRT and LRT systems internationally, and summarises the best practice for consideration for use in South Africa and incorporation into SARTSM.

The current use of the SARTSM for BRT signal control in South Africa is explained and evaluated, highlighting concerns, difficulties and lessons learned. In conclusion, recommendations are made with regards to improving the driver understanding of bus signals, and reducing confusion amongst drivers using BRT corridors.

2 SOUTH AFRICAN ROAD TRAFFIC SIGNS MANUAL

As discussed, the current legal framework controlling the design and installation of traffic signals at intersections is the SARTSM. The following provisions from the SARTSM (Ref 1) should be noted:

- A busway is classified as a separate roadway. The Road Traffic Act 29 of 1989 as amended defines that:
 - “a roadway means that portion of a road, street or thoroughfare improved, constructed or intended for vehicular traffic which is between the edges of the roadway”;
 - “the edge of roadway means the boundary between roadway and the shoulder, which is indicated by an appropriate road traffic sign, or in the absence of such sign the edge of such (bituminous or concrete) surface”.
- The allowable traffic signal aspects (Legal Implication) are the S1B aspects (Refer to Figure 1), which is the bus light signal, and are reserved for the control of minibuses and buses in a reserved bus lane. Whereas vehicular light signals can be either a disc or an arrow light signal, the S1B is a special light signal where a bus shaped lens is placed over the light. The S1B is only applicable to vehicles allowed in exclusive bus lanes. The faces may NOT be used to control buses travelling in non-exclusive lanes.

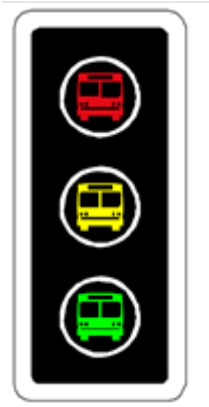


Figure 1: S1B

3 INTERNATIONAL PRECEDENT

3.1 Introduction

There are a wide range and variety of traffic signal treatments (phasing and signal aspects) for public transport systems (Buses, BRT and LRT) in major cities across the world. It would appear from the literature that no two cities have exactly the same traffic signal aspects and phasing for bus priority and BRT systems. With respect to light rail transit, there appears to be more uniformity. The following examples of signal treatments in different cities emphasize this point.

3.2 BRT Signals

In order to distinguish the signal aspects for buses from those for normal vehicles, a variety of different treatments are used as follows:

- Signal aspects having bus profiles in the lenses [Refer to Figures 2a and 2b].
- Signal aspects which are similar to the LRT systems described in Section 3.2 [Refer to Figures 3a and 3b].
- Signal aspects which are same as for normal vehicles but have supplementary signs indicating they are for buses [Refer to Figures 4a and 4b].



Figures 2a and 2b: Examples of BRT signals with bus profiles in the lenses found in Salzburg, Austria and Swansea, Wales respectively (Ref 2)



Figures 3a and 3b: Examples of BRT signals with LRT type lenses found in Stuttgart, Germany (Ref 2) and Zurich, Switzerland (Ref 3) respectively



































Figures 4a and 4b: Examples of BRT signals similar to normal signals with supplementary signs found in North Kent, England and Schaffhausen, Switzerland (Ref 2)

Light Rail Signals

Traffic signals for LRT systems generally use the 3 aspect or 2 aspect signals as indicated in Figure 5. In the 3 aspect system, the top aspect reflects a white horizontal bar (“stop”), the middle aspect a flashing white triangle (prepare to stop) and the bottom aspect a white vertical bar (“go”). In some systems the, the middle aspect is a white flashing dot.

Where there are intersections where IRT routes diverge, either to the left, or to the right or in all 3 directions, then the bottom aspects (“go”) reflect white bars at 45% indicating the direction travel.

A 2 aspect system as indicated in Figure 5 follows the same principles as the 3 aspect system except there is no flashing triangle (“prepare to stop”) aspect.

	THREE-LENS SIGNAL	TWO-LENS SIGNAL
SINGLE LRT ROUTE 	STOP  PREPARE TO STOP  FLASHING GO 	 STOP  ⁽²⁾ GO
TWO LRT ROUTE DIVERSION 	  FLASHING   ⁽¹⁾	   ⁽¹⁾⁽²⁾
	 FLASHING    ⁽¹⁾	   ⁽¹⁾⁽²⁾
THREE LRT ROUTE DIVERSION 	  FLASHING    ⁽¹⁾	    ⁽¹⁾⁽²⁾

Notes:
 All aspects (or original indications) are white.
 (1) Could be in single housing.
 (2) "Go" lens may be used in flashing mode to indicate "prepare to stop."

Figure 5: LRT Signal Aspects Examples (Ref 4)

In some systems, there is an additional aspect at the top reflecting a white "A" which indicates that the traffic signals have been activated i.e. are aware of the approaching vehicle.

3.3 Summary of Best Practice

From the review of the different LRT, bus and BRT traffic signal treatments, the signal aspects currently used for LRT systems in a number of cities gives a clear indication of what phase is intended to be used and for who the phase is intended i.e. there is no confusion for general traffic as is the case when the bus aspects look similar to the normal vehicle aspects (especially at night).

Because the 3 aspect signals follow the same logic as the normal vehicular aspects, they would be easier to understand for motorists than the 2 aspect signals.

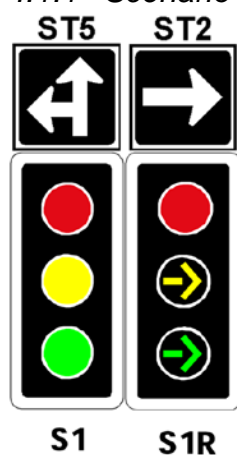
4 BRT INTERSECTION DESIGN IN SOUTH AFRICA

4.1 Application of SARTSM to BRT Design

The bus travelling in the exclusive bus lane will be controlled with the S1B traffic signal aspect during the allocated signal phase. The following phasing scenarios were applied during the traffic signal designs of intersection along the BRT route to separate the median busway and right turning vehicles;

- General traffic (through and left) and BRT buses (through) move together while right turning vehicles receive a protected right turn phase only.
- General traffic (through, left and right) and BRT buses (through and left or right) move at different times to separate conflicts with time.

4.1.1 Scenario 1: Accommodating through movement of buses only



Here, the general traffic (through and left) and BRT buses (through) move together while right turning vehicles receive a protected right turn phase only. This operation requires the right turning vehicles to move at a different time than the through and left turning vehicles which will move at the same time as the bus.

The through and left traffic movement is controlled with a S1+ST5 aspect and the right turn with a S1R+ST2 aspect. The aspect configuration is illustrated in Figure 6. The bus is controlled with the S1B aspect.

Figure 6: Aspect Configuration (S1+ST5 and S1R+ST2)

Challenges



The existing design of the S1B aspect consists of a bus symbol within the lens or LED display. However, from a distance and especially at night it is extremely difficult to differentiate between the display of the S1 and the S1B aspect. A “BUS ST” sign was developed and installed in the same position above the S1B aspect as the ST5 above the S1 and the ST2 above the S1R for the through and right turning vehicles. In addition an information text sign was fitted to all traffic signal poles containing S1B traffic signal aspects reading “bus only” to confirm to road users which signal heads are applicable for which mode of transport. (See Figure 7).

The change in the signal phasing is not conventional and existing driver expectations had to be changed since no permissive right turn was allowed and right turning vehicles had to wait for a green arrow. To inform driver of the change in phasing an advanced information sign was erected to inform driver of the change reading “traffic signal layout changed”.

Figure 7: Aspect Configuration (S1B+BUS and “Bus Only”)

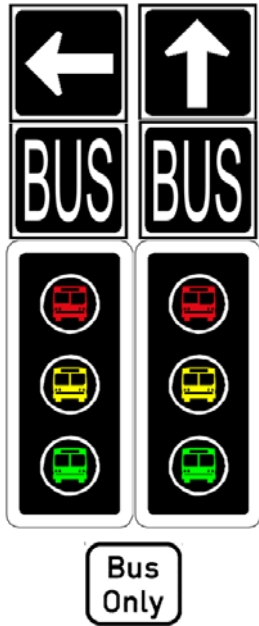


The change in the signal phasing was reinforced with an additional information sign fixed underneath the S1R+ST2 signal aspect which controls the right turning movement. The sign reading “right turn on green arrow only” (See Figure 8).

Figure 8: Supplementary Text Sign

4.1.2 Scenario 2: Accommodating through and either left or right turn bus movements

In this scenario, the intersection needs to cater for all general traffic movements (through, left and right) as well as BRT bus through and either a left or right turn movements, at different times to separate conflicts. This operation is typical where there is more than one bus lane at the stop line, allowing buses to continue straight along a corridor or to turn off it along another corridor or feeder route i.e. a through lane and a right or left turning bus lane.



The different movements of the bus must be controlled with separate traffic signal aspects, unless a dedicated bus phase is provided. The through movement will be controlled with the S1B+BUS as per scenario 1, however, an additional directional “ST” sign will be added to the traffic signal aspect configuration and consist of the following; S1B+BUS+ST1. The left turn movement will be treated in a similar manner and consist of the following; S1B+BUS+ST3. The aspect configuration is illustrated in Figure 9. The principle of this design can be applied in the same manner to accommodate right turning buses.

Figure 9: Aspect Configuration (S1+BUS+ST3 and S1B+BUS+ST1)

Challenges

In addition to the challenges for Scenario 1, which are common to both scenarios, the additional bus ST boards for the bus turn movement need to be accommodated on top of the BUS ST signs. The resulting clutter of signal aspects and signage results in driver confusion. At night, the supplementary signage can fall outside of the headlight cone of vision, leading to a reduction in driver understanding of the signal displays.

4.2 Lessons Learned/Issues and Constraints Identified

The following lessons regarding the application of the SARTSM to traffic signal design for BRT are as follows:

1. At night, it is difficult to distinguish a bus signal from a general traffic signal and hence driver confusion ensues (Refer to Figure 10).
2. In order to avoid confusion, either the bus signals need to be enlarged so that drivers can more clearly identify the bus symbols, or additional signage has to be added to the signal displays such as ST boards.
3. At night, these ST boards above the signals are not always visible, and hence supplemental signage is required below the signal heads, to distinguish them

from each other i.e. BUS ONLY, or RIGHT TURN ON GREEN ARROW ONLY (Refer to Figure 10).

4. The necessary separate signal aspects for each bus movement and car movement resulting in cluttered “totems” of traffic lights and signs.
5. Based on observations of drivers using these intersections, understanding of the complex signal displays is not universal and many illegal movements occur, resulting in unsafe situations which lead to accidents.
6. The infrastructure design requires detail planning to provide sufficient kerb islands to locate the traffic signal poles to ensure that the design is SARTSM compliant in a manner which is not confusing.



Figure 10: Image of Cape Town's MyCiti Bus and General Traffic Signals

5 SUMMARY OF FINDINGS AND RECOMMENDATIONS

The SARTSM was developed long before BRT was envisioned for implementation in South Africa. As a result, it is not adequately equipped to cater fully with the BRT requirements, without leading to general driver confusion and the need to supplementary signage.

Notwithstanding the use of supplementary signage, the driver understanding at these intersections is not at the required level to avoid needless accidents. Furthermore, at night, the bus aspects cannot always be distinguished from general traffic aspects, and the supplementary signage is often above the cone of light provided by car headlights, and hence not visible.

The conclusion from this paper is that it is that the SARTSM was never intended to cater for BRT and current utilisation of the available signal aspect and signs is not leading to the desired levels of driver understanding. Furthermore, the application of the signals aspects and signs is cumbersome.

The recommendation from this paper is that international best practice be adopted and that the signal displays for buses be entirely different from those for general

traffic. It would be advisable if the proposals put forward in this paper (LRT signal aspects) were introduced on a trial basis along a section of route in one of the cities currently implementing BRT, so that the merits of the proposals can be evaluated.

Furthermore, it is recommended that the National Department of Transport commission Consultants responsible for the updating of the South African Road and Traffic Signs Manual, to update the manual to include LRT signal aspects for use at BRT intersections. This will avoid confusion, and mitigate the need for any clutter from supplementary signage.

6 REFERENCES

National Department of Transport. 2004. South African Road Traffic Signs Manual, Volume 3: Traffic Signal Design

Citytransportinfo, 2015. 'Side-Step Congestion' / Bus Priority Systems / BRT.
<http://citytransport.info/Buses02.htm>

Citytransportinfo, 2015. Light Rail Fits In. Road Junctions, Level Crossings, And Traffic Signal Priority.

<http://citytransport.info/Signals.htm>

FHWA, 2013. "Manual on Uniform Traffic Control Devices (MUTCD)"

http://mutcd.fhwa.dot.gov/HTM/2003r1/part10/fig10d-01_longdesc.htm