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BUS KARO

Rapid Assessment of the Visakhapatnam Bus Rapid Transit System (BRTS)

SHAKTI SUSTAINABLE ENERGY FOUNDATION

A product of WRI Ross Center for Sustainable Cities

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Shakti Sustainable Energy Foundation works to strengthen the energy security of India by aiding the design and implementation of policies that support renewable energy, energy efficiency and sustainable transport solutions.

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1. EXECUTIVE SUMMARY

Over the last decade, Visakhapatnam has developed two of the six main Bus Rapid Transit (BRT) corridors with the aim of improving access and reliability of their mobility system. Over 41 km of the BRT corridor cuts across Visakhapatnam city, separated from vehicular traffic, connecting Pendurthy to Dhwaraka Nagar through two major routes. The Pendurthy Transit Corridor (PTC) cuts across the city, running through Gopalapatnam, Kanchanapalem and the city railway station, while the Simhachalam Transit Corridor (STC) traverses the path of Maddilapalem, Hanumanthwaka and Vepagunta. While the construction of the corridors was completed in 2012, the BRT in Visakhapatnam remains un-operational till date.

Upon inspection of the corridors, a number of issues have been brought to light. These include:

1. Pedestrian safety concerns due to inadequate and improper pedestrian infrastructure such as crossings (either over bridges or under bridges), pedestrian signals, sidewalks, refugee areas at junctions etc.
2. Conflicts between buses and mixed traffic at major intersections
3. Lack of and/or inadequate infrastructure at bus stations
4. Lack of enforcement of segregated lanes and the intrusion of mixed traffic into BRT lanes
5. Poor intersection design, hindering the smooth movement of pedestrians, buses and mixed traffic
6. The buses currently plying on the corridor are not specialized for BRT operations and lack the typical characteristics a BRT bus usually does.
7. Finally, the BRT has also not been branded for commuters to be able to differentiate the service from regular city bus services and identify it as a specialized, high-speed and an efficient mobility service.

While the infrastructure and design of the BRT components play a major role in the BRT, the administrative and financial model of the transit agency control the success operations. Some of the key areas of concern for the operationalization of the Visakhapatnam BRT are as follows:

1. The Special Purpose Vehicle (SPV) that was supposed to be constituted to manage the BRT operations in the city has not been formed till date. No clear structure has been defined with regard to the operating agency and their responsibilities.
2. The system lacks a financial plan for both the capital expenses to purchase the buses needed and the operational expenses to run and maintain the BRT system.
3. The system also lacks a clear operational plan that differentiates direct city bus services from the BRT services.

Recommendations proposed are aimed at operationalizing the BRT system at the earliest. Some of the main areas of intervention detailed in the report are as follows:

1. Administrative structure:
   a) For immediate operations: Andhra Pradesh State Road Transport Corporation (APSRTC) to take over BRT planning & operations
   b) SPV to be constituted for long term BRT system management.
2. Financial model:
   a) Capital expenses: One-time state finding for the procurement of specialized BRT buses

b) Operational expenses: Revenue from ticket sales, fuel-cess, lad development rights around the BRT corridor, advertising and parking charges. Additional costs can be covered through a Viability Gap Funding support from the State government.

3. Branding: The BRT system needs to be branded and advertised as a high speed, high efficiency and a convenient service to attract commuters.
4. BRT Buses: Specialized BRT buses need to be procured that have the capacity to provide level boarding and easy boarding for the disabled. Electric buses can also be explored for BRT operations at a later date.
5. BRT Stations: The Simhachalam railway station BRT bus station needs to be relocated where there is land capacity and built to avoid unsafe conditions for commuters. Amenities to improve comfort and safety such as seating, lighting, Closed Circuit Television (CCTV) and digital information systems need to be installed at stations.
6. Segregated bus ways: Improved pedestrian safety infrastructure such as crossings and signaling at the bus station and intersections. Additionally, improved signaling at major junctions with BRT priority.
7. Operational Plan: Based on the current usage of the city bus operations along the corridor, only 20.8% of all trips either start or end along the STC or PTC. This demand has however shown a growing trend and is expected to increase. A combination of direct and trunk and feeder system has the potential to improve travel time and quality of commute. This can be revisited based on demand in phase 2 of operations.

We recommend that the proposed recommendations be implemented in a phased approach where in, Phase 1 includes all activities that are needed to immediately operationalize the system and improve passenger and commuter safety; Phase 2 includes activities that will improve efficiency and operations of the system.

2. INTRODUCTION

Visakhapatnam is the largest city in Andhra Pradesh with an area of 550 km^2. It is primarily an industrial city, apart from being a port city. From a population of few thousand locals during the 18th century and early 19th century, the population has grown every decade to 2.03 million as of 2011 (Census 2011). The city doubled its population from 2001 to 2011 owing to a large migrant population from surrounding areas and other parts of the country coming to the city to work in its heavy industry.

The rapidly growing population induced an increased demand for better transportation. In view of this and increased congestion on road, the Greater Visakhapatnam Municipal Corporation (GVMC) planned and constructed a Bus Rapid Transit (BRT) corridor as a high capacity public transport system under the Jawaharlal Nehru National Urban Renewal Mission (JnNURM). While the project was approved in 2008 and construction of 2 (out of six) corridors, the Pendurthy Transit Corridor (PTC) and Simhachalam Transit Corridor (STC), was completed by 2012. The BRT system is not yet operational.

a) Corridor

In the First Phase, 2 corridors were constructed, the STC and PTC, with a combined cost of ₹452.93 crores. Work began on the 41.5 kms (20 kms of PTC and 21.5 kms of STC) BRT corridor in 2008. Segregated median corridor was constructed with barricades on both sides. The two corridors connect Pendurthy, to the north west of the city to Dwaraka Nagar through two different routes. While the PTC runs through the city, extending from the city railway station, Kancharapalem, NAD road and Gopalapatnam to Pendurthy, the STC connects Pendurthy to the RTC complex via Maddilapalem, Hanumanthwaka and Vepagunta. The BRT is an open type system with staggered organized bus stops. Though completed, the BRT still needs to get operational.

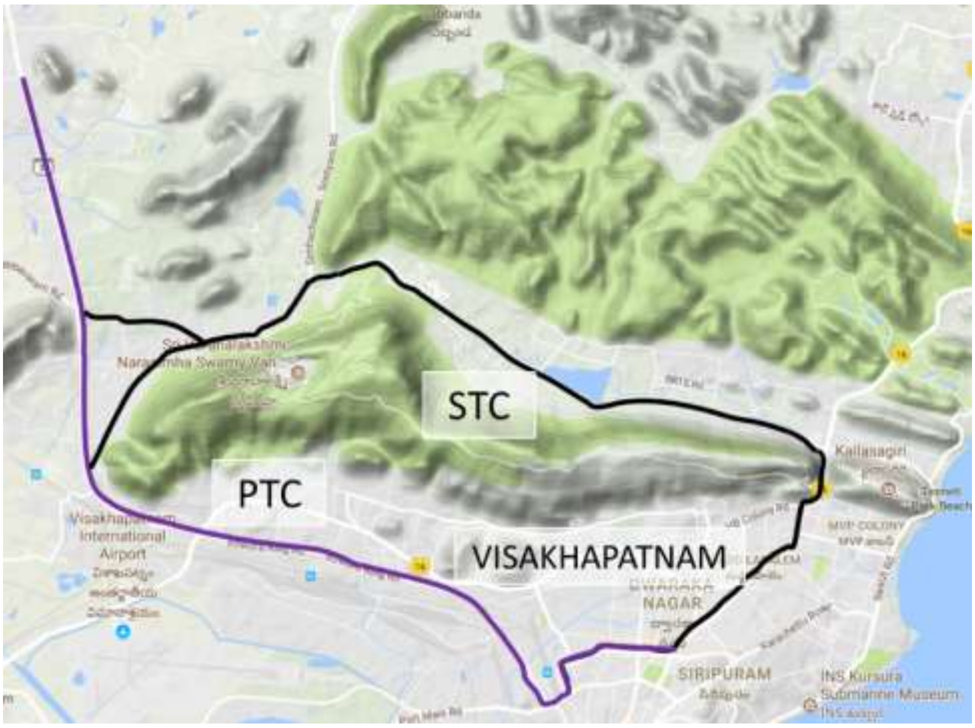

Figure 1: Map of Visakhapatnam showing the STC and PTC

3. EVALUATION OF THE CORRIDOR – ISSUES IDENTIFIED

WRI India undertook a preliminary study and met with the GVMC, Andhra Pradesh State Road Transport Corporation (APSRTC) and Visakhapatnam Smart City to understand the current status of the Visakhapatnam BRT and assess the needs to operationalize the BRTS in the city. Some of the main issues identified have been discussed in this chapter.

a) BRT Stations

Some of the major issues identified with respect to the BRT stations are the bus stop design, capacity and amenities. Capacity of bus stands was found to be lower than the existing demand resulting in commuters having to stand in unshaded areas outside the station. Certain stations also lacked amenities like proper bus route information, seating and security features such as lighting and CCTV.

Figure 2: A typical bus stop along the corridor - Highlighting major issues in at the BRT stations

The height of the platforms at the bus stop range between 0.6 meters to 0.9 meters to 1.2 meters, which do not match the height of bus floor. Buses arriving at the stations were observed to be stopping 2.5 meters to 3 meters away from the bus stop forcing commuters to get onto the road to board the bus reducing safety for commuters and increasing dwell time.

Additionally, the Simhachalam railway station BRT bus stop was non-existent. The image below shows commuters waiting for the bus on the corridor, subject to extremely unsafe conditions.

Figure 3: Commuters waiting for the Bus at Simhachalam railway station BRT bus stop

b) Corridor – Pedestrian Safety

The PTC in Visakhapatnam cuts across the city connecting Pendurthy to the city centre. This has triggered extensive development of residential, commercial and institutional use along the corridor, resulting in a high volume of pedestrian movement along the entire length of the corridor. With access to the BRT stations present at distances ranging from 100-200m from the bus stop and the lack of pedestrian crossings or midblock development, the corridor presents an extremely unsafe environment for pedestrians and commuters using the corridor. Additionally, the BRT infrastructure, by virtue of the guardrails along its length, creates a barrier for pedestrians to cross at ease. If the crossing requirements of pedestrians are not significantly addressed, it could lead to jay-walking across the corridor, or even climbing over the guardrails, resulting in extremely unsafe conditions for pedestrians.

While the BRT corridor in Visakhapatnam has guardrails, these are present only 50 - 100 meters at a stretch on either side of the BRT bus stops. With large stretches of the corridors without appropriate guardrails, pedestrians and commuters in Visakhapatnam interact with both, the mixed traffic lanes and the BRT corridor, increasing the risk of accidents, while reducing the efficiency and speed of BRT buses.

Figure 4: Pedestrians Jaywalking across the BRT corridor

Figure 5: Typical pedestrian movement at NAD junction – Highlighting the lack of pedestrian safety facilities

Additionally, footpaths, proper pedestrian crossing and pedestrian refuge islands are inadequate at junctions. The number of lanes that a pedestrian has to cross at one go is a significant determinant in the risk of an accident. As per the guideline, pedestrians should not be made to cross more than two lanes of traffic without a pedestrian refuge in between. At the NAD junction pedestrians are forced to cross more than six lanes of road traffic without any point of safe refuge in between. The traffic islands are also irregularly shaped with inadequate space and quite high (1.5 feet) for pedestrians to climb onto and wait at.

c) Operations and Financing

To monitor operations of the BRT in Visakhapatnam, a Special Purpose Vehicle was appointed as the nodal agency with the District collector as the chairman, Municipal commissioner as the Chief Executive Officer (CEO) and members from Greater Visakhapatnam Municipal Corporation, the Road Transport Corporation, traffic police and Visakhapatnam Urban Development Authority as directors. The SPV however has been inactive since it was formed and specific stakeholder responsibilities have not been laid out. Additionally, financing mechanisms for both capital and operations cost for the BRT system have also not been finalized, resulting in an inoperative BRT system. However, the BRT infrastructure, since its completion, has been used by the city bus service run by APSRTC.

4. RECOMMENDATIONS

This section highlights some of the main recommendations that can be put in place to counter the issues identified in the previous section.

a) Administrative structure

Due to the lack of a strong administrative structure, the BRT system that has been completed in 2012, has not been operational. The Special Purpose Vehicle that was mandated to be formed is inactive and lack authority. In order to operationalize the BRT at the earliest, the APSRTC an create a temporary BRT cell. unit within its administrative structure that can plan and develop operational plan for the BRT Operations. This would be advantageous as no new infrastructure cost would be required to set up a new BRT from ground up and would be efficient as APSRTC is experienced and is already aware about the demand patterns along the STC and PTC. In the meantime, a formal SPV needs to be constituted with the District collector as the chairman, Municipal commissioner as the CEO and members from Greater Visakhapatnam Municipal Corporation, the Road Transport Corporation, traffic police and Visakhapatnam Urban Development Authority as directors. Upon the formalization of the SPV as the operating agency, the APSRTC can hand over all operations to the SPV.

b) Financing Models

Capital funding:

The current buses running along the corridor, procured as a part of JNNURM, have been used for direct city bus services are not suited for BRT operations. A one-time capital funding from the State government can be used to procure special BRT suited buses.

Operational funding

The operational funding can be recovered through many modes. A majority of the revenue from service comes from fare box collection. This includes the passenger tickets served, monthly pass holders and can be accentuated onto by running chartered services for major office destinations. Advertising on buses and at stations can also be tendered to generate revenue. Setting up parking charges at stations will lead to revenue but if used efficiently can also reduce personnel vehicle usage. Revenue can also be generated by Auctioning Development Rights around bus stops. The proceeds of the sales may be split between the landowner and the transport authority. Subsidies provided on fuel to government run transit agencies are also part of revenue generation receipts. Finally, any costs that are not covered by revenue from the above-mentioned sources need to be covered through government support through viability gap funding.

c) Branding

For the Visakhapatnam BRT, integrating communications into every aspect of the, launch, and operations phases of a BRT system is essential to the success of the project. While it is important to inform citizens in the city about the changes their city is going through, it is also important to take into consideration and customize the system to their needs. With the bus system in the city not being the most popular mode of transport, it is important for the BRT to be branded as a new and unique service. Messaging plays a key role in informing different stakeholders associated with the BRT project of the status and the progress being made. For commuters specifically, messaging needs to be clear, fresh, consistent and positive. It needs to highlight the various characteristics of the system and the potential impact on their quality of commute while also informing commuters of progress being made. It has great potential to attract commuters to the system and keep them involved in the development process.

d) BRT Buses

Vehicles are an important element of conveying system identity and image. In the case of BRT systems, one size definitely does not fit all. Currently in Visakhapatnam, 50 buses had been procured for BRT operations as a part of the JnNURM scheme in 2008. These buses however have been used for direct city bus services since then. Visakhapatnam city bus service covers a total of 83 routes, of which 27 routes either pass through or run along the STC and PTC. Average length of the routes these routes is around 380 to 40 km.

A brief overview of the buses used in the 5 urban depots, Gajuwaka, Maddilapalem, Simhachalam, Steel City and Waltair, that serve urban Visakhapatnam are shown in table 1.

Table 1: Overview of public transport buses owned by APSRTC

Type	Number	Average seating capacity	Average age
City ordinary bus	270	44	9.7
JnNURM – City ordinary	79	43	8.7
City Sheetal – Mini bus	15	33	3.5
Metro Express	37	44	8.2
Semi-low floored	89	43	8.0

While APSRTC owns and operates a total of 490 buses in the city, it is unable to allocate buses specifically for the BRT because:

1. All buses service multiple routes that may or may not include sections on the BRT corridors
2. The buses are relatively old are not very energy efficient
3. The buses are of various types that may not be able to consistently provide services characteristic to BRT systems such as level boarding, boarding and seating for passengers on wheelchairs / disabled.

The following are the vehicle types which can be used in the proposed BRT system with varying capacity.

Table 2: Overview of typical vehicles used for BRT operations

Vehicle type	Typical number of passengers	Typical Vehicle Length (m)
Van	10-16	3
Mini Bus	25-35	6
Standard bus	60-80	12
Articulated Bus	120-170	18
Bi-Articulated Bus	240-270	24

To start with, we recommend using standard buses having capacity between 60 and 70 passengers at a time. The buses operating in the BRT system could be Indian buses, manufactured in India and eventually assembled Visakhapatnam. The city should also consider buses with cleaner technology. With the staggered placement of the BRT stations on either side of the corridor, city has the option of purchasing buses with double doors to the left of the bus while using these primarily as BRT buses that service certain key routes as a part of the direct city bus system as well.

Electric buses

The state of Andhra Pradesh is planning to use and promote electrical vehicles massively, as part of its plans to look at the future of mobility in urban cities. Hence, Visakhapatnam is moving towards adopting electric mobility in its BRT expansion plans. Trip patterns of the city's existing bus services suggest that about only 1.5% of the total ridership of the city is exclusively on the PTC BRT corridor, which is currently being serviced by diesel buses. Analysis of the city bus service ridership data has shown an increasing trend in this number By 2030, according to Clean Mobility Plan (CMP) projections, a total of 108 standard buses is required to migrate this fleet to electric fuel and reduce dependence on fossil fuels. This would also require an extensive charging infrastructure to support the network. The city could explore various types of charging infrastructure including, overnight depot charging, opportunity charging at the bus stations and battery swapping.

Funding Pattern

A detailed breakdown of possible funding patterns is as highlighted in the table 3 and 4.

Table 3: Funding pattern proposed for electric buses

1.	Total Cost of the Project	Rs.	234.9	Cr.
2.	Contribution sought from Department of heavy Industries (DHI)	Rs.	116.4	Cr.
3.	Contribution from State Government/ Department/ Undertakings/Municipal Corporations /Public Authorities/ Bilateral Funding	Rs.	234.9	Cr

Table 4: Cost estimates for rolling stock and charging infrastructure under the FAME scheme

Cost Estimate for Rolling Stock and Charging Infrastructure								
Particulars	Requirement	Quantity (No.s)	Market Price (Cr.)	FAME Incentive – Cost	Incentive	FAME Eligibility	Gap Funding	Cost (Cr.)
Buses (12m, AC)	108 for BRT	108	2	60% of unit cost	129.6	129.6	86.4	216.0
Auto (L1 Category BEV)	100 for BRT, 260 for LMC	100	0.02	Rs. 45,000 (Level 2, Range 80km)	0.5	0.5	1.6	2.0
Car/Cab (Segment Level II)	50, 7 seater cabs for LMC	50	0.11	Rs. 1,24,000 (10% of Market price)	0.6	0.6	4.9	5.5
Total Rolling Stock Cost						**105**	118.5	223.5
Chargers for Buses (Slow Chargers + Fast Chargers)	BRT (30 FC & 54 SC)	54	0.25 for FC & 0.07 for SC	10% of eligible demand incentive for fleet	11.28	11.28	0.02	11.4
AC Smart Chargers for LMC of BRT	10	10	0.07	0.012	0.12	0.12		
Power Dispensing Stations	Will be built for BRT at the stations and for LMC At few locations in the city in collaboration with Smart City or Electricity providers							
Total Charging Infrastructure Cost						11.4	0.02	11.4
Rolling Stock + Charging Infrastructure (BRT + LMC)						**116.4**	**118.52**	**234.9**

e) BRT Stations

BRT stations should be permanent, weather protected facilities that are convenient, comfortable, safe and fully accessible. They should be fully integrated with their surroundings and should be an urban design asset. They should provide a full range of passenger amenities, including shelters, passenger information, off-board ticketing, telephones, lighting and security provisions.

First and foremost, the location for the Simhachalam railway station BRT stop needs to be identified and station needs to be built at the earliest. As model design for the station, within the existing space constraints at the current location is as shown in the image below.

Figure 6: Bus station design

Currently the BRT stations in Visakhapatnam are very simplistic with minimal amenities. We suggest that the stations are primarily fitted with lighting and security features such as CCTV cameras to increase the safety perception for commuters. Additionally, digital/static information systems need to be fitted at all stations with information regarding the bus routes that service the station and the schedule for each of the routes. These displays need to be such that they can be upgraded at a later date to integrate real-time information about BRT locations and ETA, along with the integration of information about the direct city bus services and other modes transport around the bus station.

Station design should integrate BRT, traffic and pedestrian movements and separate them as appropriate and provision for conflict free connections to nearby destinations need to be made. All stations need to be provided a unified design theme; there should be a consistent pattern of station location, configuration and design. The height of the platform in all stations vary from 1 to 1.5 feet. This needs to be uniform and levelled based on the clearance of the new BRT buses being procured.

Station design need to optimize utilization of available space and infrastructure and add onto the same. The current stations are not at same level as the bus floor and thus need to be raised to reduce dwell time while boarding and alighting. Further stations need to be widened at accommodate all passengers within it so that they don't disperse around. It needs to even provide shelter to all passenger in times of rain and harsh weather.

Bus bays, as shown in the schematic below, need to be constructed to ensure that buses are stopping as close to the platform as possible to enable level boarding. Bus drivers need to be trained to stop right in front of the bus stop to ensure that commuters don't have to climb down onto lane before boarding the bus.

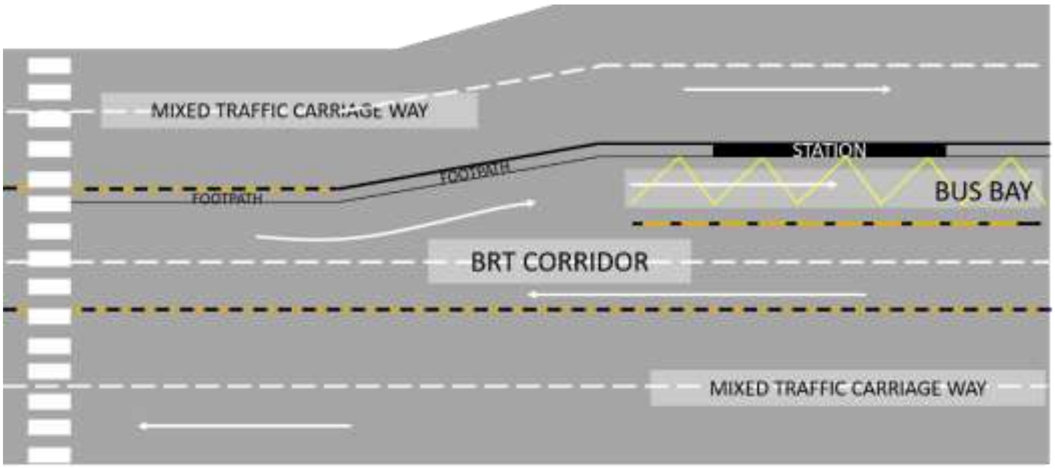

Figure 7: schematic diagram showing the bus bay at a typical BRT station

f) Segregated busways

A BRT system typically improves the traffic safety scenario, because it segregates the movement of buses from all other transport modes, while introducing other changes in the road infrastructure that are associated with safety, such as shorter pedestrian crossings and refuge islands. A central lane BRT places the buses away from the paths of pedestrians and bicyclists, who are the most vulnerable roads users. Thus, a well-executed BRT has the potential to significantly reduce road accidents. However, in case of BRT network at Visakhapatnam, road safety features have the potential to be improved to a great extent. The present network does not take into consideration accessibility to the corridor, commercial activity and local interaction around the corridor. Passenger safety needs to be considered an important parameter while operationalizing the corridor.

We recommend that a systemic study be conducted to evaluate the high crossing zones. As much importance must be given to analyzing pedestrian movements as is given to analyzing traffic movement.

Barricades

Barricades enforce the exclusive right of way of the busway. This helps in achieving high vehicle speeds along the corridor. But an infringement of busway by private vehicles as in the case of Visakhapatnam, does much harm to the BRT speeds and overall performance. With no control on access into the lane, mixed traffic vehicles enter into the system, leading to a breakdown in the appearance of enforcement further leading to mass violations of the exclusive space.

The current system employs 0.15 meters high divider with steel barricades up to 1.2 metres height to restrict public movement into and out of corridor. These barricades being irregular and only present near bus stops encourage unsafe pedestrian crossing. The current barricades are also not movable discouraging any kind of updating/widening in the future. The barricades can be made movable at places to allow for vehicle to move out of the lane in case of emergency. Even rounding off the curbing material inside the busway side and a sharp edge onto the mixed traffic lane can help buses to move out of lane in case of emergency.

Figure 8: Before and after barricading of an existing section of the PTC

The current system employs stone blocks at places which can get damaged/dislocated over time creating hazardous obstacles on the roadway and undermining the barrier function. Several mechanisms can be utilized to discourage private-vehicle use of the busway: Clear signage noting busway-use only; Distinctive coloration of the lanes; Median differentiation between the mixed traffic lanes and the busway.

CCTV tracking and fining of offenders may also have to be considered to protect the integrity of the dedicated bus lanes, highlighting the role of the traffic police in monitoring and enforcing the exclusivity of the busway.

Pedestrian crossings

A systematic study to evaluate the high crossing zones needs to be conducted and equal importance must be given to analyzing pedestrian movement and traffic movement. For the case of the corridor in Visakhapatnam with extensive edge development, a pedestrian crossing must be provided every 100 -150 meters. The exact location can be determined by local demand and space considerations.

As prescribed in the Road safety guideline prepared by WRI India for BRT infrastructure, any road with extensive edge development must have a pedestrian crossing every 100-150 meters. The exact location of the crossing should be determined by the local demand and space considerations. Pedestrians crossings should also be signal controlled where pedestrian and vehicular traffic is high. The crossings be supplemented with speed tables to induce motorists to drive at the design speed. The height of speed table should be same as the height of the footpath to allow for wheelchair access.

The number of lanes that a pedestrian is made to cross at one go is a significant determinant in the risk of an accident. In this case, with almost 6 lanes to cross. We recommend that pedestrian refuges be built. This would be to accommodate for slow moving pedestrians and non-motorized transport (NMT) vehicles which may not be able to cross the full length of road in one go. The pedestrian refuge should be wide enough to accommodate the wider NMT vehicles. Bollards can be provided along the centre line of the pedestrian crossings, wherever appropriate, to prevent vehicles from illegally using the crossing to make a U turn. The spacing between the bollards must be enough to let larger NMT vehicles to pass through.

g) Junction design

Intersections can cause significant delays in BRT operations, particularly by hindering station access, as they are the points where the BRT project has the largest perceived impact on mixed traffic and walking. An important strategy to improve the performance of intersections to better accommodate public transport, pedestrians, and other vehicles is to monitor and design general-traffic turning movements at intersections.

Junction design

Junction design needs to be considered with priority given to the BRT lane. Lane alignment has to be checked for any bottleneck while traffic movement.

The NAD junction, along the PTC, was selected as an example for this study. Some of the major issues identified include, Improper lane orientation and BRT lane segregation, large pedestrian crossing distances, lack of or poor protected pedestrian waiting areas and absence of pedestrian crossings at certain areas.

In order to improve this intersection, we recommend setting up of pedestrian refuges, clearly marking and signaling pedestrian crossings, ensuring complete segregation of BRT lanes from mixed traffic, reducing turning radii, improve access to BRT bus stops and ensuring proper lane orientation.

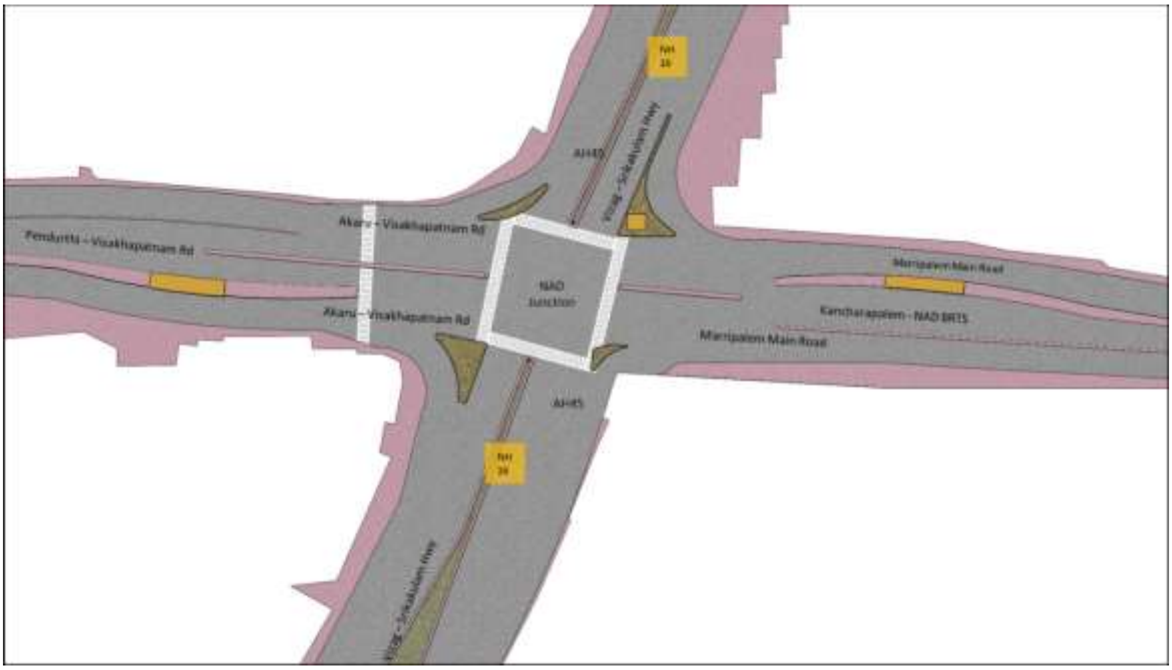

Figure 9: Existing design of NAD junction

The below image highlights some of the major areas redesigned at the NAD junction.

1. Traffic islands have been redesigned in consideration with adjoining lanes and movement of traffic therein. The islands have been designed to accommodate maximum number of expected pedestrians with additional safety measures around.
2. Accessibility to these have also been improved by linking with footpath and zebra crossings. Properly aligned pedestrian crossings and safe refuge areas at optimum distance need to be provided for pedestrians for safe movement of people.
3. Footpaths around the junctions have been widened to supplement safe movement of people around the junction.

4. Safer crossings need to be provided from footpath to the bus stands in the centre for movement of people.
5. Table top pedestrian crossings at turnings have also been added to allow for improved safety by ensuring lower motor vehicle speeds.
6. In order to ensure proper lane orientation and consistent speeds on the BRT, permanent lane segregation has been incorporated into the design.
7. Additionally, segregated bus bays have also been added at the BRT stations.

Figure 10: Improved junction design at NAD junction

h) Operational Plan

Upon closer inspection of the operations of the existing bus system and the PTC for the months of July and August 2017, in Visakhapatnam, it has been seen that only 1.42% of all trips in the city originate and end on the PTC while an additional 19.26% use the stations on the corridor as an origin or destination station only. The remaining 79.32% of trips do not use the corridor.

Table 5: Ridership patterns of public bus transport in Visakhapatnam

	July	August
I-I	1,16,667	1,27,297
I-X/X-I	15,83,397	16,71,243
X-X	65,19,027	70,39,493
Total	82,19,091	88,38,033

Here,

- I-I indicates trips that both start and end within the BRT corridors
- I-X indicates trips that start on the BRT corridor and ends in other parts of the city
- X-I indicates trips that start in other parts of the city but end on the BRT corridors
- X-X indicate trips that bots start and end outside the corridors.

There are three options in terms of overall service structure: Trunk feeder services; Direct services & mix of trunk feeder and direct services ("hybrid" services). Trunk feeder services utilize smaller vehicles in lower density areas and utilize larger vehicles along higher density corridors. The smaller vehicles thus "feed" passengers to the larger "trunk" corridors. Direct services will have less need for feeder vehicles and transfers, generally taking passengers directly from their origin to a main corridor without the need for a transfer. A service employing both the trunk services and a few buses also doing direct service but also linking major points along the trunk corridor is called a hybrid system.

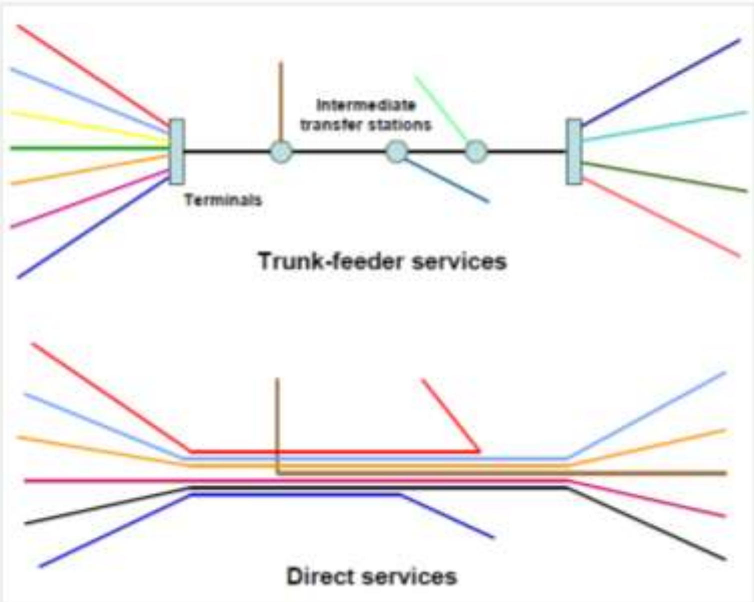

Figure 11: Schematic diagram showing different operations plans

Based on the demand analysis presented above, it is evident that a trunk and feeder system for the full stretch of the corridor will not be applicable. A combined direct and trunk and feeder system has the potential to improve travel time and quality of commute. A more in-depth route level analysis needs to be conducted to identify specific sections of the corridor with greatest demand that can be serviced by trunk services while direct city bus services operate at the remaining stations.

5. CONCLUSION

The improvements proposed in this report address each of the major concerns highlighted above. They aim at operationalizing the BRT and supporting the system to improve mobility in the city. We suggest a two-phase approach to the implementation of the recommendations with Phase 1 based on immediate need of the system to be operationalized and safety of pedestrians and commuters and Phase 2 on improved operational efficiency of the system.

Phase 1

1. Administrative structure: Set up a temporary BRT cell/unit within APSRTC, the transit agency that is current managing city bus services. APSRTC can take charge of and design BRT operations, plan and design the services in conjunction with the direct city bus operations.
2. Financial plan: The operating agency can apply for a one-time state grant to purchase specialized BRT buses.
3. Branding: The BRT needs to be re-branded as a high speed, high efficiency and comfortable service to improve the perception of the system and to attract commuters.
4. BRT Buses: The buses that are procured need to be standard double door, 12 m buses with 50 – 60 passenger capacities. The buses also need to be low floored with a 900mm clearance or high floored vehicles with provision for access for the disabled.
5. BRT Stations:
    a. While most bus stations along the PTC and STC lack amenities such as signage, lighting, seating and off-board ticketing, the Simhachalam railway station BRT bus stop is non-existent. This station needs to be built at a suitable location at the earliest to ensure the safety of commuters that are currently waiting for the bus on the corridor.
    b. All BRT stations need to be fitted with information systems showing either static bus schedules or real-time information on the arrival time of the buses.
6. Segregated bus ways:
    a. Pedestrian crossings, either on ground, over-head or underground walk ways, need to be provided at regular intervals of 150m to 200m along the length of the corridor.
    b. Smart traffic signals need to be installed at all traffic junctions that are programmed with BRT priority to improved efficiency.
7. Operational Plan: Based on the current usage of the city bus operations along the corridor, only 20.8% of all trips either start or end along the STC or PTC. This demand has however shown a growing trend and is expected to increase. A combination of direct and trunk and feeder system has the potential to improve travel time and quality of commute.

Phase 2

1. Administrative structure: Formation and authorization of the SPV as the nodal agency to manage the BRT, with the District collector as the chairman, Municipal commissioner as the CEO and members from Greater Visakhapatnam Municipal Corporation, the Road Transport Corporation, traffic police and Visakhapatnam Urban Development Authority as directors.
2. Financial model: Apart from the fare box revenue collected, the operating agency can explore revenue sources through fuel cess, land development rights for densification around BRT corridor, Advertising on their buses & buildings owned by the authority and parking charges for the operations and maintenance of the BRT system. Costs exceeding this amount can be recuperated by applying for viability gap funding for BRT operations from the state government.
3. BRT Buses: Electric buses can be tested and procured for BRT operations.
4. BRT stations:
    a. All stations must be fitted with digital information systems with real-time information regarding bus timings and schedules.

   b. Additionally, to improve safety and comfort at the stations, CCTV cameras, appropriate lighting and seating facilities need to be installed.
5. Intersection design:
   a. Traffic islands need to be redesigned to accommodate larger number of pedestrians with additional safety measures.
   b. Improved pedestrian crossing and sidewalk infrastructure is needed.
   c. Table top pedestrian crossings at turnings to reduce vehicle speeds.
   d. Permanent lane segregation at the junction to segregate the BTR from the mixed traffic.
6. Segregated bus ways:
   a. The entire length of the corridor needs to be barricaded to improve safety for commuters and pedestrians interacting with the corridor.
   b. To enable efficient BRT services and ensure pedestrian safety, all crossings need to be signaled.
   c. Bus bays need to be added at the BRT stations.
7. Operational Plan: A trunk and feeder system can be explored based on a demand assessment study conducted based on a minimum of 8 to 12 months of operations data. If the number of trips both starting and ending on the corridor is a minimum of 40%, trunk and feeder services have the potential to greatly improve commuting time and operational efficiency.

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