



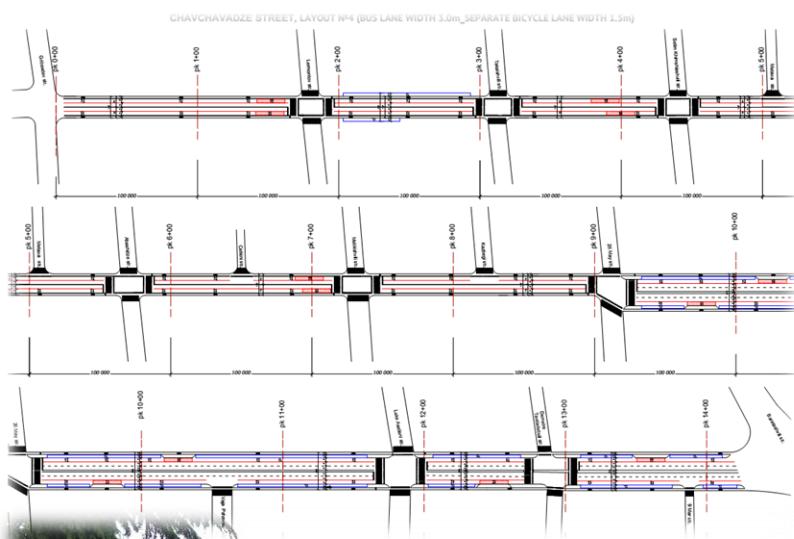
საქართველოს გარემოსა  
და ბუნებრივი რესურსების  
დაცვის სამინისტრო



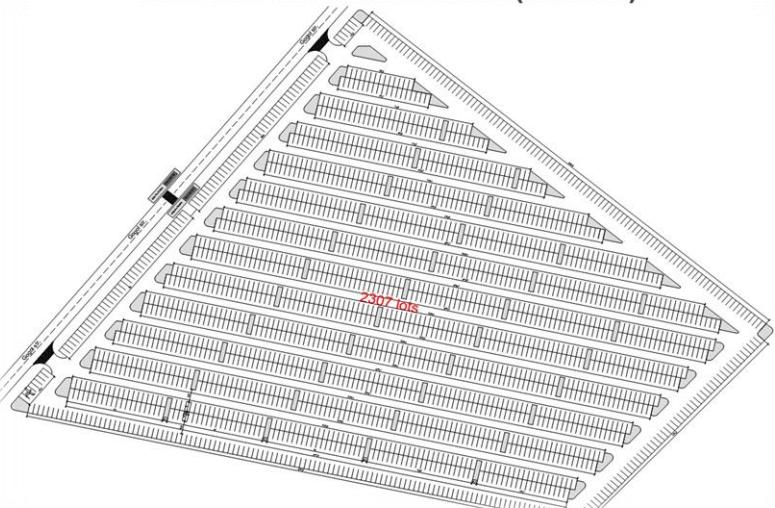
Empowered lives.  
Resilient nations.

# Sustainable Urban Transport Corridors in Batumi

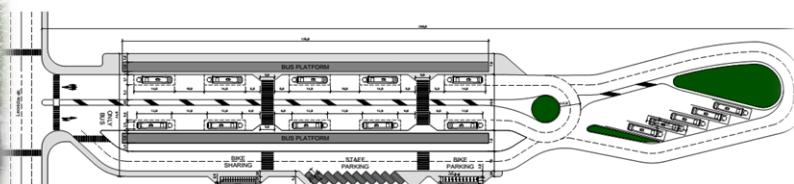
Technical Report #4



BATUMI PARK AND RIDE (NORTH)



BATUMI BUS TERMINAL (SOUTH)



The report has been prepared by a team of experts from A+S Consult GmbH



**Consultant:** A+S Consult GmbH; Germany, 01277 Dresden, Schaufussstraße 19; Tel: +49 351 3121330, E-mail: [info@apluss.de](mailto:info@apluss.de)

**Client:** United Nations Development Programme (UNDP)

**Project:** Green Cities: Integrated Sustainable urban Transport for the City of Batumi and the Achara Region (ISTBAR)

---

**Sub-project:** Feasibility Studies for Pilot Low-Carbon Urban Transport Corridor and Integrated Sustainable Urban Mobility Plan for the City of Batumi (ISUMP)

**Output 4:** Functional Plan for Sustainable Urban Transport Corridors in Batumi

The report has been prepared by A+S Consult GmbH

**CEO**

**Dr. Veit Appelt**

**Team Leader**

**Daniel Wolf**

Batumi  
2017

**Consultant:** A+S Consult GmbH; Germany, 01277 Dresden, Schaufussstraße 19; Tel: +49 351 3121330, E-mail: [info@apluss.de](mailto:info@apluss.de)

**Client:** United Nations Development Programme (UNDP)

**Project:** Green Cities: Integrated Sustainable urban Transport for the City of Batumi and the Achara Region (ISTBAR)

---

**Published by the United Nations Development Programme (UNDP)**

© UNDP Georgia, 2017

All rights are reserved

Published in Georgia

The report has been prepared by the company A+S Consult GmbH in the scope of the project – "Green Cities: Integrated Sustainable Transport for the City of Batumi and the Achara Region", funded by the Global Environmental Facility (GEF) and implemented by the United Nations Development Programme (UNDP), with support from Batumi City Hall and the Ministry of Environment and Natural Resources Protection of Georgia.

The views expressed in this report are those of the Authors and do not necessarily represent those of GEF and UNDP.



საქართველოს გარემოსა  
და ბუნების რესურსების  
დაცვის სამინისტრო



## **TABLE OF CONTENTS**

<b>1</b>	<b>Introduction .....</b>	<b>6</b>
<b>2</b>	<b>Engineering Specifications and Recommendations .....</b>	<b>6</b>
2.1	Road Sections .....	6
2.1.1	Dedicated Curbside/Offset Bus Lanes .....	6
2.1.2	Dedicated Median Bus Lanes .....	8
2.1.3	Shared Bus-Bike Lane .....	9
2.1.4	Recommended Material for Dedicated Bus Lanes .....	11
2.2	Intersections .....	15
2.2.1	Shared Transit/Right-Turn Lane.....	15
2.2.2	Right-Turn Pocket.....	16
2.2.3	Dropped Transit Lane .....	17
2.2.4	Transit Approach Lane/Short Transit Lane.....	18
2.2.5	Traffic Lights Priority .....	20
2.2.6	Application of Intersection Recommendations in Batumi.....	23
2.3	Bus Stops.....	23
2.3.1	Basic bus stop .....	29
2.3.2	Enhanced bus stop .....	31
2.3.3	BRT-Station.....	32
2.3.4	Transit center .....	33
2.3.5	End-of-line or terminus facility .....	34
2.3.6	Locations of bus stops.....	34
2.4	Park & Ride .....	35
2.5	Bus Transfer Terminals .....	39
<b>3</b>	<b>Implementation Plan .....</b>	<b>48</b>
3.1	Road section .....	48
3.2	Budgets .....	58
3.2.1	Dedicated Bus Lane .....	58
3.2.2	Bus Stops.....	58
3.2.3	Park & Ride .....	58
3.2.4	Bus Transfer Terminals .....	58
3.2.5	Traffic Lights Priority .....	59
3.3	Investment and Action Plan.....	59

**Consultant:** A+S Consult GmbH; Germany, 01277 Dresden, Schaufussstraße 19; Tel: +49 351 3121330, E-mail: [info@apluss.de](mailto:info@apluss.de)

**Client:** United Nations Development Programme (UNDP)

**Project:** Green Cities: Integrated Sustainable urban Transport for the City of Batumi and the Achara Region (ISTBAR)

---

**4 Conclusion.....63**

**5 Bibliography .....64**

## **1 INTRODUCTION**

Development of the sustainable urban transport should be supported by the appropriate engineering solutions. One of these solutions is a public transport priority by the creation of exclusive public transport lanes.

In the city of Batumi, two demonstration low-carbon corridors were chosen. The first one affects Chavchavadze - Abuseridze (CA) streets, while the second – Chavchavadze – Baratashvili - Gorgiladze streets (CBG). For these corridors detailed engineering designs for road sections and intersections with specification of materials have to be prepared, as well as conceptual designs and detailed specifications for bus stops, park-and-ride lots and bus transfer terminals. Finally, a budget per each measure and overall investment and action plan should be developed.

## **2 ENGINEERING SPECIFICATIONS AND RECOMMENDATIONS**

### **2.1 Road Sections**

#### **2.1.1 Dedicated Curbside/Offset Bus Lanes**

Dedicated bus lanes are typically applied on major routes with frequent headways (10 minutes at peak) or where traffic congestion may significantly affect reliability. Lanes may be located immediately at the curb or in an offset-configuration, replacing the rightmost travel lane on a street where parking is permitted.

Bus lanes reduce delays due to traffic congestion and help raise the visibility of the high-quality service. They are subject to encroachment due to double-parking, deliveries, or taxicabs. Strict enforcement is necessary to maintain their use and integrity. Dedicated lanes should be separated from other traffic using solid single or double white stripes.

Sometimes, BUS-ONLY pavement markings should be applied to emphasize the lane and to deter drivers from using it.



Figure 1 - Curbside bus lane

Bus lane width should be determined based on the available street space and the competing needs of bicyclists, pedestrians, and motorists. The minimum width of a curbside bus lane is 3,5m while the minimum width of an offset bus lane is 3 m.



Figure 2 - Offset bus lane

If the bus lane is offset-configured, bus bulbs (for bus stops) should be installed. Also, bus lanes may have complementary effects with other bus rapid transit elements, such as off-board fare payment and transit signal priority.

Today off-board fare payment exists in Batumi, when the payment is conducted using the tickets, bought in the kiosks or elsewhere, or plastic card, that contains some amount of money.

Bus lanes may be separated with soft barriers (i.e., rumble strips) or hard barriers (concrete curbs).

If hard separation is used, bus lanes should be designed to allow passing at selected points.

Intersections, driveways from the courtyards, parkings or fuel stations.

Dedicated bus lanes may be implemented on a 24-hour basis or active during some periods of the day only. For Batumi, this period can be from 6:30 a.m. until 10 p.m. (Figure 3).



Figure 3 – Dedicated bus lanes that operate within specific intervals of the day (Paris, France)

### **2.1.2 Dedicated Median Bus Lanes**

Dedicated median bus lanes are typically applied on major routes with frequent headways or where traffic congestion may significantly affect reliability. Median bus lanes are applied along the centerline of a multilane roadway and should be paired with accessible transit stops in the roadway median where needed. Dedicated median bus lanes eliminate conflicts with potential drop-offs, deliveries, or illegal parking along the roadway edge.



Figure 4 - Dedicated Median Bus Lanes

The minimum width of a median bus lane is 3,5 m per direction.

Dedicated bus transit lanes require median boarding islands in the roadway at each stop. These stops must be fully accessible and lead to safe, controlled crosswalks or other crossings. For dedicated median bus lanes, BUS-ONLY pavement markings emphasize the lane and deter drivers from using it. Also, dedicated lanes should be separated from other traffic with solid single or double white stripes, at a minimum. Separation of the dedicated median bus lane with soft barriers (i.e., rumble strips) and/or hard barriers (concrete curbs) should be considered to reduce encroachment from moving vehicles.

Dedicated median bus lanes should have complementary rapid transit elements, such as off-board fare payment and transit signal priority.

### **2.1.3 Shared Bus-Bike Lane**

The shared bus-bike lane is not a high-comfort bike facility, nor is it appropriate at very high bus volumes. However, buses and bicycles often compete for the same space near the curb. On streets without dedicated bicycle infrastructure, curbside bus lanes frequently attract bicycle traffic, prompting some cities to permit bicycles in bus lanes.



Figure 5 - Shared Bus-Bike Lane

Shared bus-bike lanes can accommodate both modes at low speeds and moderate bus headways, where buses are discouraged from passing, and bicyclists pass buses only at stops. In appropriate conditions, bus-bike lanes are an option on streets where dedicated bus and separate high-comfort bicycle facilities cannot be provided. They are most commonly applied on two-way streets with curbside or offset bus lanes, and no existing or planned bicycle facility.

Applications should generally be limited to bus lanes with operating speeds of **50 km/h or less**, and transit headways of **4 minutes or longer**.

Lanes may be placed directly adjacent to the curb or offset from the curb by a parking lane. Curbside shared bus-bike lanes provide basic bicycle access on transit streets when no space is available for dedicated bikeways. As on other streets with shared bicycle lanes, bicycle operation must be permitted across the entire road surface. Jurisdictions with "as far right as practicable" rules for bikes must explicitly permit flexible operation on streets with bus-bike lanes.

Pavement markings must indicate that the lane is dedicated to transit, including a solid white line and BIKE BUS ONLY or similar marking.

Buses must operate on the right side of the lane and pull to the curb at stops when possible. Coordination with transit operator instruction is key to the success of a bus-bike lane.

The width of a shared bus-bike lane is **3–3.5 m**, in case passing the buses at the stops is prohibited, and **4.5 m** to allow safe passing, (Figure 6).

Bicycle shared lane markings should be placed in the center or left side of the lane. At stops, place markings at the left side of the lane (Figure 5).

In case city decided to implement shared bus-bike lanes, drivers of the buses shall be trained in advance in regard of special attention to necessary for driving along hared bus bike lanes.

Recommendations regarding the type of public transport lanes along the CA and CBG corridors are considered in chapter **Error! Reference source not found..**

Figure 6 - Shared bus-bike lane and bus stops with bike sharing

#### **2.1.4 Recommended Material for Dedicated Bus Lanes**

Bus lanes, as well as bike lanes, can be visually separated from the surrounding by a fully-colored demarcation (as seen in Figure 6). There are different technologies, that can be used for that purpose, which differences are e.g. in the material used, the longevity and the price. The NACTO (National Association of City Transportation Officials) proposes 4 technologies, which we use here as reference: 1) Paint, 2) Durable Liquid Pavement Markings (DLPM) and Methyl Methacrylate (MMA), 3) Thermoplastic and 4) Embedded Paint.

The main requirements to the material/technology are the followings:

- improved night visibility
- appropriate skid resistance
- capable of full cure in a wide range of temperatures allowing for a longer marking season
- can be applied to either concrete or asphalt

Overview from (<http://nacto.org/publication/urban-bikeway-design-guide/bikeway-signing-marking/colored-pavement-material-guidance/>).

##### **2.1.4.1 Paint:**

Paint, sometimes with additives such as reflective glass beads for retro reflectivity and sand for skid resistance, is the most widely used method to mark road surfaces. It is considered a non-durable pavement

marking, is easily worn by vehicle tires and the elements in snowy winter climates, and often requires annual reapplication. Paint is the least expensive of the overlay materials.

Maintenance Considerations - Spot maintenance requires a simple reapplication of paint.

Costs - \$0.6 Sq. Ft. for raw materials, \$1.20 – \$1.60 Sq. Ft. installed.

Longevity - Six months to two years based on weather, motor vehicle traffic and snow removal operations (if applicable).

#### **2.1.4.2 Durable Liquid Pavement Markings (DLPM) include epoxy and Methyl Methacrylate (MMA):**

Epoxies are adhesive, waterborne acrylics that are typically applied as a paint or spray. MMA are 2-part liquids comprised of a resin and activator. While both coatings can be skid resistant, retro reflective and can adhere to concrete or asphalt surfaces, epoxies are sensitive to moisture and temperature and may require long dry times. MMA may be installed at any temperature, is durable and dries quickly, but is more expensive than epoxy.

Maintenance Considerations - Some cities have reported that epoxy color intensity fades over time due to color instability under ultraviolet lighting (sunlight) exposure. Pooling water can reduce material longevity.

Material Cost - Epoxy: \$1 – \$3 Sq. Ft. for raw materials. \$8-11 Sq. Ft. installed. - MMA: \$3 – 4 Sq. Ft. for raw materials. \$8-11 Sq. Ft. installed.

Longevity - Similar to thermoplastic. Poor pavement quality impacts treatment longevity. Epoxy paint used in peer cities has proven skid resistance and longevity of 3 – 5 years. MMA may last as long as 3-6 years.

#### **2.1.4.3 Thermoplastic, another type of durable pavement marking**

This is a type of plastic made from polymer resins that becomes a homogenized liquid when heated and hard when cooled. Thermoplastic can be pre-formed in specific shapes, such as tiles that can be assembled like a puzzle to color bicycle facilities. Thermoplastic can also be used for bicycle lane symbols, arrows, pavement legends and shared lane markings.

Thermoplastic tends to last longer than epoxy and is easier to apply than MMA. Retro reflective and anti-skid materials can be applied or mixed throughout the plastic.

Material Cost - \$3 – \$6 Sq. Ft. for raw materials, \$10 – \$14 Sq. Ft installed.

Longevity - Average of 5 years, or 3 times the lifetime of paint under the same conditions. Many installations have lasted significantly longer.

#### 2.1.4.4 Embedded in asphalt:

Colored asphalt is composed of the same material as standard asphalt, but has a colored pigment added. The colored asphalt may be installed as a thin layer over conventional asphalt to reduce cost.

Material Cost - More expensive than standard asphalt installation based on cost of pigment. When applied as a thin top layer within new construction, pigmented asphalt costs between 30 and 50 percent more than a non-colored structural asphalt section. For thin overlay applications, the difference in cost will be greater.

Longevity - Based on motor vehicle traffic, but typically similar to conventional asphalt.

choice of red for bus lanes lends itself to the use of colored asphalt for two reasons: 1) the coloring agent can be successfully applied to either black bitumen or clear bitumen (as opposed to other colors, which can only be implemented with the more expensive clear bitumen), and 2) naturally red-colored rock can be used for the aggregate agent.

#### 2.1.4.5 Recommendations

We recommend to not use paint, because of the low longevity. Thermoplastic and MMA are better in longevity but are expensive. If we assume the installation costs for MMA with 8-11\$ per sq. ft. we get for the CA corridor with a length of 4,82 km and bus lane in each direction, costs of about \$2.82-\$3.77 million. For the CBG corridor, respectively, with a length of 3,86 km and bus lane in each direction, costs of about \$2.65-\$3.02 million. Thermoplastic is even more expensive. Embedded pigments in asphalt seems to be less expensive, but there also have to be construction work to be undertaken.

We recommend to mark the bus lanes with letters "Bus Only" on the asphalt, to demarcate it with double line from the remaining lanes and to additionally add a physical demarcation with elevated barrier between the bus lane and the remaining lane (see Figure 7 – in the picture there is a high physical barrier added. It is also possible to install a lane separator curb system, which allows e.g. the crossing for emergency cars – see Figure 8). Prices for such separators start from \$5 for 1m (Chinese production) – so for the equipment of the 4,82km CS corridor on both sides there should be an investment for the acquisition of about \$24.110 to be calculated (installation not included) For the CBG corridor with 3,86km, respectively \$19.300.

**Consultant:** A+S Consult GmbH; Germany, 01277 Dresden, Schaufussstraße 19; Tel: +49 351 3121330, E-mail: [info@apluss.de](mailto:info@apluss.de)

**Client:** United Nations Development Programme (UNDP)

**Project:** Green Cities: Integrated Sustainable urban Transport for the City of Batumi and the Achara Region (ISTBAR)

---



Figure 7 - Demarcation between bus lane and lane for individual transport



Figure 8 - Lane separator curb system

## 2.2 Intersections

### 2.2.1 Shared Transit/Right-Turn Lane

On streets with a right-side dedicated transit lane that accommodates a moderate volume of right-turn movements, the transit lane can permit right turns approaching an intersection, (Figure 9).

On streets with a right-turn lane but no transit lane, buses can be permitted to use the right-turn lane for through-movements.

#### Application

At locations where right-turning vehicles can typically clear through the intersection quickly.

Can accommodate moderate right-turn volumes at intersections where right turn on red is permitted (e.g. green arrow in Germany allows turning right every time on intersections) and pedestrian volumes are low.

Can be applied to streets with or without dedicated transit lanes.

#### Benefits

Shared transit/right-turn lanes allow vehicles to make right turns across a transit lane.

The operational benefits of permitting right turns from transit lanes accrue entirely to right-turning motor vehicles.

Where driver compliance is very low, permitting right turns from the transit lane may sometimes be safer than prohibiting turns.

If vehicle right-turn volumes are high enough for right-turn queues to occur with regularity, right turns should be accommodated separately from transit in a turn pocket.

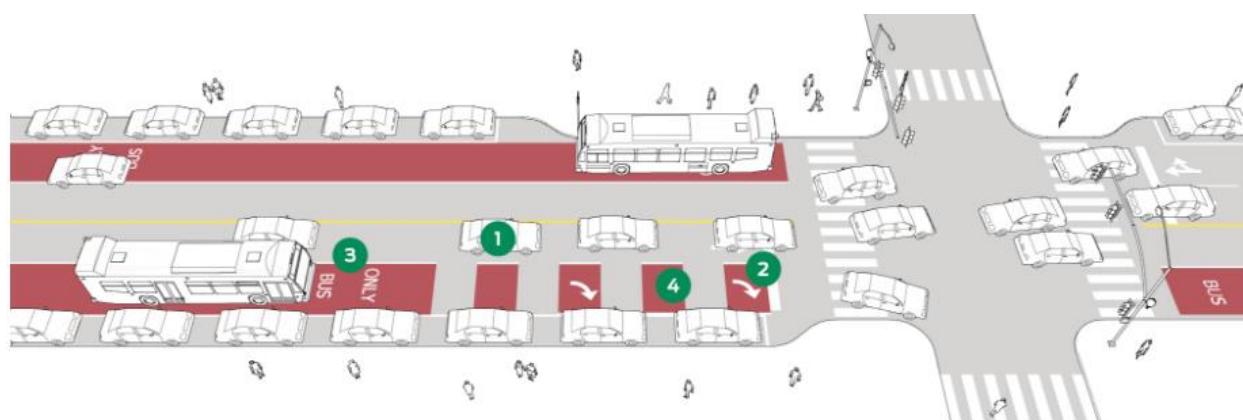


Figure 9 – Example Shared Transit/Right-Turn Lane

#### Recommended

The left-side line of the transit lane should be dashed for 15–20 m in advance of the intersection.

Mark pavement with right-turn arrow. Install right lane must turn right and except buses signs.

Install BUS ONLY signs and markings on the receiving side of the intersection.

## **2.2.2 Right-Turn Pocket**

Where right-turn volumes are high enough (approaching unstable flow, LOS D, Volume\Capacity Ratio  $\geq 0,7$ ) to interfere with transit operations but cannot be prohibited, providing a right-turn pocket to the right of the through transit lane reduces bus delays, (Figure 10).

Right-turn pockets should be considered only after other alternatives are exhausted, since they lengthen the time needed for safe pedestrian crossings, preclude the use of near-side curb extensions, and use valuable curbside space.

### **Application**

At intersections with high right-turn volumes on streets with a dedicated offset transit lane transit.

Apply only where impacts to the pedestrian realm can be avoided. Right-turn pockets should generally not be carved from existing sidewalks, as would be necessary for use with curbside transit lanes.

Where right turns must be accommodated, but would delay transit vehicles if present in the transit lane. At locations with high pedestrian crossing volumes and little offset distance, even low right-turn volumes can be problematic for transit.

Where a protected bike lane or raised cycle, track exists to the right of the transit lane and/or curbside parking.

### **Benefits**

Provides dedicated space for right turns while giving priority to through-moving transit.

Permits dedicated right-turn phases, potentially beneficial for pedestrian and bicyclist safety and operations at high-pedestrian intersections.

### **Recommended**

A white skip line must be marked on both sides of the transit lane to indicate that vehicles may transition across it.

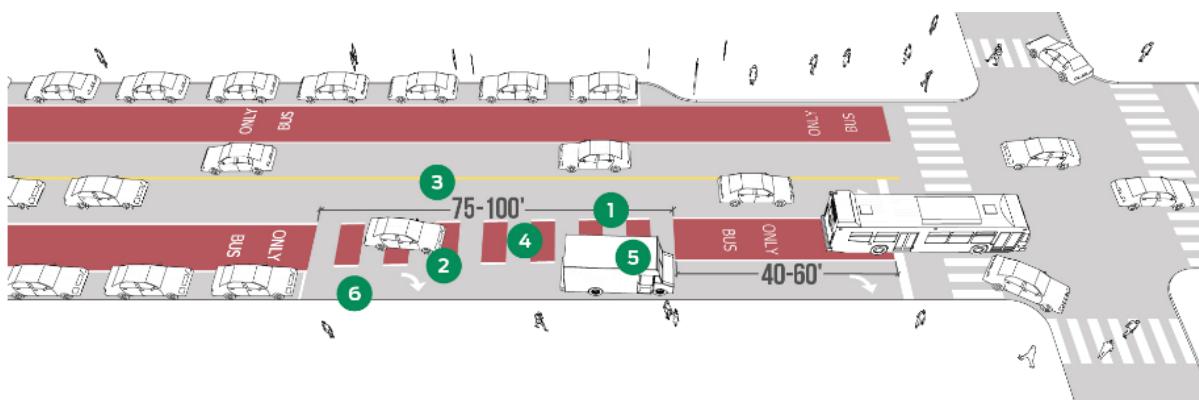


Figure 10 – Example Right-Turn Pocket

The right-turn pocket should be provided to the right of an offset transit lane with a transition treatment to allow vehicles to cross the dedicated transit lane.

The transition zone should be 15–25m at low traffic speeds, and the dedicated transit lane should resume to create an approach area that accommodates at least one transit vehicle prior to the stop bar. With 40-foot buses, the transition zone should typically begin at least 30 m from the crosswalk.

The turn pocket should be 3-3.5m wide if routinely used by trucks at peak periods. 2.75m of width may be sufficient if passenger cars are the primary form of turning traffic at peak periods.

Pre-existing turning conditions should be observed carefully prior to design to ensure that transit vehicles can pass at peak transit-demand periods, often corresponding to peak queue periods. Turn pockets should accommodate the longest routinely occurring queue, but should be no longer than necessary to clear blockages from the transit lane. All but the first 9 m of the transition zone can be considered as part of the storage length, as peak traffic will transition extremely slowly.

### 2.2.3 Dropped Transit Lane

On some narrow transit streets, mixed traffic is expected to use the transit lane both for right turns and to occasionally divert around vehicles waiting to turn left. If enforcement is robust and/or automated (by means of ANPR cameras – automatic number plate recognition), dropping the transit lane approaching an intersection can clarify which movements are permitted.

The dropped transit lane will have a relatively low impact on transit operations, especially where the elimination of double-parking and curbside loading is more important for transit operations than eliminating intersection delay (Figure 11).

Other vehicles may enter the transit lane to circulate around left-turning vehicles, but must rejoin mixed-travel lanes after the intersection when dedicated transit lanes resume.

## Application

On transit lanes where automated enforcement is tied to the lane design, it may be important to formally permit through-movements in the transit lane at some intersections.

On two-way streets with one transit and one mixed-traffic lane per direction, where left turns are permitted but no left-turn pocket or lane is present. This condition is most relevant when left-turn volume is low, with one to two vehicles turning per signal cycle.

### **Benefits**

Dropped transit lanes alleviate mixed-traffic delay and congestion at pinch points by permitting through-moving vehicles to merge right and bypass left-turning vehicles.

Buses and streetcars are generally able to maintain priority, as vehicles utilizing the dropped lane must merge and yield to through-traffic.

### **Recommended**

Mark a skip line between the through mixed-traffic lane and the dropped transit lane to indicate to motorists that they may enter the transit lane, and install through/right arrows at the intersection approach.

Install RIGHT LANE BUS ONLY or other applicable sign where the transit lane resumes.

If private vehicles are permitted to continue across the intersection and merge left after the intersection, use lane reduction arrows (Figure 11) to direct vehicles back into mixed-travel lanes.

End the transit-only lane 15–20 m before the intersection, depending on left-turn volume.

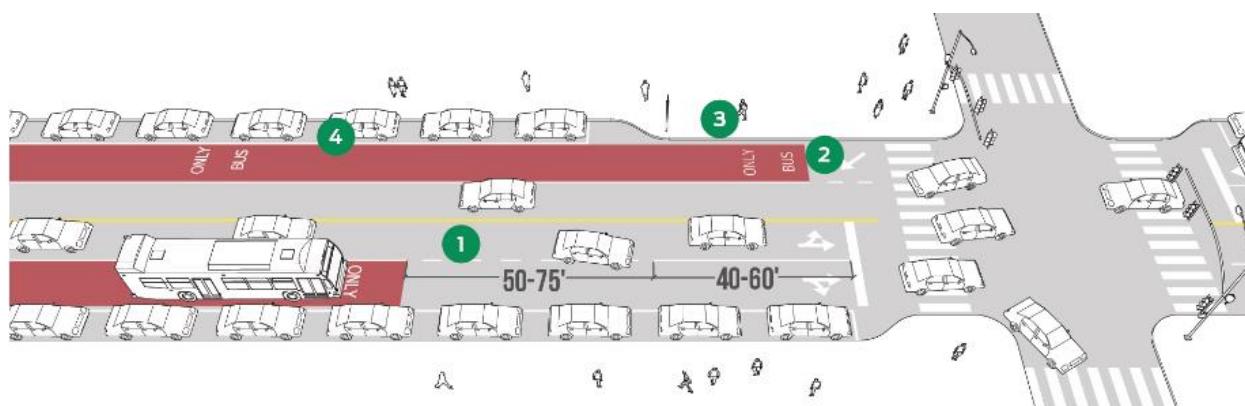


Figure 11 - Dropped Transit Lane

If a stop is located at the intersection, provide a far-side in-lane or curbside stop.

Install BUS ONLY word message markings at the end of the bus lane and where it resumes on the other side of the intersection.

### **2.2.4 Transit Approach Lane/Short Transit Lane**

Short transit lanes on the approach to major intersections, sometimes paired with active signal priority, allow transit vehicles to bypass long queues that form at major cross streets (Figure 12).

Since these streets often have long signal cycles or break the progression of the transit street, they often present a significant source of delay across downtown, neighborhood, and corridor transit streets. Transit approach lanes let the transit vehicle stay in its lane, a major benefit to both bus and streetcar lines.

### **Application**

On streets that do not otherwise have dedicated transit lanes:

At the approaches to signalized intersections where transit encounters long delays.

At locations with a high volume of motor vehicle right turns.

Signalized intersections with transit operating in a curbside or offset lane.

Where a bicycle intersection approach is provided in a similar manner, with a dedicated lane and a right-turn pocket to the right.

Where a right-turn/queue jump with signal priority is not practical, such as locations with long right-turn queues.

### **Benefits**

Allow transit vehicles to bypass general vehicle queues and right-turn queues.

Transit vehicles proceed into the approach lane without changing lanes, an advantage over combined right-turn/queue lanes—this is especially important for retrofitting existing streetcar lines, and reduces delay for both bus and rail.

Allows separate signal phases or other accommodation of right-turning traffic.

The transit approach lane must be conspicuous and enforceable. Use clear signage and pavement marking to communicate to motorists the exclusivity of the transit approach lane.

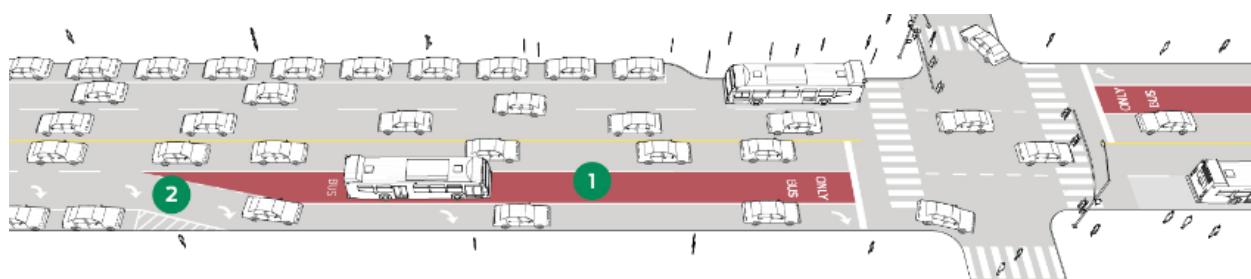


Figure 12 - Short Transit Lane

### **Recommended**

The dedicated approach lane should be long enough to allow the transit vehicle to fully bypass a routinely forming queue. Queue length calculations must account for the additional length of the queue after a general traffic lane is reassigned to a transit lane; in the example shown, this length is twice the pre-existing queue length.

Right turns either should be accommodated with a dedicated turn pocket/turn lane to the right of the transit approach lane, or should be restricted to prevent queuing in the transit lane.

## **2.2.5 Traffic Lights Priority**

Providing priority for public transport at signalized intersections is an excellent way to reduce public transport travel time and increase schedule reliability, helping to make public transport more attractive for customers and less expensive to operate.

Transit signal priority is the technical name for providing public transport vehicles with priority at traffic signals. There are two types of Transit signal priority (TSP) /9/:

- Passive Traffic Signal Priority – In these systems the traffic signals are set to turn green based on an average public transport vehicle speed. There is no interaction between the public transport vehicle and traffic signal system; the signal timing is programmed to be more optimal for public transport speeds than private vehicle speeds. Passive priority is better than nothing, but, especially as technology becomes less expensive, active priority systems are a much better option.
- Active Traffic Signal Priority – In an active TSP system the bus sends a signal to the traffic signal controller. The traffic signal controller, which is located in a box near the traffic signal decides how the traffic signal should react to the information. There are several different types of active TSP systems depending on the method the public transport vehicle uses to send the signal, the type of data sent by the vehicle, and the way in which the controller adjusts the traffic signal timing to provide priority.

Three active traffic signal priority systems are outlined below:

- Dedicated Priority – phasing changes
  - The simplest traffic signal priority systems turn the signal green for public transport every time the vehicle approaches. These systems adjust the traffic signal ‘phasing’ when an approaching bus or tram sends a message to the traffic signal (a ‘phase’ is a combination of signal indications that are displayed simultaneously, e.g. red for eastbound and westbound, green for northbound and southbound = one phase). The action is not immediate; however, as the original phase must end before the signal turns green. For example, if a pedestrian signal is underway, enough time must be given for the pedestrian warning phase and to allow pedestrians to finish crossing the street.

- These systems are not very popular because they can cause fairly significant traffic congestion in areas with sophisticated traffic signal control systems designed to move traffic efficiently.
- Longer Green Time – timing changes
  - To address the problem of traffic congestion caused by dedicated priority systems, another approach is to adjust the traffic signal 'timing' – the amount of time provided to the traffic signal 'phase' for the public transport. In these systems, the timing is only adjusted when the bus sends a message to the traffic signal controller saying that it would benefit from this added time.
  - For example, say a bus is approaching a traffic signal that is green but about to turn yellow. The bus sends a message asking the traffic signal to stay green a little longer so that it can pass through the intersection without stopping. Similarly, if the bus is approaching the intersection and the traffic signal has been red for a long time, it can send a signal asking the traffic signal to turn green a little bit early.
  - If the bus needs to stop to pick-up or drop-off passengers on the corner ahead of the traffic signal (near side) then it makes little sense to extend the green light when a bus approaches since the bus may need to stop anyway. It is critical for traffic engineers and public transport planners to work closely in the physical design of stops/facilities and traffic signal systems.
- Phase & Timing Change – Zurich approach
  - Zurich developed a hybrid approach to traffic signal priority that combines timing and phasing changes into an integrated system. The approach was developed and implemented in the early 1980s and is a fundamental reason for the city's high quality of public transport.
  - The Zurich system combines an automatic prediction of when buses and trams will arrive at a traffic signal with a flexible approach to traffic signal 'phasing' and 'timing'. The automatic prediction system is straightforward: induction loops in the street sense when a bus or tram is passing over them and the travel time between the sensor and the intersection is known, thus the traffic signal receives warning that the tram or bus is, for example, 30-seconds away. Additional sensors communicate updated information to the traffic signal to optimize the signal setting process.
  - After receiving the information on bus or tram arrival, the traffic signal controller determines what the best combination of 'phases' and 'timing' would be so that the public transport vehicle receives a green light exactly when it needs it. This means that green time is not wasted; in other words, either automobiles, pedestrians or public transport are always moving through the intersection. This is important because if nothing is moving,

people or bikes might ‘walk against the light’ – a safety problem – and automobile drivers would complain that the traffic signal was red for no reason.

- The unique thing about the Zurich system is that it works with both ‘phasing’ and ‘timing’. In other words, the ‘phasing’ of the traffic signal changes to provide a green light for public transport exactly when the public transport needs it. The change in ‘phasing’ is relatively unique: it means that the traffic signal pattern is not be consistent. This can be problematic when people are used to constantly repeating patterns and therefore must be introduced carefully.

The existence of separate bus lanes is a major requirement for a TSP, when the traffic congestion is too high to be able to calculate a precise arriving time at the intersection.

Another important requirement is the existence of an accurate locating system for public transport vehicles. There are two different solutions – 1) the vehicles send their location to a central infrastructure, 2) the local infrastructure detects the location of the vehicle. The first solution can be realized by installation of GPS trackers to the vehicles, which send their location periodically to a central server. The central server forwards the information to the local traffic lights controller, who reacts respectively. The second solution requires the installation of loops or infrared beacons near the intersections for identifying and locating the buses – the buses identify themselves with an electronic ID. The information about the bus arrival is directly sent to the traffic lights controller without any central server needed.

The main problem in Batumi is that a majority of the traffic lights controllers are out of administrative access due to difficulties and controversy with the manufacturer Vialis (16 intersections in Batumi, on CBG and CA). This does not allow any remote access to the controllers, which results in the inability to reprogram them for traffic lights priority or other optimizations. A second minor problem is that the traffic light controllers are from different manufacturers. This will result in some more efforts for adjusting the complex system, but it is possible to design TSP on a corridor with different traffic lights controllers.

For Batumi, we recommend a combination of phase & timing change, as it Zurich has implemented. Professional traffic lights controller software like LISA+ from Schlothauer & Wauer supports this TSP logic, which has to be programmed for the controllers. Modern traffic lights controllers are able to work with programmed logic. In terms of the location method, we recommend the loops or infrared beacon solution. It is state-of-the-art, it is supported by modern traffic lights controllers and does not require central server infrastructure to function. This eliminates certain points of failure for the system as a whole.

A possible road map for TSP implementation could look like to following:

- 1) **Solving the problems with Vialis** and obtain remote full access to the controllers – alternatively replace them with controllers from another manufacturer
- 2) **Planning and Design of traffic lights programs** for each intersection on corridors with Phase & Timing TSP and optimizations for the private transport according traffic volumes from the

transport model; simulating and evaluating the effects on traffic flow and the public transport efficiency; tuning the complex system; testing traffic-actuated control

- 3) **Building of separate bus lanes**
- 4) Installation of **local bus location system** – loops or infrared beacons – connection to the local traffic lights controller
- 5) Equip **buses with electronic ID sender**
- 6) **Update traffic lights controllers** with new program logic

## 2.2.6 Application of Intersection Recommendations in Batumi

Examples of some intersections in Batumi for design of separate bus lane, together with possible bike lane configurations.

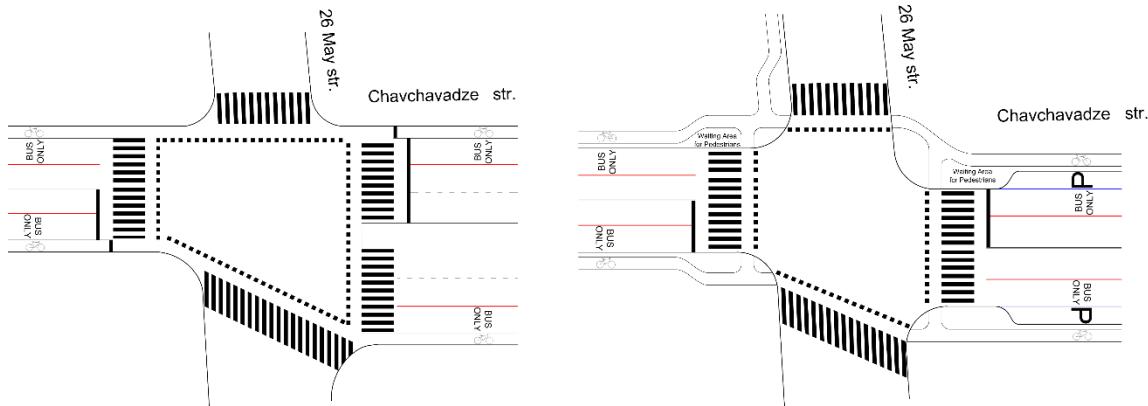


Figure 13 - An examples 26 May - Chavchavadze intersection

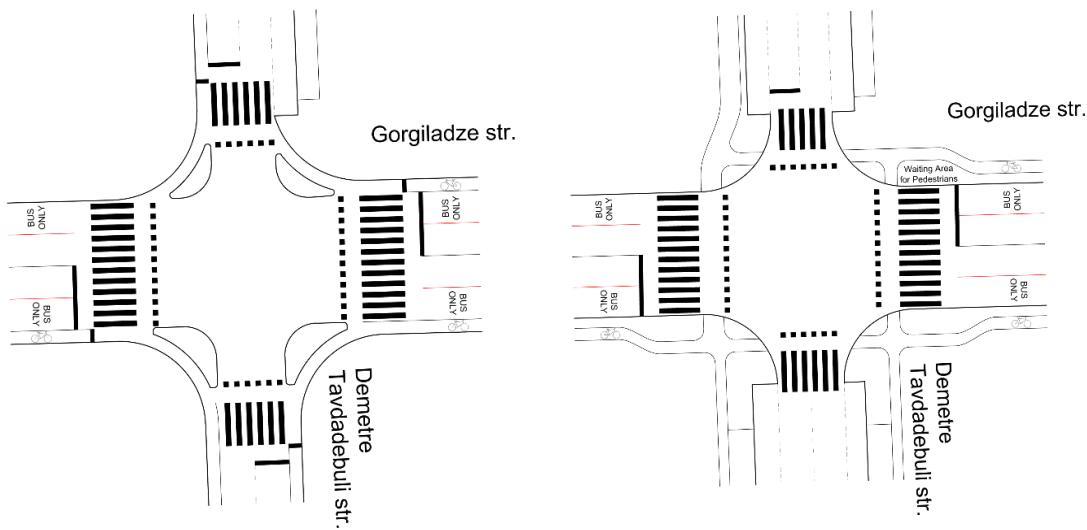


Figure 14 - An examples Gorgiladze - Demetre Tavdadebuli intersection

## 2.3 Bus Stops

Six common basic requirements should be followed when designing bus stops:

- Stops should be placed based on population density and/or major passenger generators (i.e. major employment centers, regional shopping centers, hospitals, etc.);
- Bus stop locations should be clearly marked by a bus stop sign with appropriate vertical and horizontal clearance;
- Bus stop locations should have adequate parking restrictions to allow buses to pull into and out of the bus zone unimpeded;
- Bus stop locations should have a level surface and preferably a firm surface to accommodate boarding and alighting of passengers with special needs;
- Pathways leading to and from bus stop areas should be level, and preferably a firm surface to accommodate passengers with special needs;
- Bus stops should be located in places with minimal above grade obstacles (i.e. guide wires, power poles, utility boxes, etc.)

Surface bus routes, especially those without dedicated lanes, should have clearly marked bus stops that call attention to the stop and explain the route. Frequency and placement of the bus stops should serve the maximum number of destinations while minimizing delays.

The specific design of a bus stop should consider the following elements:

- Siting stops for the convenience of passengers;
- Pedestrian access to and from stops including connectivity with footways;
- Suitability of waiting area;
- Shelters and seating;
- Security and lighting;
- Information - timetables, route maps, service numbers;
- Bus stop pole and flag;
- Approach and exit paths for buses;
- Type and height of kerbs;
- Drainage;
- Surface markings for buses.

There are, in general, three categories for bus stop locations (Figure 15):

- Far-Side bus stops
- Near-Side bus stops
- Midblock bus stops

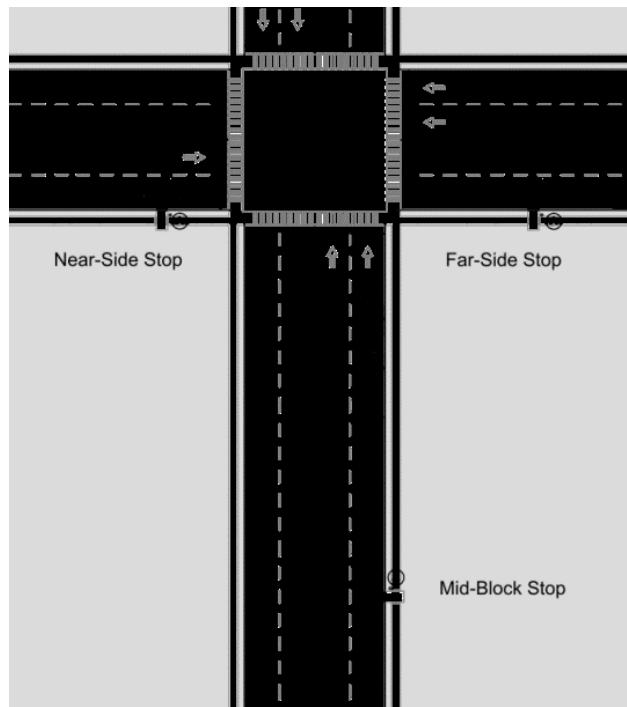


Figure 15 - bus stop locations

**Far-side bus stops** are the most common and are generally preferred by designers. They allow pedestrians to cross behind the bus, which is safer than crossing in front of the bus. On multilane roadways, they also increase the visibility of crossing pedestrians for drivers waiting at the signal (Figure 16).



Figure 16 - Far-side bus stops

**Near-side bus stops** should ideally be used in these circumstances (Figure 17):

- On long blocks where the nearside stop interfaces better with pedestrian destinations, such as parks, waterfronts, and schools.

- Where the bus route is on a 1-way street with one lane of traffic and does not permit passing.
- Where specific traffic calming features or parking provisions restrict the use of far-side stops.
- Where access to a senior center or hospital is located at the near-side of the intersection.
- Where driveways or alleys make the far-side stop location problematic.



Figure 17 - Near-side bus stops

**Midblock bus stops** require more space between parked cars and other barriers to allow buses to enter and exit the stop, except where there is a bus bulb (Figure 18).

They are recommended for:

- Long blocks with important destinations midblock, such as waterfronts, campuses, and parks.
- Major transit stops with multiple buses queuing.



Figure 18 - Midblock bus stops

Bus stops must have safe access via sidewalks and appropriate street crossing locations. Where possible, pedestrian crossings should be accommodated behind the departing transit vehicle. The amount of sidewalk space around a bus stop should meet the intended demand and ridership levels. Streets with insufficient queuing space at bus stops should consider the implementation of a bus bulb or dedicated waiting area. Bus stops are required to meet ADA standards, including the provision of landing pads and curb heights that allow for buses to load passengers in wheelchairs. Bus bulbs should be applied where offset bus lanes are provided, where merging into traffic is difficult, or where passengers need a dedicated waiting area (Figure 19). Where applied, bus bulbs should be 12 m long and at least 1.8 m- wide with no step to the sidewalk (based on a 12 m-foot bus). If there is a step to the sidewalk, the bus bulb should be at least 3 m in width or be designed to accommodate the length of the wheelchair ramp used on most standard 12-m buses.



Figure 19 - Bus stops

Information provided to riders at a bus or transit stop should include an agency logo or visual marker, station name, route map, and schedule. Bus stops should include a system and/ or route map and schedule on the bus shelter or other street furniture.

Real-time information systems may be added at bus stops to enhance the rider experience and create a predictable travel experience for riders.

Bus stops for BRT may have special features that are not usually applicable for the typical bus stops. There is a huge variety of BRT bus stop types defined by their different characteristics:

- Island type platform or side platforms (applicable for the central alignment of BRT);
- At-station payment to access the bus;
- Screen doors at the stations;
- Platform height.

The type of the stations used for each BRT system depends on the aim of the system. If there is a purpose of integration of BRT into the public transport system with some mixed-use sections, then bus stops have to be compatible with the general buses. In some cases, BRT is built as close to the rail as it possible, so the stops can have high island platforms, requiring special rolling stock.

BRT stations and stops play a key role in defining a BRT system and in the system's performance. Good BRT station or stop design can do the following:

- Attract new riders.

- Promote visibility and facilitate branding of the system.
- Provide shelter from the weather.
- Ensure safe accessibility for all, including people with disabilities.
- Provide passengers with information, including system maps and real-time arrival information.
- Provide passengers with a safe and secure environment by including such items as CCTV cameras, a public-address system, public and security telephones, lighting and fencing.
- Enable passengers to board through multiple doors.
- Enable precise berthing at designated stopping points.
- Enable level boarding by matching platform height with vehicle floor height and using precision docking.
- Enable passengers to pay their fares before boarding using off-board fare payment equipment.
- Provide passengers with amenities such as newspaper boxes, signage, waste recycling, special lighting, seating and bicycle parking.
- Provide passengers with an attractive environment, using features such as landscaping and public art.
- Create a sense of place within the community, encouraging development and other activities to occur near the station or stop.
- Ensure ease of access to users of other modes, including bicyclists, pedestrians and automobile drivers.
- Ensure easy connections with other local and intercity modes of transportation.

BRT station and stop types can range from simple bus stops to full-size stations comparable to large rail terminals. The type selected will depend on a number of parameters, including project budget, estimated passenger demand, surrounding area land use zoning, and available right-of-way.

We may recognize the types of bus stops as follows:

- Basic bus stop;
- Enhanced bus stop;
- BRT station;
- Transit Center;
- End-of-line or terminus facility.

### **2.3.1 Basic bus stop**

The advantage of basic stops is that they are quick, easy and inexpensive to install. However, they have many disadvantages. They do little to distinguish BRT from traditional bus service and do not communicate permanence. They have low capacity and few, if any, passenger amenities. These features reduce a basic stop's ability to attract choice riders and its ability to encourage transit-oriented development, (Figure 20, Figure 21).

**Consultant:** A+S Consult GmbH; Germany, 01277 Dresden, Schaufussstraße 19; Tel: +49 351 3121330, E-mail: [info@apluss.de](mailto:info@apluss.de)

**Client:** United Nations Development Programme (UNDP)

**Project:** Green Cities: Integrated Sustainable urban Transport for the City of Batumi and the Achara Region (ISTBAR)



Figure 20 - Bus stop (San-Francisco, USA)

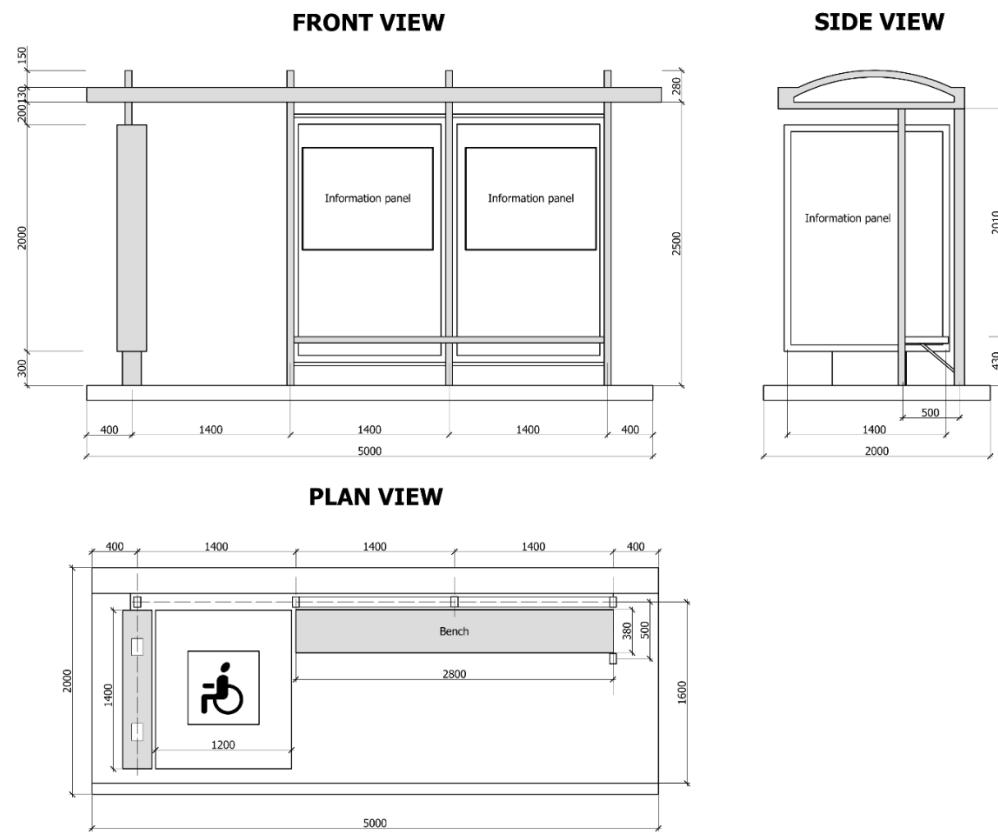


Figure 21 – Example Basic bus stop

### **2.3.2 Enhanced bus stop**

An enhanced stop is a designated point for passenger boarding and alighting that may include a few amenities, such as a small shelter, passenger information, seating, lighting and branding elements. Typically, these stops are smaller in size and scale than stations.

The advantages of enhanced stops are that they are quick and easy to install and inexpensive in comparison to full stations. The disadvantages are that such stops may only moderately distinguish the BRT service from traditional bus, (Figure 22, Figure 23).



Figure 22 - Enhanced bus stop (Paris, France)

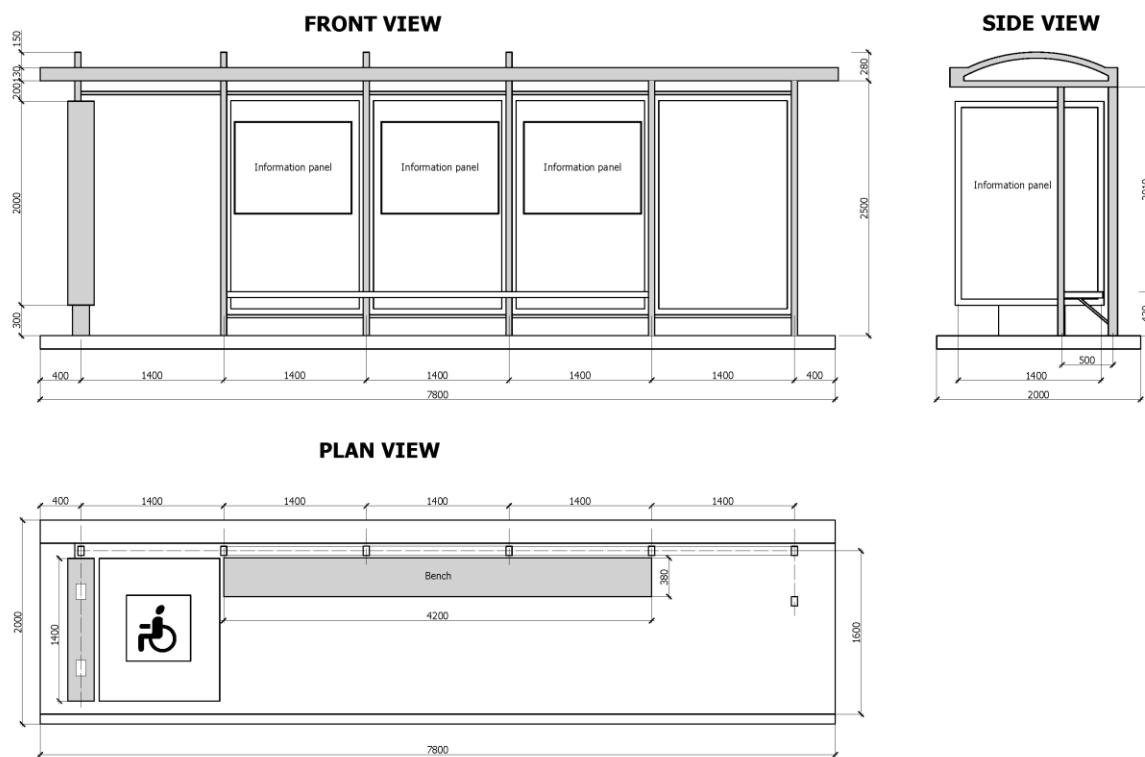


Figure 23- Example Enhanced bus stop

### 2.3.3 BRT-Station

A station is a substantial facility that can include many of the following attributes: shelter, level boarding, opportunity for advance fare collection, a unique name, a distinctive look and feel, passenger information, lighting and security, seating and other features typically associated with rapid or rail transit stations.

The advantages of stations for BRT are that they are attractive, convey permanence and can provide more substantial passenger amenities than those found in enhanced stops. They also offer higher capacity than simple or enhanced stops and are easy for passengers to identify and locate in a street environment. In addition, they may have enhanced security features.

These features maximize the BRT system image and reinforce the feeling of a rapid transit or "rail-like" system.

The cost of the BRT station construction heavily depends on the type of the stop, its features and facilities. Despite the wide range, the average price of the BRT stop can be estimated as \$200.000 /7/.



Figure 24 - BRT station (Curitiba, Brazil)

#### 2.3.4 Transit center

A transit center is a station located on or off a transit line that enables passengers to transfer to another transit line or service, generally without leaving the physical boundaries of the station. It also may function as an end-of-line facility for some routes.

Transit centers can increase convenience for transferring riders, allow for creation of a fare-paid zone that further eases transfers, and maximize the interface of BRT and local services. They also may provide a greater opportunity for commercial and food services and for TOD. Agencies should be aware that transit centers typically require much more space and a greater capital investment.

Transit centers are recommended where the BRT alignment interfaces with other modes and/or other transit services.



Figure 25 - Metro Link Portland Hills Transit Center (Halifax)

### 2.3.5 End-of-line or terminus facility

An end-of-line or terminus facility (Figure 26) is an endpoint that may also include a place for vehicles to turn around and wait, a rest facility for drivers, an area to perform minor vehicle maintenance, the opportunity for transfers to local buses or other modes, a park-and-ride lot, and other facilities.

A terminus facility clearly identifies the endpoint of the BRT guideway. Agencies should keep in mind that this option may require more space to accommodate spare or replacement vehicles, and it may be less attractive for transit-oriented development.



Figure 26 – End of line station with center island layout

### 2.3.6 Locations of bus stops

The following factors can influence the detailed location of a bus stop or bus shelter and should be taken into consideration at the planning stage:

- Proximity to adjacent junctions;
- Proximity to pedestrian crossings;
- Bends or crests in the road;

- On-street parking;
- Existing accesses to residential and business properties; and,
- Footway or verge width.

Designers should also be looking for sites where there is the opportunity to install shelters.

In the uniformly built-up areas, the optimal distance between the stations of the BRT is approximately 450 meters (1500 feet). If this distance is exceeded, passengers have to spend more time on the access to the stations than they save because of the higher speed of buses. If the distance between the stops is less than recommended, the speed of the bus will slow down and cause more time loss than the access time. Thus, the average distance between the BRT stops should not be less than 0.3 km (0.2 miles) or greater than 0.8 km (0.5 miles).

Recommend locations of BRT like bus stops on CBG and CA corridors drawings are in the Appendix.

## 2.4 Park & Ride

We propose to install at minimum two P&R places in the outer city regions with a direct connection to a "Metro" bus lines – bus rapid transit (see the red line in Figure 28). The "Metro" bus line is a proposed especially dedicated line, which connects the Park & Ride places with the city in a comfortable and fast way.

One P&R should be in the northern part of the city, the other in the southern part. Every P&R gets a colored marking – e.g. northern "blue", southern "orange". The bus lines, serving the P&R will show the color of the P&R to which they are going. The main function of a Park & Ride is to encourage the people leaving their car at a parking space in an outer city region and not driving to the inner city. The more the P&R facility is far from the city center the better it is. The final criteria are how much the P&R can contribute to unburden from traffic amount.

It can be an advantage to combine P&R with a bus terminal, but it is not necessary. Multistory facilities in the inner city will have no function as P&R. They are only providing additional parking space or substituting on-street spaces.

A third P&R could be installed closer to the city, beside the Leonidze street. This location is also under investigation for a bus terminal, so here would be a combined bus terminal with P&R solution possible and the better opportunity for commuters from Khelvachauri to use the P&R. This third P&R can be realized as On-Ground Parking, as well as a multistorey facility. To take a decision it is necessary to undertake further investigations on the land price and availability and compare the cost of one to another.

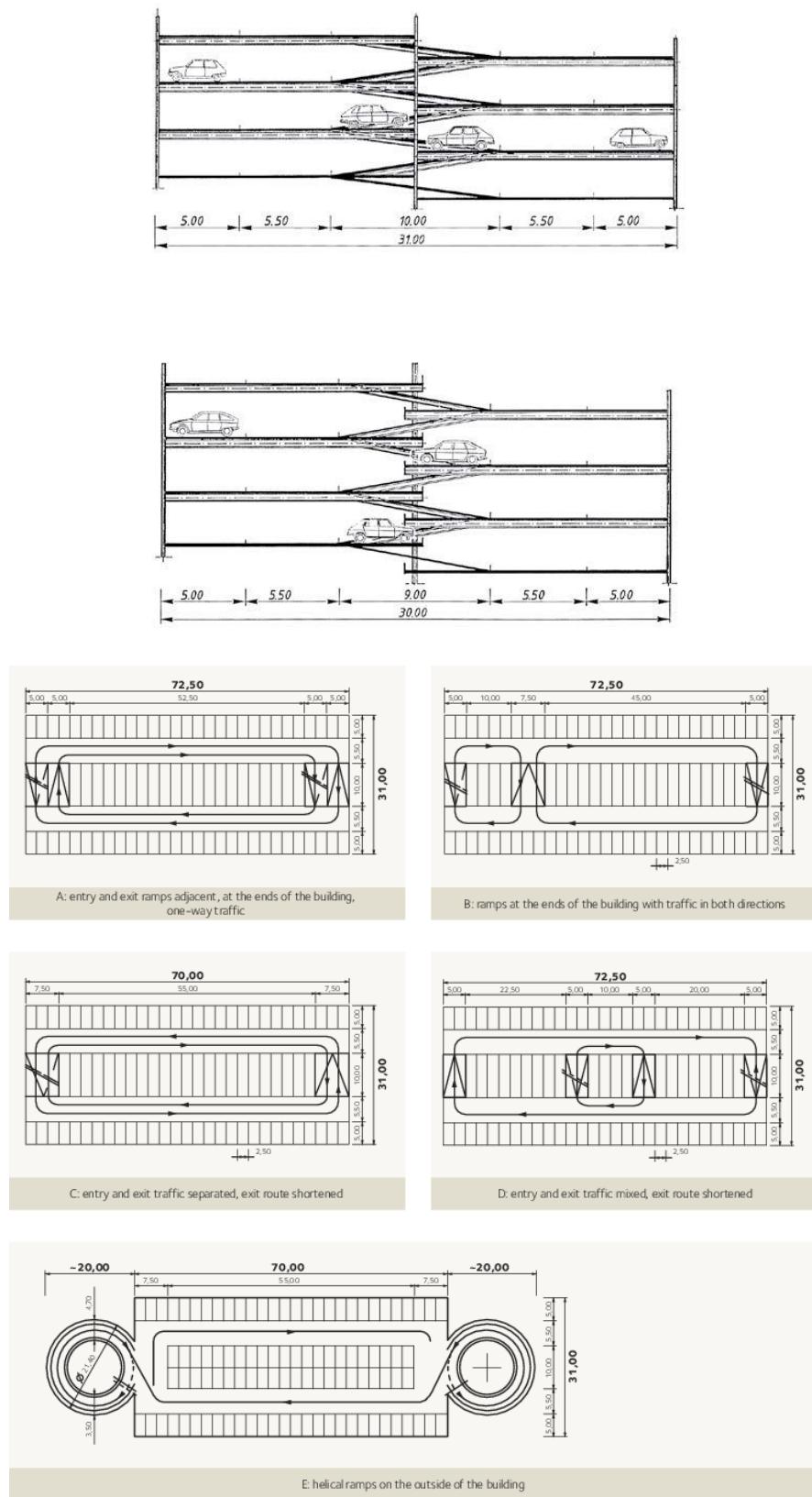


Figure 27 - Conceptual design of parking lots placement on the Multistorey Parking

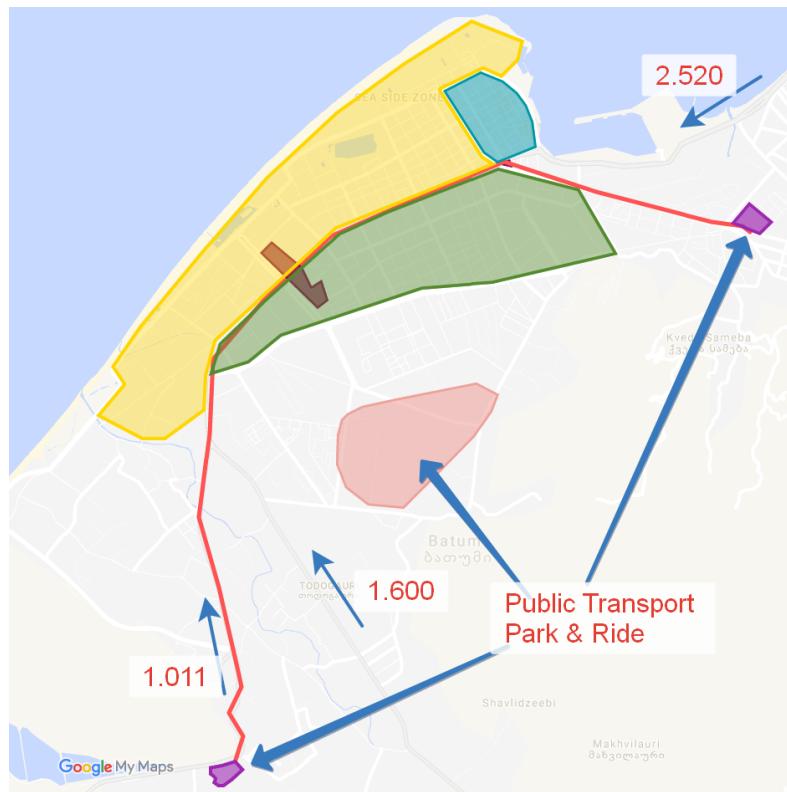


Figure 28 – Park & Ride

The parking capacity of an On-Ground is about 400 spaces per ha. The 2 outer city locations have about 4,5 ha each and can provide space to up to 1.800 cars.

Conceptual designs of the touristic park and ride facilities in Batumi are shown on Figure 29, Figure 30 (more detail in the Appendix).

The first tourist park and ride facility is located on the north of the city near the Gogol str. - Mayakovsky str. intersection; its area is 4.9 ha and it allows 2307 cars to park.

The second tourist park and ride is located on the South, close to the airport and near the b2 highway; its area is 4.4 ha and capacity is 1947 lots.

Each parking lot is 5\*2.3 m, and the width of the bi-directional driveways between the lots is 6.5 m.

PuT stops are planned near each tourist park and ride.

**Consultant:** A+S Consult GmbH; Germany, 01277 Dresden, Schaufussstraße 19; Tel: +49 351 3121330, E-mail: [info@apluss.de](mailto:info@apluss.de)

**Client:** United Nations Development Programme (UNDP)

**Project:** Green Cities: Integrated Sustainable urban Transport for the City of Batumi and the Achara Region (ISTBAR)

---

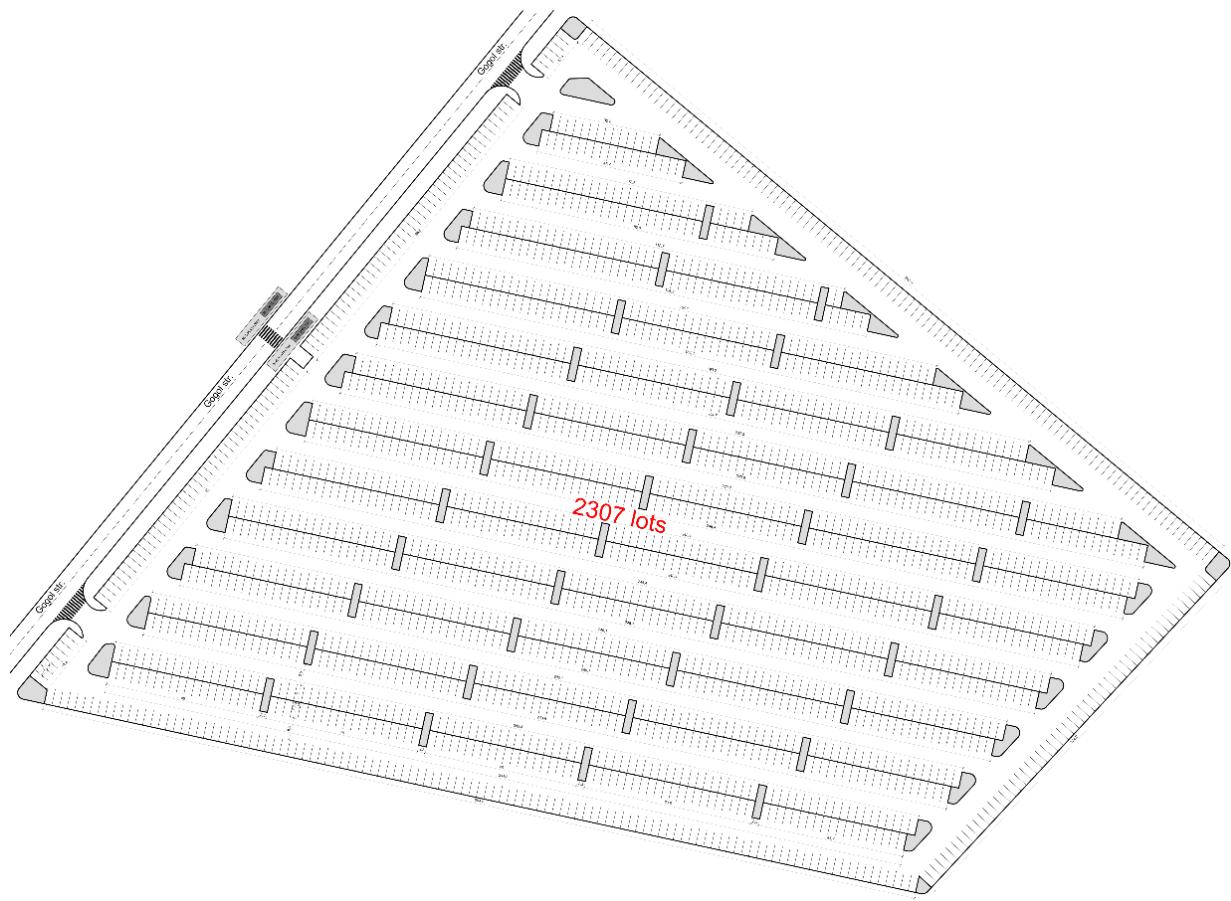


Figure 29 – Conceptual design of the North tourist Park & Ride

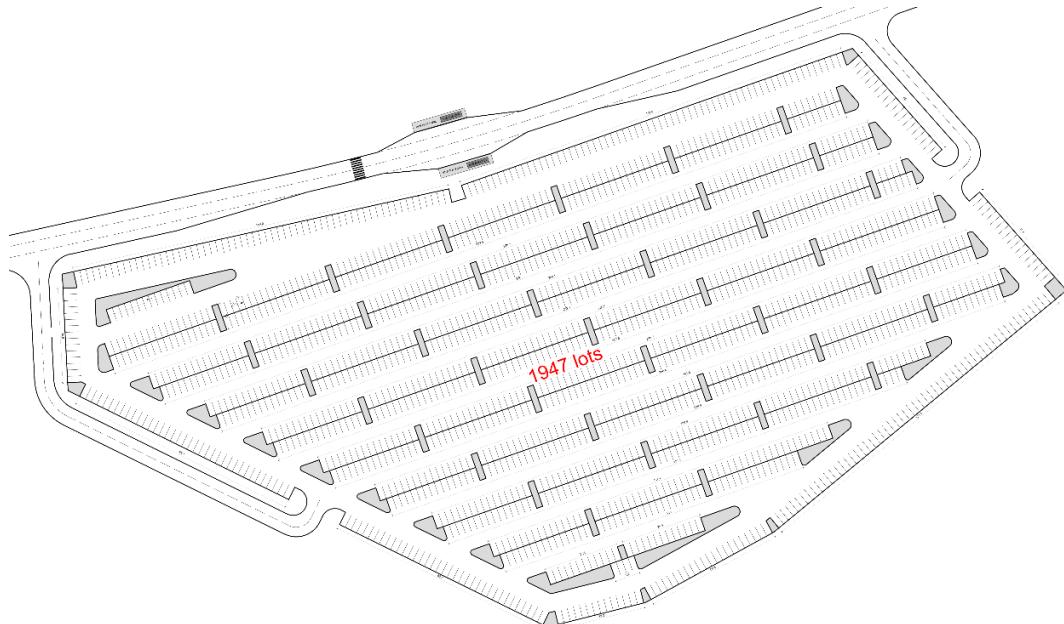


Figure 30 - Conceptual design of the South tourist Park & Ride

## 2.5 Bus Transfer Terminals

In the "Feasibility Study for Low Carbon Sustainable Transport Measures along Demonstration corridors" are 2 different bus terminals proposed – one in the south-western part of the city and a second on Tbilisi Square integrated with Parking Facilities. The bus transit terminals aim to support the fast, comfortable and secure interchange between different bus routes. In the case of Batumi this is mainly related to the interchange between city and regional buses.

The design of the terminals depends heavily on the number of routes, the headway of the routes and the expected number of buses that will serve the terminal. At the moment we know, that the current bus network is far from an optimal solution. In the aforementioned feasibility study were analyzed different optimizations of the bus network. This process is not finished yet and has to be detailed in the discussions with the administration and the transport agency in the future. Because of the current uncertainty in the concrete numbers we can actually give only recommendations on the principles, which should be considered in a design process when the bus network optimization is on the way and should be supported by transit terminals. The core principles are taken from the Auckland Public Transport Interchange Design Guideline /1/ and are examined in the following.

The primary requirements of a customer using the interchange are shown in Figure 31.

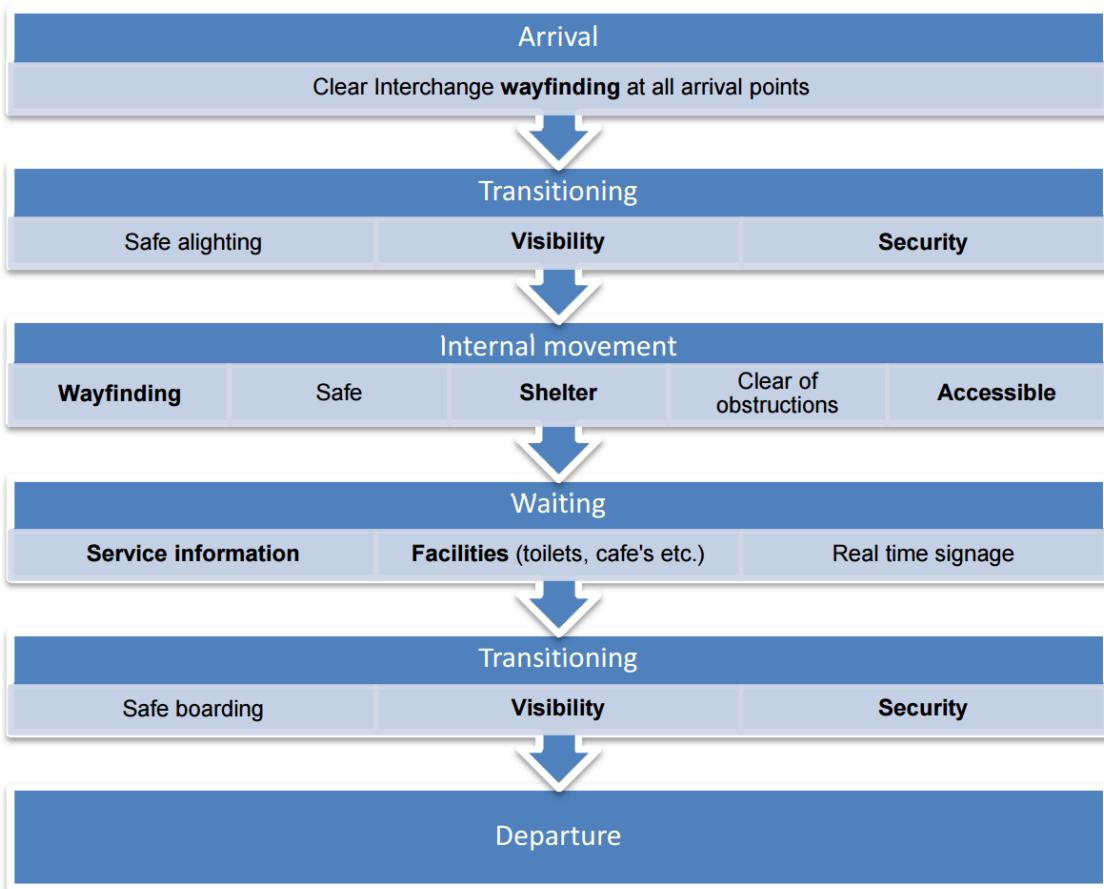


Figure 31 - Primary requirements of customer use of interchange

Bus drivers may also spend time on the interchange. So, they also have certain requirements, which are shown in Figure 32.

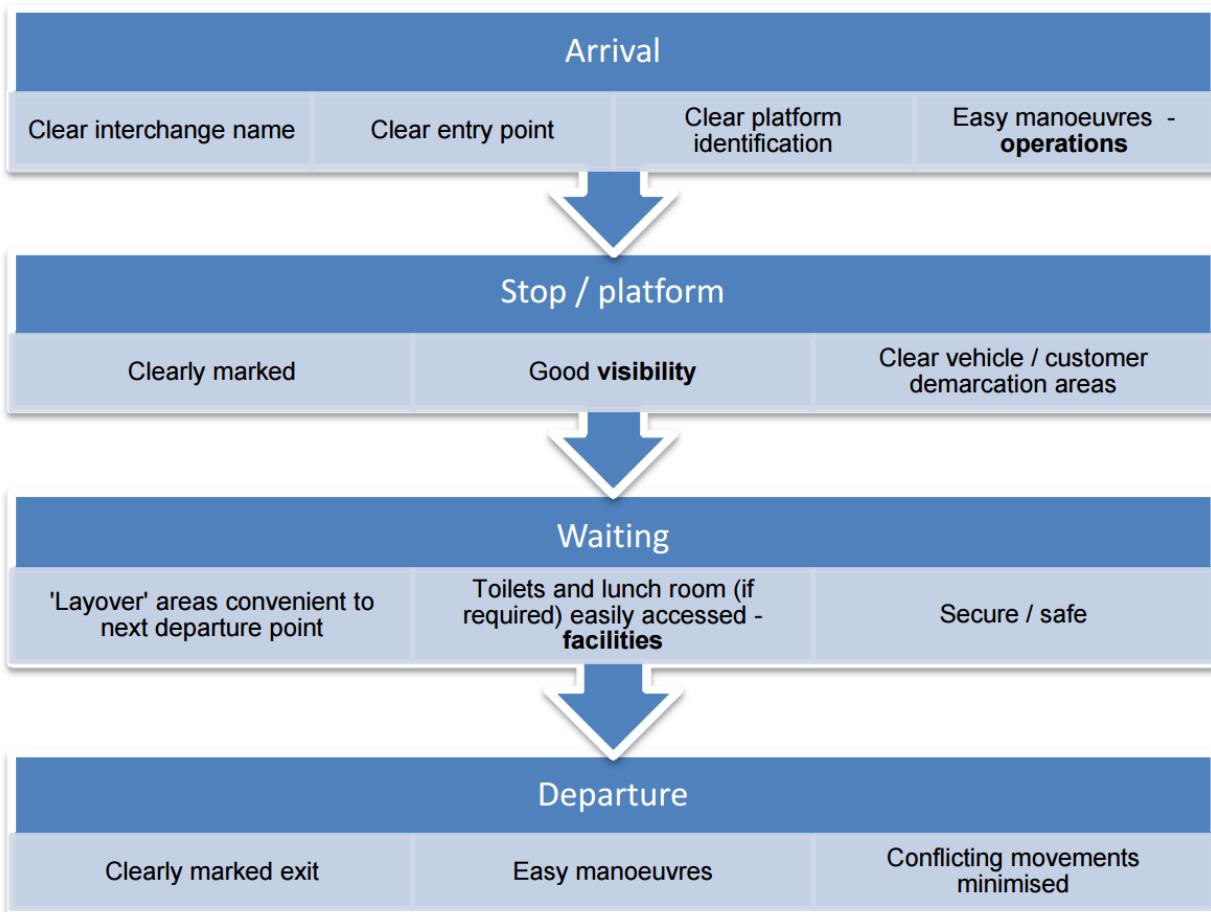


Figure 32 - Primary requirements of bus driver's use of interchange

The priority attributes of an interchange and considerations for the attributes are therefore:

- Visibility
  - Making the interchange feel secure
  - Making the interchange accessible
  - Making the interchange easier to use
- Wayfinding
  - Informing choice at journey decision points
  - Providing reassurance
  - Identification of obstacles
  - Identifying the location of supporting facilities such as toilets and ticket offices
- Shelter
  - Comfort of waiting
  - Security of waiting
  - Visibility of vehicles and customers
  - Operational costs

- Security
  - Layout of the interchange
  - Construction materials used
  - Lighting used
  - Electronic systems such as CCTV
  - Operations
- Accessibility
  - Layout of the interchange
  - The need for clear routes free of obstructions
  - Providing for pedestrian desire lines
  - Integration with surrounding land use
- Service information
  - Provision of static network, timetable and fare information
  - Local area maps
  - Electronic access to information including real time arrival and departure information
  - Integration with wayfinding measures
- Facilities
  - How long might customers be waiting?
  - How many customers will be using the facility?
  - Where are the majority of customers waiting?
  - Where have customers come from?
  - What complementary facilities are provided in adjacent land use?
- Bus operations
  - Bus operational areas need to be well signed and well lit
  - Good demarcation required between bus areas and customer areas
  - Bus maneuvers are easy to make with margin allowed for bus type variances
  - Vehicle conflict areas should be avoided or engineering controls put in place
  - Reasonable allowance for growth in bus numbers and type using the interchange in the future

**Consultant:** A+S Consult GmbH; Germany, 01277 Dresden, Schaufussstraße 19; Tel: +49 351 3121330, E-mail: [info@apluss.de](mailto:info@apluss.de)

**Client:** United Nations Development Programme (UNDP)

**Project:** Green Cities: Integrated Sustainable urban Transport for the City of Batumi and the Achara Region (ISTBAR)

---



Figure 33 - Example Public Transit Terminal Design Manchester I



Figure 34 - Example Public Transit Terminal Design Manchester II

The approximate cost of the bus terminal greatly depends on the size and design of the terminal. The expected price of the terminal at the Figure 34 was 5 million GBP, or 6.2 million USD in 2014.

**Consultant:** A+S Consult GmbH; Germany, 01277 Dresden, Schaufussstraße 19; Tel: +49 351 3121330, E-mail: [info@apluss.de](mailto:info@apluss.de)

**Client:** United Nations Development Programme (UNDP)

**Project:** Green Cities: Integrated Sustainable urban Transport for the City of Batumi and the Achara Region (ISTBAR)



Figure 35 - Example Public Transit Terminal Design Plan



Figure 36 – Covered Bus Transit Interchange

The conceptual designs for the bus transfer terminals are shown on the Figure 37, Figure 41(more detail in the Appendix).

Tbilisi square bus terminal has a capacity to fit simultaneously 6 city buses and 4 suburban ones. The width of each city bus platform is 2 m, and the length is 15 m. Also, bike parking and bike sharing places are provided.

While the buses are expected to be located at ground level, multistorey parking can be located above the bus transfer terminal. The expected capacity is 75 lots at the 1<sup>st</sup> storey of the parking and 80 lots for the above ones. Parking entrance and exit ape proposed to lead to Tsereteli str.

The second bus terminal is located near the Leonidze - Gagarin str. intersection, and has a capacity to handle 10 city buses simultaneously, provide resting place for another 5 buses; it can also offer the place for bike parking, bike sharing and staff parking.

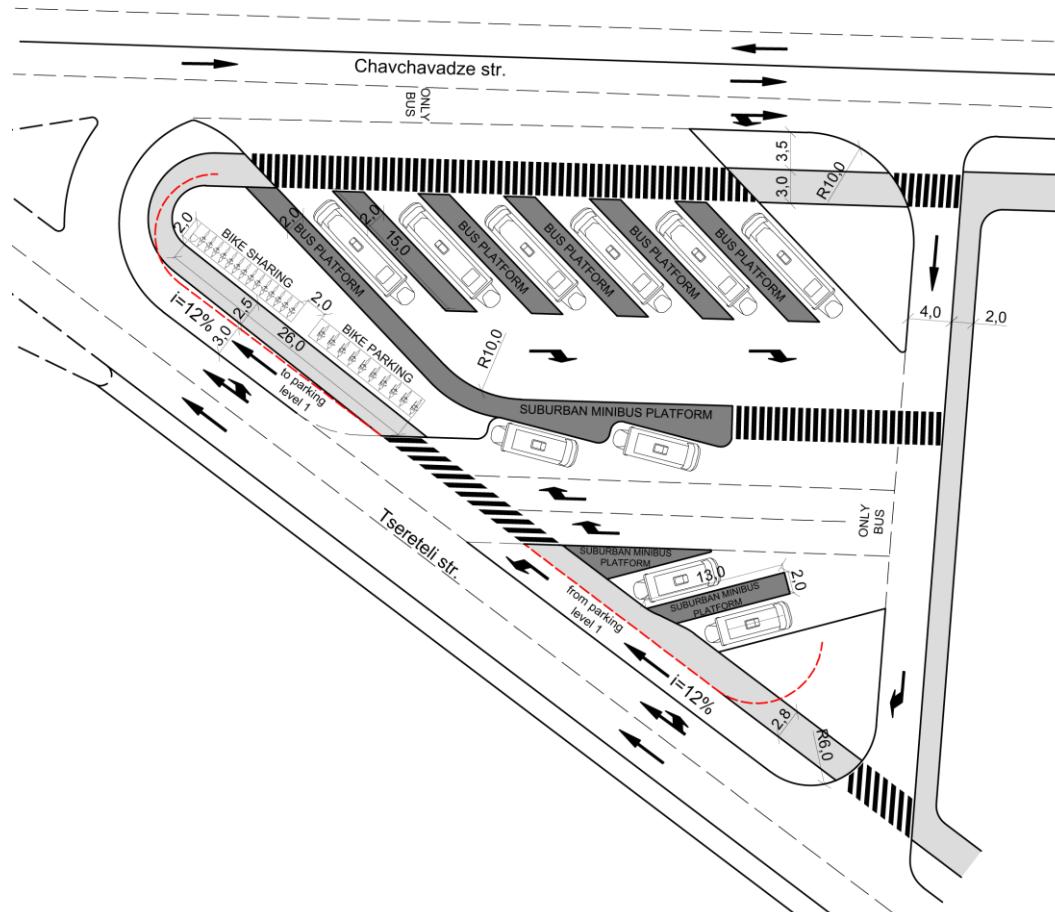


Figure 37 - Conceptual design of the bus terminal on Tbilisi square

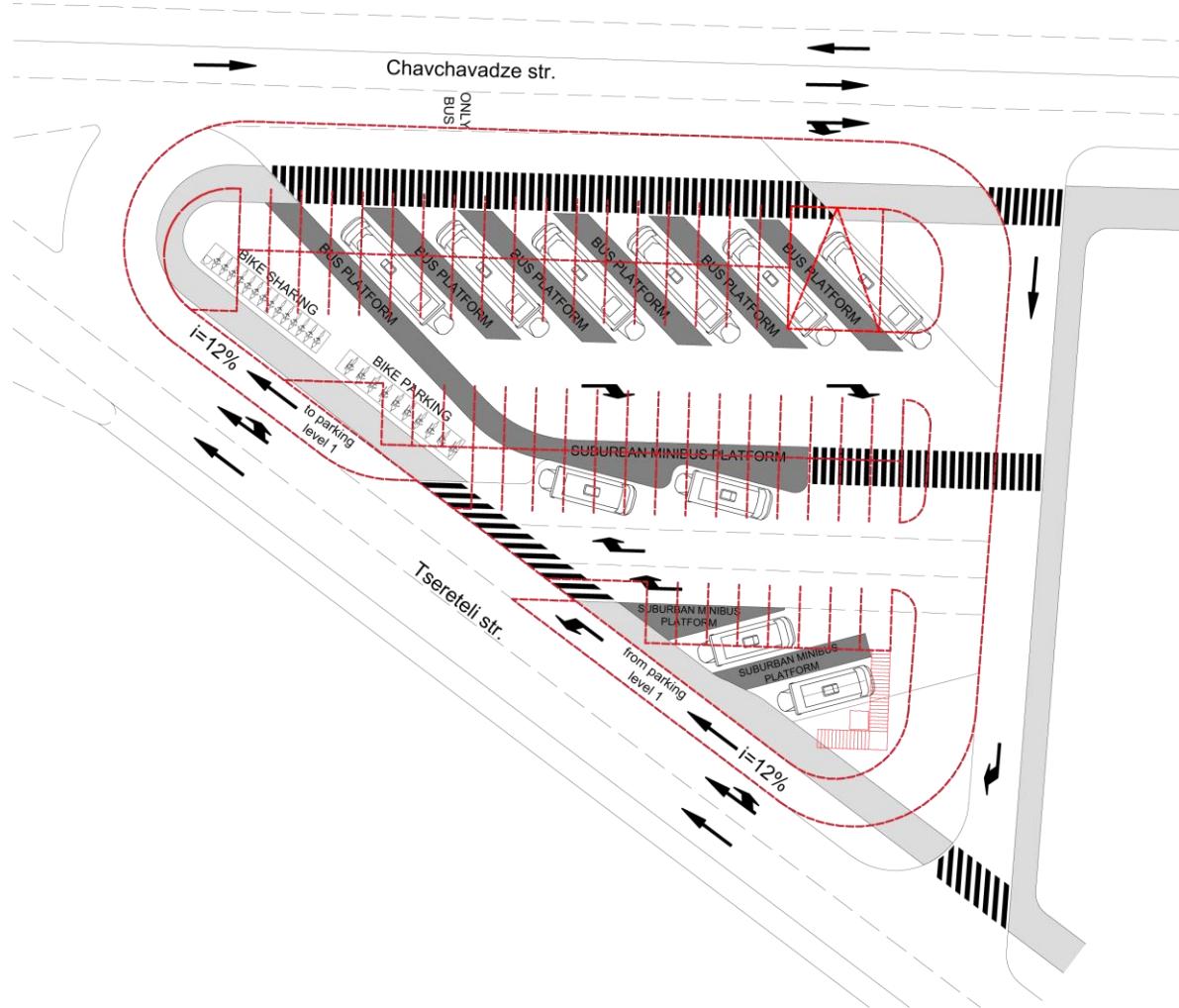


Figure 38 - Conceptual design of the parking located above the bus terminal on Tbilisi square

**Consultant:** A+S Consult GmbH; Germany, 01277 Dresden, Schaufussstraße 19; Tel: +49 351 3121330, E-mail: [info@apluss.de](mailto:info@apluss.de)

**Client:** United Nations Development Programme (UNDP)

**Project:** Green Cities: Integrated Sustainable urban Transport for the City of Batumi and the Achara Region (ISTBAR)

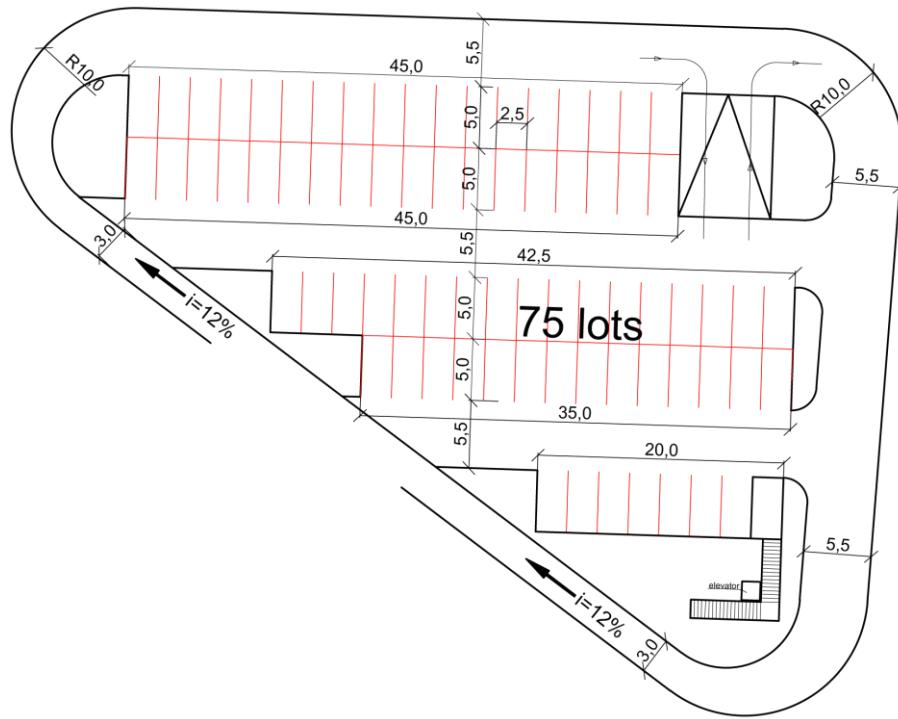


Figure 39 - Conceptual design of the parking (level – 1) on Tbilisi square

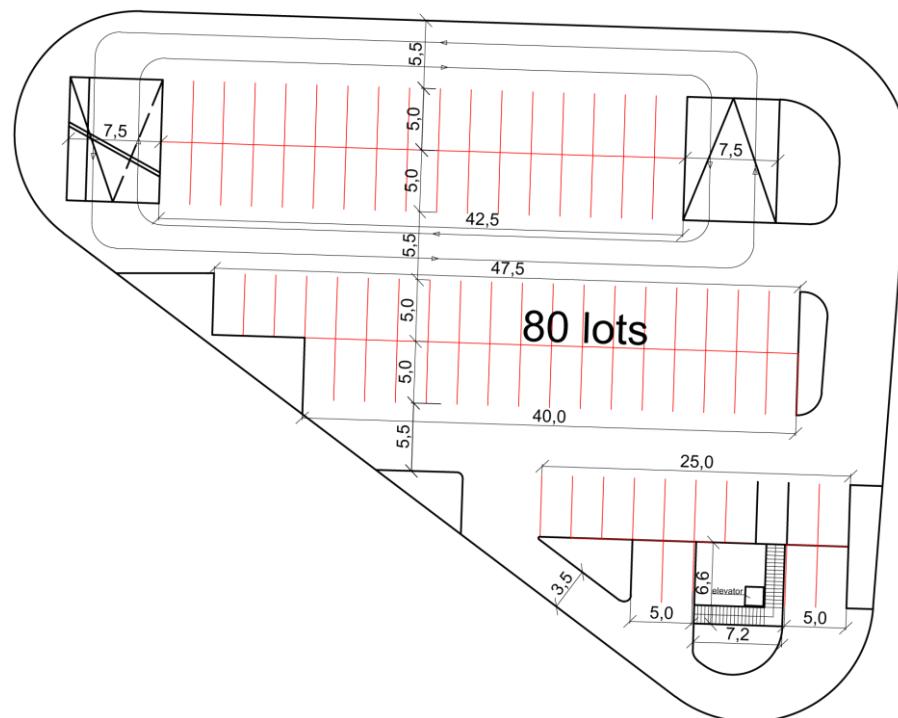


Figure 40 - Conceptual design of the parking (level – 2 and above) on Tbilisi square

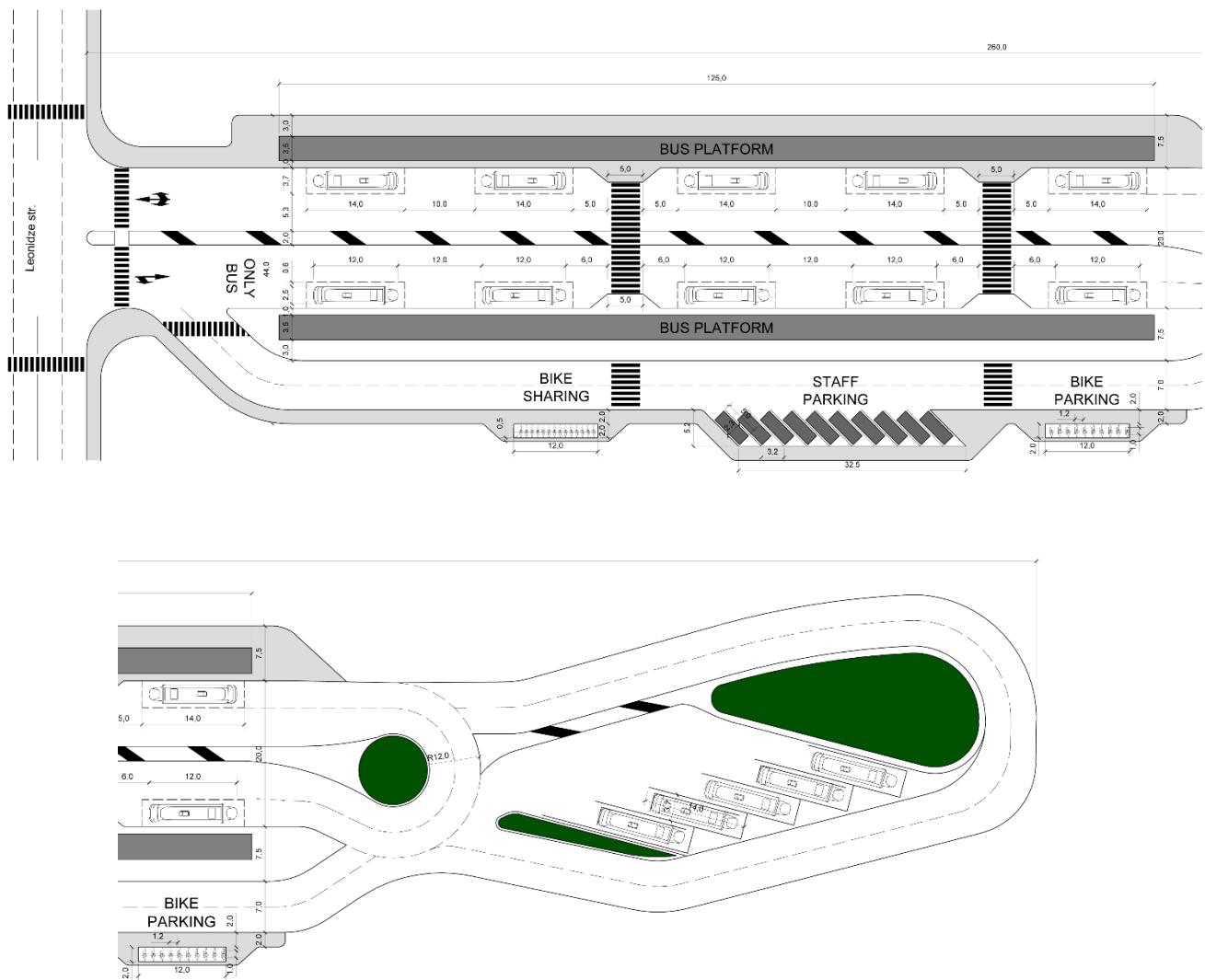


Figure 41 - Conceptual design of the bus terminals on Leonidze - Gagarin str.

### 3 IMPLEMENTATION PLAN

#### 3.1 Road section

For the purpose of road section planning in the CA (Chavchavadze, Abuseridze) and CBG (Chavchavadze, Baratashvili, Gorgiladze) corridors the drawings of Abuseridze, Chavchavadze and Baratashvili and Gorgiladze streets were available as the initial information.

The recommendations referred to in paragraphs 2.1, 2.2, were used to develop options for the road sections.

For corridor CA, five project variants were designed:

- 1) Bus dedicated lane 3.0 (3.5) m wide (parking is preserved), (Figure 42,Figure 43).

According to this layout, the number of lanes for the private transport (in a single direction) on Abuseridze str. is:

- 2 lanes, 3.0 m wide for the section from Kobaladze str. to Abashidze str. (300m);
- 2 lanes 3.0 m wide for the section from Abashidze str. to Griboedov str. (1.100m);

The lane width for Chavchavadze street is:

- 1 lane, 3.5 m wide for the section from Griboedov str. to Baretashvili str. (1.400m).

Midblock bus stops are planned at the location of parking spaces.

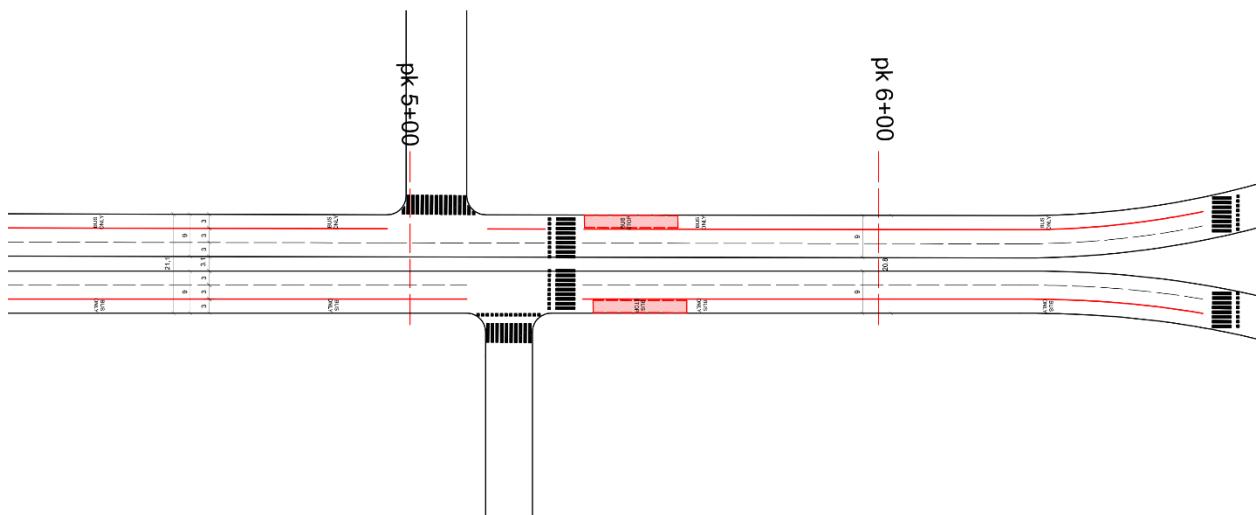


Figure 42 – Example of bus lanes on Abuseridze str.

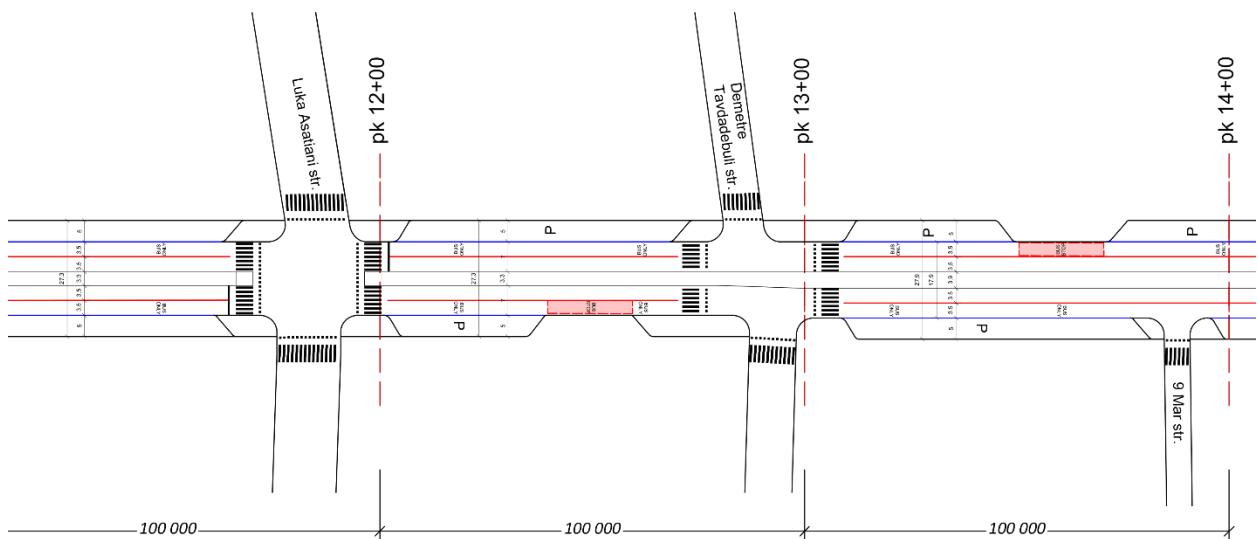


Figure 43 - Example of bus lanes on Chavchavadze

- 2) Dedicated bus lane 3.5 m wide (without parking), (Figure 44,Figure 45)

According to this layout, the number of lanes for the private transport (in a single direction) on Abuseridze str. is:

- 1 lane, 3.5 m wide for the section from Kobaladze str, to Abashidze str (300m);
- 2 lanes 3 m wide for the section from Abashidze str. to Griboedov str (1.100m);

The lane width for Chavchavadze street is:

- 1 lane, 3.5 m wide for the section from Griboedov str. to 26 May str (900m);
- 2 lanes, 3.5 m wide for the section 26 May str. to Baratashvili str (500m).

For this layout near-side and far-side bus stops are proposed.

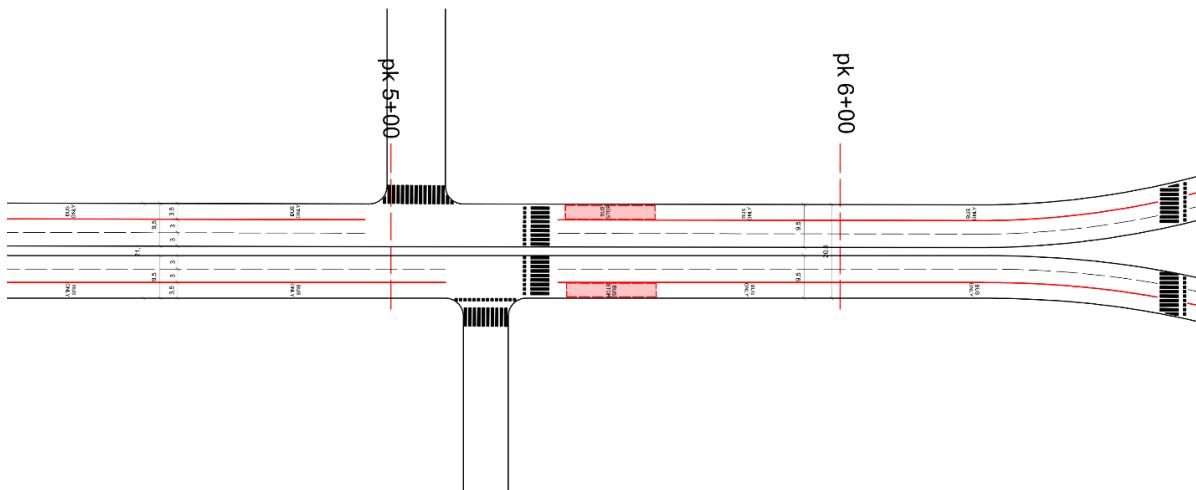


Figure 44 - Example of bus lanes on Abuseridze str.

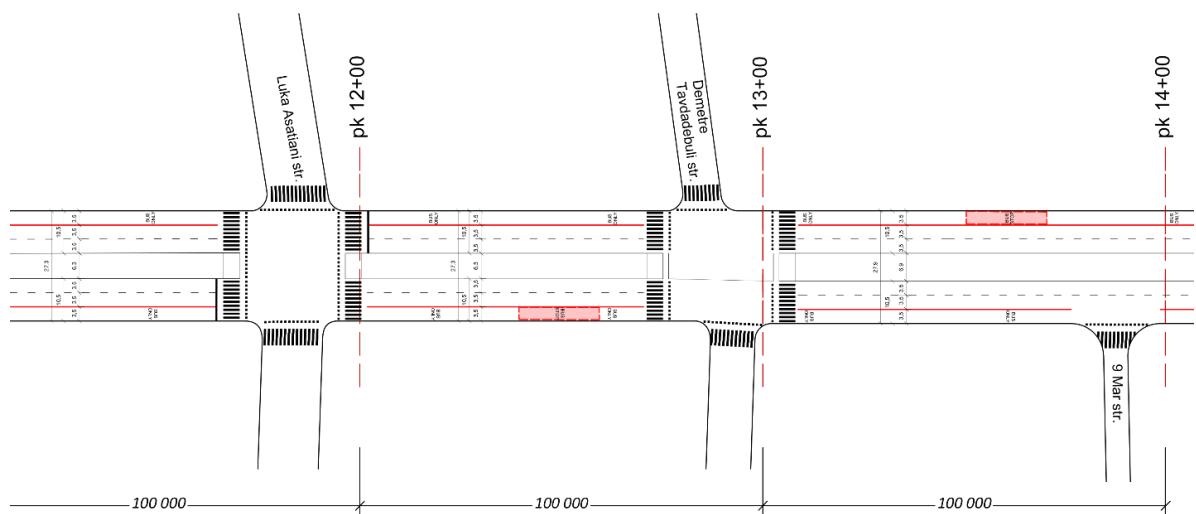


Figure 45 - Example of bus lanes on Chavchavadze str.

### 3) Shared Bus-Bike lane (parking preserved), (Figure 46,Figure 47).

For this planning, shared bus-bike lanes 4.5m wide are proposed.

Number of lanes in one direction for the private transport:

Abuseridze str. is:

- 1 lane 3.5 m wide on the Abuseridze str. from Kobaladze str. to Gribodov str (1.400m).

On the Chavchavadze str. is:

- 1 lane 3.0 m wide on the section from Gribodov str. to 26 May str (900m);
- 1 lane 3.5 m wide, on the section from 26 May str. to Baretashvili str (500m).

Midblock bus stops are planned at the location of parking spaces.

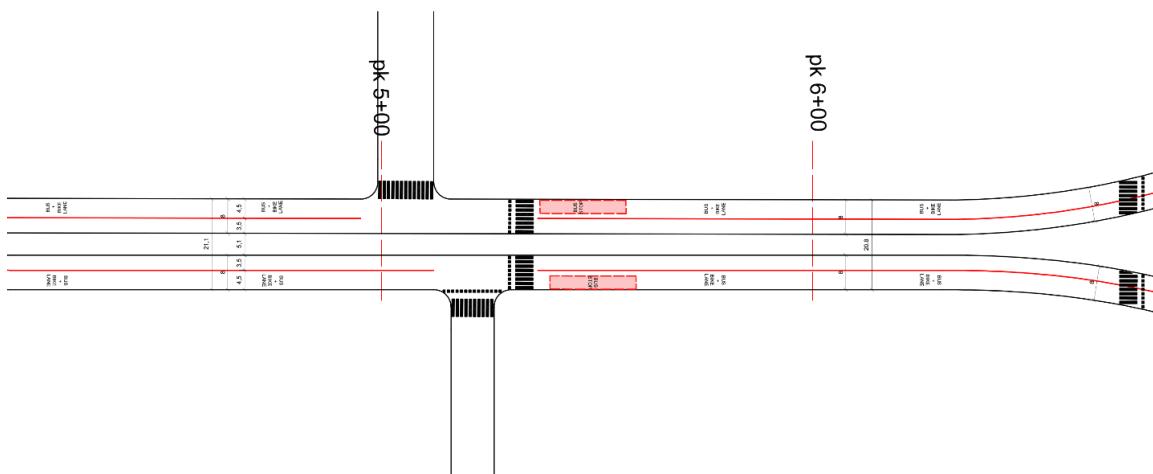


Figure 46 - An example shared bus-bike lane on Abuseridze str.

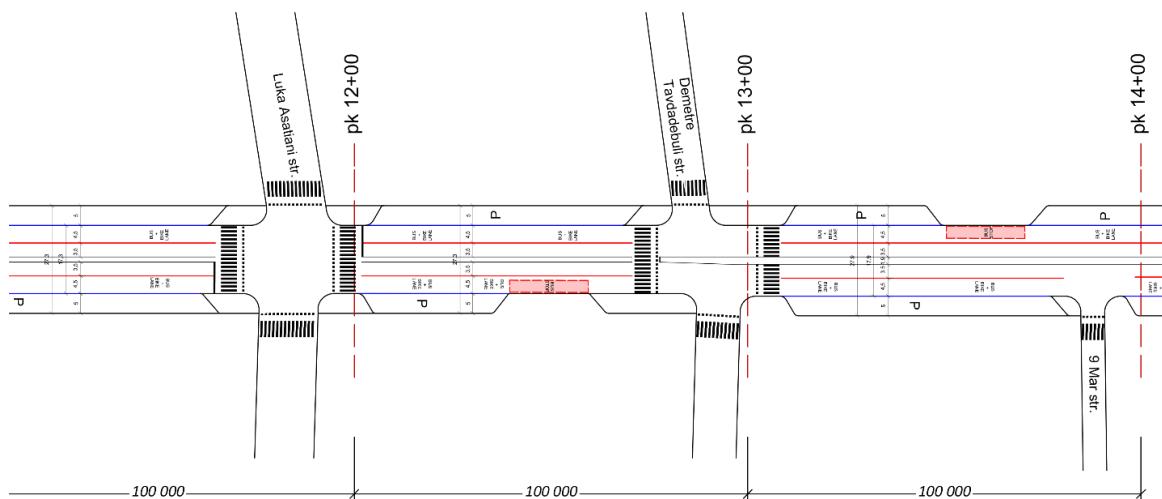


Figure 47 - An example shared bus-bike lane on Chavchavadze str.

- 4) Bus dedicated pane with a separate bicycle lane and preservation of parking spaces (Figure 48, Figure 49).

This planning solution considers a dedicated bus lane 3 m. wide, as well as bicycle lane 1.5 m wide with the parking places preserved.

Number of lanes in one direction for the private transport:

- 1 lane 3.5 m wide on the Abuseridze str. from Kobaladze str. to Gribodov str. (1.400m).

On the Chavchavadze str. is:

- 1 lane 3.0 m wide on the section from Gribodov str. to 26 May str. (900m);
- 2 lanes 3.0 m wide, on the section from 26 May str. to Baretashvili str. (500m).

Midblock bus stops are planned at the location of parking spaces.

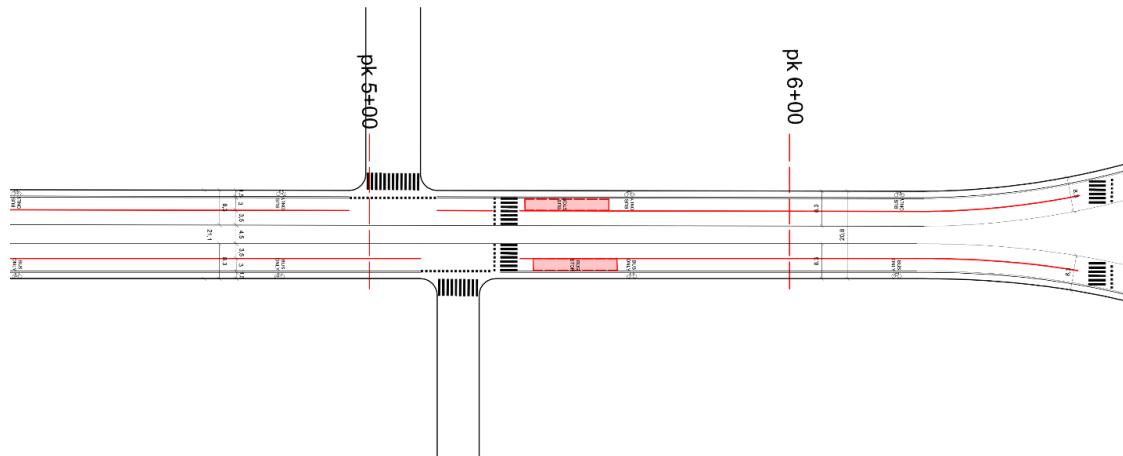


Figure 48 - Example of bus lanes on Abuseridze str.

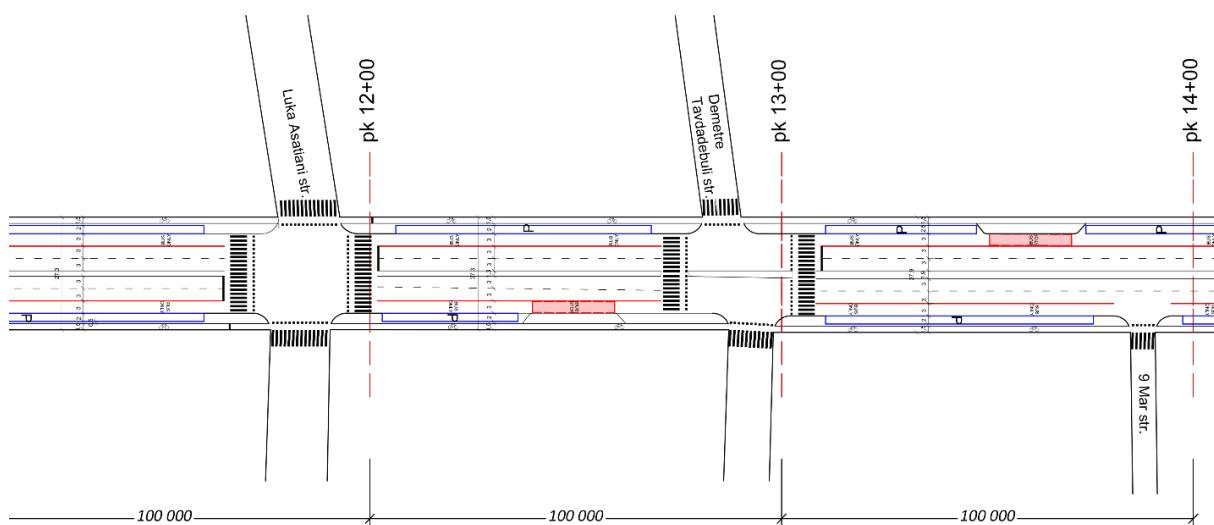


Figure 49 - Example of bus lanes on Chavchavadze str.

Dedicated bus lane with a separate bicycle lane without parking spaces, (Figure 50, )

This layout proposed a dedicated bus lane 3 m wide, as well as bicycle lane 1.5 m wide with the parking places removed.

Number of lanes in one direction for the private transport:

- 1 lane, 3.5 m wide for the section from Kobaladze str. to Gribodov str. (1.400m).

The lane width for Chavchavadze street is:

- 1 lane, 3.0 m wide for the section from Gribodov str. to 26 May str. (900m);
- 2 lanes, 3.5 m wide for the section 26 May str. to Baratashvili str. (500m).

For this layout near-side and far-side bus stops are proposed.

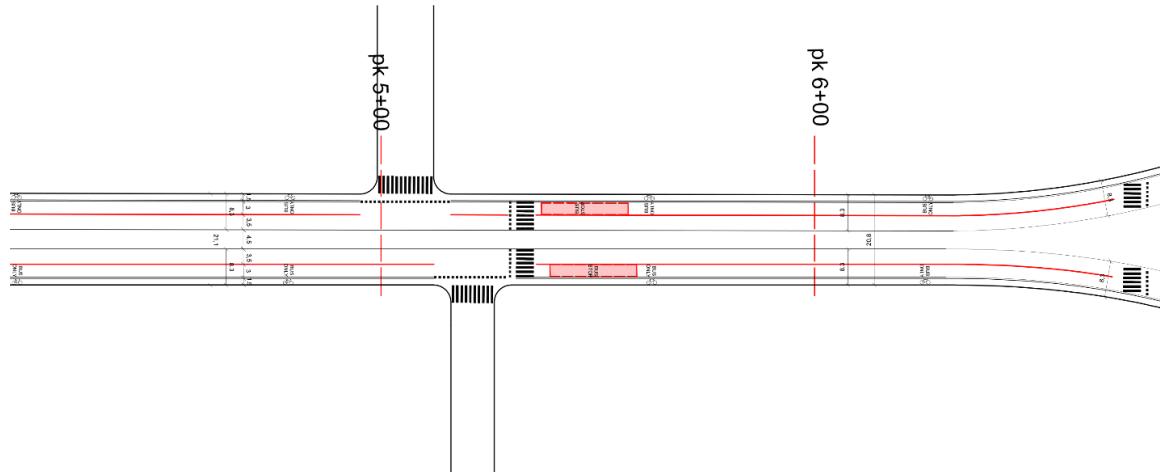


Figure 51 - Example of bus lanes on Abuseridze str.

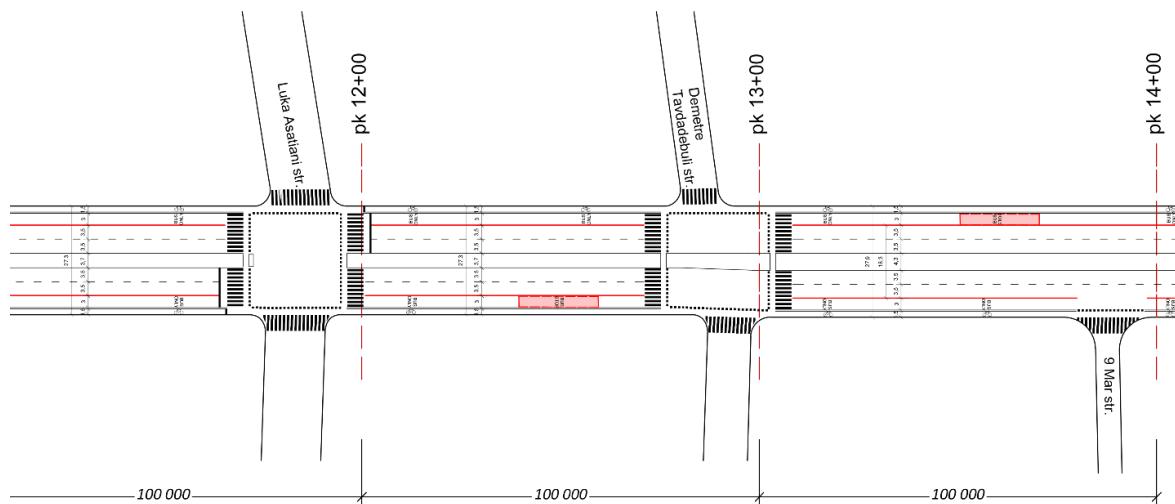


Figure 52 - Example of bus lanes on Chavchavadze str.

Comparison table of the possible layouts for the corridor CA

Layout №	Street name	Bus lane width, m	Number of lanes for cars	Width of lanes for cars	Parking	Bicycle
1	Abuseridze	3.0	2	3.0	-	-
	Chavchavadze	3.5	1	3.5	+	-
2	Abuseridze	3.5	1(2)	3,5 (3.0)	-	-

	Chavchavadze	3.5	1 (2)	3.5	-	-
3	Abuseridze	4.5	1	3,5	-	+ (bb)
	Chavchavadze	4.5	1	3.0 (3.5)	+	+ (bb)
4	Abuseridze	3.0	1	3.5	-	+ (s)
	Chavchavadze	3.0	1(2)	3.0	+	+ (s)
5	Abuseridze	3.0	1	3.5	-	+ (s)
	Chavchavadze	3.0	1 (2)	3.0 (3.5)	-	+ (s)

(s) – separated bike lane; (bb) – shared bus-bike lane;

For corridor CBG, three project variants were designed:

Neither of the alternatives considers road widening.

- 1) This layout proposed a dedicated bus lane wide 3.0m with the parking places removed, (Figure 53, Figure 54).

Number of lanes in one direction for the private transport:

The lane width for Gorgiladze street is:

- 1 lane, 3.0 m wide for the section from Javakhishvili str. to Baratashvili str. (1.600m);

The lane width for Baratashvili street is:

- 2 lanes, 3.0 m wide for the section from Gorgiladze str. to Chavchavadze str. (500m).

For this layout near-side and far-side bus stops are proposed.

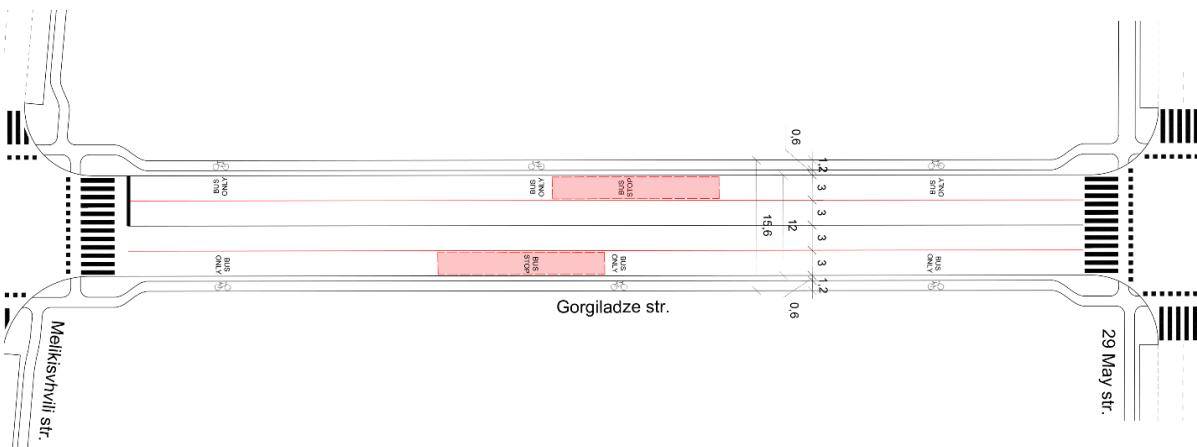


Figure 53 - Example of bus lanes on Gorgiladze str.

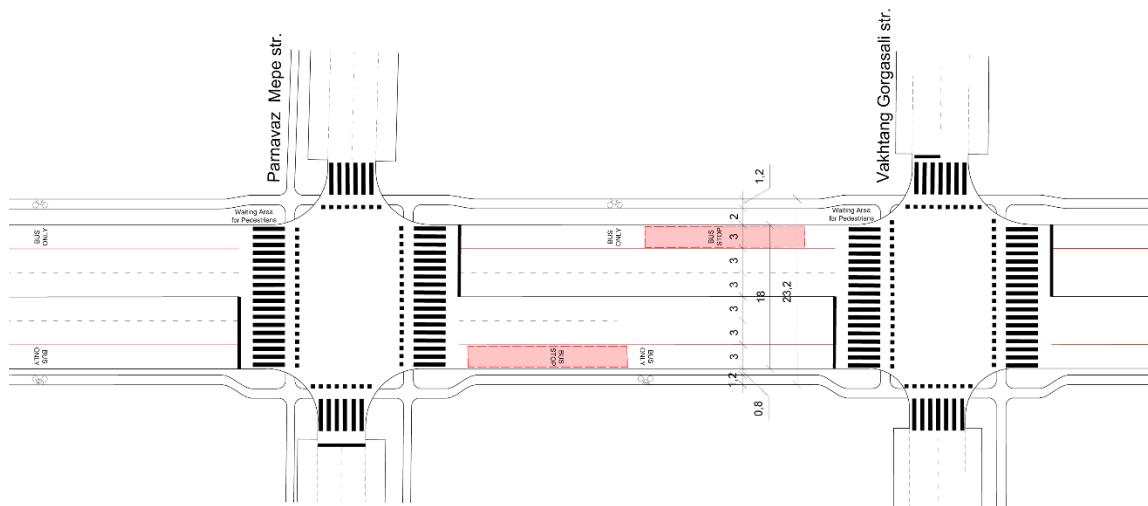


Figure 54 - Example of bus lanes on Baratashvili str.

- 2) This layout proposed a dedicated bus-bike lane wide 3.0m with the parking places removed, (Figure 55, Figure 56).

Number of lanes in one direction for the private transport:

The lane width for Gorgiladze street is:

- 1 lane, 3.0 m wide for the section from Javakhishvili str. to Baratashvili str. (1.600m);

The lane width for Baratashvili street is:

- 2 lanes, 3.0 m wide for the section from Gorgiladze str. to Chavchavadze str. (500m).

For this layout near-side and far-side bus stops are proposed.

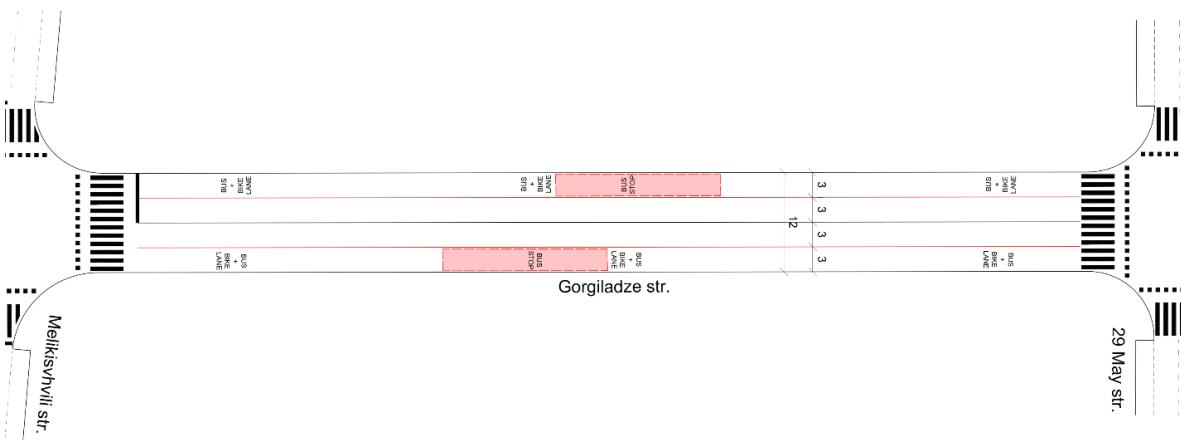


Figure 55 - Example of bus lanes on Gorgiladze str.

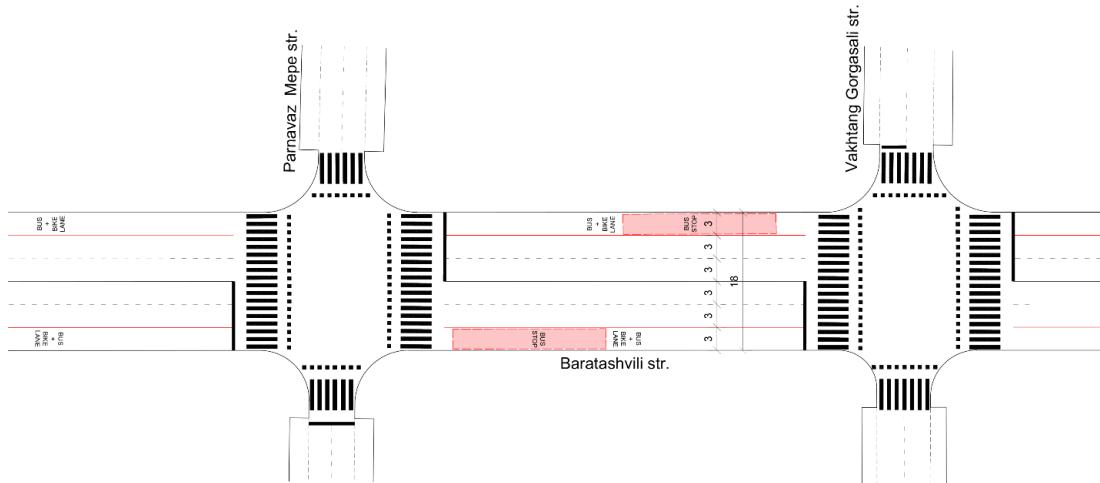


Figure 56 - Example of bus lanes on Baratashvili str.

3) This layout proposed a dedicated bus-bike lane wide 4.5m, with the parking places removed, (Figure 57, Figure 58).

One-way traffic along the Gorgiladze from Baratashvili str. to Javakhishvili str. is proposed.

Number of lanes in one direction for the private transport:

The lane width for Gorgiladze street is:

- 1 lane (one way), 3.0 m wide for the section from Javakhishvili str. to Baratashvili str. (1.600m);

The lane width for Baratashvili street is:

- 2 lanes, 3.0 m wide for the section from Gorgiladze str. to Chavchavadze str. (500m).

For this layout near-side and far-side bus stops are proposed.

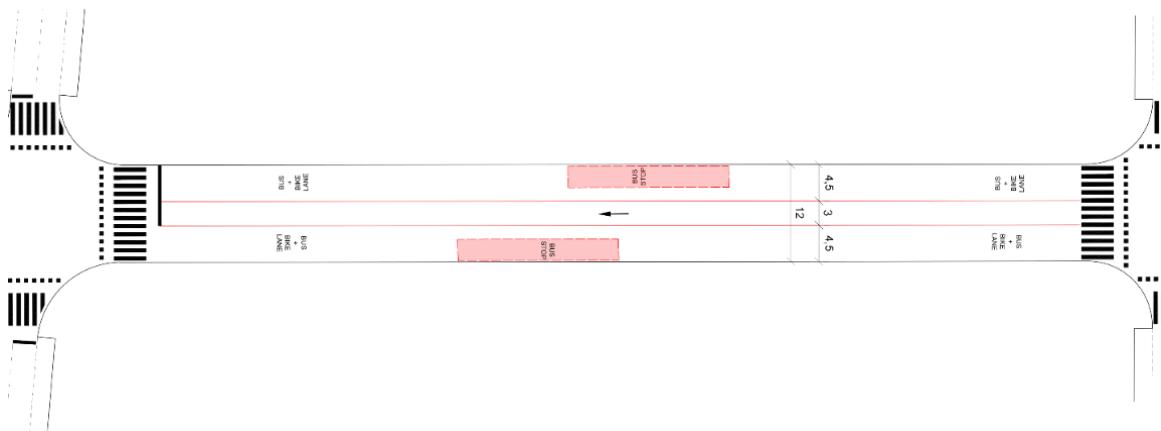


Figure 57 - Example of bus lanes on Gorgiladze str.

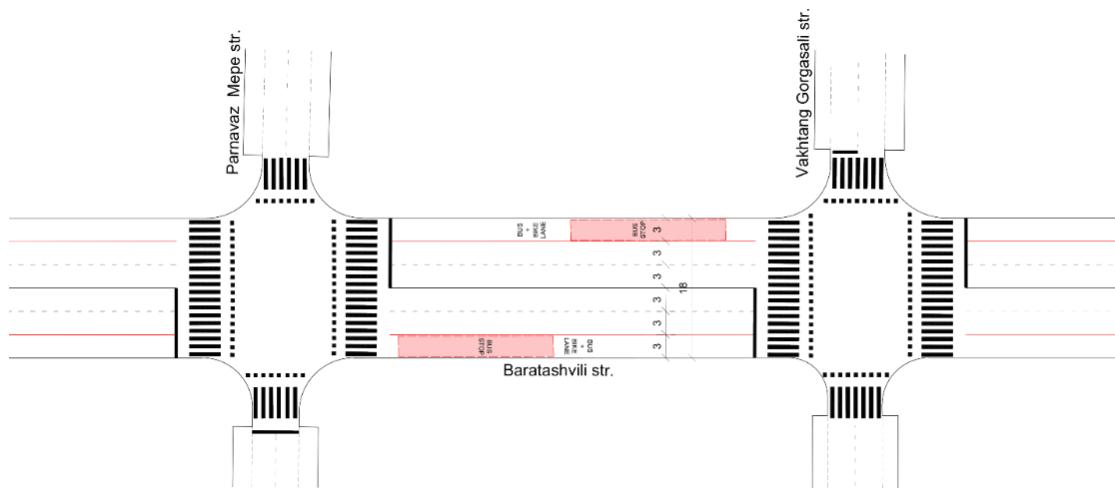


Figure 58 - Example of bus lanes on Baratashvili str.

Comparison table of the possible layouts for the corridor CBG

Layout №	Street name	Bus lane width, m	Number of lanes for cars	Width of lanes for cars	Parking	Bicycle
1	Gorgiladze	3.0	1	3.0	-	+ (f)
	Baratashvili	3.0	2	3.0	-	+ (f)
2	Gorgiladze	3.0	1	3.0	-	+ (bb)
	Baratashvili	3.0	2	3.0	-	+ (bb)
3	Gorgiladze	4.5	1 (one way)	3,0	-	+ (bb)
	Baratashvili	4.5	2	3.0	-	+ (bb)

(f) – bike lane along pavement; (bb) – shared bus-bike lane;

Given the Bus Network optimization together with the bicycle infrastructure development concept from the Output 5 and Parking space concept, layout #4 is the most optimal way of CA corridor implementation, layout #2 is the most optimal way of CBG corridor implementation.

Right turns are allowed from the bus lanes, where they are separated with the dashed line (10-20m) before the intersection (Figure 59).

Access to the bus lane is allowed in the places, where parking lots are located.

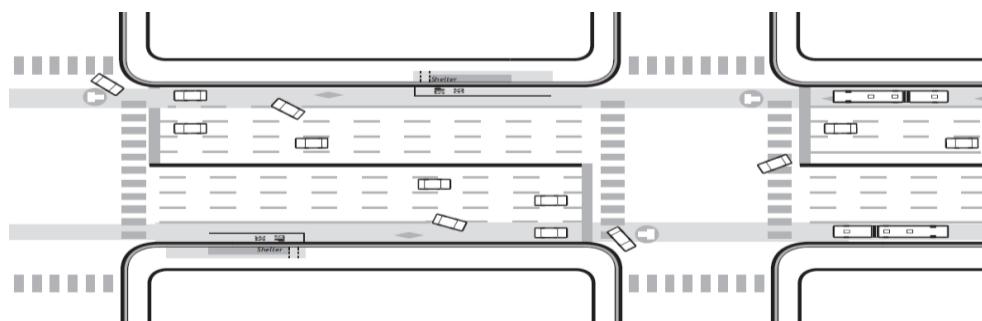


Figure 59 - Example of right turn, performed from the bus lane

Common street maps are presented in the Appendix.

## 3.2 Budgets

### 3.2.1 Dedicated Bus Lane

A dedicated bus lane can be constructed in different ways, which can result in different costs. We assume in this study a BRT-like system with the following configuration:

- Separator curbs or 10cm blocks to separate the bus lane physically
- Alternatively marking with a double line to separate the bus lane
- Markings on the bus lane with "Bus only" or "Bus + Bike only"
- No markings on intersections
- No full colored marking of the bus lane

Material costs for the separator curbs are about \$5.000 for km. Material costs for colored markings with double line – when MMA is used – is about \$8.500 per km.

### 3.2.2 Bus Stops

We assume in this study, that the bus stops will be new construction and will be a simple sheltered bus stop. BRT bus stops are very expensive (\$200.000 in Bogota TransMilenio project /7/) and are designed for high capacity, which we do not see in Batumi. A simple sheltered bus stop without special BRT functionalities fulfilling the corridor requirements costs about \$10.000-\$30.000 /8/, depending on the level of quality and equipment (e.g. real-time information displays)

### 3.2.3 Park & Ride

Regarding the investigations within this project on Parking strategy, the On-Ground Parking is expected to have building costs of about \$2.000 per Parking space. We assume, that Park & Ride will be constructed in the outer city regions as on-ground parking. Inner City multistory parking's should not facilitate Park & Ride functionality.

### 3.2.4 Bus Transfer Terminals

The construction costs for bus transfer terminals heavily depends on the equipment and comfort that should be provided to the customers. A transit station terminal can range from \$450.000-\$2.500.000 /8/.

This numbers we will us in the budget calculations. A fully equipped bus transfer terminal for BRT capacities was calculated in the Bogota TransMilenio project with \$3.000.000 /7/

### 3.2.5 Traffic Lights Priority

Regarding the calculation sheet from ITDP for BRT-systems the costs for updating (installing sensors, adapting program logic on an existing controller) an intersection for bus priority ranges from \$11.000-\$22.000 per intersection.

## 3.3 Investment and Action Plan

	Costs from	Costs to	number of items	item
<b>BRT-like Corridor CA</b>	<b>\$458,516.40</b> \$76,419.40 \$240,000.00 \$77,000.00 \$65,097.00	<b>\$1,144,275.60</b> \$190,712.60 \$720,000.00 \$154,000.00 \$79,563.00	1 24 7 4822	project Bus Stops Traffic lights priority bus lane (curbs markings)
<b>BRT-like Corridor CBG</b>	<b>\$368,532.00</b> \$61,422.00 \$200,000.00 \$55,000.00 \$52,110.00	<b>\$928,428.00</b> \$154,738.00 \$600,000.00 \$110,000.00 \$63,690.00	1 20 5 3860	project Bus Stops Traffic lights priority bus lane (curbs markings)
<b>Public Transport Park &amp; Ride</b>	<b>\$7,200,000.00</b>	<b>\$12,600,000.00</b>	3600	parking places
<b>Bus Transit Terminals</b>	<b>\$900,000.00</b>	<b>\$5,000,000.00</b>	2	Bus Terminals

Table 1 shows the calculation for investments in the infrastructure and equipment for realization of a BRT-like system on the CA and the CBG corridor.

Figure 60 shows the proposed action plan for the realization of a dedicated bus lane on CA or CBG corridor. It has to be underlined, that an information strategy and campaign is an essential part and the realization should start with it and has to be accompanied by it over all the time. Two central requirements, before starting with the realization of dedicated bus lanes are the reorganization of the bus network (as proposed in output 2 of this project) and the execution of the new parking strategy (as proposed in output 3 of this study). The reorganization is necessary, as there are currently so much bus routes on the CA corridor, that it does not make any sense to introduce a dedicated bus lane, because there will be no

**Consultant:** A+S Consult GmbH; Germany, 01277 Dresden, Schaufussstraße 19; Tel: +49 351 3121330, E-mail: [info@apluss.de](mailto:info@apluss.de)

**Client:** United Nations Development Programme (UNDP)

**Project:** Green Cities: Integrated Sustainable urban Transport for the City of Batumi and the Achara Region (ISTBAR)

---

measurable effect in that case. The new parking strategy is needed, as the introduction of dedicated bus lanes requires the removal of a lot of currently available parking places on the corridor.

	<b>Costs from</b>	<b>Costs to</b>	<b>number of items</b>	<b>item</b>	<b>costs per item from</b>	<b>costs per item to</b>
<b>BRT-like Corridor CA</b>	<b>\$458,516.40</b>	<b>\$1,144,275.60</b>				
	\$76,419.40	\$190,712.60	1	project		
	\$240,000.00	\$720,000.00	24	Bus Stops	\$10,000.00	\$30,000.00
	\$77,000.00	\$154,000.00	7	Traffic lights priority	\$11,000.00	\$22,000.00
	\$65,097.00	\$79,563.00	4822	m bus lane (curbs, markings)	\$13.50	\$16.50
<b>BRT-like Corridor CBG</b>	<b>\$368,532.00</b>	<b>\$928,428.00</b>				
	\$61,422.00	\$154,738.00	1	project		
	\$200,000.00	\$600,000.00	20	Bus Stops	\$10,000.00	\$30,000.00
	\$55,000.00	\$110,000.00	5	Traffic lights priority	\$11,000.00	\$22,000.00
	\$52,110.00	\$63,690.00	3860	m bus lane (curbs, markings)	\$13.50	\$16.50
<b>Public Transport Park &amp; Ride</b>	<b>\$7,200,000.00</b>	<b>\$12,600,000.00</b>	3600	parking places	\$2,000.00	\$3,500.00
<b>Bus Transit Terminals</b>	<b>\$900,000.00</b>	<b>\$5,000,000.00</b>	2	Bus Terminals	\$450,000.00	\$2,500,000.00

Table 1 - Investments for BRT-like systems on CA and CBG corridors

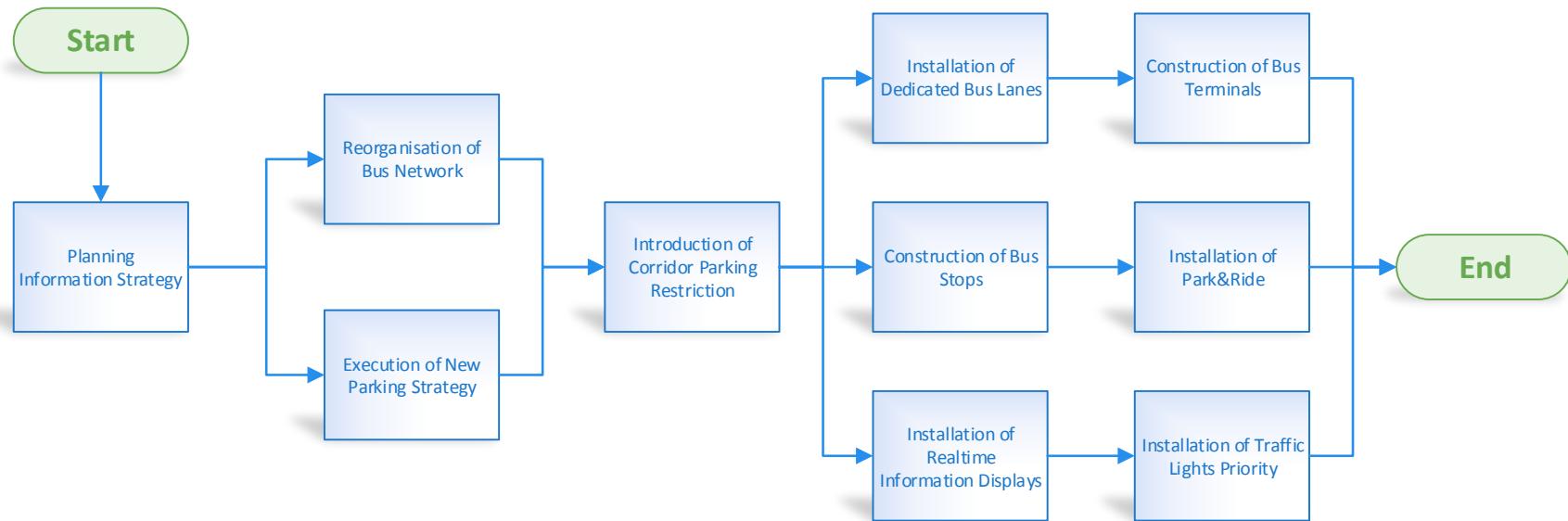


Figure 60 - Action Plan for Corridor Optimization

## **4 CONCLUSION**

This report consists of the findings of Output 2 and Output 3 with regard of the CBG and CA corridors and provides engineering specifications for sustainable urban transport measures identified for mentioned corridors.

We have performed detailed engineering designs for typical road sections and intersections with specification of materials for the dedicated bus lanes, conceptual designs and detailed specifications for bus stops, park-and-ride lots and bus transfer terminals along the demonstration low-carbon sustainable urban transport corridors.

5 design alternatives are proposed for the CA corridor (Chavchavadze, Abuseridze) and the most optimal layout #4 is recommended for implementation. It includes 3 m wide dedicated bus lane, and 1.5 m wide bicycle lane with the parking places preserved.

5 design alternatives are proposed for the CBG corridor (Chavchavadze, Baratashvili, Gorgiladze) and the most optimal layout #2 is recommended for implementation. It features dedicated 3.0m wide bus-bike lane with the parking places removed.

Also, locations of the bus transfer terminals were chosen, as well as their conceptual design developed.

The first bus transfer terminal is located at the Tbilisi square and has a capacity to fit simultaneously 6 city buses and 4 suburban ones. Multistorey parking is planned above the bus transfer terminal. The expected capacity is 75 lots at the 1<sup>st</sup> storey of the parking and 80 lots for the above ones. Parking entrance and exit are proposed to lead to Tsereteli str.

The second bus terminal is located near the Leonidze - Gagarin str. intersection, and has a capacity to handle 10 city buses simultaneously, provide resting place for another 5 buses; it can also offer the place for bike parking, bike sharing and staff parking.

The conceptual designs for 2 park & ride facilities for the tourists have been developed. The first tourist park and ride facility is located on the north of the city near the Gogol str. - Mayakovskiy str. intersection; its area is 4.9 ha and it allows 2307 cars to park. The second tourist park and ride is located on the South, close to the airport and near the b2 highway; its area is 4.4 ha and capacity is 1947 lots.

Action plan for the implementation of a dedicated bus lane on CA or CBG corridor have been proposed and the calculation for investments in the infrastructure and equipment for realization of a BRT-like system on the CA and the CBG corridor have been performed. The total cost of CA corridor implementation is \$18,46 mil, for the CBG corridor - \$17,56 mil.

## **5 BIBLIOGRAPHY**

1. Auckland Transport. Public Transport Interchange Desing Guidelines [Internet]. 2013. Retrieved from:  
[https://at.govt.nz/media/imported/4394/Public\\_Transport\\_Interchange\\_Design\\_Guidelines.pdf](https://at.govt.nz/media/imported/4394/Public_Transport_Interchange_Design_Guidelines.pdf)
2. NACTO. Colored Pavement Material Guidance [Internet]. 2017. Retrieved from:  
<http://nacto.org/publication/urban-bikeway-design-guide/bikeway-signing-marking/colored-pavement-material-guidance/>
3. London. London Bus Lane and Bus Stop Construction Guidance [Internet]. 2013. Retrieved from:  
[http://nacto.org/wp-content/uploads/2016/04/3-4\\_London-Bus-Lane-and-Bus-Stop-Construction-Guidance\\_2013.pdf](http://nacto.org/wp-content/uploads/2016/04/3-4_London-Bus-Lane-and-Bus-Stop-Construction-Guidance_2013.pdf)
4. Roads Service Belfast. Bus Stop Design Guide [Internet]. 2005. Retrieved from:  
<https://www.planningni.gov.uk/downloads/busstop-designguide.pdf>
5. OCTA. Bus Stop Safety and Design Guidelines [Internet]. 2004. Retrieved from:  
<https://countyconnection.com/wp-content/uploads/2010/06/OCTA-Bus-Stop-Guidelines-2004.pdf>
6. Riverside Transit Agency. Bus Stop Design Guidelines [Internet]. 2015. Retrieved from:  
[http://www.riversidetransit.com/images/stories/DOWNLOADS/PUBLICATIONS/DESIGN\\_GUIDES/Design%20Guidelines%20-%20Aug%202015.pdf](http://www.riversidetransit.com/images/stories/DOWNLOADS/PUBLICATIONS/DESIGN_GUIDES/Design%20Guidelines%20-%20Aug%202015.pdf)
7. ITDP. BRT Planning Guide Sample Operator Contract and Infrastructure Cost Calculator [Internet]. 2007. Retrieved from: <https://www.itdp.org/brt-planning-guide-sample-operator-contract-and-infrastructure-cost-calculator/>
8. Arlington. Bus Stop and Transit Station Types - Arlington Transit [Internet]. 2017. Retrieved from:  
<http://www.arlingtontransit.com/tasks/sites/ART/assets/File/ACBusStopnTransitStation.pdf>