OLD MAHABALIPURAM ROAD

Facilitating transport needs of people

MARCH 2011
Introduction

Old Mahabalipurm Road (OMR), formally known as Rajiv Gandhi Salai, passes through one of the fastest growing IT hubs in the country. With special incentives given to IT firms such as higher floor space index (FSI), a lot of them have set shop on this corridor. Present estimates show that there are nearly 1.4 lakh people employed in the IT industry on this corridor. Future projections estimate that this number will grow more than two fold to about 3 lakhs. While most of the businesses are in the Indira Nagar (Tidal Park) to Sholinganallur section, the corridor extends up to Siruseri where a large IT hub has been created by SIPCOT. Growth can also be seen in areas extending off OMR, such as Taramani and Perungudi. Thiruvanmiyur and Velachery are important residential areas that are connected to OMR and many people who work in the IT industry live in these areas. In addition, there are existing settlements and urbanizing villages on OMR where people have lived for many decades if not centuries.

OMR toll road was a prestigious project of TNRDC. However, the toll-road project has been in the making for many years now. Only the northern end of the road (Madhya Kailas to TIDAL Park) has been fully developed. In the remaining length, only the central section (about half of the width of the total right of way) has been developed, as six lanes of motor vehicle carriageway, three lanes in each direction. Street edge sections (or the slow moving zone) for pedestrians & cyclists, and service lanes for vehicles accessing property edges, are yet to be completed. This forces all activities on to the limited built section, i.e., the motor vehicle carriageway. Pedestrians walk on the carriageway for lack of any other place to walk. Stationary activities like parking, street vending, also encroach on the carriageway. This problem becomes even more acute at intersections.

Tamil Nadu Urban Infrastructure Financial Services Limited (TNUIFSL), on behalf of the Government of Tamil Nadu (GoTN), commissioned a study to look at solving junction problems on OMR. This study was conducted by Louis Berger, a consulting company and a proposal was prepared. Hereinafter, the term ‘proposal’ refers to the report prepared by Louis Berger. This proposal has serious limitations. It has not addressed many key issues and seems entirely opportunistic. It proposes an elevated road as the solution without looking at its impact, especially on public transit connectivity and metro rail.

This report has been prepared by the Institute for Transportation & Development Policy, an international non-profit agency that promotes sustainable and equitable transportation worldwide. This report attempts to bring a holistic view of transportation needs on OMR and addresses key issues related to traffic problems on OMR. ITDP is recognized as an expert in this field and has been instrumental in the implementation of sustainable transport initiatives worldwide. In India, ITDP partnered with Ahmedabad Municipal Corporation (AMC) and CEPT University in the development of Ahmedabad Janmarg Bus Rapid Transit (BRT) system. Janmarg BRT was given the award of the best MRT system in the country by Union Government of India. It is now recognized worldwide as a best practice. ITDP has also been appointed by the Transport Department, GoTN, to develop a detailed feasibility study for implementing BRT in Chennai with specific emphasis on OMR.
An assessment of the issues that cause traffic problems on OMR shows that there are three important issues that need to be addressed to solve the problem.

- **Serving the needs of people through high quality public transit** - With the expected growth of OMR as an IT services hub, the solution for the transportation needs of people who want to reach OMR or for those who live on or near OMR, can only be met with high quality public transit. Public transit can use road space efficiently. On the other hand, increasing road capacity, even doubling it through appropriate infrastructure, will only provide marginal increase in transportation capacity if dependence is on private modes. *Existing formal and informal modes of public transit already account for nearly three quarters of the total trips. Though not all trips can be achieved through public transit, the aim should be to have upwards of 80% of trips on efficient public transit.*

- **Improving overall flow of vehicles through Junction improvement** - *Junctions are the principal constraint points for throughput on any road.* Adding more capacity between junctions does not solve the problem. The aim should be to increase the throughput of traffic at junctions such that the available capacity of between junctions is well utilized. A lot can be done for improvement of junctions through at grade solutions. Thumb rules cannot be used to solve complex traffic problems. Innovative, simple and inexpensive solutions need to be explored even if grade separators are to be created in certain instances.

- **Network of streets to improve accessibility** - OMR is the only available arterial road in the entire area for many kilometers. For that matter, there are no other parallel roads, arterial or otherwise, to reduce the strain on OMR. All traffic flows into OMR from different cross roads, uses it for a certain part of the trip, and then flows out into another cross road. No alternate routes exist. Good urban planning includes development of a fine grid of streets for high accessibility and low congestion. *In the long run, the aim should be to add additional road capacity in the form of an interconnected network of streets rather than adding capacity on a single road. This process should be started as soon as possible because creation of additional roads takes time.*
Serving the needs of people through high quality public transit

The Government of Tamilnadu has given a clear mandate to promote the use of public transit in the city. The latest master plan for Chennai city endorses this view. The government has taken various steps such as increasing the bus fleet of MTC, replacement of old buses and creation of the multibillion dollar Metro Rail system. Unfortunately, the present proposal prepared by the consultants (Louis Berger, commissioned by TNUIFSL) has no mention of the impact their elevated road proposal will have on public transit users.

- It has not looked at existing ridership on public transit on OMR.
- It doesn’t take into account seamless rapid-public-transit connectivity to Chennai Metro Rail being developed at great cost.
- The proposal, if implemented, is greatly reducing the potential use of high capacity Metro Rail being developed at great expense, existing MRTS, proposed Bus Rapid Transit, and extended feeder network.
- It also foregoes the option of the creation of Metro Rail line on OMR, if deemed necessary, in the future. Unless the proposed elevated road infrastructure (created at a cost of nearly 700 crore rupees) is torn down, a metro rail line will be difficult to implement.

Any permanent structure should be erected only and only after a very thorough study has been done on its impact on all modes and the constraints it places in the present and future. The aim should be to look at flexible at-grade solutions that can be modified as and when needed at little expense. The proposal should be vetted by key state agencies such as Chennai Metropolitan Development Authority (CMDA) and Chennai Unified Metropolitan Transport Authority (CUMTA) since they have the mandate to look at the transportation needs from a citywide perspective. An independent expert committee audit to assess impacts such as transportation, social, economic and environmental impacts is valuable.

Bus Rapid Transit (BRT) can explored as a possible means of serving the mobility need of hundreds of thousands of people who come to OMR for work or live on OMR. This does not require any permanent structures and can be implemented quickly. BRT is also not a single line service but is a network of routes that connects OMR to other areas in the city and provides rapid high quality service to large numbers of people. BRT forms a key connection to the Metro Rail and MRTS network. A BRT study has been commissioned by the Transport Department, Government of Tamil Nadu. A detailed feasibility report will be ready by June 2011. It will address all elements of implementing BRT, including connectivity, operations, physical design and financing. In the meantime, this document attempts to put forward some key ideas about BRT and its impact.
Assessment of existing traffic conditions

As part of a study commissioned by TNUIFSL, traffic counts were conducted at multiple locations. These include mid-block (between junctions) counts at five locations as well as junction counts at four locations. The survey also gathered origin destination information at toll plazas. This O-D data was not available in the published document. As part of the BRT study being conducted by ITDP on behalf of Transport Department, GoTN, detailed information of MTC bus operations has been collected and additional surveys done on site to corroborate the data. This information has also been used in the analysis.

Of all the locations where mid-block traffic counts were done on OMR, maximum traffic volume was found at NIFT. The total volume of vehicles in peak direction was 5100 vehicles (4200PCU). The average daily traffic (ADT) at this location in both directions is 1.07 lakh PCU. The table below gives a breakup of traffic and passengers by mode. This case will be used to demonstrate the state of affairs. Similar assessment was made of the other locations to get a holistic picture. However, the results were very similar so it is sufficient to use counts at one location to show the distribution of road space by mode and distribution of passengers by mode.

<table>
<thead>
<tr>
<th>Mode</th>
<th>Vehicle volume (ADT)</th>
<th>PCU (ADT)</th>
<th>% road occupied by mode</th>
<th>Average passengers per vehicle</th>
<th>Passenger volume</th>
<th>% passengers by mode</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cars</td>
<td>40000</td>
<td>40000</td>
<td>37%</td>
<td>1.2</td>
<td>48000</td>
<td>11%</td>
</tr>
<tr>
<td>Motorized 2 wheelers</td>
<td>58000</td>
<td>29000</td>
<td>27%</td>
<td>1.2</td>
<td>69600</td>
<td>15%</td>
</tr>
<tr>
<td>3 wheel auto rickshaws</td>
<td>12000</td>
<td>12000</td>
<td>11%</td>
<td>4</td>
<td>48000</td>
<td>11%</td>
</tr>
<tr>
<td>City buses</td>
<td>2800</td>
<td>8500</td>
<td>8%</td>
<td>65</td>
<td>182000</td>
<td>41%</td>
</tr>
<tr>
<td>Other buses</td>
<td>2800</td>
<td>8500</td>
<td>8%</td>
<td>35</td>
<td>98000</td>
<td>22%</td>
</tr>
<tr>
<td>Goods vehicles (LCV/HCV)</td>
<td>6000</td>
<td>9000</td>
<td>8%</td>
<td>0</td>
<td>0</td>
<td>0%</td>
</tr>
</tbody>
</table>

Average Daily Traffic (ADT)
All figures are rounded for readability

City buses occupy 8% of road space but carry 41% of the total passenger volume. All forms of public transit, including shared auto rickshaws and private buses, carry three quarters of the total passengers while occupying one quarter of the road space. On the other hand, two thirds of road space is occupied by private passenger vehicles (cars and motorized two wheelers) but carry only a quarter of the total passengers. The pie charts below clearly show this assessment. Modes of public transit are shown in shades of green while private modes are shown in shades of red and yellow.
Growth of vehicles from 2008 to 2011 and future projections

The proposal under questions Growth patterns were studied with data available from CTTS study conducted in 2008 on behalf of CMDA. The table below shows that the growth of vehicles in a period of three years from 2008-2011 is 45% globally. The growth of road space needs of private modes has grown by 50% while that of public modes has increased by 69%. However, public transit modes still occupy a modest 27% of road space in 2011, as compared to 23% in 2008. The total ridership on public modes as a share of total trips has remained more or less constant at 74%.
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Cars</td>
<td>28000</td>
<td>28000</td>
<td>40000</td>
<td>40000</td>
<td>43%</td>
</tr>
<tr>
<td>Motorized 2 wheelers</td>
<td>36000</td>
<td>18000</td>
<td>58000</td>
<td>29000</td>
<td>61%</td>
</tr>
<tr>
<td>3 wheel auto rickshaws</td>
<td>7500</td>
<td>7500</td>
<td>12000</td>
<td>12000</td>
<td>60%</td>
</tr>
<tr>
<td>City Buses</td>
<td>2100</td>
<td>6300</td>
<td>2800</td>
<td>8500</td>
<td>35%</td>
</tr>
<tr>
<td>Other Buses</td>
<td>1100</td>
<td>3300</td>
<td>2800</td>
<td>8500</td>
<td>158%</td>
</tr>
<tr>
<td>Goods vehicles (LCV/HCV)</td>
<td>7000</td>
<td>10500</td>
<td>6000</td>
<td>9000</td>
<td>-14%</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>73600</td>
<td></td>
<td>107000</td>
<td>45%</td>
</tr>
</tbody>
</table>

2008 figures are from CTTS done by Wilbur Smith on behalf of CMDA
2011 figures are from proposal by Louis Berger done on behalf of TNUDF
All figures are rounded for readability

**Peak hour vehicle volume (PCU)**

![Graph showing peak hour vehicle volume (PCU) from 2005 to 2030]
As per IRC, a design period of 15-20 years should be adopted for arterials. If the design is based purely on existing growth rate (assuming it is linear), then the suggested infrastructure will congest by year 2016, a time by which the infrastructure suggested by the proposal would have just about been opened. From present figures, it is obvious that even doubling the road capacity by the creation of an elevated structure will not be sufficient if people are expected to depend on private modes of transport. Transportation needs of a large proportion of people who use OMR will have to be on public transit. It clearly points out to the need for an integrated mass rapid transit system.

Chennai is already in the process of creating a high quality Metro Rail system. There is also an existing MRTS elevated rail system that is underutilized. Use of road space by public transit and private modes will have to be made more efficient. Those presently using shared autos for their commute will have to be attracted to bus based transit. Those who depend on private company buses can also be attracted to public transit. Further, bus operations will have to be streamlined. The need of the hour is to create a high quality, high capacity BRT system that is integrated with the upcoming Metro Rail system and the existing MRTS. This will allow people living all over Chennai to have quick access to OMR through a rapid seamlessly-integrated high-quality public transit system.

Bus Rapid Transit Design

Bus Rapid Transit system is a high-quality customer oriented transit that delivers fast, comfortable and low cost mobility. BRT can provide the same quality of service as Metro Rail to a large number of citizens across the city at a relatively low cost. As a complementary system to Metro Rail, it can extend the reach of Metro Rail without downgrading the quality of service. In many senses, BRT can be called ‘Think Rail, Use Buses!’ BRT typically has a few distinct qualities

- Dedicated bus lanes in the center of the street (to avoid conflict with curb side activities and turning movements)
- Frequent and high quality stations (typically every 500m apart)
- Special buses that allow step-less boarding into the bus (need not be expensive low-floor buses)
- Electronic ticket fare collection at stations (like at metro stations using contactless smart cards or tokens)

BRT is not just about creating a dedicated lane and putting all types of buses into it. Such experiments have been done in other places in India and across the world only to result in bad image and failure. It should be developed as a high-quality integrated system.
BRT systems can handle a wide variety of demand depending upon how they are designed. Systems can be designed for capacity as high as 45000 passengers per hour per direction (pphpd) or as low as 5000 pphpd. In a simple configuration of BRT, only one bus lane per direction is required and space for station in the middle of the two lanes at an average spacing of half km. The maximum capacity of such a system is approximately 10000 pphpd. To

- Step-less boarding – ability to get in and out of the bus without climbing steps. The bus floor level and station floor level is the same.
- Electronic fare collection at BRT stations (in place of ticketing inside bus as is the present practice)
- Use of articulated buses (high capacity vestibule buses which are 18m long as against standard buses of 11-12m length)
Figure 3.11. This typical BRT alignment on a 36 m street can already accommodate large passenger volumes of up to 6,000 passengers per hour per direction (pphpd) with 12 m buses. With articulated buses, a single-lane system can carry 10,000 pphpd.

The BRT lanes plus buffer normally occupy 7.6 m in the street cross section. At stations, the width increases to 11.6 m. The additional 4 m width needed for the station is gained by ending the on-street parking lanes.

Pedestrian access to the station is provided via a raised crosswalk (elevation +150 mm relative to the carriageway) to ensure safety.
Figure 2.15. A typical BRT station (above) designed for 12m buses requires sufficient length for passenger access ramps, ticket vending, turnstiles, boarding/alighting, and internal circulation. For stations with lower demand, a single entrance may be provided (below). The design provides two docking bays to increase system capacity.

Docking bays should be staggered to reduce friction between passengers boarding and alighting on opposite sides. Docking bays for 18m articulated buses (below) consist of two openings: a front opening of 3m and a rear opening of 6m.
The first step of improving capacity is to create step less boarding. Step-less boarding decreases the time taken to get into a bus from around 2.5 sec per passenger to 0.5sec. This substantially reduces bus wait times and thereby increases the speed of the system. The second step is to put ticket fare collection function at station. This reduces the time wasted by a waiting bus till all passengers are given a ticket, a common practice at where many passengers get into a bus at a single stop. Images below show these two functions. The third is the use of articulated, high capacity bus. The drawings on the previous page show how bus station infrastructure created for BRT need not be changed as demand increases.

This configuration requires 7.6m of road width at non-station locations and 11.6m at station locations. It also assumes that the dedicated corridor will be exclusively used by special BRT buses and will not be accessible to other vehicles such as intercity buses, standard city buses or other large vehicles. The drawings on the next page shows such a configuration of BRT system on a street of 36m width (120 feet).

For demand higher than 10000 passengers per hour per direction, an additional lane is required at BRT stations. An overtaking lane increases capacity in two ways. The first is to allow express services that do not stop at all locations. While a local service bus stops at a station, the express bus can overtake and go past without having to wait behind the local bus. The second is to have multiple stopping bays in a given direction at the same stop. So while one bus is docked at a given platform, a second bus can overtake it and go to its own docking bay. The image below shows such a configuration of BRT. The right of way required for such a BRT remains 7.6m at non-station locations. However, at stations, the width required is 16.3.

<table>
<thead>
<tr>
<th>Type of BRT system</th>
<th>Passenger capacity (pphph)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bus lane (standard 12m bus)</td>
<td>3000</td>
</tr>
<tr>
<td>+ Step-less boarding (12m bus with special doors)</td>
<td>5000</td>
</tr>
<tr>
<td>+ Station ticketing (12m bus with special doors)</td>
<td>6500</td>
</tr>
<tr>
<td>+ Articulated bus (18m high capacity bus &amp; special doors)</td>
<td>9500</td>
</tr>
<tr>
<td>+ Overtaking lane</td>
<td>27000</td>
</tr>
<tr>
<td>+ Express service</td>
<td>45000</td>
</tr>
</tbody>
</table>

BRT on OMR
Presently, the peak hour volume of public transit buses on OMR is 120 buses per hour with a total volume of 7800 passengers per hour per direction. With modal shift from company run buses and shared auto rickshaws, the total ridership in the near future can go up to 12000 passengers per hour per direction. Further growth of OMR as an IT services hub will only result in more growth in ridership and can go up to 20000 passengers per hour per direction. Design of BRT therefore needs to take into account both the immediate requirement as well as future potential.
TYPICAL DESIGN FOR BRT CORRIDORS (ROW 40M) - Plan

1. Saidapet - Adyar - Tidel Park - Perungudi - Thoraipakkam - Sholinganallur - Naavalur - Siruseri

2. Saidapet - Airport - Chromepet - Tambaram - Vandalur - Estancia IT SEZ - SRM Engineering College - Marathalainagar - Singaperumbadi - Mahindra World City
TYPICAL DESIGN FOR BRT CORRIDORS (ROW 40M) - Section through mid block

scale 1 5m all dimensions are in meters
The BRT system proposed on OMR will not run exclusively on OMR. It will also connect the BRT to various other places. The OMR BRT network is expected to connect to the Metro Rail network at Saidapet/Guindy location. This means that BRT routes will play along Sardar Patel Road before turning on to OMR. BRT routes are also expected to originate from Velachery and turn onto OMR at Taramani Junction. In the future, BRT may also connect to Medavakkam after turning at Sholinganallur Junction. Therefore, any design for BRT should take into account the ability of BRT buses to turn at each of these intersections conveniently. Detailed designs for these would be included in the feasibility report to be submitted in June 2011.
Junction improvements and grade separators

Determining road capacity & improving throughput

*Road capacity is principally determined by the capacity constraint at intersections (junctions).* The turning movement conflicts at intersections necessitate that only a limited number of directions of traffic flow can occur at any one time while the remaining have to wait for their phase in the signal cycle. A four phase signal cycle means that while one set of flows are in process, the others have to wait at the signal for their turn. This translates into the predominant direction of traffic having to wait at a signal for half to three quarters of the time. *Good traffic engineering therefore attempts to improve junctions to maximize the throughput, not add additional capacity or improve speed in the mid-block sections.*

**Junction improvement starts with utilizing the full right of way effectively at the junction.** Simple junction improvements can be in the form of adding additional queuing lanes at the junction. This can be done by removing any parked vehicles, bus stops or other obstructions, adding space of service lane to the main carriageway. Care must also be taken that pedestrians get adequate walking and waiting space before crossing the street. Otherwise, they will overflow into the junction thereby reducing the overall throughput of vehicles. Further, signal cycles at each intersection should be improved such that...
cycle time and time for each phase within a cycle is optimal. A good example is the poor placement of the bus stop for northbound buses at Sholinganallur junction and malfunctioning signals. Bus stop being very close to the junction creates a bottleneck. Lack of pedestrian facilities push pedestrians onto carriageway. Where it is technically possible to accommodate as many as four lanes for mixed traffic to flow into the junction, just about two lanes are actually available as queuing space. No doubt, this creates long queues during peak hour traffic, increases the wait time at signals and reduces throughput.

The second stage of improvement is through reducing the number of phases within a signal cycle. Right turn restrictions, which are often employed by traffic police, are one such basic form of junction throughput improvement. Converting a four phase signal cycle to a two phase signal cycle effectively reduces the wait time for each of the remaining phases thereby improving the overall throughput at the junction. However, such restrictions must also provide road users an alternative path to reach their destination. In case of places with frequent streets.

A better way of improving junction throughput is a combination of two phase signal cycle with appropriately placed U-turns to accommodate right turning movements away from the junction. Typically, such U-turns are placed 100-150m away from the intersection to avoid any conflict with traffic queue of the opposite direction. Another innovative way of accommodating the right turns is through creation of a signalized roundabout. The geometry of the roundabout is changed to mimic a square and therefore gets the moniker of square-about. A signalized roundabout can accommodate all twelve directions of movement (Left-Straight-Right movement from each of the four arms) in two phases of a signal cycle.

The last resort of improving junction throughput is through the creation of grade separator. However, care must be taken that the grade separator improves the overall performance of the junctions. Often, a grade separator created for one direction of movement creates a bottleneck of the turning movements at the surface level, especially when right of way is restricted. So, while conditions for the main direction of traffic improve, conditions for right turning movements at the surface level deteriorate enormously.

The directional movement of at each of the junctions was not made available as part of the report nor are there any calculations to substantiate the size of the physical infrastructure proposed. It must be noted though that the turning movement into an out of OMR at each of the junctions are around one quarter of the total flows into the respective junction. If all junctions are considered, then the total number of vehicles coming into or out of OMR vs those who are traveling exclusively on OMR is over two thirds. This clearly indicates that the issue is one of junctions and not that of mid-block flows on OMR.

Proposed elevated structure

The proposed elevated structure seems opportunistic rather than holistic. It puts in structures based on available road width rather than look at the transportation needs of those who have to use OMR to reach their destination on OMR or one of the connecting streets. As per IRC, states that an interchange (grade separator) ‘may’ be justified in case of the total volume of traffic exceeding 10000 PCU. However, it does not automatically necessitate a
grade separator. IRC further states that ‘it will be necessary to carry out cost-benefit study taking into account transportation cost’ (IRC 92-1985). No such study seems to have been performed.

Elevated rotaries have been employed in the design of the elevated structure. IRC clearly notes that the maximum volume a rotary can handle efficiently can be taken as about 3000 vehicles per hour entering from all intersection legs (IRC-65-1976 3.3 (c)). Therefore, it is clear that the proposed structure will have a severe capacity constraint.

The rotary radius for a design speed of 40kmph should be 26-46m (diameter of 52-92m). Further, it states that the weaving length between arms should be ‘at least 4 times the width of the weaving section’ with a minimum of 45m. None of these criteria are met by the design. 40m diameter rotaries have been proposed at all locations except for Sholinganallur. Therefore all proposed rotaries, except Sholinganallur junction rotary, do not satisfy IRC. Since existing right of way is limited to 40m, the suggested 32m outer radius of the elevated rotary structure will necessitate extra land. **Therefore, such rotary design is completely inappropriate and does not satisfy the requirement of enhancing capacity for vehicular traffic on OMR.**
Basic principles of traffic engineering have been ignored. For example, in the design of the ramp towards Perungudi from Perungudi junction elevated rotary occupies the entire right of way of the arm leaving no space for traffic at ground level.
In the mid block sections where down/up ramps have been proposed, the total space occupied by elevated structures is 40m, i.e., the full right of way of OMR. This leaves no space for pedestrian path. The ramps go till the edge of the right of way. As per IRC 103-1988 (Pedestrian Facilities), minimum footpath width is 1.5m in addition to dead width of 0.5m on either side from a dead wall. Therefore a minimum of 2.5m of pedestrian path at either edge of OMR is a necessary part of the design. These are just a few examples and there are many other cases where basic principles of road design have been ignored. A thorough assessment of the proposal should be made by an expert committee.

**Suggested improvement to Junction**

While it is beyond the scope of this report to give detailed designs for junctions, there are a few suggestions to be considered. Presently, the junctions are not treated differently in design from the mid-block sections. At junctions, more number of lanes is required for traffic than at mid-block to maintain the same level of flow. It is possible to combine the service lane space with the main carriageway to add to the capacity of carriageway. Two phase signal options as mentioned in the earlier section should be explored. Below is an example of design has been made in case of Sao Paulo BRT. While the geometry will have to be adapted to the local context, the idea of a split intersection with two-phase signals has been employed in this example.
Also simple ‘Michigan-U’ turns can also be employed. The next image shows a variation of this possibility. It is suggested that such solutions be first implemented to improve the condition of traffic which do not require construction of grade separators.
Further, in the long run, if need be, split-flyovers can be explored. In case of a split-flyover (as the images below show), the BRT system remains at ground level, while the two main directions of traffic along OMR go on two split parallel flyovers. This allows for turning movements to happen at grade, including BRT. BRT routes which need to turn at certain junctions can use the ground level intersection without having to exit the BRT lane till the intersection.

Split flyover configuration along BRT - The two directions of traffic along BRT have exclusive flyovers with a split in the middle which accommodates BRT lanes and station at ground level
Conceptual layout for Split Flyover with Michigan-U along with BRT at ground level