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Bus Priority System for Bengaluru

Concept Paper

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3/23/2011

Summary of quick win concepts to increase relative speed of Bus transit in Bengaluru via implementation of a part-BRT system on select arterial routes.

CONTENTS

INTRODUCTION

WHAT IS BUS PRIORITY SYSTEM

Bus Priority System (BPS) is a collection of quick win concepts that can be implemented to win more commuters for Bus transit in Bengaluru. These concepts provide cost-effective and visible measures to increase average speed of movement of Buses on arterial routes of Bengaluru.

WHY PRIORITY?

Buses operating in mixed traffic lanes are subject to delay caused by congestion, which reduces the appeal of bus transit. Dedicated bus lanes can provide excellent right-of-way to Buses, but the reduction in private vehicle capacity can only be justified along roads with consistent accommodating width. Further, building dedicated bus lanes may either be infeasible or too expensive for narrow arterial roads of Bengaluru.

The Bus Priority System (BPS) concepts described in this paper provide a compromise between dedicated bus lanes and buses operating in mixed traffic conditions. The goal of BPS is to cause a visible and effective increase in average speed of Buses on select arterial routes of Bengaluru.

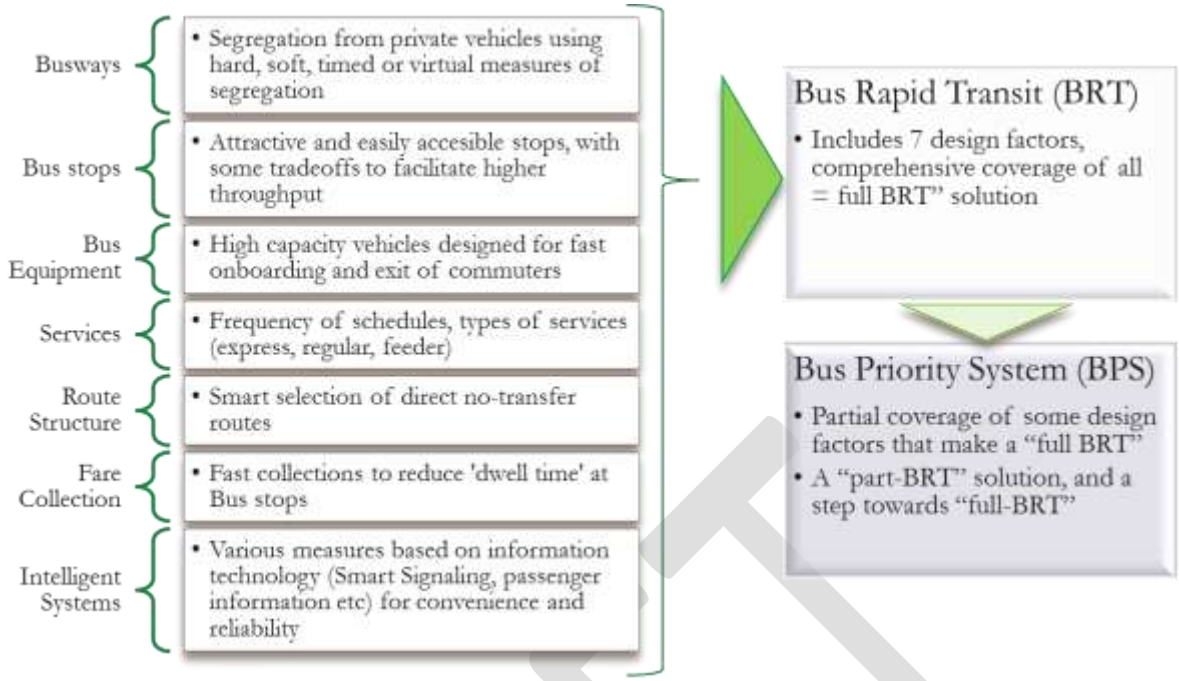
WHAT THIS PAPER IS NOT

Besides priority, there are other complimentary measures related to quality of service, routing and connectivity that make Bus transit even more compelling for commuters. While some of these have been touched upon in this paper, the objective is to focus on a few cost-effective, easy to implement and scalable measures to increase effective speed of Buses on select arterial routes of Bengaluru.

BPS CONCEPT AND BUS RAPID TRANSIT (BRT)

PART-BRT SOLUTION

Bus Priority System (BPS) is not an alternative to the popular Bus Rapid Transit (BRT) solutions. There are seven major components of BRT system. All of these implemented as per reference system from Curitiba would lead to what is referred to as “full-BRT” solution. BPS is to be visualized as a cheaper and easily implementable version that does not require all components of a BRT system.



A POSSIBLE STEP TOWARDS FULL-BRT

BPS is also to be seen as the first step towards "full-BRT". Depending on the characteristics, some traffic corridors in Bengaluru may be good candidates for "full-BRT", like Outer Ring Road, Bellary Road, Peripheral Road. However, it has been acknowledged by BBMP and BMTC (reference: news reports, BPS Seminar at CiSTUP, IISc, Jan 11 2011) that the radial arterial routes that connect to the CBD have constraints that inhibit implementation of "full-BRT" systems. BPS should be considered as a solution for such corridors.

BPS CASE STUDIES

Though "full BRT" is a more popular subject, priority measures for Bus are in operation at several metropolitan cities around in Western Europe, Canada, United States and Japan.

- London: Descriptions and history of London Bus Priority Network (LBPN), and "Red routes" are available in multiple publications. Priority measures in London has increased patronage, reduced accident rate on roads, and reduced congestion on select corridors. (reference #15)
- West Midlands (near Birmingham) pilot on 3 routes to develop a "Bus showcase" network increased bus-patronage by 10.3% to 22.8% where 6-13% of converts were former car users. (reference #14)
- Bus Priority measures in Leeds City Centre reduced journey times on outbound services – "inbound buses saved between 10 and 30 per cent on previous journey times". (reference #14)
- Los Angeles, several changes were made to the transit system including, low floor buses, signal priority, and a reduction in the number of stops. Overall benefits from all changes: a 20-27% reduction in travel time. Benefit due to signal priority estimated (subjectively) to be 30 to 40% of this reduction. (Reference #4)
- Ottawa and Zurich too have Bus priority measures in place and these have been described as successful in various journals and publications. (multiple references)
- Springfield, Mass., US: The Green Light Special service has reduced travel time across the entire route by nearly 15 minutes; from 45 minutes to 30 minutes. This time savings is a combination of the route's limited stop and I-91 express operations, more efficient routing and the Transit Signal Priority System. (Reference #12)

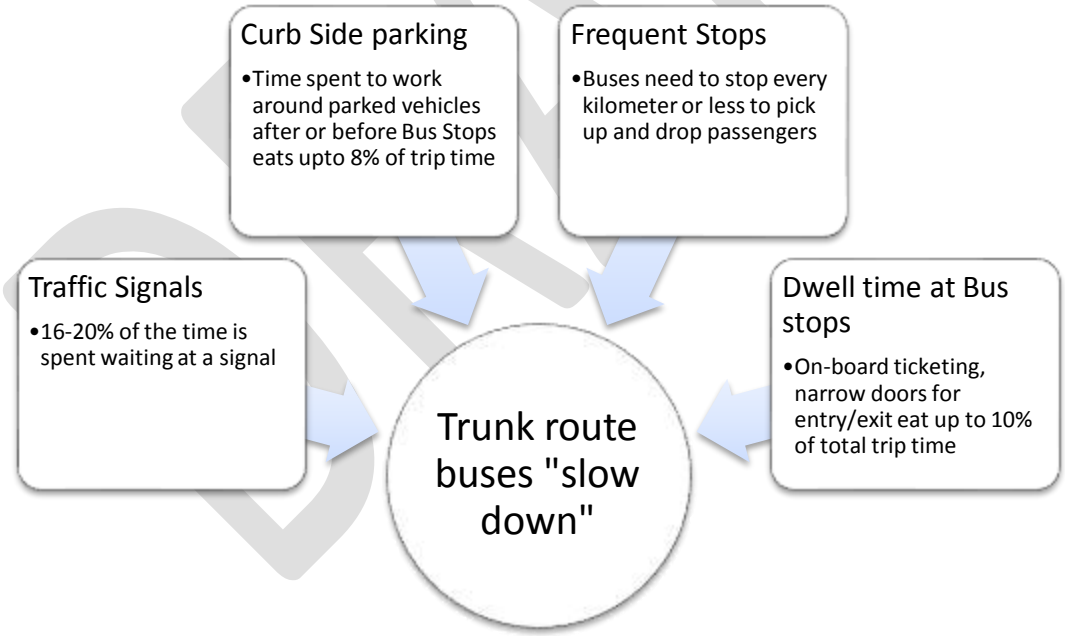
- San Francisco: Depending on the location and extent of measures, there was a 6 to 25% reduction in transit signal delay. (Reference #5)

We can pick design elements from case studies at cities with comparable traffic density to conceptualize BPS from Bengaluru.

DESIGN DRIVERS FOR BPS

Buses waiting in traffic queue (towards Whitefield) before Kundalahalli Signal. The queue is more than 1 KM in length in the morning hours

There are a lot of factors that "slow down" a Bus on roads of Bengaluru. Following diagram shows four of them that can be addressed in practical and cost effective ways.



BPS is a collection of measures that work on these four slow down factors.

DESIGN GOALS

Field trips were conducted on a sample route (G1/333E) to collect time data on Bus movement, and time spent due to the four direct slow down factors described above. Table below provides further summary of these "slow down" factors.

Slow down factor	Share of trip time	Can be reduced to
Traffic Signals	16-28%	11-14%
Curb side parking	8-10%	5%
Frequent stops (excluding dwell time)	6-9%	3-4%
Dwell Time at Bus stops	13-21%	6-11%

These time estimates are based on data collected on field trips.

- Timings were recorded on total of 16 field trips done on G1 or 333E.
- 12 trips were done in semi-peak hours (around 10 AM or 5 PM), 4 in peak hours (9 AM, 6.30 PM)
- 7 trips were end to end (Tubarahalli to Richmond flyover), 5 medium distance (HAL Airport to Richmond flyover, 4 short distance (HAL Kalyana Mantapa to Tubarahalli)
- Total time "spent" at stops was divided 70:30 into Dwell time (door open to door close) and the rest (deceleration, acceleration, any waits with closed doors).
- "Can be reduced to" are estimated values based on time that would be taken with BPS measures described in this paper.

ESTIMATED IMPACT

Following table shows the targeted reduction in "drag" due to these slow down factors, and estimated impact on the 90 minute trip time route that was studied as part of this paper.

Aggregated Drag	Current	Targeted	Estimated time saved on 90 minute run
Range	43-69%	25-34%	18-35%, or 16 to 31 minutes

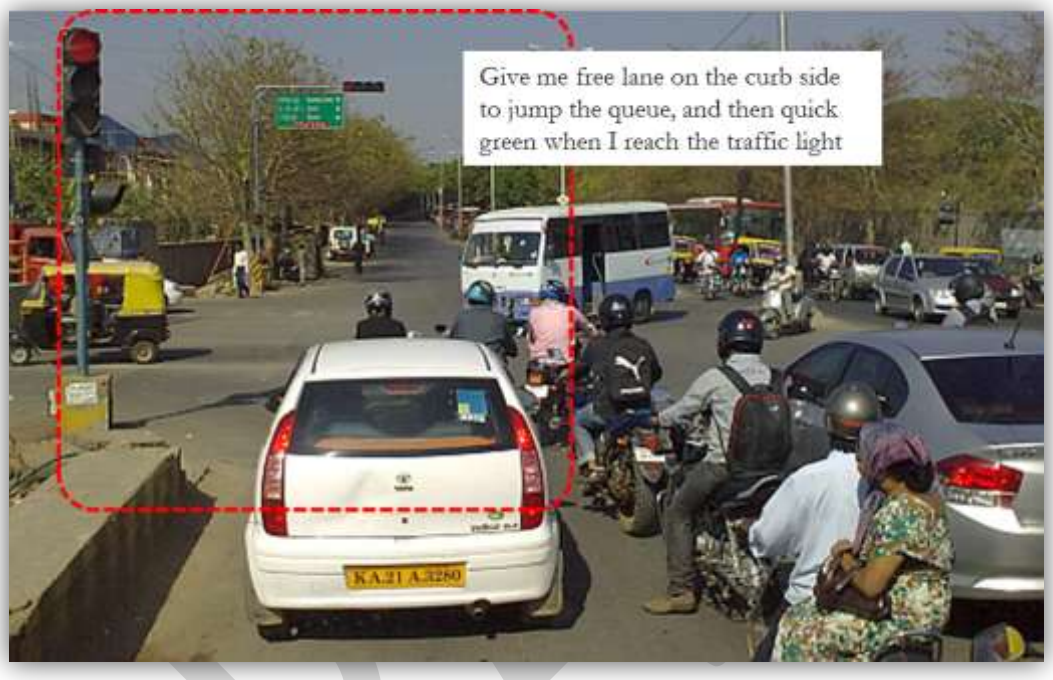
TIME GAIN MEASUREMENT - RISKS

BPS measures could lead to increased adoption of Buses on the chosen routes. Increased adoption would lead to increase in dwell times, and demands for increase in number of additional express bus stops. These would have negative effect on journey time improvements effected by BPS.

DESIGN ELEMENTS

The BPS concept relies on multiple preferential or priority measures that make bus movement more competitive vis-à-vis private vehicles. Design parameters of these elements would be decided based on the bus frequency and throughput goals for the trunk route.

TRAFFIC SIGNALS

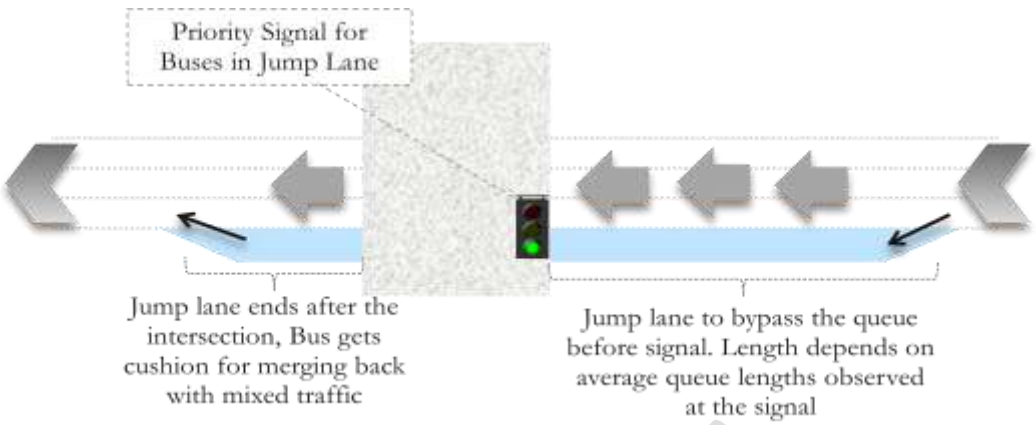


Statistically speaking, traffic signals are the biggest drag on smooth movement of Buses. Further, heavy and large nature of buses, with slower acceleration than cars and two wheelers make it harder for the Bus to edge ahead of the traffic before or after signals.

QUEUE JUMP LANE

Along with rest of the traffic, Buses spend significant time waiting on signals. A special lane on the curb side can help Buses bypass the queues that build up before traffic signals. The special lanes, designed to make Buses 'jump' the queue are called "Queue Jump Lanes" (QJL).

Queue Jump Lanes (QJL) combined with Traffic Signal priority (TSP) for Buses can be doubly effective in prioritizing Bus over regular traffic at 3 way and 4 way intersections on corridors.



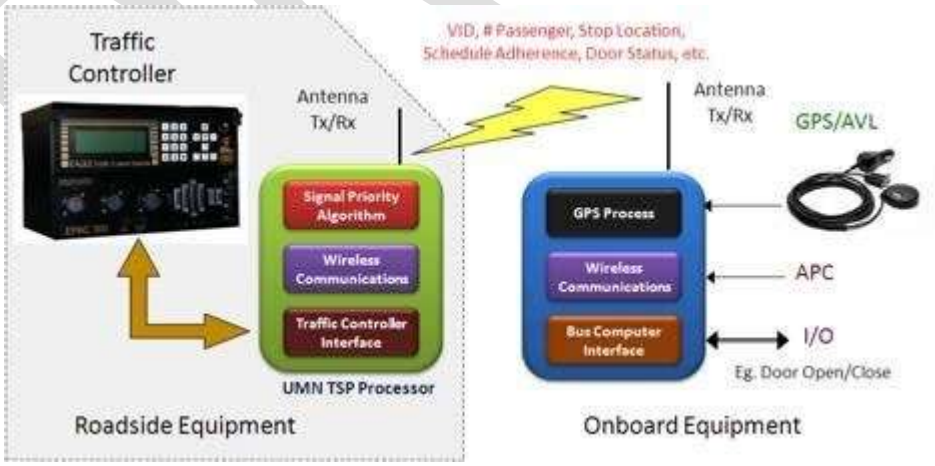
Queue length observed before congested signals range from 10-25 cars. Assuming average car length to be 12 feet, length of QJL would range from 120-250 feet. Further, positioning of Bus stops would have to be on the far-side at least 4 bus-lengths after the signal so that the TSP activated greens are not "wasted" even if up to 4 buses arrive in a bunch.

TRAFFIC SIGNAL PRIORITY

Traffic Signal Priority (TSP, sometimes also referred to as Transit Signal Priority) is sensor-based intelligent system where TSP module installed on the Bus communicates with a traffic signal to activate it. Simple implementations rely on direct wireless communication between the Bus and Traffic Signal. Advanced implementations involve feeding of Bus location data (via GPS) to Traffic Signals.

TSP would introduce traffic rules that give buses priority when re-entering traffic, staggered stop lines and special bus lanes and traffic signals that give transit vehicles a head start in traffic queues at intersections, and technologies that allow buses to activate green lights on traffic signals.

TSP could be designed for "early phase activation" (return to green expedited for QJL when bus approach is detected) along with "phase extension" (green time extended for QJL when bus approach is detected).

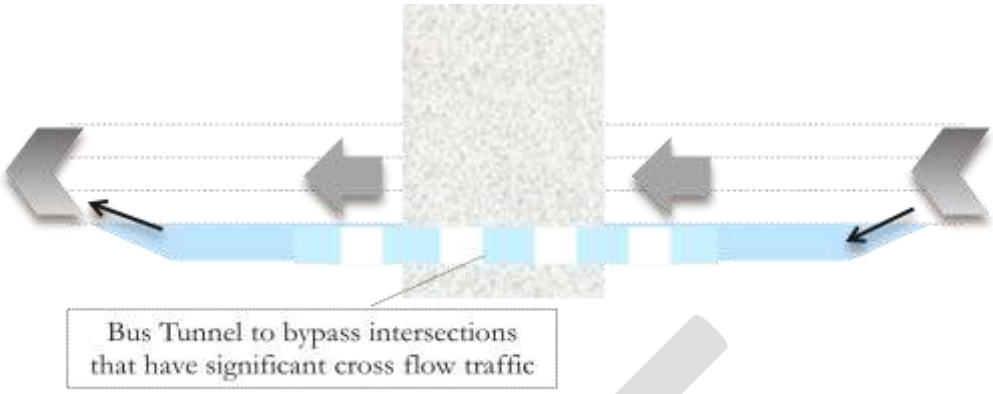


TSP should be combined with QJL to derive maximum benefits at intersections on arterial corridors.

BUS TUNNEL

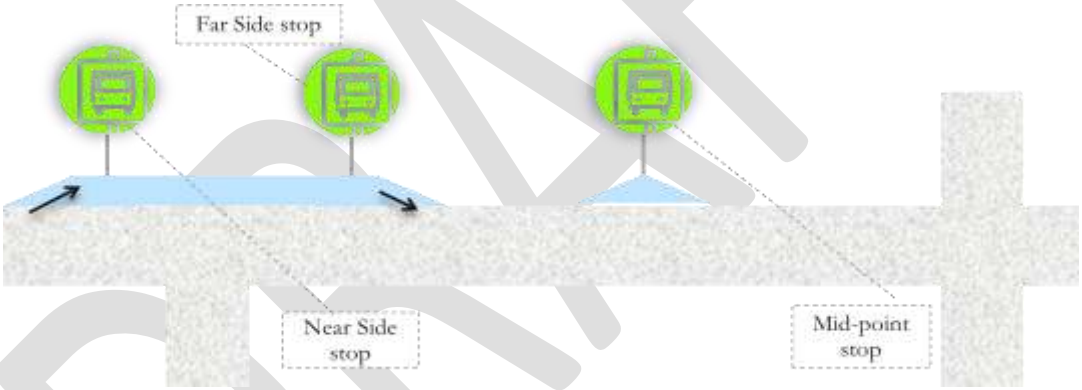
Simulations and research indicates that at intersections with significant cross flow volume and pedestrian movements, Traffic Signal Priority could introduce significant wait time for cross flow traffic.

Such intersections are likely to be found when arterial road go through dense business districts or commercial areas. Bus Tunnels can be used to bypass the intersection and provide preferential treatment to the bus.



MID-POINT PLACEMENT OF BUS STOPS

Bus stops placed on the near-side of a signal (as in before a signal) would cause a regular or TSP activated green to be "wasted". And if far-side bus stops are placed too close to the signal, "troop movement" of buses (many buses moving one after another, either by design, or due to unplanned bunching) could block the intersection.



Placing the Bus stops as close to the mid-point between two intersections would be ideal for routes where BPS would be implemented.

CURB SIDE PARKING

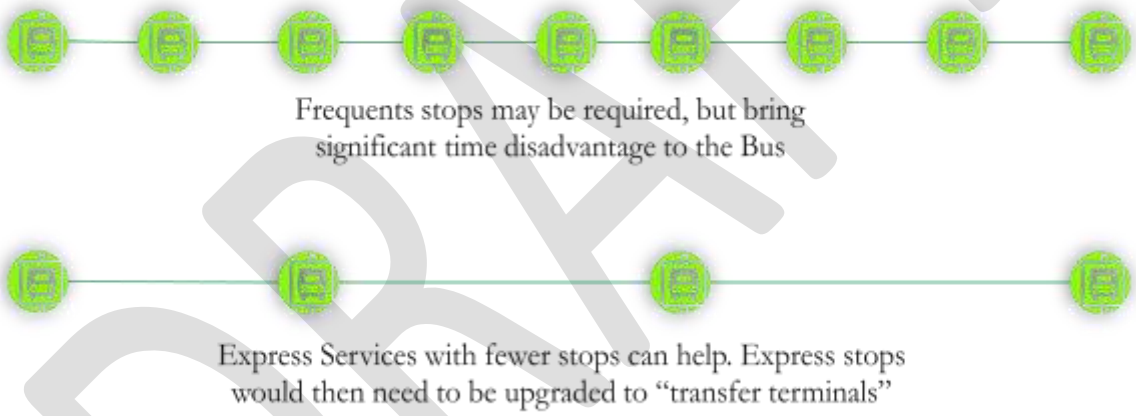
VIRTUAL BUS LANE WITH PARKING ENFORCEMENT

Strict enforcement of parking during commute hours, barriers to keep pedestrians on pavements, coupled with road engineering measures to ensure consisted width of curb-side lane could provide us "virtual" Bus Lane during commute hours. During non-peak hours, the virtual bus lanes would be used for mixed traffic or parking.

FREQUENT STOPS

EXPRESS SERVICES

Express services that would halt at fewer Bus Stops could help reduce travel time for long commutes.



Express Services would stop only at large transfer Terminals, where they would connect with feeder services.

> 333P (Vajra service) runs on the same route as 333E, but covers the distance 20-30% faster, primarily because the service (by virtue of being expensive) stops at fewer stations than 333E. The "express service" concept is thus already in existence, but benefits only those commuters who can afford Vajra fares.

DWELL TIME AT BUS STOPS

Wide double width door, with holding space for just boarded or about to exit passengers

Driver's collecting fares themselves isn't very common, but even with a conductor, considerable time is spent in collecting fares

WIDER LOW FLOOR DOORS

Following procurement criteria for the Bus equipment would further increase the dwell time at Bus stops

- Wider doors both at the front and back side of the Bus.
- Low floor holding area for passengers to stand and wait just before their Bus stop.

Based on observations at Maratahalli and HAL Airport Bus Stops, 6-8 people boarding and 6-8 people exiting takes 40% less time for 333P/335EBuses (Volvo equipment with two double width low floor doors) as compared to G1 Buses (semi low floor Ashok Leyland equipment with single width door at front, and double width door at back, both without low floor holding area for standing passengers).

BUS OVERTAKING LANES (OPTIONAL)

For express-services, wherever possible, an extra lane to allow them to overtake regular and feeder services would reduce time spent waiting behind another Bus. Operational and enforcement measures to ensure that only Express services Bus are permitted to overtake any other Bus are also recommended.

The recommendation is marked optional as Bengaluru does not have concept of express services. Further, the concept involves enforcement measures that may be hard to implement and enforce in present day situation.

OFF BOARD OR ELECTRONIC TICKETING (OPTIONAL)

Faster fare collection mechanisms can reduce the dwell time at Bus Stops. Two options available are

- Off board Ticketing: Commuter to buy tickets before boarding the bus
- Electronic Ticketing: Pre-paid smart cards as tickets.

The recommendation is marked optional as BMTC conductors issue tickets after boarding is complete and Bus starts moving. Except for the cases where drivers issue tickets by themselves, it is arguable if on-board ticketing introduces significant delays in Bus movement.

ENFORCEMENT ELEMENTS

For Indian traffic conditions, measures like Queue Jump Lanes, Bus tunnels and Virtual Bus Lane would need measures to aid in enforcing the segregations.

SIGNAL MOUNTED STATIC CAMERAS

Bangalore traffic police is already using signal mounted cameras to aid in enforcing signal discipline. Same would need to be made available on all intersections that would be taken up for QJL and TSP.

BUS MOUNTED CAMERAS

To monitor and enforce VBL and also QJL, cameras mounted on the front side of Bus can take pictures of blocking or parked vehicles. Pictures can be clicked by automated sensors (expensive), or manually by the driver (cheaper option). Further, to cut costs, only some (say, 1 in 4) of the Buses need to have the actual cameras mounted, rest could have dummy replica mounts as deterrents.

SEGREGATION MESSAGING BOARDS

Variable messaging boards at the start and end of segregation zones would communicate the location and effective hours of operation of Queue Jump and Virtual Bus Lanes. These message boards would have the same technology that would be used by the Traffic Priority System (TPS)

- The message boards would have approach sensors that can communicate only with the approaching BPS Buses.
- Upon sensing approach from any vehicle that doesn't have the corresponding wireless equipment, the sensors could flash warnings.

SUMMARY OF DESIGN ELEMENTS

The table below provides a summary of all design elements proposed as part of the BPS concept

Element	Slow down Factor addressed	Relative cost	Enforcement effort required
Jump Lane with Priority Signals	Signals	Medium	Medium
Bus Tunnel	Signals	High	Low
Curb side virtual lane	Parked vehicles	Low	High
Mid-side placement of Bus Stops	Bus Stops	Low	Low
Express Services	Bus Stops	Low	Low
Off Board/Electronic Ticketing	Dwell Time at Stops	Medium	Medium
Wider low floor doors	Dwell time at Stops	High #	- None -

PILOT PROPOSAL

ROUTE G1 – WHY?

Bengaluru is already invested in Big-10, a distinctly branded and successful initiative to market a fixed number of radial trunk routes to commuters. These routes (12) are natural candidates for piloting BPS.

However, large portions of many of these 12 Big-10 routes are earmarked for sizable public transport investments like Metro, High Speed Rail, or Mono. Radial route G1, running along Old Airport Road is:

- Currently not marked for any sizable investments
- Key connectivity to fast growing suburban catchment region (Whitefield)

We used 333E which overlaps with most of G1 as a sample for studying and piloting the BPS concepts.

IMPORTANT CAVEAT - SIGNAL FREE CORRIDOR

If G1 route (Old Airport Road, Varthur Road) is made completely signal free, the traffic signal related BPS design elements will become redundant. In absence of significant choke points where Buses can get priority treatment, BPS ***may not be able to*** make G1 competitive enough to private vehicles.

In case all signals are eliminated from route G1, we will only be left with service and operational tweaks (express services, Mid-point Bus Stops etc.). In that case, it is recommended that extra lane width acquired as part of signal free project be developed as dedicated bus lanes and full-BRT be considered as the solution for the route.

DESIGN GOALS

Total length of route (333E from Hope Farm Circle to Richmond Flyover) that has been studied in this paper is about 16KM. Average trip time recorded on this stretch during peak commute hours is 78 minutes. Thus, the average speed during peak hours is ~ 12 KM / hour.

- The primary design goal of BPS Pilot is to increase the average speed during peak hours by 20%, to 14.5 KM / hour.
- The secondary goal is to build priority measures that are visible to private vehicle users. These visible measures would create positive relative perception of G1 services.

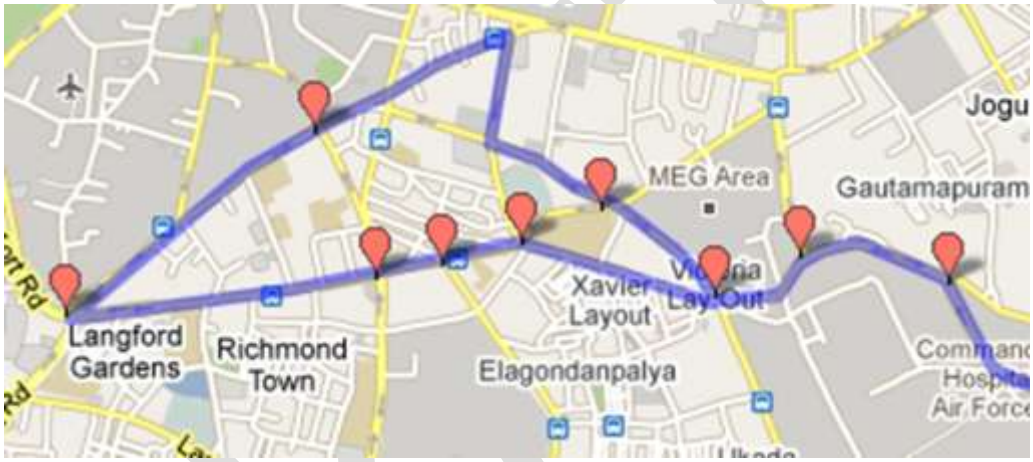
ROUTE ANALYSIS – TRAFFIC HOT SPOTS

Route 333E, excluding a few points at the start and end, goes through three distinct regions

1. Inner CBD – Till Inner Ring Road
2. Outer CBD – Inner Ring Road till Outer Ring Road
3. Beyond CBD - Outer Ring Road area and beyond

INNER CBD – 9 SPOTS

Based on times recorded on field trips, 9 candidate spots emerge in the Inner CBD area. Route map below shows these spots marked, from Richmond Flyover till start of Old Airport Road:



Amongst these 9, the top-4 in terms of "queues" seen during peak commute hours are:

1. Richmond Road/Hosur Road
2. Lifestyle signal
3. Lower Agram Road/Victoria Road
4. Trinity Church Road/Old Airport Road

OUTER CBD – 7 SPOTS

7 spots based on wait times recorded on field trips

Amongst these 7, the top-3 in terms of queues seen during peak hours are:

1. Wind Tunnel road signal
2. Suranjan Das road signal
3. Domlur 7th cross road signal

BEYOND CBD – 6 SPOTS

6 candidate spots were noted in the region beyond the CBD, from Marathahalli, till Hope Farm Circle.

Amongst these 7, the top-3 in terms of queues seen during peak hours are:

1. Kundalahalli Gate Signal
2. Marathahalli CT Road (main bus stand)
3. Marathahalli Outer Ring Road

APPLYING BPS ELEMENTS

SUMMARY OF TOP HOT SPOTS

From the list of 22 hot spots observed in the inner-CBD, outer-CBD and beyond-CBD stretches of 333E route from Richmond Flyover to Hope Farm junction, 10 were narrowed down for more observation and analysis. Summary is provided below.

Area	Spot	BPS Considerations
Inner CBD	Richmond Road/Hosur Road	Significant cross road traffic (another Big-10 route intersects), but enough width for QJL
	Lifestyle signal	Mostly one way flow, candidate for QJL before signal, and VBL till Vellara junction
	Museum Road / FM Cariappa Road	Cross traffic of relatively less volume and significance, candidate for QJL with TSP
	Trinity Church Road/Old Airport Road	Free pass QJL possible for route towards Richmond Road, also for route towards Domlur
Outer CBD	Wind Tunnel road signal	Candidate for QJL with TSP
	Suranjan Das road signal	If cross traffic is determined to be significant, then this signal is a candidate for Bus Tunnel, or else, just QJL without TSP
	Domlur 7thcross road signal	Candidate for QJL and TSP, cross traffic has to be encouraged to use the nearby flyover
Beyond CBD	Kundalahalli Gate Signal	Candidate for QJL only for route coming in towards Marathahalli. Special application of TSP possible
	Marathahalli CT Road (main bus stand)	Candidate for Virtual Bus Lane with parking enforcements
	Marathahalli Outer Ring Road	Candidate for QJL with TSP

5 HOT SPOTS, DETAILED FOR BPS

From the narrowed down list of 10 busy spots, following 5 were picked for applying BPS concepts. (starting from Outer Ring road, coming in towards the CBD):

1. Marathahalli Market Area (CT Road area near Marathahalli bus stop, through to Outer Ring Road)
2. Suranjan Das Road signal, eastbound
3. Wind Tunnel Road signal
4. Lifestyle Signal
5. Start of Richmond Road (Vellara Junction)

MARATHAHALLI MARKET AREA

Outer Ring Road signal and the dense section near Marathahalli main bus stop are the two big choke points for the Bus in this area.

Old Airport Road has 3 lanes worth of width around the ORR signal. Curb Side lane can be re-designated as QJL. The QJLs on both sides can be used as the free left turn lane for rest of the traffic.

ORR SIGNAL, GOING EAST

A Queue Jump Lane of 15 car lengths, or 225 feet, or 80 meters would take Buses straight to the signal. Curb side parking enforcement would create the space for QJL. Traffic turning left into ORR would also use this free pass.

ORR SIGNAL, COMING IN WEST

A 70 meter long QJL starting after the railway over-bridge ends would take Buses straight to the signal. Curb side parking enforcement would create the space needed for QJL. Traffic turning left into ORR would also use this as a "free left turn" lane.

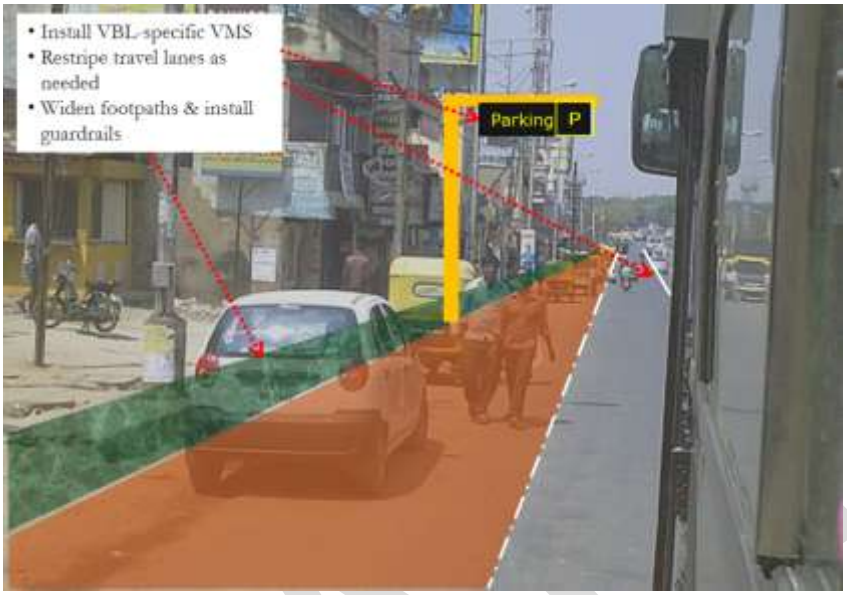
REST OF THE MARKET AREA

For the rest of the market area, it is possible to create a "virtual bus lane" (VBL) that would be enforced only during commute hours (8-10 AM, 6-8 PM). Creating a VBL would require the following

- Markings for VBL
- Variable Messaging Boards indicating if the VBL is in operation
- Parking enforcement during VBL operating hours
- Cameras mounted on the Bus to spot VBL violations

While west bound (towards the CBD) stretch has 3 lane-worth width, east bound stretch of Old Airport Road adjoining the HAL land has only 2.5 lane-worth of width at a few spots. Providing pedestrian pavements only on south side of the road away from HAL land could provide the additional 1.5 meter width needed to make space for the VBL.

Picture below visualizes VBL, on the west-bound stretch of old airport road at Marathahalli.



WIND TUNNEL ROAD SIGNAL

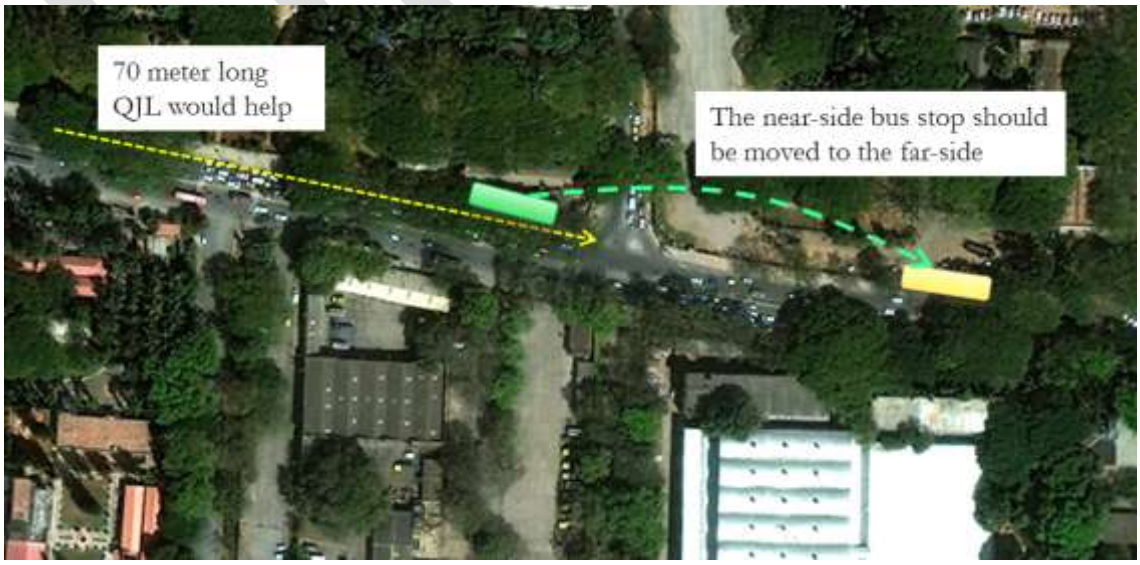
QJL with TSP. Length of QJL would be about 25 car lengths, or 130 meters

However, with this QJL in place, the bus stop situated 60 meters before the signal (a near-side stop) would block the QJL and cause wasting of green lights. Moving the bus stop 70 meters east from its current location just before the start of proposed QJL would be ideal.

Additionally, the Bus stand would have to move bit backwards, to be placed 150 meters before the signal so that it is before QJL. Bus stand in the QJL would lead to "wasting" of greens.

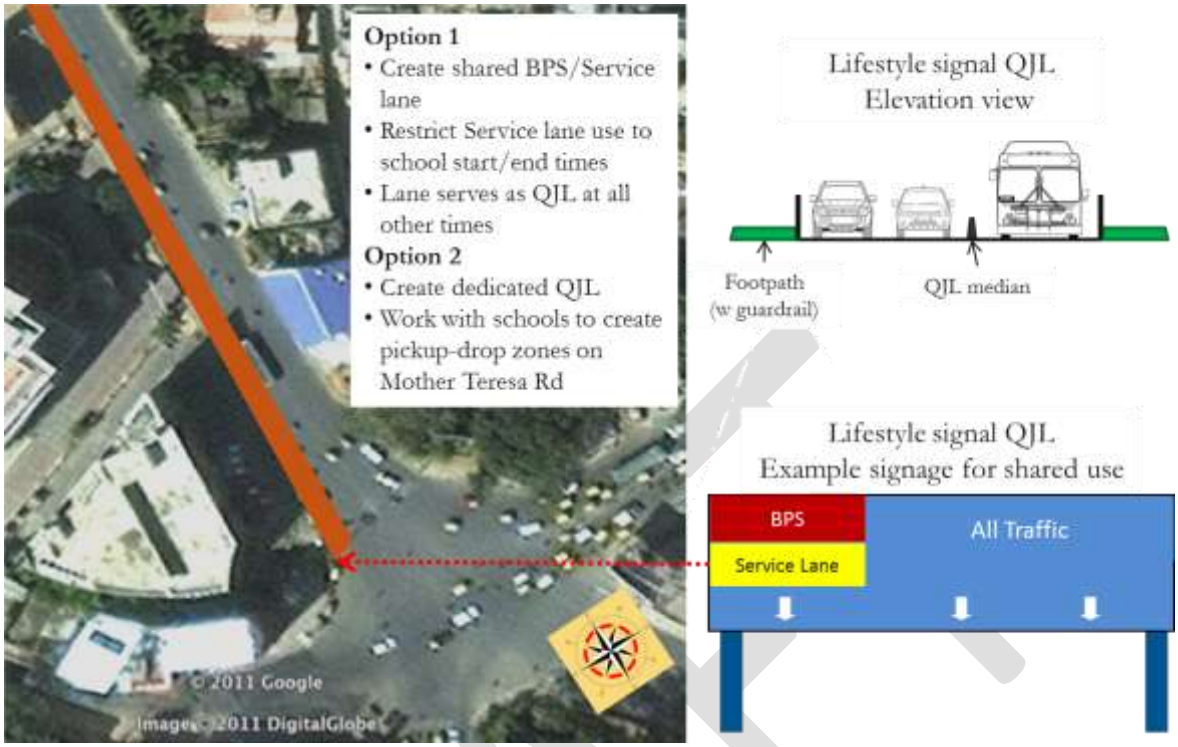
SURANJAN DAS ROAD SIGNAL, EASTBOUND

The eastbound bus stop is situated 10 meters before the signal and suffers from the problems of near-side bus stops. Greens are wasted.



LIFESTYLE SIGNAL

After the signal, a virtual bus lane (VBL) till Vellara junction would segregate buses from regular traffic during peak hours. This VBL will start right after the Lifestyle signal as visualized in the picture below:



Optionally, a 50 meter QJL ***before*** Lifestyle signal would fast forward buses to the signal. 10 second head start to the QJL via a bus activated signal would give buses enough time to cross the signal before competing traffic and enter the VBL described above.

START OF RICHMOND ROAD (VELLARA JUNCTION)

A Queue Jump Lane of 25 car lengths, or 375 feet, or 130 meters would take Buses straight to the signal. There is enough width to create the QJL cum VBL.

OTHER BPS MEASURES FOR THE PILOT ROUTE

EXPRESS SERVICE

An express service running on the pilot route with only 10-12 Bus stops would reduce the number of stops (from about 30) to nearly a third. With 25-30% of total journey time estimated to be spent at bus stops, reducing the number of stops to a third would cut this share down to 10-12% levels.

A sample list of Bus stops - some with mid-point placement applied to adjust their location - are marked on the route image below. Shortened list of Bus stops can be decided based on current data on stops that see maximum boarding and exit of passengers.

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APPENDIX: ADDITIONAL OPERATIONAL MEASURES<TBD>

<TBD: avoid theoretical flood, keep to 5 measures that connect with BPS concepts described above>

Few complimentary but critical operational measures that can be combined with BPS concept but not detailed in this paper are listed below. These could be considered as part of the implementation plans for BPS in Bengaluru:

- Trunk-and-feeder operations, via select transfer terminals on express services
- Customer Information Systems on all Stops on BPS route
- Facility to either carry bicycles or rent-bicycles at all express bus stops (or transfer terminals)
- Single Ticket journey on combination of express, regular and feeder services