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City Government of Addis Ababa

Ethio-French Cooperation
for Urban Development

2002-2010

Agence Française de Développement

Addis Ababa

Bus Rapid Transit Line

Feasibility Study

October **2010**

egis rail

Lyon Town Planning
Agency

FEASIBILITY STUDY

BUS RAPID TRANSIT LINE

ADDIS – ABABA

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1. SUMMARY

The Addis Ababa City Government (AACG) mandated the consultant team (Egis Rail and Lyon Town Planning Agency – LTPA) to study a mass transport corridor for Addis Ababa City that could feed the LRT system currently being studied by the Ethiopian Railway Corporation. The objective is to propose a “quick win” solution, easy to implement, and that could run with and without the LRT system being operational.

After a review of the past studies on the transport planning issue in Addis Ababa, the consultant team proposes some evolution to build a long term mass transit network, consisting of different modes: LRT, BRT, and other efficient bus lines.

Based on this network, the consultant classifies the BRT lines proposed according to several criteria defined by AACG (easy implementation, ridership...) to identify which one is the most feasible and the most suitable in a short term period.

The corridor B2 (Wingate – Regional bus station – Gofa Gabriel) is ranked 1st in the classification and thus proposed for a feasibility study.

This corridor is 12 km long including its extension to Wingate and comprises 17 stops with an average distance between stations of approximately 700 m. It passes through densely populated and central areas, with many of them concerned by LDP projects. It has a common section of 1 km long with the LRT project in the Merkato area and crosses again the LRT close to Mexico square.

The BRT line is suggested to be operated with thermic buses, although in a medium term a switch to trolleybuses is proposed. The design is compatible with this evolution.

The BRT line could operate with headways of 2 minutes, reaching a peak capacity ranging from 5 400 to 7 500 persons per hour per direction (pphpd), depending on the choice of the rolling stock.

The investment cost including the Wingate extension is estimated around 680 million Birrs, for the complete BRT line. This includes the rolling stock and basic systems and equipments, but excludes the widening of the streets and their renewal (only the perimeter of the BRT is taken into account for this estimate).

The implementation strategy includes a 1st phase, “light BRT”, with basic BRT features (right of way, stations, priority at junctions), scheduled for mid-2011, and a 2nd phase, “full BRT”, with full street renewal, scheduled for mid-2013.

The funding is forecasted to be provided by Addis Ababa City Government and Anbessa, with a possible involvement from AFD (French Development Agency).

2. PRELIMINARIES - STUDY OBJECTIVES

2.1. PRELIMINARIES

The Ethio-French project (2002 – 2010) for the implementation of the revised master plan of Addis Ababa provides support to Ethiopian teams of the municipality to set processes to get into development on 6 areas:

1. Support to the Planning Commission (ex. ORAAMP), and now the Planning Department,
2. **Mass transport high capacity lines/bus corridors and the central station in la Gare (East – West axis)**,
3. Development projects, public-private partnership,
4. Secondary markets,
5. Wide land supply (with basic infrastructure) for housing,
6. Solid waste management.

In the frame of the new management of the project (Addis Ababa government and AFD, Agence Française de Développement), Addis Ababa City Government and Lyon Town Planning Agency (LTPA) signed a contract in October 2005.

Through this contract, Addis Ababa City Government (AACG) asked LTPA to go on providing its technical support to the project, as it used to do since 2002.

The issue n°2 of the project 'mass transport high capacity lines/bus corridors and the central station in La Gare' focuses on the preparation of AACG to develop high capacity bus corridors, on the east-west axis, notably through a support to Addis Ababa Transport Authority.

In this frame, a prefeasibility study of a bus corridor along the east-west axis has been finalised in 2004 by Semaly, Ilex and LTPA, in coordination with Addis Ababa Road Authority.

The Transport Master Plan studied by Indian consultants in 2005 validated the principle of two major lines crossing in La Gare, and notably approved the implementation of a new mass transport corridor on the east-west axis.

In September 2007, in accordance with the coordinator of the project in the Addis Ababa City Government, LTPA proposed to Mr Gerhard Menckhoff, consultant on transport issues, to do a specialized mission in Addis Ababa. The purpose of this mission was to realise an expertise on Mass transport technologies (BRT/LRT), implementation strategies and institutional set up.

In 2008, a study tour was organized in Lyon for higher officials from Addis Ababa City Government, Ministries, and National organizations for a better understanding of mass transport implementation projects, either for LRT and Bus Rapid Transit (BRT).

In 2009, LTPA signed an addendum to the contract signed in 2005 to focus its assistance for 2009 and 2010 on 3 subjects:

- Regional planning, with a joint study for AACG and Oromyia Regional State
- The evaluation of the master plan finalized in 2002
- Mass Transport.

However, the mass transport issue has evolved in 2010 since the context has changed with the creation, in 2007, of the Ethiopian Railway Corporation (ERC), which the National Government decided to mandate for studying a Light Rail Transit (LRT) system in Addis Ababa. One of the 2 lines of the LRT system is the East West axis corridor, object of the former studies of the Ethio-French project.

The AACG, nevertheless, wishes to go on focusing on mass transport issues, and decided to ask LTPA and its partner Egis Rail (new name of SEMALY), to study another mass transport corridor which could be a feeder for the LRT system. This corridor would be operated with a BRT system, according to the will of AACG.

2.2. STUDY OBJECTIVES

The main objective of this study is to evaluate a Bus Rapid Transit (BRT) corridor in Addis Ababa.

The first task is to design a long term network taking into account the Light Rail Transit (LRT) currently being studied by ERC. A priority BRT corridor should then be identified in this network and studied at feasibility study level of details.

This first BRT route should be implementable without heavy works and should serve as a feeder line for the LRT network.

The mission began by a one week field study in Addis Ababa in May 2010. At this occasion, the consultant team from Egis Rail and Lyon Town Planning Agency had the opportunity to meet the transport stakeholders of the city.

A second mission took place from October 11th to October 14th of 2010 to present the draft report and the recommendations of the consulting team.

The present report takes into account the last meetings on the BRT project held in October and the remarks from Addis Ababa City Government and other stakeholders on the draft report. It is thus the final report of the feasibility study.

3. THE BUS RAPID TRANSIT CONCEPT

Bus Rapid Transit are mass transportation systems using buses that were first designed in South America at the beginning of the 70's. Curitiba in Brazil was the first city to implement such a "surface metro". Since the first projects, BRT have always been associated with urban projects.

Illustration 1: Example of BRT line in Curitiba (Brazil)

The main features of a BRT line are:

- A dedicated right of way in order to avoid any disturbance from the general traffic
- Priority at junctions with traffic lights to achieve high commercial speed
- A new organisation of public spaces: cars, park, sidewalks…
- Special vehicles (bus or trolleybus) clearly identified as being the vehicles of the BRT line
- Stations with platforms at the same level than vehicle floor to enable rapid boarding and alighting
- Platforms with shelters and equipments to provide comfort for the passenger during waiting time as well as pre board fare collection and fare verification
- High frequency, good commercial speed and regularity so that the line is attractive to users

BRT lines are often set in the middle of the street to avoid disturbance from cars that are coming from adjacent roads. A typical organization of the public space could be:

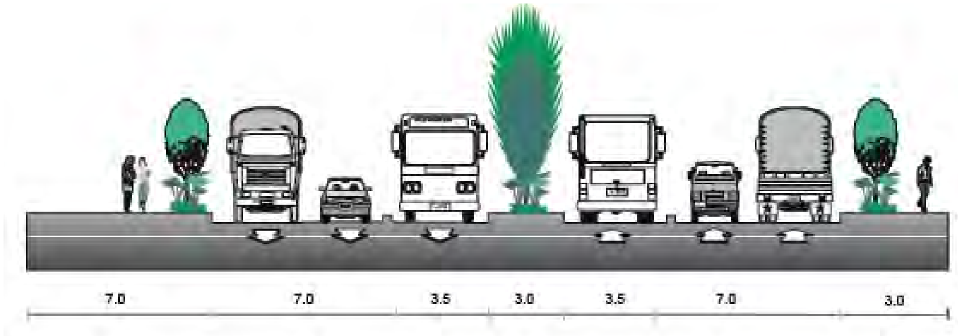

Illustration 2:Typical organization of the public space with a BRT line

More features on the institutional side are part of the BRT concept and can insure and/or improve the efficiency of the system for the users. Such features can be [Menckhoff, 2007]:

- Fare-integration between routes, corridors, and feeder services;
- Entry to system restricted to prescribed operators under a modern business and administrative structure (i.e. "closed system");
- Independently operated and managed fare collection system;
- Clear route maps, signage, and real-time information displays that are visibly placed within stations and vehicles;

This concept will be used to design Addis Ababa first BRT line, but it will, of course, be adapted to the local specificities of the city.

More details about the Bus Rapid Transit concept can be found in the "Expertise on Mass Transport Technologies (BRT/LRT)" report by Gerhard Menckhoff issued in 2007.

4. IDENTIFICATION OF THE CORRIDOR

4.1. DEFINITION OF THE LONG TERM GLOBAL NETWORK

4.1.1. Previous studies

At least three main studies or documents from the past 10 years are to be mentioned. They helped at defining the backbone of a public mass transport system in Addis Ababa. They are:

- **The City Development Plan 2001-2010**: One of the great merits of this structural plan has been the emphasis on coordinating land-use planning with mass transit development. It convincingly defines two main corridors:[1] (a) the East-West axis which would be served by tram-lines and buses on segregated lanes, and (b) the North-South axis which would also be served by a mix of these two modes;
- **Semaly Study**: As part of its assistance that lasted from 2001 to 2004, Semaly (now renamed Egis Rail) was contracted by LTPA to start the process of implementing mass transit lines along the two axes defined in the master plan, with a major interchange at La Gare. It recommended the construction of a 16 km long bus corridor for the East-West corridor, between Tor Hailoch and Ayatt[2], which was to be physically segregated from mixed traffic and provide one reserved bus lane in each direction. Semaly also defined a long term network with extension and complementary lines to the North South and East West corridors;
- **CES Study ("Transport Master Plan")**: This World Bank financed study, which was carried out in 2004-05, proposed another variation for a long term mass transit network, still based on the development of a North South and East West Axis. It proposed two different modes for implementation, BRT and LRT, but for instance on the East West Axis, a first phase with BRT, and an evolution with LRT at elevated grade, that was a quite criticized proposal.

Of course, there are other studies focused on Mass transport lines, but not on a global network, more on specific lines, the last one (and the most remarkable) for a BRT project along the East West axis being the one from Mr Menckhoff in 2007.

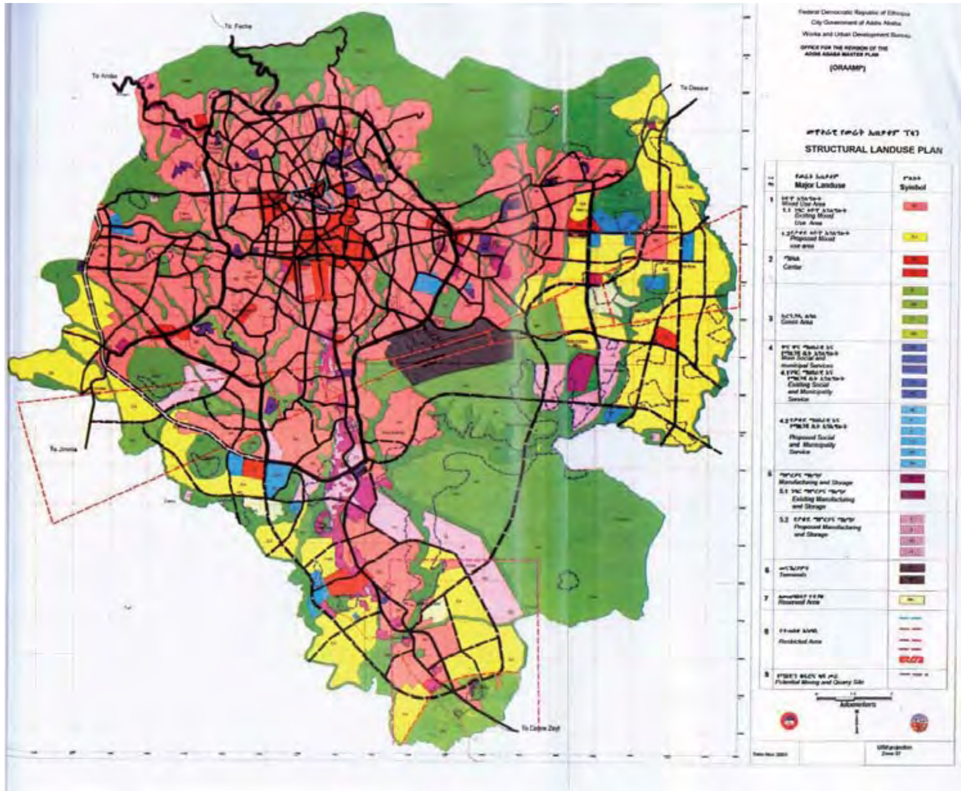

Illustration 3: Land use from the City Development Plan

[1] *City Development Plan 2001-2010, Executive Summary,* Office for the Revision of the Addis Ababa Master Plan, August 2002
[2] *Addis Ababa Mass Transport System (high-capacity lines) – East-West Axis Feasibility Study of a Bus Corridor*, LTPA - Ilex- SEMALY, 2004

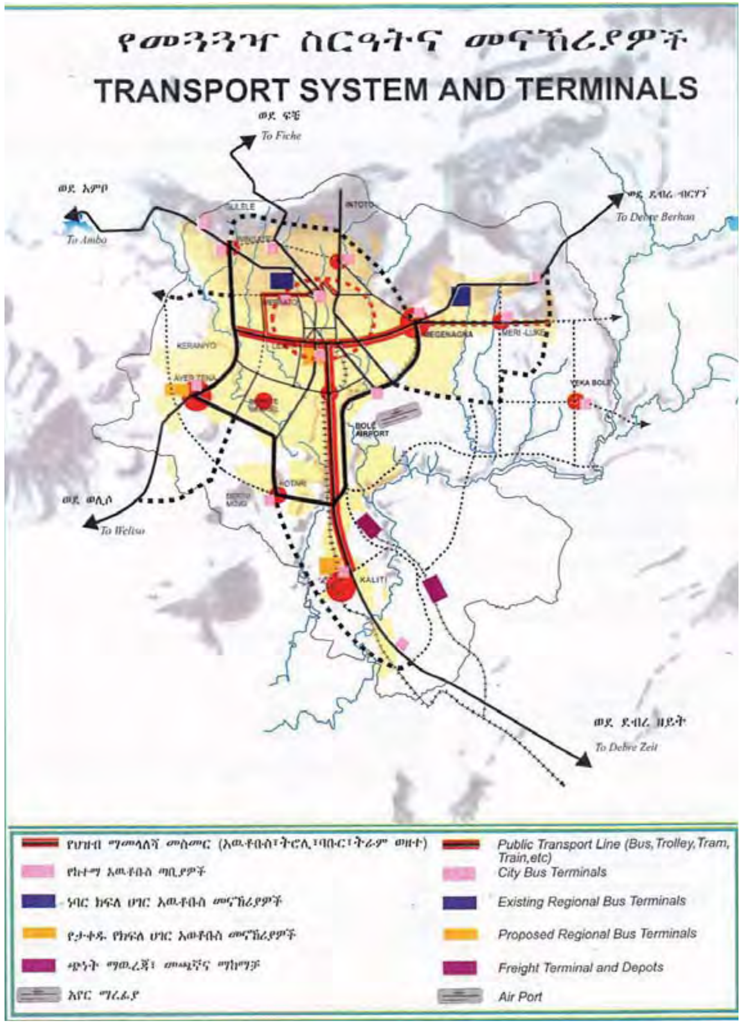

Illustration 4: Mass transport lines from the City development plan designed in 2002

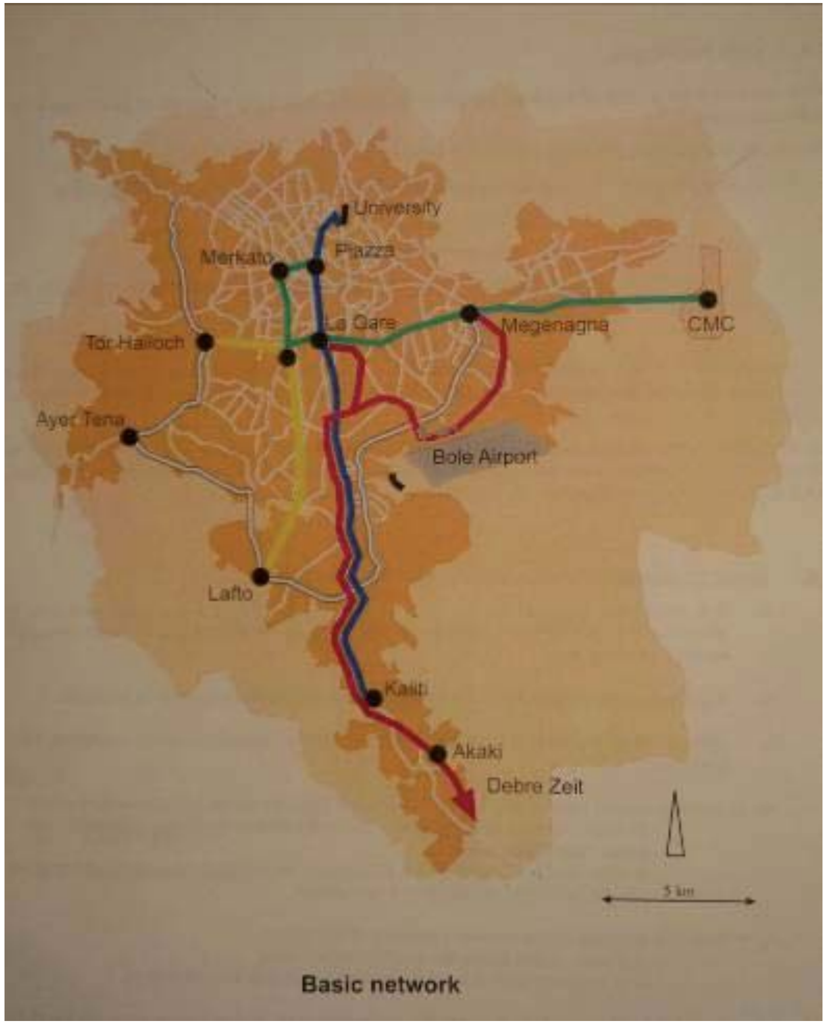

Illustration 5: Global network designed by Egis Rail in 2004

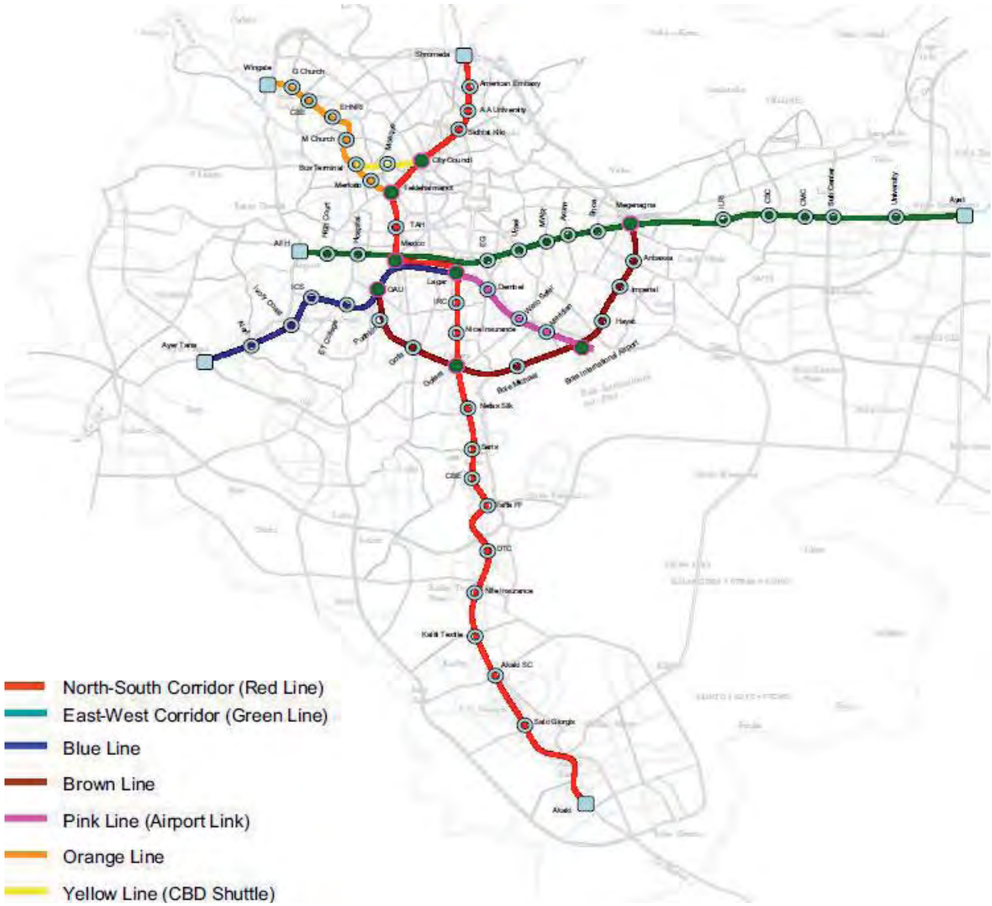

Illustration 6: Transportation master plan designed by CES (Indian consultants) in 2005

4.1.2. Proposed long term network

Taking into account the previous studies (transport and city planning), a long term network was designed for Addis Ababa. In order to have a comprehensive network, three types of lines were designed:

- **L:** Light Rail Transit lines (North – South and East – West axis). The two LRT lines were included according to the latest information from the Ethiopian Railway Corporation LRT team.
- **B:** Bus Rapid Transit (seven lines). Those lines were designed to serve the main areas of the city and to feed and complement the two LRT lines.
- **C:** Main bus lines (three lines). These bus lines were identified as important bus lines with high frequency, but, unlike BRT, without fully segregated infrastructure along the entire route.

For clarity reasons, regular bus lines were not included in the long term network.

The twelve lines of the long term network are the following:

L1	**Ayatt – Megenagna – Tor Hailoch – Ayer Tena**
L2	**Shiro Meda – Merkato – La Gare – Kaliti**
B1	**Ayer Tena – Tor Hailoch – Wingate**
B2	**Gofa Gabriel - Mexico – Merkato – Wingate**
B3	**Gofa Gabriel – La Gare – Gulele**
B4	**Megenagna – Arat Kilo – Shiro Meda**
B5	**Megenagna – Bole**
B6	**Bole Airport – La Gare**
B7	**Tor Hailoch – Lideta – Kera – Bole**
C1	**Total – Pushkine – Mexico**
C2	**Bole – Urael – Cassanghis**
C3	**North – Meriluke – South**

The proposed network will serve as a backbone for the global transportation system of the city. The Anbessa network and other public transport system will have to be reorganized in order to be coherent with this backbone network.

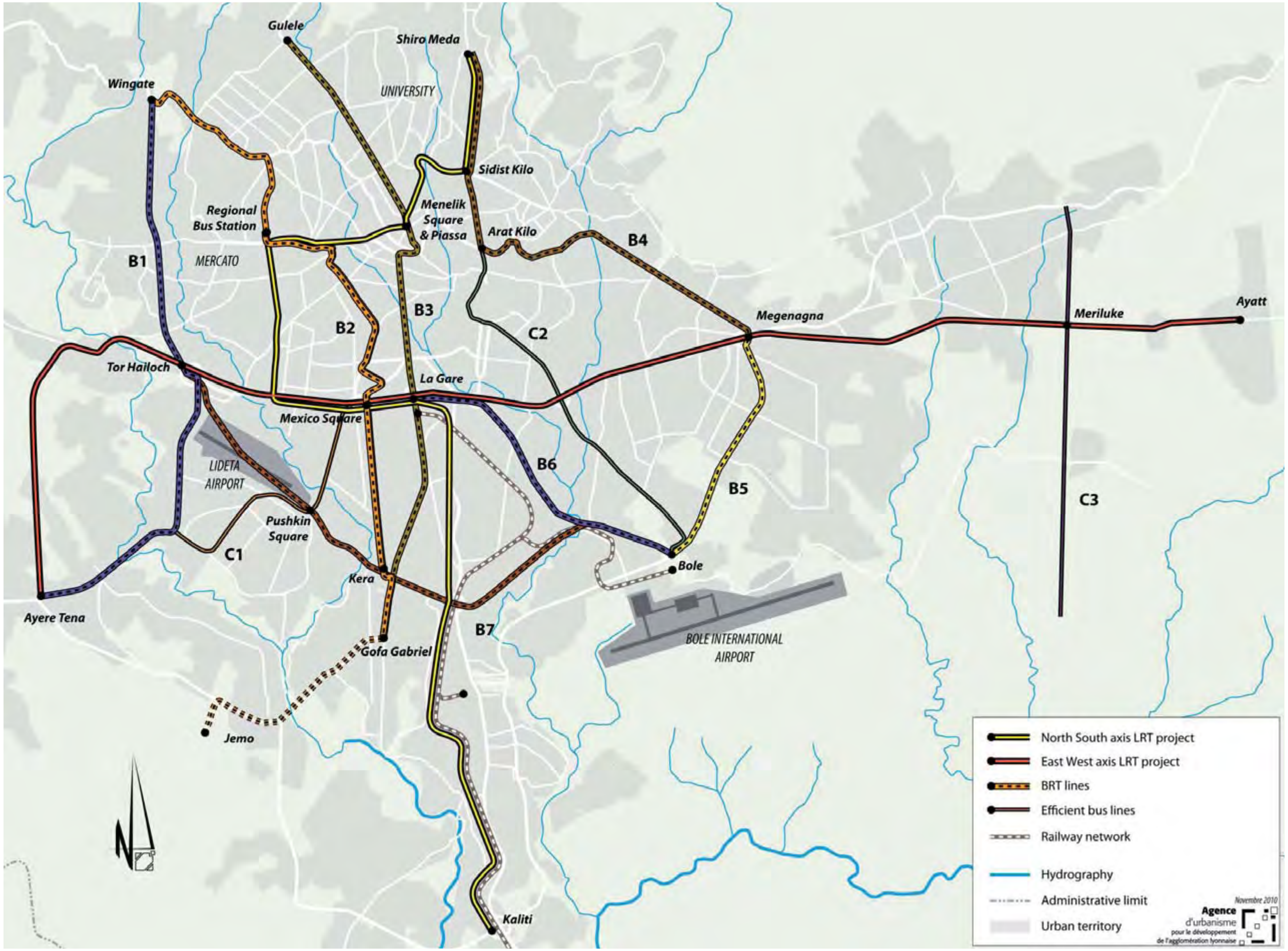

Illustration 7: Map of the long term network

4.2. IDENTIFICATION OF THE FIRST CORRIDOR TO BE IMPLEMENTED

In order to identify the BRT route that should be given priority to, a multicriteria analysis was performed on the seven potential BRT corridors.

The selected criteria are the following:

- Ridership : the expected level of ridership on the BRT line
- Long term network : the coherence of the BRT route with the global network (especially the LRT network)
- Autonomy : the performance of the BRT line before the LRT network is completed
- Easy implementation : the easiness of implementation (availability of right of way, no heavy works, …)
- Limited impact on traffic : the aim is to limit the impact of the BRT line on the general traffic (existing alternatives for cars, limiting congestion)
- Type of population served : the type of population served knowing that the objective is to serve middle – middle low income population
- Existing city / developing areas : the characteristics of the served areas (existing or developing areas) knowing that the objective is to serve the existing areas first

4.2.1. Analysis of corridor B1: Ayer Tena – Tor Hailoch – Wingate

The route is a north west – south axis serving densely populated areas of the city identified as secondary centres of the city (Ayer Tena, Tor Hailoch, and Wingate). Its alignment is following the way of the ring road enabling to have a fast and efficient BRT route.

Considering the areas served, very high ridership can be expected on this route. The connection with the east – west axis at Tor Hailoch makes this route coherent with the long term network; such a route will serve as feeder route for the LRT network.

However, as the route is not serving Addis Ababa city centre, its autonomy is limited, it will not be very efficient without the LRT network.

Considering the current layout of the ring road and the need for fully segregated lanes for the BRT, this route is not easily implementable. For its construction, modification of the current layout of the ring road would be needed, requiring heavy works.

By using the way of the ring road, the implementation of this corridor would have a limited impact on the general traffic.

By serving middle / middle – low income population and existing parts of the city, this corridor responds to the objectives assigned for the two last criteria.

4.2.2. Analysis of corridor B2: Gofa Gabriel – Mexico – Merkato – Wingate

This north – south corridor runs from Wingate (connection with the ring road) to Gofa Gabriel through densely populated areas and serves major trips generators like Merkato and Mexico square. The served areas will allow this route to have a very high ridership.

The integration with the LRT network is excellent; the corridor has one connection with the north – south axis near Merkato (regional bus station) and on connection with both LRT lines at Mexico square. These connections will enable this BRT route to feed both LRT lines.

The implementation is relatively easy as the roads along the corridor are quite wide (no widening is needed, although some pinch point will have to be studied specifically) and no heavy works are required.

On some sections, this corridor will have an impact on the general traffic. However, it will be limited by the existence of alternative routes (see part 6.6.3.) for cars along the BRT corridor.

By serving middle / middle – low income population this corridor meets the objective. This route also achieve high performance on the last criteria as existing parts of the city are served and as the route can be extended south towards developing parts of the city like Gofa Condominiums.

4.2.3. Analysis of corridor B3: Gofa Gabriel – La Gare – Gulele

This north – south axis starts at Gofa Gabriel and runs up to Gulele. The central location of the corridor should bring very high ridership on this BRT route. The coherence of this route with the LRT lines is correct (one connection at La Gare with the east – west axis and one at Menelik Square with the north – south axis), however the section between La Gare and Kera is quite close to the LRT route (less than 1 km), and this could divert traffic from the LRT network.

The main difficulty with this route is the connection with La Gare coming south from Kera. In order to build the BRT line, the existing rail tracks would have to be cut and major works would have to be performed in the area. These works are not compatible with a quick implementation of the BRT line.

Another drawback of this corridor is its impact on the general traffic. On its north section it uses roads with limited alternative for cars thus having an impact on congestion on those sections.

By serving middle / middle – low income population and existing parts of the city, this corridor responds to the objectives assigned for the two last criteria.

4.2.4. Analysis of corridor B4: Megenagna – Arat Kilo – Shiro Meda

This route uses a part of the ring road from Megenagna to the area of Arat Kilo then heads north to Shiro Meda. The section between Megenagna and Arat Kilo has light urban density along the east of the line. The section north of Arat Kilo is densely populated and has major trip generators like the University. Considering this, high ridership can be expected on this corridor.

The connection with the east – west axis at Megenagna makes this route coherent with the long term network; such a route will serve as feeder route for the LRT network.

However, as the route is not serving Addis Ababa city centre, its autonomy is limited, it will not be very efficient without the LRT network.

The construction of this corridor is quite easy as wide roads are found all along the route.

By using the way of the ring road and wide streets, the implementation of this corridor would have a limited impact on the general traffic.

By serving middle / middle – low income population and existing parts of the city, this corridor responds to the objectives assigned for the two last criteria.

4.2.5. Analysis of corridor B5: Megenagna – Bole

This corridor connects Megenagna to Bole Airport. Considering the population along this route and the importance of the airport, high ridership can be expected on this BRT route.

Like the previous corridor, the connection with the east – west axis at Megenagna makes this route coherent with the long term network.

However, as the route is not serving Addis Ababa city centre, its autonomy is limited, it will not be very efficient without the LRT network.

Considering the current layout of the ring road and the need for fully segregated lanes for the BRT, this route is not easily implementable. For its construction, modification of the current layout of the ring road would be needed, requiring heavy works.

By using the way of the ring road, the implementation of this corridor would have a limited impact on the general traffic.

By serving middle / middle – high income population and existing parts of the city, this corridor doesn't totally respond to the objectives assigned for the two last criteria.

4.2.6. Analysis of corridor B6: Bole Airport – La Gare

Extending the previous one, this corridor runs from Bole Airport to La Gare. The expected ridership is high as a result of the importance of the airport and La Gare areas.

This route connects with both LRT routes at La Gare making it fully coherent with the long term network. In addition, by serving the central area of La Gare, this route will be very efficient even before the LRT is built.

The main drawbacks of this route are the difficulties of implementation considering the layout of Bole road and the high traffic running on it.

By serving middle – high income population and existing parts of the city, this corridor doesn't totally respond to the objectives assigned for the two last criteria.

4.2.7. Analysis of corridor B7: Tor Hailoch – Lideta – Kera – Bole

This route is mainly east – west running from Lideta to Bole through Kera.

The connection with the east – west axis at Tor Hailoch makes this route coherent with the long term network. However, the absence of connection with Addis Ababa city centre limits the autonomy of the line.

This corridor is relatively easy to implement as the road are quite wide along the corridor. The width of the streets also limits the impact of this route on the general traffic.

By serving middle / middle – low income population and existing parts of the city, this corridor responds to the objectives assigned for the two last criteria.

The multicriteria analysis can be summed up if the following chart:

	Ridership	Long term network	Autonomy	Easy implementation	Limited impact on traffic	Type of population served	Existing city / development
B1	+++	++ Tor Hailoch	+	- Considering the current layout of the ring road	++	+++	++
B2	+++	+++ Mexico / Merkato	+++	++	++ Existing alternatives	+++	+++
B3	+++	++	+++	- Connection with La Gare	+	+++	++
B4	++	++ Megenagna	+	+++	++	+++	++
B5	++	++	+	- Considering the current layout of the ring road	++	+	++
B6	++	++	+++	+	- No alternatives	+	++
B7	++	+++	+	++	++	+++	++

Considering the results of this analysis, the most suitable corridor for first BRT implementation seems to be corridor B2 running from Wingate to Gofa Gabriel.

This corridor is the one selected for the next steps of this feasibility study.

Illustration 8: Location of the B2 corridor in the long term network

The route from Wingate to Gofa Gabriel is about 12 km long. The line could be extended in the future to the south towards Gofa Condominiums. The alignment for this extension has not been studied yet considering that the existing roads could not accommodate for a proper BRT line.

The section from Wingate to Gofa has been split in two sections:

- The main section running from Regional bus station (Merkato) to Gofa Gabriel (representing about 8 km). This section seems adapted for the first phase of Addis Ababa first BRT line. This main section is studied in details in the following chapters.
- A northern extension of this main section running from Regional bus station up to Wingate (about 4 km) which could be built in a second phase. This extension is briefly described in the current study.

4.3. RANKING OF THE OTHER BRT CORRIDORS

After corridor B2, the most interesting corridor seems to be B6 running from Bole Airport to La Gare. If the LRT is not completed when building corridor B6 it would be interesting to extend it from La Gare to Mexico Square in order to connect it with the BRT running on corridor B2.

Then, if the LRT is completed, it would be interesting to have efficient public transport on circular routes around the city. This ring could be achieved, starting east, by implementing corridors B4 and B5 Shiro Meda – Arat Kilo – Megenagna – Bole airport. Then, the southern and western parts could be built with corridor B7 (running on Bole – Kera – Lideta – Tor Hailoch) and B1 (on Ayer Tena – Tor Hailoch – Wingate).

After the complete ring is built, the last corridor, B3, can be implemented creating another efficient North – South axis and crossing the La Gare area.

This would complete a highly efficient public transport network with good complementarities between the LRT and the BRT routes.

The ranking of the BRT corridors can be summed up in the following table:

B2	**Gofa Gabriel - Mexico – Merkato – Wingate**
B6	**Bole Airport – La Gare**
B4	**Megenagna – Arat Kilo – Shiro Meda**
B5	**Megenagna – Bole**
B7	**Tor Hailoch – Lideta – Kera – Bole**
B1	**Ayer Tena – Tor Hailoch – Wingate**
B3	**Gofa Gabriel – La Gare – Gulele**

5. URBAN CONTEXT OF THE SELECTED CORRIDOR

5.1. AN AXIS LOCATED IN THE CITY CENTRE

The B2 corridor is mainly located in the central part of the city, meaning in an urban and relatively dense environment. The urban tissue is mainly constituted of G+1 to G+2 building, which represent the major part of the constructions in Addis Ababa. Some exceptions can be found either when the axis passes through small centralities, e.g. close to the Anwar Mosque, or when it comes close to specific building or areas, e.g. ministries or other administrative buildings close to Mexico, or the slaughterhouse close to Kera junction. At those places, one can find higher building, most of the time for office uses.

The axis goes along different landmarks and areas that have important functions for the whole city: the regional bus station, the Merkato area, Mexico square, the African Union…

Illustration 9: Usual urban tissue along the axis

Illustration 10: Small centralities with higher storey buildings

Illustration 11: Dense urban tissue along the axis

The different areas crossed by the axis are either commercial areas (serving Merkato, the commercial heart from the city, or passing by Kirkos, close to the commercial mall), administrative and tertiary areas (the Mexico neighbourhood), or mixed use residential and commercial areas (with number of spare parts shops between Tekle Haymanot and Mexico, and more various shops along Kera road).

Some major hotels (Wabe Shebele) and some public equipment can be found all along the axis: hospitals, schools, ministries...

As a whole, the functions are quite mixed which is a good criterion to insure regular and abundant ridership to the public transportation line project.

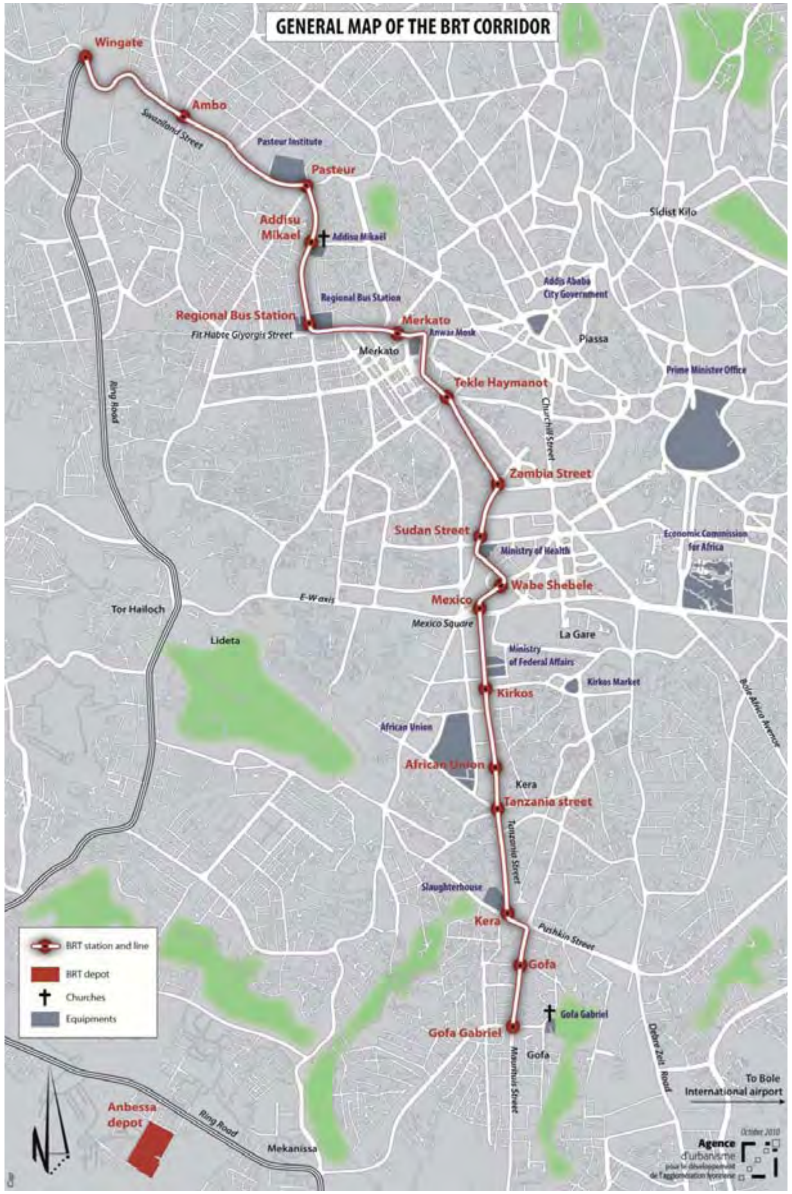

Illustration 12: General map of the BRT corridor

5.2. A RELATIVELY SMOOTH TOPOGRAPHY

The axis, going basically from the northern part to the southern part of the city, follows the general altitude pattern of the city going from a highest point (2450 m above sea level approximately around the regional bus station), to a lowest point (2280 m close to Gofa Gabriel Church). There are some slopes along the axis, but none of them all along the 8 km reaches 5 %. Those slopes will not be a problem for the implementation of a bus system.

5.3. A DENSELY AN POPULATED AREA

As previously said, the urban tissue is relatively dense around the axis.

Considering the Kebeles population extracted from the 2007 census, and with the hypothesis of a homogeneous spread out of the population inside each Kebele (which is really a rough approximation), we have estimated, that in a radius of 1 km around each of the bus station proposed along the axis (a "buffer zone"), are living 386 000 inhabitants, which represent 14 % of the city population (2007 census).

Here below is a representation of the 1 km "buffer zone" around every proposed bus station of the first stage of the BRT project.

Illustration 13: Buffer zone around the proposed B2 BRT axis, 1st phase [LTPA, 2010]

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5.4. A FAVOURABLE STREET STATUS

The different sections from the axis chosen for the corridor have a width ranging from 20 m to 30 m.

The physical aspect of the roads is generally correct, but some further technical studies would be needed to check the load bearing capacity of its structure to allow regular service of articulated buses to travel above it.

The utilities networks (water supply, sanitation, electricity, telecommunication), according to interviews made with Addis Ababa Roads Authority, are mainly located under the sidewalks, meaning they probably won't have to be displaced even though the structure of the road has to be modified. This is as well a preliminary assessment that would have to be confirmed by further technical surveys.

Plantations are to be found on some sections in the central part of the road. They help protecting from the sun, and bring a different ambiance, more friendly, to the street scenery. They have to be preserved as much as possible.

The central part of the road is usually materialized through at grade separation consisting of curb stones of approximately 10 cm high.

5.5. A LOW REGULATIONS TRAFFIC MANAGEMENT

As commonly observed in Addis Ababa city, the level of traffic regulations all along the axis is quite low.

No parking policy exists along the axis, implying on-street parking whenever needed. This will be particularly difficult to manage with the implementation of a BRT system, especially on the busiest and narrowest sections of the line (e.g. Kera road). Some parking areas are to be found, randomly located and with no specific demand oriented strategy. One example of such areas can be found close to Mexico Square.

Neither are there lots of regulations implemented for traffic control around the axis. Almost no traffic lights and no stop signs are to be found. The biggest intersections (Tekle Haymanot, Kera) are managed through roundabout layouts.

All the sections of the B2 corridor are currently bidirectional, with usually 2 x 2 lanes of general traffic. Most parts of the feeding streets are as well bidirectional.

5.6. THE PUBLIC TRANSPORT SITUATION ALONG THE AXIS: BUSES, MINIBUSES AND TAXIS

Bus lines	*Wingate optional section: Wingate*	*Wingate optional section: Gulele*	*Wingate optional section: Pasteur*	*Wingate optional section: Addisu Mikael*	Regional Bus station	Merkato	Tekle Hamyanot	Zambia Street	Sudan Street	Wabe Shebele (Kemaw street)	Mexico Square	Kirkos	Tanzania Street	Bulgarian Embassy	Kera	Gofa	Gofa Gabriel
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Illustration 14: B2 corridor + proposed bus station and the actual Anbessa bus lines

The public transport along the axis is of three types: the Anbessa bus service, the minibuses, and the taxis.

Here above is a chart summarizing all the Anbessa bus lines having a common section with the chosen corridor.

39 lines out of the 93 from the Anbessa network have a common section with the B2 BRT axis. No bus line is currently fully corresponding to the proposed corridor, but some have long common sections on both sides of Mexico square. For instance, lines 6, 38, 72, and 79 are common with B2 between at least Mexico square and Kera junction, whereas lines 52 and 74 have common sections between the regional bus station and the north of Mexico square.

It is interesting to underline that for instance line 6 is the 2nd biggest ridership line from the 93 Anbessa bus lines serving the city of Addis Ababa. And line 52 being among the 10 biggest ones.

Minibuses and taxis were not counted along the axis, and no official numbers are available at this geographical scale, but observation leads to take into account these two modes, well represented in the traffic. Three main minibus stations were at least observed: one at the regional bus station, one at the junction of Alexander Pushkin Street and Tanzania Street, and one close to Mexico square, at the beginning of Mozambique Street.

5.7. THE URBAN PROJECTS ALONG THE AXIS: MAINLY LDP'S

Six Local Development Plans are to be found along the axis, showing a strong urban renewal will from the authorities in the central part of the city.

5.7.1. Merkato LDP

It doesn't directly impact the BRT line, as it is located a few blocks away from the axis. But it will probably impact the LRT project, with road widening along its main axis.

5.7.2. Piassa LDP

The BRT line goes along the western border of Piassa LDP, on Tesema Aba Kemaw Street, from Fitawari Gebeyu Street to T Haymanot roundabout.

No specific impact has to be reported about the street structure.

The LDP project proposes further street widening along Tesema Aba Kemaw Street, up to 30 m, where the BRT line is located. It then will have to be adjusted, regarding the BRT insertion.

The project proposes along the axes mixed development buildings, mainly commercial, with some residential at the back.

There is also a compulsory building line that will insure clear demarcation between public spaces and private ones, and alignment for the buildings.

The height regulation is comprised from minimum G+3 to maximum G+ 7 levels, which will slightly increase the actual level of building in this part.

5.7.3. T Haymanot LDP

The BRT line goes along the eastern border of T Haymanot LDP, on Tesema Aba Kemaw Street, from Uganda Street to Liberia Street. That means that both projects are strongly linked, with a common linear of more than 1 km.

It proposes one new feeding street on Tesema Aba Kemaw Street that will not have a strong impact on the BRT line operation, neither on traffic management (motorized vehicle will be able to find their way doing a tour around the block).

As for T Haymanot / Piassa LDP, the LDP project proposes a further street widening along Tesema Aba Kemaw Street, up to 30 m, where the BRT line is located. It then will have to be adjusted, regarding the BRT insertion.

The functions proposed are mainly commercial (except for the location of the Orthodox Church), which will insure probably more ridership to the line. Behind the axis, as for Piassa LDP, the proposed land use is mainly residential.

As for T Haymanot/Piassa LDP, the height regulation proposed is comprised from minimum G+3 to maximum G+ 7 levels and compulsory building line is drawn, insuring continuity and an "urban boulevard" landscape for Tesema Aba Kemaw Street.

5.7.4. East West axis LDP

The East West Axis LDP impacts the BRT line at their crossing, close to Mexico Square.

No street impact is to be encountered, and the land use proposed is mixed use. The impact is thus not preeminent, and compatibility between the LDP and the BRT project is insured.

5.7.5. La Gare LDP

As for Merkato area, the la Gare LDP is not directly impacting the BRT line project. The LDP is mostly centered on the crossing between Ras Mekonen Street and Churchill Avenue, the La Gare building and the railway tracks.

Nevertheless, the LDP aims at developing here a new centrality for Addis Ababa, being an intermodal station (buses, LRT, railway, taxis, etc), and the main terminal for Addis Ababa public transport system.

It thus develops high rise buildings from G+4 to G+12 to be consistent with the high level of accessibility from the area. The BRT line, with its stop close to Mexico and Kirkos mall, will insure a complementary accessibility to this (yet today and forecasted) central point for Addis Ababa.

5.7.6. Sengatera LDP

The Sengatera LDP is common with the BRT line on its western part, its limit being Tesema Aba Kemaw and Kemaw Street between Sudan Street and Ras Abebe Aregay Street.

Illustration 15: LDP projects and BRT

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It has no street connection impact on the BRT project, but offers no widening opportunity for Kemaw Street, its width remaining at 20 m. The width will remain thus quite narrow for the insertion of the BRT, allowing only 1x1 lanes for vehicles and the possibility to mix with BRT in exceptional cases.

The proposal is again to locate shops and offices along the axis and residential apartments at the back from the street (except for the Ministry of Health located at the north east corner of the LDP). The alignment of building is compulsory, and the proposed FAR (floor area ratio) is ranging from 3.6 to 4.2 along the street, meaning pretty high rise buildings giving to the axis an aspect of "urban boulevard".

5.7.7. Mexico

An empty plot is currently under study for development at the north eastern part from Mexico square (cf. Mexico map at the LRT Project section below). It has no direct impact on the BRT line, but this project will probably reinforce the landmark and the central function of Mexico.

5.8. THE LRT PROJECT

Following the recommendation of the Master Plan of Addis Ababa City Government and of the transport Master Plan, Ethiopian authorities have decided to implement a North – South and East – West Mass Transport system.

This system is currently under the responsibility of the Ethiopian Railway Corporation, which is managing the project, funding, and studying the design.

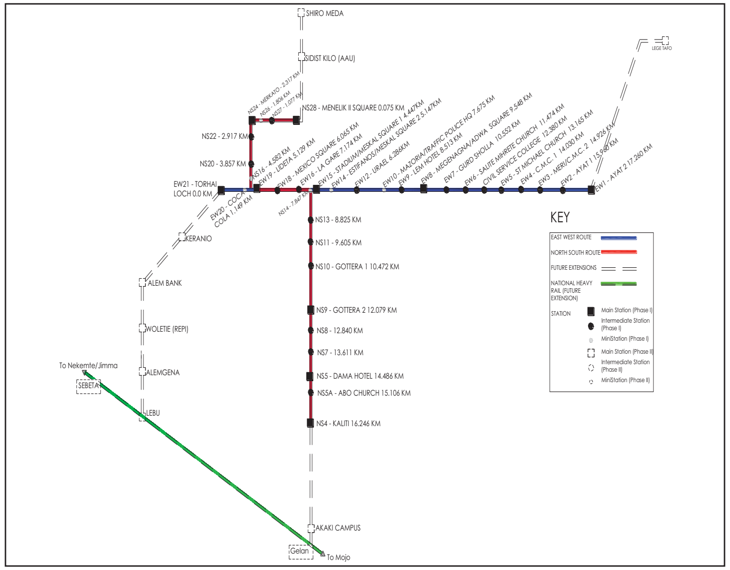

Illustration 16: Map of the LRT project (EW and NS line) [ERC, 2009]

The proposal for the Phase 1 of the LRT system comprises an East – West Line from Ayat to Tor Hailoch (17.26 km) and a North – South Line (16.25 km) from Shiromeda to Kaliti. The total length of Phase 1 will be 33.5 km.

The two lines share common tracks between Mescal Square and Lideta along Ras Mekonen Street and Chad Street, on a distance of approximately 2 km.

The LRT system has been designed to primarily operate at-grade. Grade separation structures are only provided where heavy traffic movements cross the line; where highway widths are inadequate to incorporate a median alignment at ground level; for topographical reasons; or where there are major environmental constraints.

The features of the project are the following (example of the North South Route, the headways, rolling stock and thus capacity being the same for the E/W route):

Operation Indices in N-S Route Table 3.3-1

Indices \ Operation Stage		Initial Stage	Long-Term
Operation Length (km)		16.8	36.0
Tramcar Marshalling		One unit	Two units
Rated Passengers (Persons/tramcar)		286	572
Operated Trains in Peak Hours (couple/h)	Section with shared rail	20	30
	Other sections	10	15
Minimum Travelling Interval (Minutes)	Section with shared rail	3	2
	Other sections	6	4
Transport Capacity (thousand passengers/h)	Section with shared rail	5.7	17.1
	Other sections	2.9	8.6
Train Allocation (train)	Operated Tramcars	18	56
	Spare Tramcar and Maintenace Tramcar	2	6
	Total	20	62

Illustration 17: Feature of the the LRT project (NS line) [ERC, 2009]

The preliminary design has been delivered in 2009, and the project is now under discussion for funding purposes. An agreement has been found with the Chinese Government that will fund most of the project through a loan to the Ethiopian Government.

Outside the feeding issue, where the B2 BRT line has to feed the LRT system, with impact on ridership, two areas are concerned with LRT overlapping, involving insertion issues:

1 – The first one is close to Merkato and the Regional bus station, where an overlapping of 1 km is to be found between the LRT project and the BRT corridor. Whereas the western part, close to the regional bus station, is at grade, the eastern has first been designed as an elevated part, which constitutes a real interaction issue for both projects. The alternative route proposed by ERC shown here below inside the Merkato is narrow and difficult to operate.

Illustration 18: 1st LRT and BRT crossing

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2 – The second one is in the Mexico square area, where the BRT line will cross the LRT. According to ERC, the LRT should cross the whole area of Mexico on a viaduct, its arrival and departure part being far from the BRT line crossing (more than 100 meters away). As the viaduct height rules from ACCRA requires a minimum height of 5.4m, and the height requested for the BRT line being 4 m, there should be no impact on any of the two infrastructures.

Illustration 19: 2nd LRT and BRT crossing

6. DESCRIPTION OF THE CORRIDOR

6.1. BRIEF DESCRIPTION OF THE FIRST SECTION

This section runs on 8 km from the Regional bus station to Gofa Gabriel. Its precise route and the location of the 13 stops are shown on the map below (the LRT lines are also depicted):

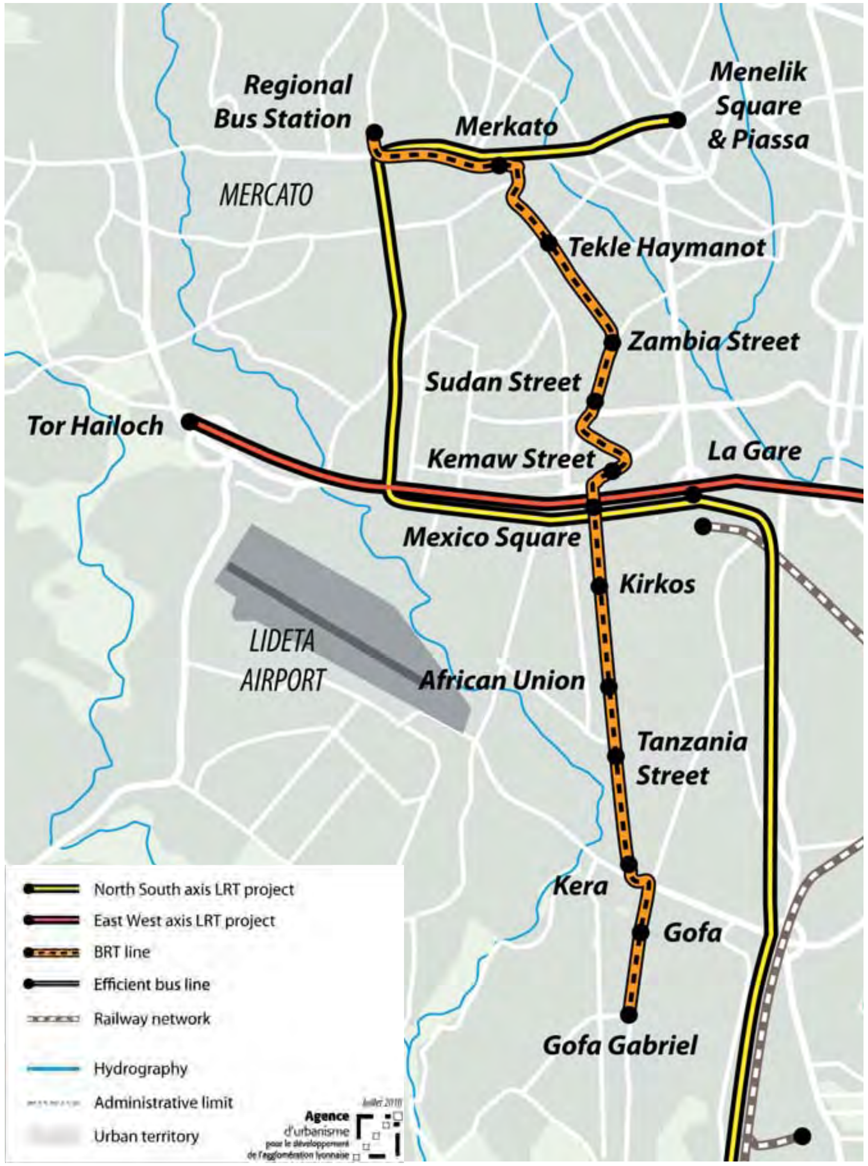


Illustration 20: Map of the main section of the B2 corridor

The name of the stations and the distance between them are given in the following chart:

Regional bus station	-
Merkato	980 m
Tekle Haimanot	880 m
Zambia street	940 m
Soudan street	450 m
Kemaw street	590 m
Mexico square	340 m
Kirkos	670 m
African Union	650 m
Tanzania Street	550 m
Kera	910 m
Gofa	580 m
Gofa Gabriel	480 m
Total length	**8020 m**
Average interstation	**670 m**

6.2. HYPOTHESES FOR DESIGNING THE BRT LINE

One of the key assignments of this study was to design a BRT line that could be built without heavy works (i.e. without widening the streets). In order to assess the capacity of the proposed line to be built under those conditions, it has been drawn at the scale 1/1000.

The hypotheses for inserting the line are the following:

- The BRT platform is 7 metres wide
- The BRT platform is separated from the road by 0.5 metres curb stones (one on each side of the platform). Cars should not be able to cross these curb stones except on very specific sections.
- There should be two lanes for private vehicles (6.5 metres wide) on each direction
- There should be at least 2 or 3 metres for each sidewalk
- The station platforms are 25 m long and 3.5 metres wide each. Such stations can accommodate for any bus available on the market today, the longest being the bi-articulated 24 metre buses. At station, the BRT platform can be reduced to 6 m.

With these hypotheses, the ideal width of the road is 30 metres. This enables stations to be inserted easily and allows widening the sidewalks or planting trees when there is no stop.

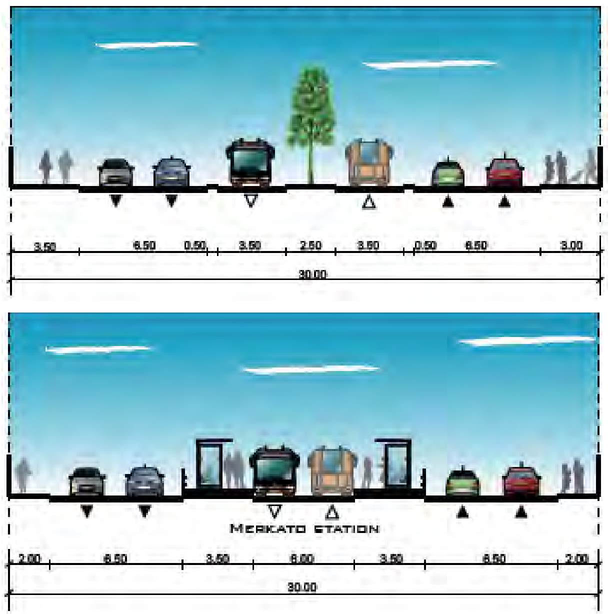


Illustration 21: Typical 30 m cross sections

When the road is less than 30 metres wide, and there is no room for inserting two lanes on each direction, it has been suggested to make one 3.5 metres lane for private cars and to allow them to get on the BRT platform to overpass another car if it has broken down. This configuration has only been used in areas where no other solutions were possible without widening the streets. Private cars getting on the BRT infrastructure should remain exceptional in order not to penalise to commercial speed of the BRT.

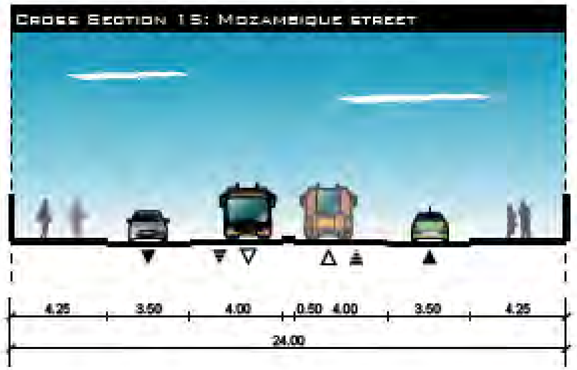


Illustration 22: Cross section used when the width of the street is limited

On a few sections, where stations have to be inserted in narrow streets, land acquisition in necessary. Those cases are shown on the maps. The stations locations have also been adjusted in order not to require any building demolition.

In order to achieve high commercial speed on the BRT, not all existing crossroads are re-established after the construction of the BRT. For example, cars coming north from Burkina Faso Street cannot turn left on Fit Habte Giyorgis Street, they have to turn right and drive to the next crossroad to make a U turn. This movement is shown on the following map:

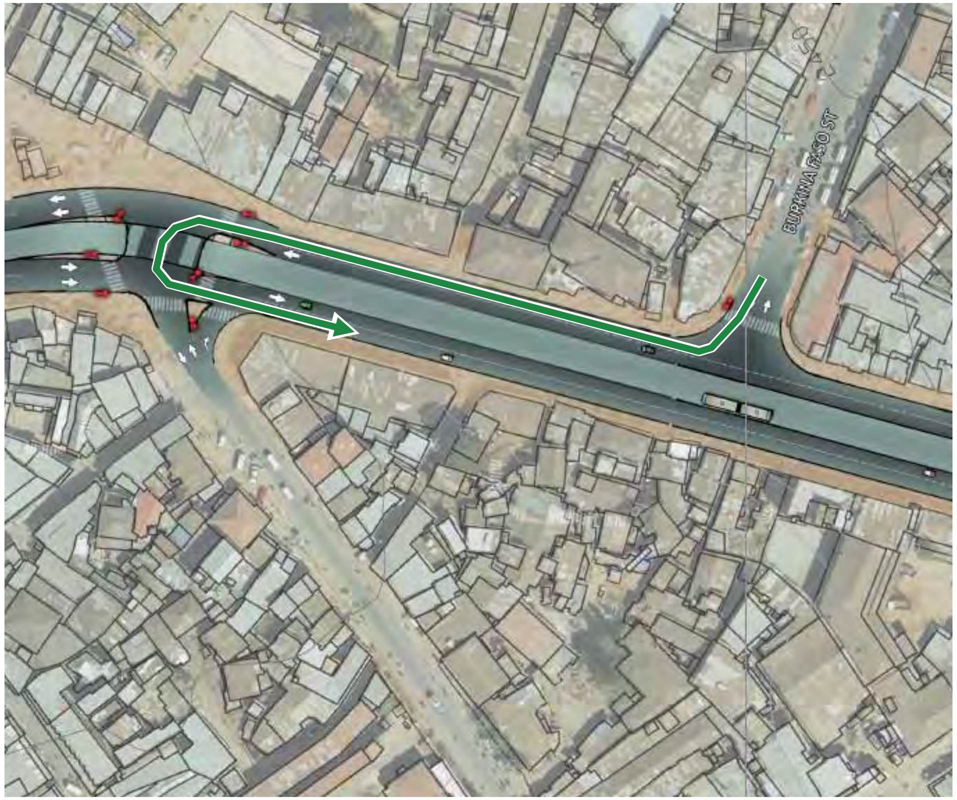


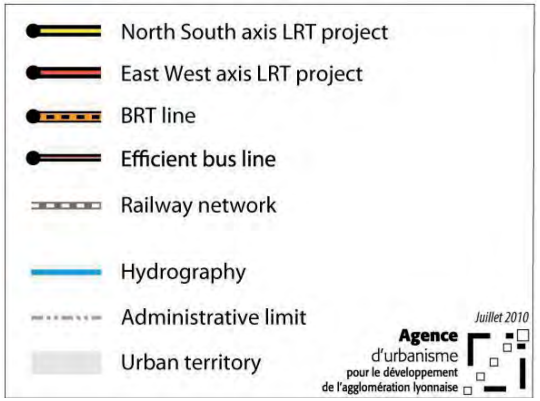
Illustration 23: Movement replacing left turn in Fit Habte Giyorgis Street

All the crossroads that are re-established are equipped with traffic lights which will improve their capacity. The re-established crossroads and traffic lights are clearly marked on the maps. Regarding the junctions, the maps have to be seen as a first proposal. Each of these junctions will have to be reconsidered during the detailed design study.

The proposed design has been made for diesel buses but it is fully compatible with trolleybuses. The energy providing infrastructure (overhead wires and poles) can be set up on the proposed project without major modifications. Power substations locations, however, have not been studied yet. If the City Government decides to implement a trolleybus system, further studies will have to be performed to design the power providing system and to locate the substations.

6.3. DETAILED DESCRIPTION OF THE FIRST SECTION

For clarity reasons, the line has been split into four sequences, each sequence is described individually. The maps of the main section, at the scale 1/1000, can be found in the appendix of this document.



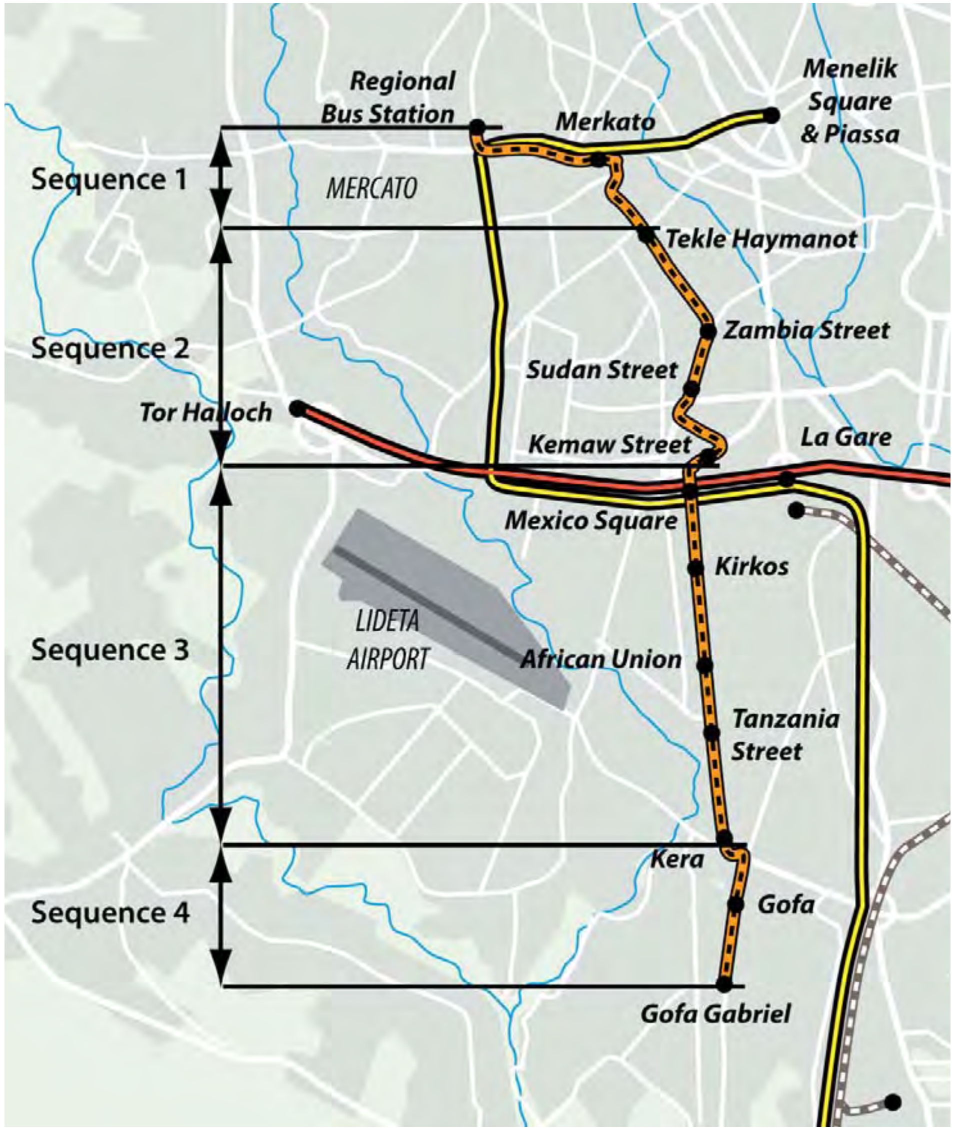


Illustration 24: Description of the 4 sequences

6.3.1. Sequence 1: Regional Bus Station to Tekle Haymanot roundabout

Illustration 25: Fit Habte Giyorgis Street near the Regional Bus Station

The northern end of the line is located in Somalia Street between the two parts of the regional bus stations (cross section 1)[3]. In order for the BRT to turn around, it is suggested to build a roundabout north of the bus station. For this purpose, a piece of land should be acquired. There is also a need for one BRT to stop and wait without impacting the general traffic. This stop can be created just south of the new roundabout.

From the terminus, the BRT runs along Fit Habte Giyorgis Street (cross section 2) up to the mosque where it turns south in Tesema Aba Kemaw Street (cross section 5). It then follows that street up to Tekle Haymanot roundabout.

On most of this sequence, the typical width of the streets is around 30 meters enabling to insert two lanes for cars on each direction. There is only one 200 meters section where the width drops to 21 meters (cross section 4). In that case, one 3.5 meters car lane is inserted and there is a possibility for private cars to get on the BRT infrastructure in order to overpass another car.

Two stations are located on this sequence:

- The terminal station near the Regional Bus Station. It is suggested to dissociate the BRT station and the LRT station in this area. The LRT station could be located in Fit Habte Giyorgis Street and the BRT station in Somalia Street. Those two stations stay close enough to allow good exchanges between the two transport systems and the Regional Bus Station.
- One station on Fit Habte Giyorgis Street at the North-western corner of the Mosque (cross section 3). This station located in a busy place, would serve the Merkato, the Mosque, the surrounding centrality, and could also attract people from the City Council area.

Addis Ababa city could take advantage of the construction of the BRT line to reorganize and extend the Regional Bus Station. It would be interesting to keep all coaches coming from the Addis Ababa Region on the western side of the Bus Station and to devote the eastern side for urban buses (Anbessa), mini buses and taxis. This would prevent mini buses from parking along Somalia Street on areas that will be needed for the BRT.

At Tekle Haymanot roundabout, the bus lanes go directly through it. The crossing of the roundabout is secured by traffic lights.

On Fit Habte Giyorgis Street, the BRT overlaps with the LRT north – south line. This represents about 1 km and one common station. The latest LRT project shows that the LRT will be elevated (on a viaduct) from the junction with Ummer Semete Street to the junction with Burkina Faso Street. On this section, it is possible to have the BRT run under the LRT infrastructure. This configuration needs to be taken into account in the feasibility studies of both projects. There is one common station on this section, the Merkato station. Here again, it is possible to have the LRT station platforms over the BRT station. Such a station should include stairs linking LRT and BRT levels and overpasses might be necessary in order for pedestrians to flow smoothly between the sidewalks and the station.

The organization of the station is depicted below.

[3] The cross section are included in the maps of the BRT line (see appendix)

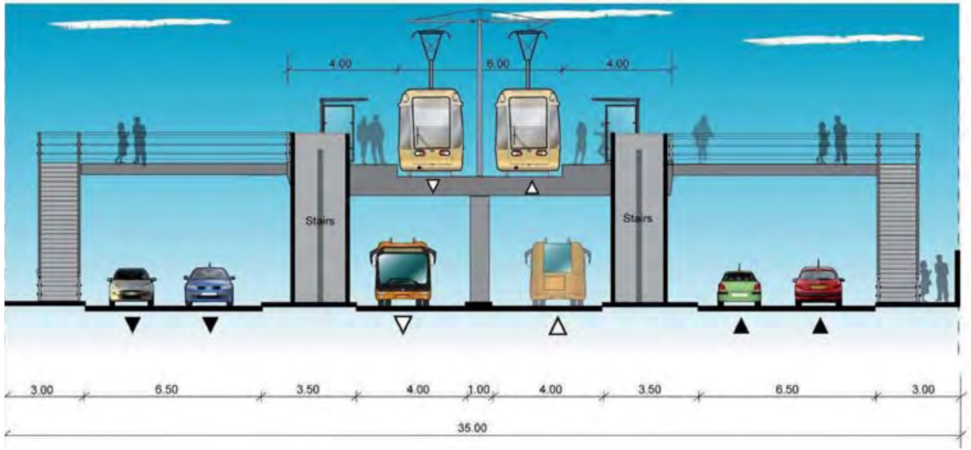


Illustration 26: LRT and BRT infrastructures at the Merkato station

When the LRT returns back at grade, it is possible to have both infrastructures run side by side. On such a section, it is not possible to have stations located at the same place for both transport modes because the needed width would be too large. Both LRT and BRT stop at the regional bus station, but the LRT stops on Fit Habte Georgis Street and the BRT on Somalia Street. As a result, there is no conflict between the locations of these stations.

The side by side organization is depicted below.

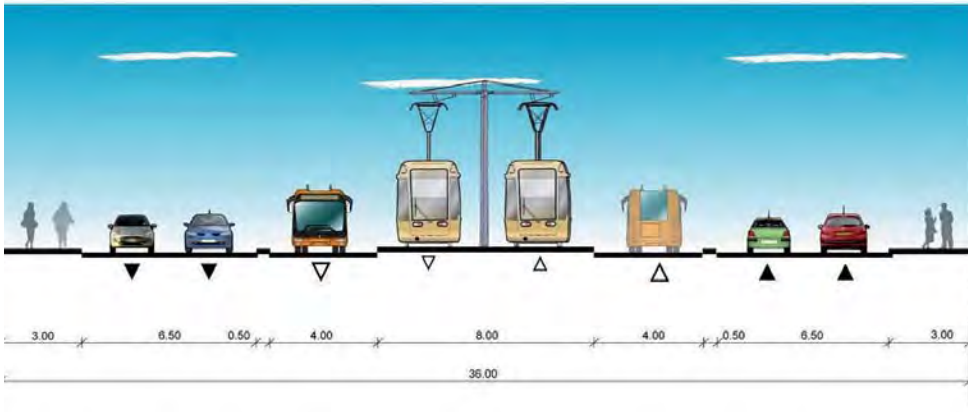


Illustration 27: LRT and BRT infrastructures running side by side

The roundabout south of the regional bus station where the two infrastructures separate (BRT going North and LRT going South) will be handled like a conventional junction with traffic lights in order to avoid any conflict.

6.3.2. Sequence 2: Tekle Haymanot roundabout to Wabe Shebele

Illustration 28: Tesema Aba Kemaw Street

After Tekle Haymanot roundabout, the line runs south along Tesema Aba Kemaw Street (cross section 6 – 7 – 8) up to the crossing with Kemaw Street. It then takes Kemaw Street (cross section 10) and Ras Abebe Aregay Street up to Wabe Shebele.

For the whole section on Tesema Aba Kemaw Street the width of the street (more than 30 meters) allows to have two lanes for cars on each direction. It is even possible to have trees between the two BRT lanes. Further studies will be required to know if the existing trees can be kept or if new ones have to be replanted. On all sections with trees between the BRT lanes, the curb stones marking the BRT infrastructure should be crossable by the BRT vehicles. This allows a BRT to get off its infrastructure in order to overpass another BRT that has broken down.

There is a pinch point in Kemaw Street. The 21 meter width of the road does not leave enough space for multiple car lanes or for parking lanes. Our suggestion is to have one 3.5 meter car lane and to allow private cars to get on the BRT infrastructure in order to overpass another car. In order to provide parking areas for the shops of the street, it is suggested to turn the current gas station into an organized car park. This car park is not compulsory for the BRT to operate but could be useful for the customers of the surrounding shops.

On Ras Abebe Aregay Street, the width of the street allows to have two lanes for cars on each direction.

Four stations are located on this sequence:

- One station immediately south of Tekle Haymanot roundabout. This location is strategic to serve all the busy areas around the roundabout.
- One station at the crossing with Zambia Street. This station would serve the nearby Tikur Anbesa hospital and office buildings. Near the station, a piece of land which is currently unused could be turned into a taxi stand.
- Another station at the crossing with Sudan Street (cross section 9). This allows a connection with the bus lines running on Sudan Street.
- On station on Ras Abebe Aregay Street near Wabe Shebele Hotel serving the hotel and the office and administration buildings. This station could also attract people from the Churchill area. Next to this station, it is possible to dedicate an area for taxis and minibuses.

6.3.3. Sequence 3: Wabe Shebele to Kera

Illustration 29: Mozambique Street near African Union station

After Wabe Shebele, the BRT continues on Ras Abebe Aregay Street up to Mozambique Street (last street before reaching Mexico Square). The BRT then follows Mozambique Street and Tanzania Street all the way down to Kera junction. Such a way allows the BRT to serve the Mexico Square area without having any impact on the traffic in the Square.

There is no problem for inserting the BRT infrastructure in Ras Abebe Aregay Street. However, in Mozambique Street some difficulties are found. In the north section, between Ras Abebe Aregay Street and Ras Mekonen Street, the way is really narrow (20.5 meters) and one station needs to be established to serve the Mexico Square area (cross section 11). Our suggestion is to close this part of the street (70 meters long) to general traffic (except for people getting in or out of the houses of this street) and to have the station as close as possible to Ras Mekonen Street.

Continuing south, the BRT crosses the LRT East – West and North – South axis running on Ras Mekonen Street. The crossing of the BRT has no impact on the LRT infrastructure because, on this section, the LRT is elevated on viaduct.

On Mozambique Street south of the East – West axis, the width of the street varies between 25 and 35 meters. The design strategy is the same as on the rest of the line: when it is not possible to have two car lanes per direction, one 3.5 meter lane is constructed while allowing cars to get on the platform if it is necessary to overpass a broken car (cross section 12 – 15).

The insertion of the two stations on this part of the street requires extending the public space on adjacent areas. Stations were positioned so that no building demolition was required, only land acquisition.

In Tanzania Street, the road is wide enough to plant trees between the BRT lanes (cross section 16 – 17). Here again, on all sections with trees between the BRT lanes, the curb stones marking the BRT infrastructure should be crossable by the BRT vehicles in order to allow a BRT to get off its infrastructure to overpass another BRT that has broken down.

Five stations are located on this sequence:

- One station just north of Ras Mekonen Street serving the Mexico Square area. This station would also be connected to both LRT lines whose stations should be placed just east of the Mozambique Street / Ras Mekonen Street intersection. On the other side of the intersection, it would be interesting to organise an area for minibuses and taxis by acquiring land on the electric power station.
- One station near the road leading to Kirkos market (cross section 13). This market, as a major trip generator in the city, should have access to the BRT line. This station, located 600 meters away from the market provides an efficient connection. This station requires land acquisition.
- Another station located near the street leading to the African Union (cross section 14). This station requires land acquisition.
- One station located at the beginning of Tanzania Street serving the shops and the population of the area.
- One station on Kera junction (cross section 18). This station is strategic because it allows a good connection with buses coming from the Pushkin Square area and serves the slaughterhouses. Taxis should be reorganised on the western part of Kera junction in order to provide good connection between the BRT and the taxis.

6.3.4. Sequence 4: Kera to Gofa Gabriel

Illustration 30: Mauritius Street

After Kera, the BRT turn east into Alexander Pushkin Street for 200 meters and then heads south towards Gofa Gabriel in Mauritius Street. The terminus is located just before the junction with the road leading to Gofa Gabriel Church.

On this sequence, the design strategy remains the same: two car lanes are build on each direction except on the southern part of Mauritius Street where there is only one 3.5 meter lane and where private cars are allowed to enter the BRT platform to overpass (cross section 20).

After the last station, the Gofa Gabriel roundabout is used by the BRT vehicles to turn around.

Two stations are located on this sequence:

- One intermediate station on Mauritius Street will allow serving the numerous shops located on the street (cross section 19). This station requires land acquisition in order to be inserted in a satisfying way.
- The terminal station north of Gofa Gabriel roundabout (cross section 21). It serves the busy areas around Mauritius Street and the Gofa Gabriel Church located 500 meters away. South of the roundabout, taxis areas should be constructed to facilitated the connection with the BRT for people coming from the south by taxi or minibus.

6.4. WORKSHOP / DEPOT AREA

In order to operate the BRT line, a workshop / depot should be created. This area will be used for buses storage and maintenance. Offices and the Operating Control Centre of the line could also be located near the depot.

The maintenance part of the depot requires the following functionalities:

- Oil station
- Washing plant
- Painting
- Overhaul
- Quick repairs
- Big repairs
- Vehicle lifting

In order to accommodate for all these functions, 20 000 to 25 000 square meters are required. Below is a possible layout for the depot area. Its precise layout will depend on the characteristics of the piece of land on which it is built.

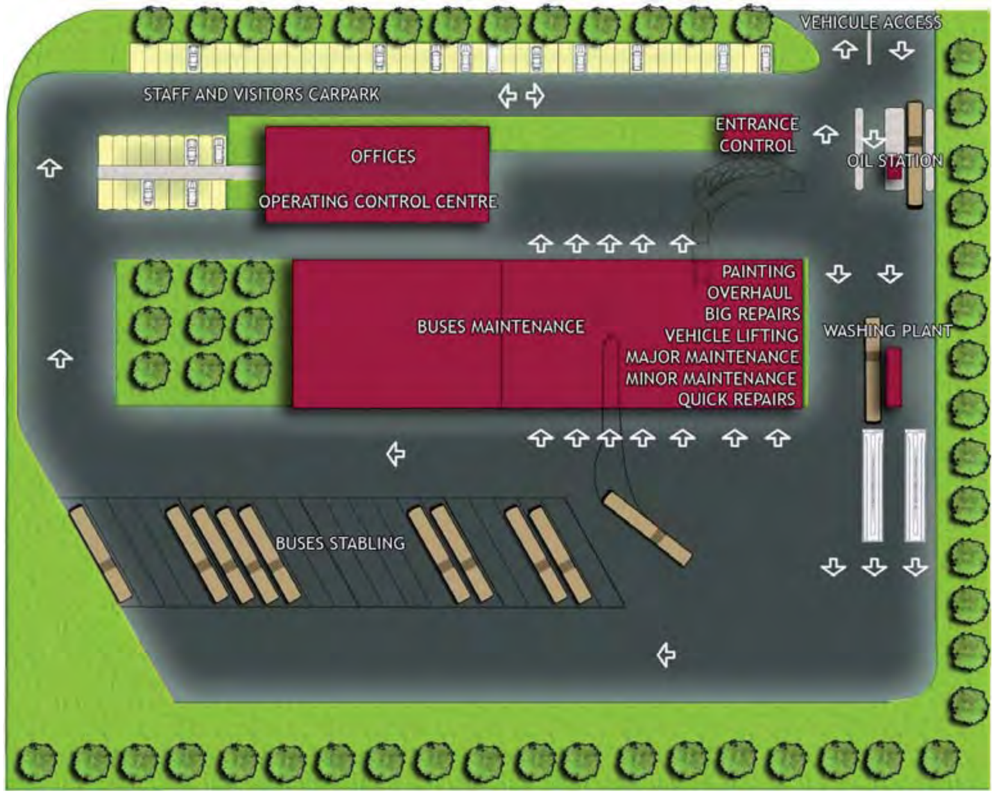


Illustration 31: Layout of the workshop / depot area

The only suitable piece of land that has been identified so far is the Anbessa Mekanissa depot in the Jemo area. The area is large enough to accommodate for the BRT depot and the site is not very far from the Gofa Gabriel terminus. In addition, buses can be sent to the Wingate terminus using the ring road thus reducing the amount of dead mileage.

6.5. DESCRIPTION OF THE WINGATE EXTENSION

In addition to this main section, the line could be extended to the North towards Wingate. The length of the extension is about 4 kilometres.

In this extension, the line runs on Somalia Street after the Regional Bus Station. One stop could be located in the area of Addisu Mikael church. The line then turns West in Swaziland Street. If follows on that street, which then becomes Ambo Road, until it reaches the Wingate area in connection with the Ring Road. Three stations could be located on Swaziland / Ambo Road:

- One just after the Swaziland Street / Somalia Street junction, serving the Ethiopian Health and Nutrition Research Institute office (Pasteur Institute).
- Another in the area of Medhane Alem School serving the school. This station could also attract people coming from the northern parts of the city.
- The terminus would be located near the Ring Road interchange. Around the station, a park and ride facility could be constructed for people coming from the western parts of the city on Ambo Road.

Between the Regional Bus Station and Swaziland Street, the width of the road might restrict the private cars lanes to one per direction. If this is the case, the BRT infrastructure will be made crossable for cars as it is done on other parts of the BRT line.

The name of the stations and the distance between them are given in the following chart:

Wingate	**-**
Ambo	**1 350 m**
Pasteur	**1 180 m**
Addisu Mikael	**690 m**
Regional bus station	**740 m**
Merkato	**980 m**
Tekle Haimanot	**880 m**
Zambia street	**940 m**
Soudan street	**450 m**
Kemaw street	**590 m**
Mexico square	**340 m**
Kirkos	**670 m**
African Union	**650 m**
Tanzania Street	**550 m**
Kera	**910 m**
Gofa	**580 m**
Gofa Gabriel	**480 m**
Total length	**11 980 m**
Average interstation	**750 m**

An insertion of another station could be studied at a further stage to minimize the distance without station between Wingate and Pasteur.

On this extension, the road will soon be widened to 30 meters or more by Addis Ababa Road Authority. As a result, there should not be any problem to build the BRT infrastructure and two car lanes per direction on this section.

The maps of this extension, at the scale 1/1000, are included in the appendix of this document.

6.6. POSSIBLE EXTENSION TO JEMO CONDOMINIUM (NEFAS SILK LAFTO SUB CITY)

An interesting option could be to extend the corridor towards Jemo condominium through Gofa condominium and Mekanissa junction, using the new 2*3 lanes road constructed by Addis Ababa Road Authority and part of the Ring Road. Three main reasons are to be underlined for this proposal:

- The new condominium of Gofa and Jemo (10 000 apartments) host large amounts of population and are developing urban areas. The potential clients for the BRT are thus quite numerous.
- The BRT could take advantage of the large right of way of the road and the (so far) low traffic congestion, and thus run without specific infrastructure. The only pre requisite would be stations and priority for BRT at the ring road crossings (2 crossroads).
- This extension could come very close to the Mekanissa Anbessa bus depot which is the potential depot for the BRT buses. It would thus reduce the dead mileage.

This option would lengthen the corridor by approximately 5 km.

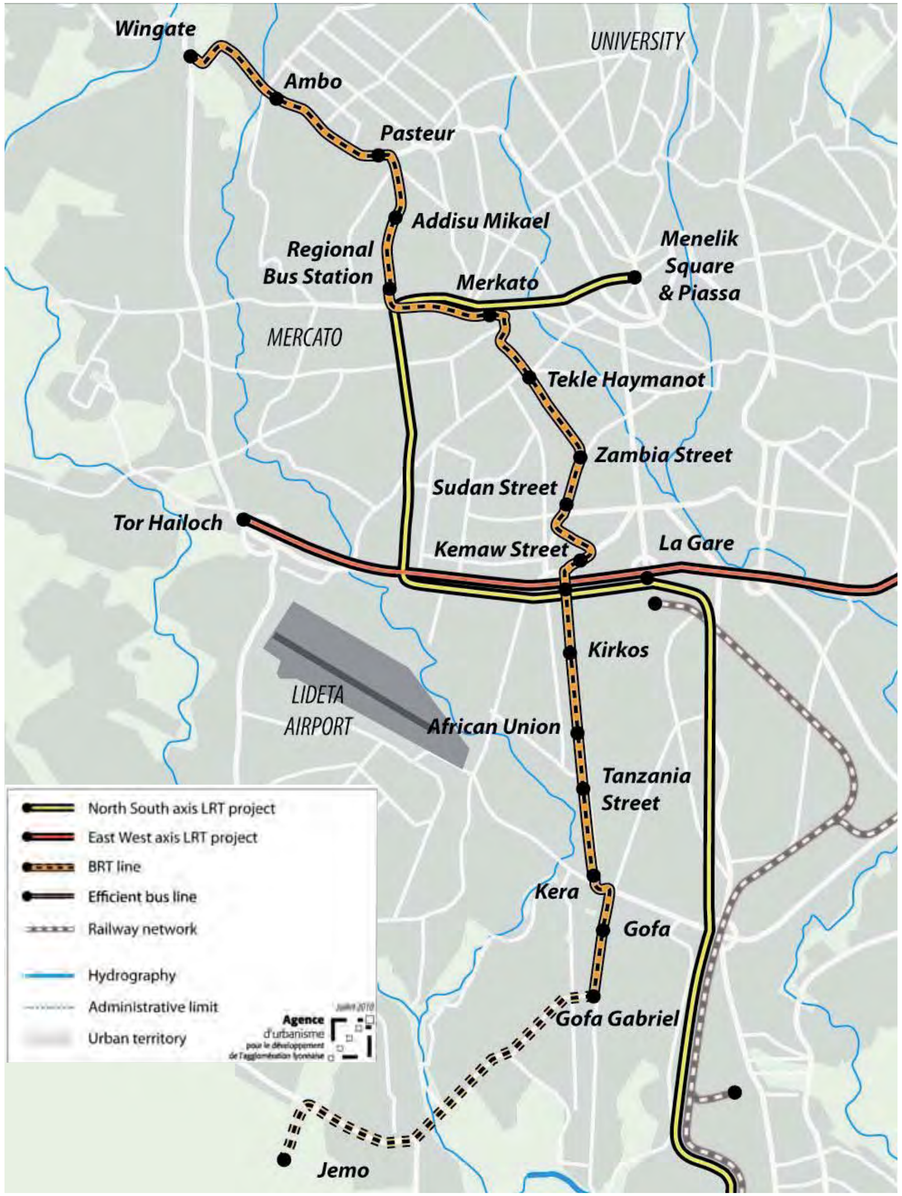


Illustration 32: Map of the whole B2 corridor including the Wingate extension and a possible extension to Jemo

6.7. MAIN IMPACTS OF THE PROJECT

Buses and mini-buses together with walking are currently dominant and necessary for many people who cannot afford to own a car of to take the taxi. These main modes are the most efficient in terms of pollution, capacity, security, and giving them a high priority would certainly be a good way to improve the general urban mobility in Addis Ababa.

The reorganisation of the public space, in order to construct the BRT, will be favourable to all users for numerous reasons:

- The flow organisation and hierarchy is the best way to improve the capacity of each mode and to avoid disturbing conflicts,
- It prevents accidents by separating the different flows, each with their specific features,
- It creates a possibility for the public authority to establish a priority according to its aims for the city development, taking into account social equity and economic efficiency.

6.7.1. Buses along the BRT corridor

Only the buses operating under the BRT system will be allowed to run along the separated lane. The corridor will thus be operated at a first stage as a closed system. The improvement of the general conditions for buses running on the BRT corridor would be an important factor in the enhancement of the attractiveness of the whole network:

- The services will have better headways with more buses,
- The commercial speed will increase from 16 km/hour presently (and less than 13 km/hour during peak period) to 21 km/hour; this represents a benefit of about 15 minutes on a 8 km long trip,
- The operating company will benefit from this increase in commercial speed which reduces the number of buses and drivers required at peak hour,
- The higher quality of service, especially the improved regularity, will increase the users' satisfaction.

6.7.2. Minibuses and taxis

Minibuses and taxis will take advantages to this project as they will be clearly out of the bus spaces and as their stations will be more identifiable and handy for the users.

But strict regulations will have to be implemented during the first stage of operation to prevent these vehicles to drive on the BRT lane. This will be part of institutional support needed for the project.

Nevertheless, taxis and minibuses stops will have to be connected to the major stations of the corridor in order to improve the global efficiency of the transport system.

6.7.3. Private cars

Private cars will have the same advantages as all other users of the public spaces:

- The general security will be improved and conflicts with other modes will be reduced
- The organisation and the separation of the different flows will optimise the general traffic
- The traffic lights set up at the BRT crossroads will increase their capacity. This will benefit to every user of the road

However, on some section, the setting up of the BRT infrastructure in the middle of the street will reduce the space dedicated to private cars thus limiting the capacity on the axis. To tackle this capacity problem, the municipality should set up a circulation plan diverting cars to parallel axis. The aim is to limit the traffic along the BRT to local traffic; transit traffic should be diverted as much as possible.

For example, cars running today on Tanzania Street and Mozambique Street could be diverted to Roosevelt Street or Ras Lulseged Street. Cars running on Tesema Aba Kemaw Street could be diverted to Dej Welde Mikeal Street. The following map shows, in green, the alternatives routes along the BRT corridor.

Illustration 33: Map of the alternative routes for cars along the BRT corridor (first phase)

With such a circulation plan, the impact of the BRT on the general traffic can be greatly reduced.

Agence d'urbanisme

6.7.4. Parking

Along the BRT route, up to two car lanes par direction will be built. This will reduce the parking possibilities along the axis. In order to maintain sufficient parking capacity, especially for shops, and to avoid having cars parked on the lanes, it could be interesting to identify dedicated parking areas. Such an area has already been identified on Kemaw Street, but other suitable spots could be found along the BRT route, especially when the right of way for private vehicles will be limited to 2*1 lanes.

As for minibuses and taxis, strict regulations will have to be implemented for preventing parking on sequences where the remaining traffic flow will just have a one lane capacity per direction. Indeed, uncontrolled parking in those sections would inevitably lead to disturbance in the BRT operations and probably to traffic and bus jams.

Other alternative options, during the 1st stage implementation of the BRT, could be to offer parking spaces along perpendicular road to the BRT corridor, and to authorize temporarily parking on sidewalks before the final widening of the right of way. Each section will have to be studied carefully at the detailed design stage to propose alternatives as accurate as possible.

6.7.5. Pedestrians

Safety and security are particularly relevant for pedestrians. Narrow sidewalks or their complete absence contributes to conflicts with motor vehicles. As the BRT project is also an urban project improving the whole public space along the corridor, pedestrian movements will be safer and nicer, benefiting to everybody and especially to young people. The organisation of the different flows is a very efficient way to optimise and secure the pedestrian movements. This is true in general, but particularly during the transfer between different public transport lines.

6.8. SOCIO-ECONOMIC IMPACT

The main socio-economic impacts resulting from the BRT project are the following:

Positive impacts:

- The time spent in the traffic for public transport users will be reduced as an efficient BRT line is implemented. For car users, if the required roads widening are performed, the impact in terms of travel time can also be positive.
- The safety for pedestrians and for road users in general will be greatly improved. This is mainly a result of the implementation of traffic lights.
- The new buses will emit less pollution and make less noise than current buses.
- With the BRT line, the affordable public transport network will be extended; this will benefit the low income classes of the population.
- The operation of the BRT line will be profitable thus generating revenues for future lines or for compensating the deficit of other bus lines
- The project will have a positive impact on the image of Addis Ababa City which will be one of the few African cities possessing a BRT line

Negative impacts:

- The project will require some land acquisitions which will force people out of their land. However these acquisitions will be limited and the people will be compensated for their land.
- The line will require a significant initial investment for its implementation.

7. ROLLING STOCK AND SYSTEMS

7.1. ROLLING STOCK CHOICE, BUS / TROLLEYBUS

The choice of mode is of great importance for the mass transport line, and, for different reasons, some options have already been dismissed: LRT and metro. The remaining option for the BRT line is the bus, but propulsion mode is an issue the city of Addis Ababa is concerned about.

Indeed, Ethiopia does not have natural oil reserves, so it will need to import energy to supply a thermic transport system. Oil price variations depend on international market movements and importations costs could be disturbed by economic troubles (crisis…) or regional geopolitical issues. Then, petrol energetic mode doesn't guarantee a secure power supply.

In another side, the country has a great hydro-electric potential and many undergoing projects, which could be exploited in order to supply an electric transport network. In this way, power production and distribution will stay on the national territory and energetic security will depend on regularity and quality supplied by the national power company. Sustainability and fluidity of the electric network as part of the investment and operating costs could be determined by these features.

The purpose of this chapter is to explain, from the Lyon experience and case studies (Sao Paulo, Lagos, Quito) taken from the literature, what are the advantages and inconvenient for thermic and electric buses.

7.1.1. Description of the two propulsion modes

Internal Combustion Engines

The most common propulsion mode, and the one that would be likely if a conventional bus is selected for a BRT application, is the internal combustion (e.g., clean diesel and CNG spark ignition) engine driving a torque converter connected to an automatic four-, five- or six-speed transmission (gearbox) that is then connected to a driveshaft. Power output is typically in the range of 250 to 350 gross horsepower; however, for articulated vehicles operating on hilly terrain, engines up to 450 gross horsepower have been used.

After deductions for driving auxiliaries such as an alternator and air-conditioning compressor and after friction losses through the drive train, the net horsepower delivered to the wheels can be substantially less than the gross horsepower output. The trend is for vehicles to require more withdrawal of power for the alternator as the quantity of electrical equipment (e.g., electric rather than direct-driven air conditioning) on board increases.

Electric Trolley Buses

The other common propulsion system that has been proven over many decades of operation is the electric trolley bus. It uses an electric power usually provided from overhead contact (trolley) wires to drive motors that can be reversed to break the vehicle (saving brake wear and tear) and to regenerate power for other vehicles that may be simultaneously accelerating. In hilly cities, like Lausanne (Switzerland), three vehicles going down generate power for one vehicle climbing. Unlike rail vehicles that have only one contact wire because rails provide the ground, trolley buses collect power from two wires, one hot, one ground at about 500 to 750V (DC or AC).

Trolley buses sometimes carry on-board energy storage or power production mechanisms, usually batteries or a small “donkey” engine plus generator, to enable them to operate for short distances away from overhead contact wires, in order to get around obstructions or to get to the maintenance facilities if there are central power system problems.

Trolley buses generally also have the highest power to weight ratio of any transit vehicle, power that can be effectively transmitted to the pavement through high-traction rubber tires. A vehicle with electric propulsion will always have the potential for higher starting torque and higher horsepower at any given revolutions per minute (RPMs) than a thermic engine of equivalent physical size and weight. An electric vehicle has excellent acceleration and hill climb ability because the maximum tractive effort (the force applied at the wheel) of a direct current motor occurs at 0 RPMs. Electric traction allows high acceleration from a standing start, which is useful when there is frequent starting and stopping. However, this advantage fades as starting and stopping are less frequent and high speed is desired.

Today, some 340 trolleybus systems are running in the world, but nowhere in Africa, probably because of high investment costs and difficulties to operate. However this tendency would probably changes in the next years with raising oil prices and enhanced municipality interest around electric public transport, which could take investment costs down.

For the Addis Ababa case, it is interesting to note that the Ethiopian Railway Corporation has already engaged discussions with Elco, the electricity national provider, to organize with the “committee of utilities”, the electricity provision for the LRT system. The BRT project could benefit from such an initiative in the case the trolleybus system is chosen.

7.1.2. Financial costs

Different case studies show that investment and operating costs are generally higher with trolleybuses system than with diesel buses system.

Investment costs

The electric network needs more infrastructures and has more impact on public urban space, through the implantation of overhead wires, electric poles and energy supply sub-stations. In São Paulo, the overhead power lines cost $840.000 per kilometre (for both directions) to install. In addition there is the cost of sub-stations, which also requires 8 to 50 square meters of land, depending on the type. These costs do not exist with diesel buses.

Trolleybuses vehicles are more expensive than conventional diesel buses, because of smaller scales of motor productions. In São Paulo, they are 52% more expensive than diesel buses. Trolleybus with alternative electricity motors are cheaper ($ 250 000) than continuous electricity motors ($ 345 000) and diesel buses are the cheapest one ($ 150 000). Nevertheless, in oriental Europe and South-east Asia markets, vehicles are cheaper to buy. In case of local manufacture, the cost of vehicles could be even lower.

The typical purchase prices for BRT vehicles in Brazil and USA are shown in the table below:

Pays	Vehicle Type/feature	Cost (US$)
Brazil	12m. Diesel Bus	$ 150,000
	12 m. Trolleybus (AC)	$ 250,000
	12 m. Trolleybus (DC)	$ 345,000
	12m. Hybrid (local production)	$ 225,000
	12m. Hybrid (imported)	$ 900,000
USA	12m. Diesel Bus	$ 300,000
	18m. Articulated Diesel Bus	$ 550,000
	18m. Articulated Trolleybus	$ 900,000

At the end, global investment costs in infrastructure (without rolling stock) were higher for the Quito's BRT trolleybus ($ 5 million/km) than for the BRT diesel buses ($ 2 million/km). Lagos' city spent $1.7 million/km to build its BRT operating with diesel buses.

Operating costs

Operating costs for the trolleybus system are in general higher than for the diesel bus system. The electric network needs more maintenance and more physical interventions by staff (failures, blocks...). It needs more material knowledge and more skills from part of the technicians and from the staff in general. The most important operating costs are:

- Engine maintenance which is slightly cheaper for a trolleybus
- Electricity which is currently more expensive than diesel, in Europe and Latin America, but which will be probably cheaper in the long term for Addis Ababa
- Power line maintenance which represents the main cost difference

In São Paulo, the most important problem that trolleybuses are facing is economic. Trolleybuses operation costs are 31% higher than for a diesel bus. Electricity is more expensive (US$ 0.53/km) than diesel (US$ 0.43/km) (ITDP 2008), however when the cost of electricity, the cost of power maintenance, and vehicle maintenance are included, trolleybuses also cost more to operate (US$ 0.52/km) than diesel buses (US$ 0.42/km).

Labour costs represent perhaps the greatest difference into operating costs between systems in developed nations and systems in developing nations. Whereas staff salaries can represent between 35 and 75 percent of operating costs in Europe and North America, the labour component of systems in developing countries may be well less than 20 percent (Menchkoff; 2007).

7.1.3. Quality and availability of the service

Diesel BRT has in general a higher capacity than trolley BRT, because of the difficulties to overpass stations and manoeuvring around obstacles (other trolleybuses, street vendors…), due to wire lines inelasticity. This lack of flexibility can create important disturbances on the network, commonly called "bus bunching" which can prejudice quality and fluidity of the global network. This mostly happens in cities where trolley buses are mixed with general traffic, as for example in São Paulo. It should not be the case in Addis Ababa.

7.1.4. Recommendation for rolling stock

Trolleybuses seem to be the most promising solution, but not really fitting for a "quick win" solution expected by the Addis Ababa City Government. The solution proposed by the consulting team is to implement first a diesel bus, but to let it open for an evolution towards a trolleybus system. That means that all technical aspects will be reviewed to allow a further trolleybus development (with station and doors location compatibility, insertion of overhead wires and sub stations…). The following table summarizes the comparison between these two modes in the current situation of Addis Ababa.

Evaluation criterion		Addis Ababa value coefficient	Diesel BRT	Diesel evaluation	Trolley BRT	Trolley evaluation
Power supply	Power supply mode	20	Low security supply, dependence on international market	10	National supply, more secure	15
	Network availability	10	Availability if good supply	10	Operating issues could disturb the network availability (technical, institutional…)	5
Total energy		**30**		**20**		**20**
Costs	Investments costs (rolling material, rolling stock, stations, pavement…)	20	Inferior: cheaper vehicles and less infrastructures	15	Superior: vehicle more expensive, most infrastructures (overhead wires, poles, supply sub-stations….)	10
	Fixed operation costs (staff salaries, administrative expenses, insurance…)	5	Inferior: Operation easier, less staff salaries, less admin. expenses	5	Superior: new technology, more staff, more administration…	0
	Variable operating costs (fuel/electricity, spare parts, maintenance…)	10	Variable fuel prices	5	Electricity prices more constant	10
	Repayment of capital (vehicle depreciation, cost of capital...)	5				
Total costs		**40**		**25**		**20**
Service quality	Capacity and availability service	10	Higher vehicle capacity, easier overpass and manoeuvring	10	Lower vehicle capacity, difficult over passing	5
	Institutional organisation	10	Easier institutional and administrative request	10	New technology, slower request, new stakeholder (electricity company)	5
	Quality and sustainability material	5	Less motor sustainability	0	More sustainability, constant power, best to climb slopes	5
	Renewal technology and material	5	More vehicles on international market, research around clean diesel and vehicles capacity (bi articulated)	5	Less vehicles on international market	1
Total quality		**30**		**25**		**16**
Impacts	Air pollution	5	Gas emissions	0	No gas emissions	5
	Visual pollution	1	None	1	Poles and overhead wires	0
	Noise pollution	2	High	0	Low	2
	Comfort	2	Worst	0	Best	2
Total impacts		**10**		**1**		**9**
Total		**100**		**71**		**65**

7.2. SYSTEMS AT STATIONS

Each BRT station should be equipped with the following systems:

- Shelter for the passengers waiting for the next bus. This increases the overall comfort of the line and reduces the perceived waiting time.
- Ramps for disabled people to easily get on the station platform.
- Passenger information displaying the direction of the next bus and optionally the estimated waiting time.
- Fare validation systems. It is best for the efficiency and the regularity of the line that the fare validation systems are located on the station platforms and not in the vehicles, this enables faster alighting and boarding (from an average boarding time of 3 seconds for non board fare validation, it drops to 0.3 with off board fare validation). In the case of Addis Ababa, a manual validation system requiring employees at each BRT station would be recommended to stick with a simple and easy implementable solution.

In order to provide easy access to the BRT stations, the streets along the station should be equipped with a clearly identified pedestrian crossing. Those crossings are shown on the maps of the BRT line.

They could be possibly managed with traffic lights used for the crossroads traffic management.

8. OPERATION

8.1. TYPE OF OPERATION

In order to meet its objective of feeding the LRT lines, the BRT line has to be efficient and attractive. To achieve this, and in accordance with the BRT concept, the line will be operated as a backbone line: specific buses will run between the two terminus and no other buses will use the BRT infrastructure. Regular Anbessa and regional bus lines will be feeding the BRT at the main interchanges. The following diagram shows the selected type of operation.

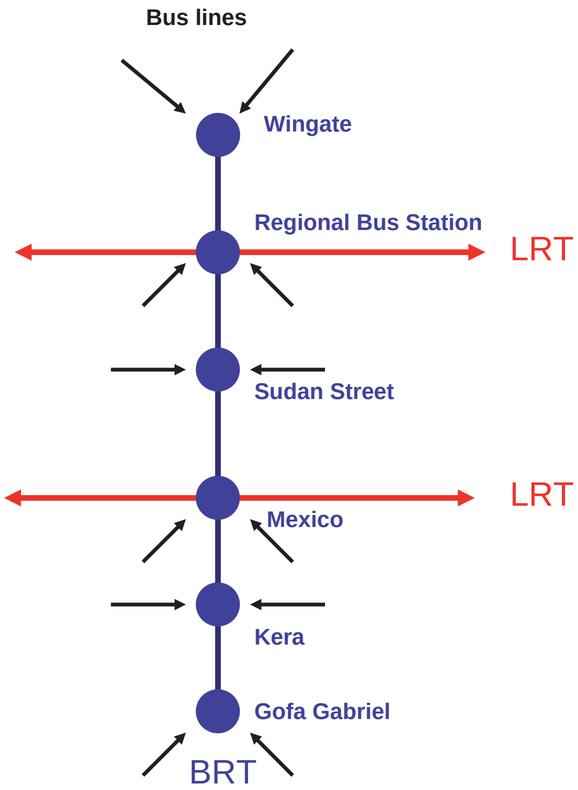


Illustration 34: Backbone operation principle

The main interchanges, to be efficient, will have to be designed to facilitate connection between the different modes for the passengers.

Yet, for an easy implementation, the solution for the BRT interchanges have been limited to a close location with the other bus or LRT station, and a facilitated connection for the passenger through pedestrian sidewalks and crossroads improvement. As said previously, the feeder buses for the BRT system, especially the one from Anbessa networks, will have to be reorganized, with their own stations well connected with the interchanges defined here above.

To increase the visibility and the image of the BRT, it is interesting that the BRT vehicles have a specific colour or design to differentiate them from regular Anbessa buses.

8.2. HUBS

The main stations of the corridor will operate as hubs. That means they will operate as interchange between the different transport modes: BRT line, Anbessa regular buses, minibuses, taxis, private vehicles (with possible park and ride facilities), and pedestrians. Some urban projects could be developed around those hubs. As they will become major points of accessibility in the city, they could thus host new buildings, offices, equipments...

Here below is a proposal of the transport modes that could be connected in each hub:

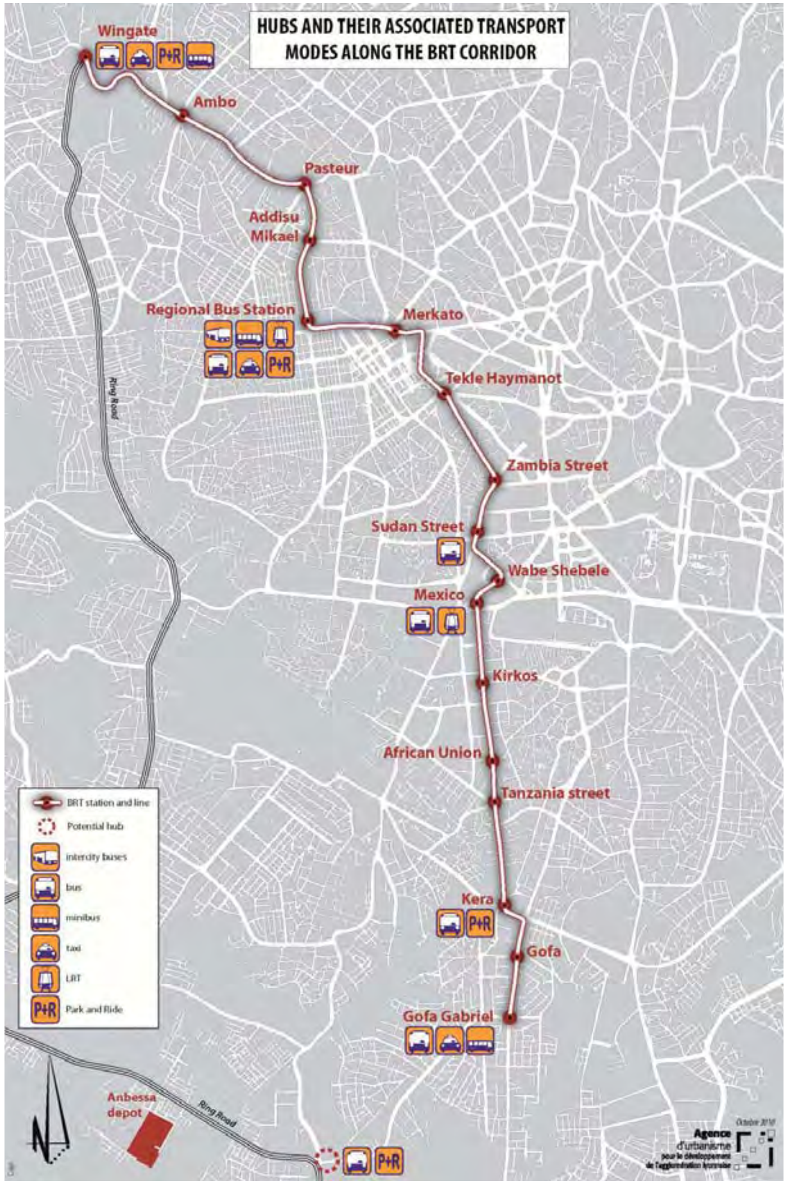


Illustration 35: Hubs and their associated transport modes along the BRT corridor

8.3. CROSSROAD MANAGEMENT

With the proposed design, all crossroads are at grade and traffic lights are required in order to give priority to the BRT vehicles and/or eventually to a particular flow, to assure the pedestrian security mainly close to the stations, and to manage the crossroad for better security and capacity.

Without traffic lights, pedestrian never have right of way and it is impossible to have a hierarchy between the different modes.

We can also note that in high traffic situation, regular traffic lights do not reduce the capacity of a boulevard and its adjacent roads.

We can describe as following the functioning of a crossroad with a station:

- In a first phase the direct traffic can go with buses and car flow. The vehicles turning left and right are stopped. This phase is the one with bus priority. The vehicles turning right can go at the end of this phase.
- In a second phase, the transversal traffic can go. Vehicles turning left and right are stopped; they can proceed at the end of the phase.
- This phase is the one during which pedestrians can cross the BRT infrastructure, particularly to go to the stations platforms.
- In a third phase, vehicles turning left, crossing the bus corridor, are running. Some pedestrian crossings are possible in this phase to reach the stations platforms.

Although it is not supposed to happen in normal operation, BRT vehicles have the possibility to leave the bus corridor to go to a perpendicular route; or to enter in the bus corridor, coming from a perpendicular route. The special functioning is the following:

- To leave the bus corridor without blocking another bus, the bus must stop out of the bus lane, just before the lane for cars turning left, during phase 1 and turn right just before phase 2. Some specific material can mark the emplacement where the bus must wait.
- To enter in the bus corridor the bus uses phase 2 or 2bis, depending of its provenance.

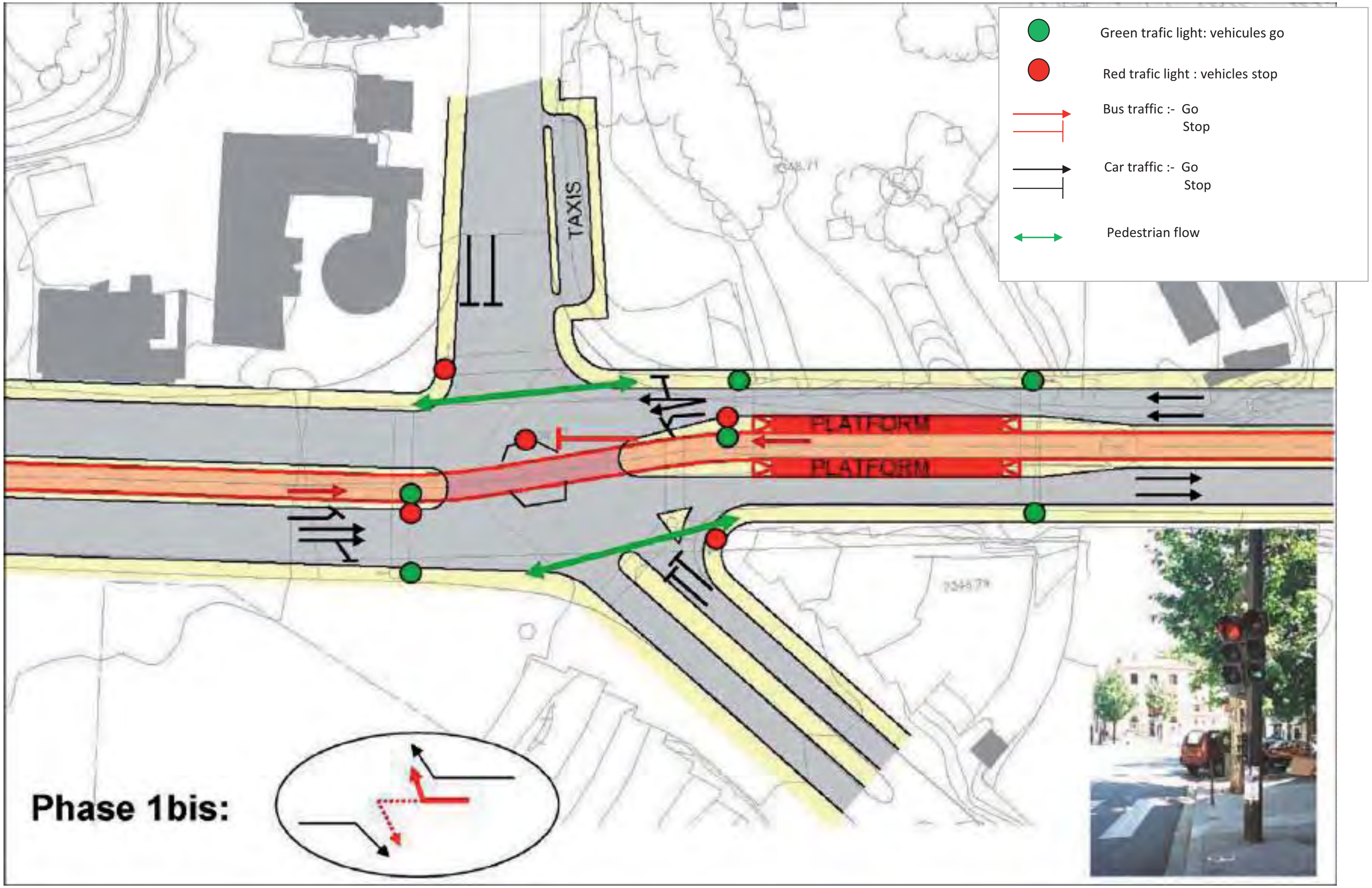


Illustration 36: Phase 1: Buses and direct car flows with longitudinal pedestrians

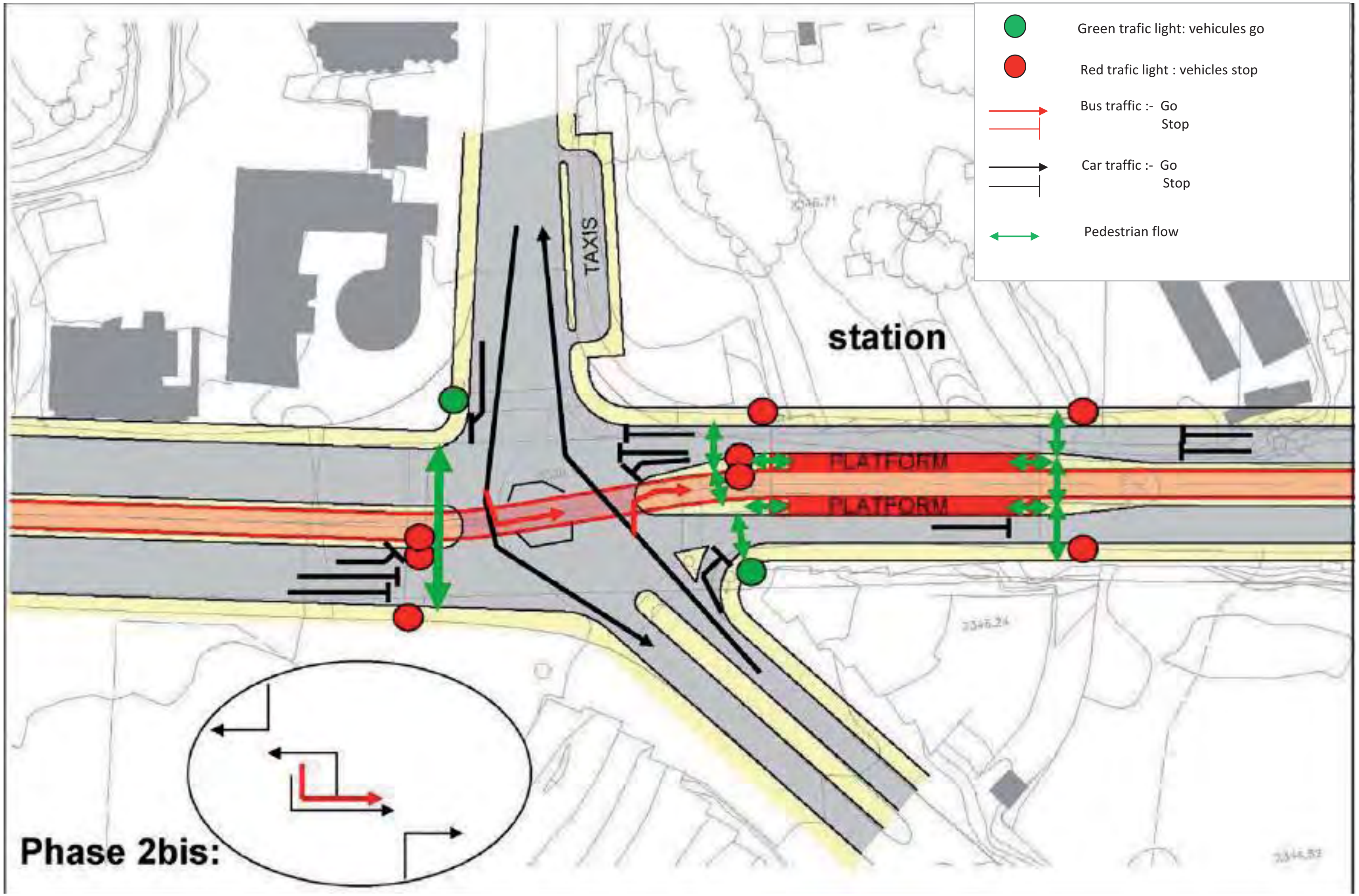


Illustration 37: Phase 2: No buses in the station, transversal car flows and pedestrians

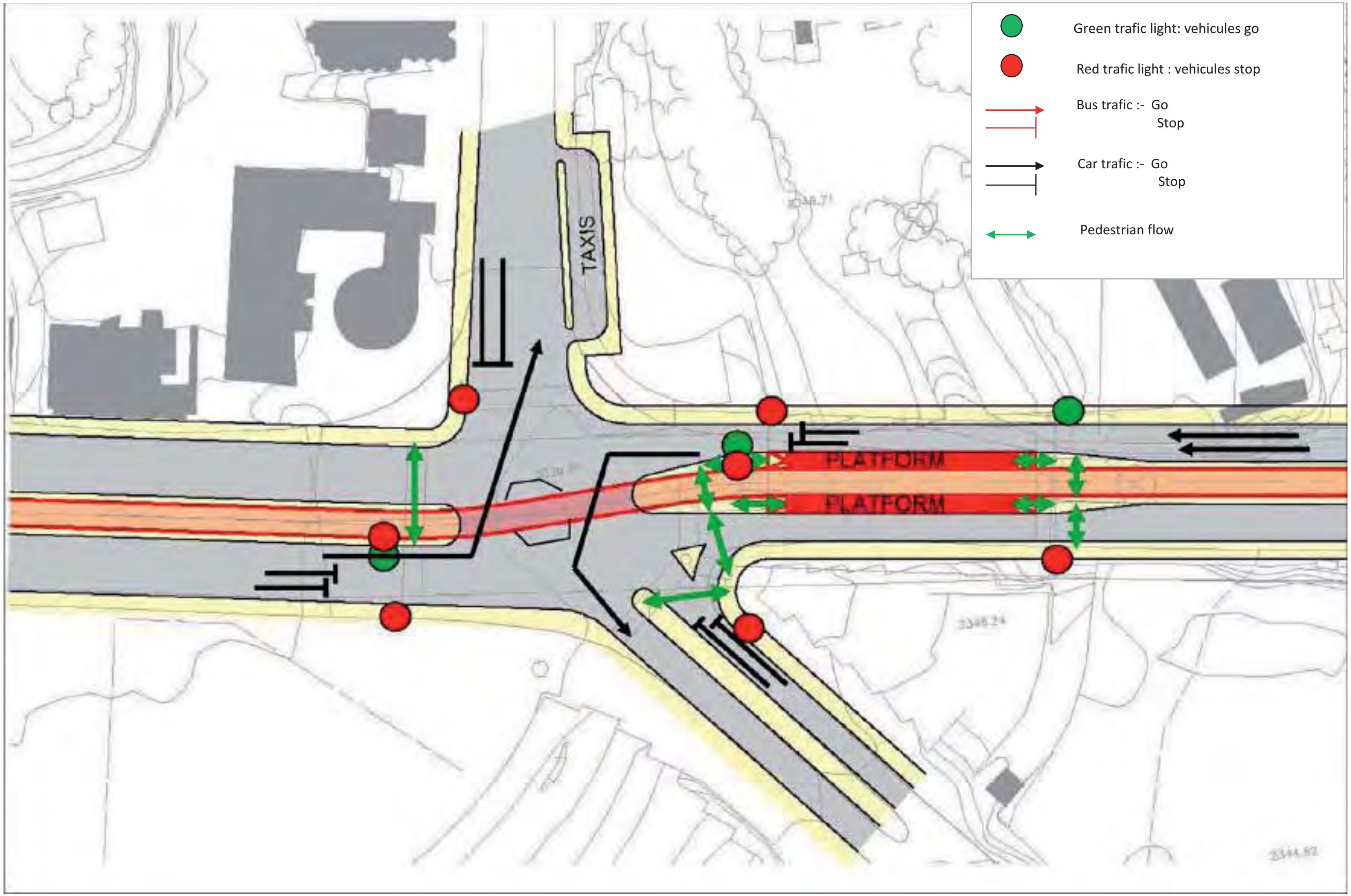


Illustration 38: Phase 3: No buses in the station, car flows turning left and pedestrians

8.4. TYPE OF ROLLING STOCK

8.4.1. General case

The proposed design of the infrastructure allows any type of bus to run on it as long as the doors are located on the right side of the vehicle.

As high ridership is expected on the corridor, two main types of buses could be adapted:

- Articulated buses (~18m), either thermic or trolley buses. Those buses can accommodate between 150 and 180 persons depending on the interior design and the number of seats. These buses are widely used in the world and many manufacturers provide them. This could lead to lower prices as the competition between manufacturers can be high.
- Bi-articulated thermic buses (~24m). These buses have a capacity of around 250 passengers. Fewer manufacturers provide these buses. As a consequence, competition between them will be limited.

The choice between articulated and bi-articulated buses should be made when more is known about the ridership of the line. As headways cannot be reduced to less than 2 minutes on the proposed BRT infrastructure, if the expected ridership is above 5 400 passengers per hour per direction bi-articulated buses will have to be used.

Illustration 39: Articulated trolley bus in Lausanne (Switzerland)


Illustration 40: Articulated thermic bus in Johannesburg (South Africa)

Illustration 41: Bi-articulated 24m bus

8.4.2. Case of Addis Ababa

In the case of Addis Ababa first BRT line, the city government and Anbessa have already ordered articulated buses for operating the line. The main characteristics of these buses are the following:

- Overall length : 18 m
- Overall width: 2.5 m
- Seating capacity: 49
- Standing capacity : 112
- Passenger door : 3 doors on the right side, width of 1340 – 1400 mm
- Maximum speed : 80 km/h
- EURO III emission standard

8.5. HEADWAYS, CAPACITY OF THE SYSTEM

Considering the current Anbessa lines running on common sections with the future BRT line, the ridership can be expected as high on the BRT route. However, no precise figure for the ridership at peak hour can be determined yet.

Anyway, in order for the line to be attractive and to reach high capacity, headways have to be limited so that the waiting time is reduced. As a hypothesis, this study will consider 2 minutes as the peak hour headway on the BRT line. This allows a capacity up to 5 400 pphpd with articulated buses and 7 500 pphpd with bi-articulated buses.

Theses capacities may be under the one encountered for other BRT systems, such as Bogota, Curitiba, or even Lagos. Two main reasons can be found for this choice:

- No passing lanes can be inserted at stations (they would allow to combine express and local service), because they would require too many land acquisition for a “quick win” solution;
- Limiting more the headways (e.g. reaching 1 min or 30 s) would require elevated over passes or tunnels for crossroads management, 2 min being the limit for traffic light and at grade management; this is again incompatible with a quick and easy implementable solution.

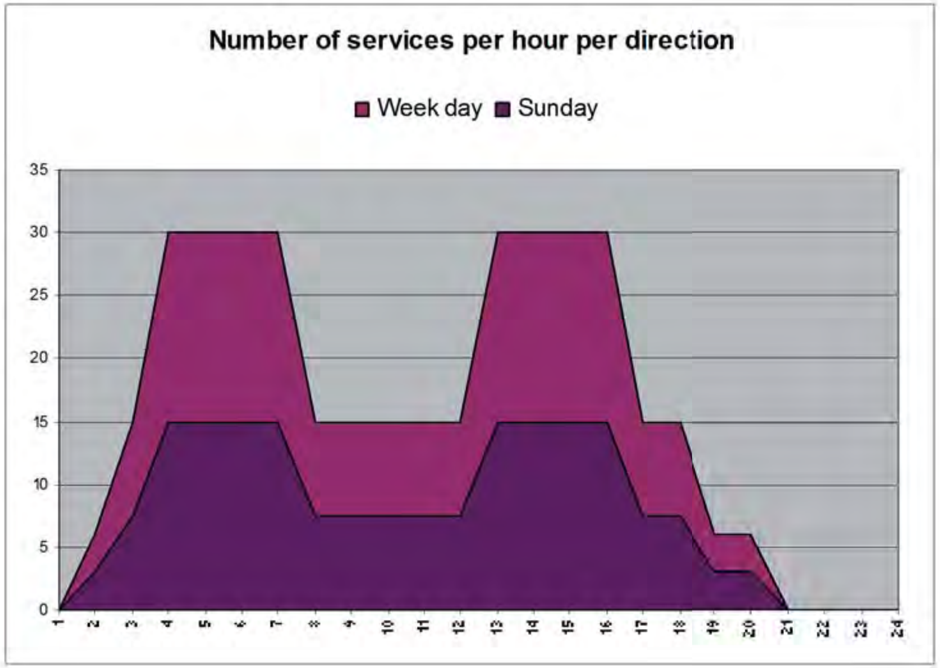


Illustration 42: Number of services per hour per direction with 3 minutes headway at peak hour

8.6. COMMERCIAL SPEED

The commercial speed was computed using a specific tool taking into account the description of the Addis Ababa BRT line.

It was estimated by taking into account the following assumptions:

- Maximum speed: 50 km/h
- Stopping time at each station: 40 s
- Acceleration and deceleration limited to 1.2 m/s²
- Priority rate at crossroads: 85%
- Stopping time at the terminus: 6 minutes

The commercial speed is estimated to 21.3 km/h from terminus to terminus for the main section and 22.2 km/h for the route including the Wingate extension. The increase in commercial speed for the extension is due to the longer interstation and the fewer number of crossroads on the Regional Bus Station – Wingate section.

The results could be compared with the present commercial speed, i.e. an average 16 km/hour for a working day and 13 km/hour at peak period [Semaly, 2004].

It has to be noted that this speed will only be achieved with high priority at crossroads. As a consequence, the result of the computation can only be realistic with an optimisation of the traffic lights all along the corridor.

The total travel time from terminus to terminus is 22.6 minutes for the main section and 32.3 minutes for the route including the Wingate extension.

The figures hereafter show the profile of the speed along the route (main section and main section + Wingate extension).

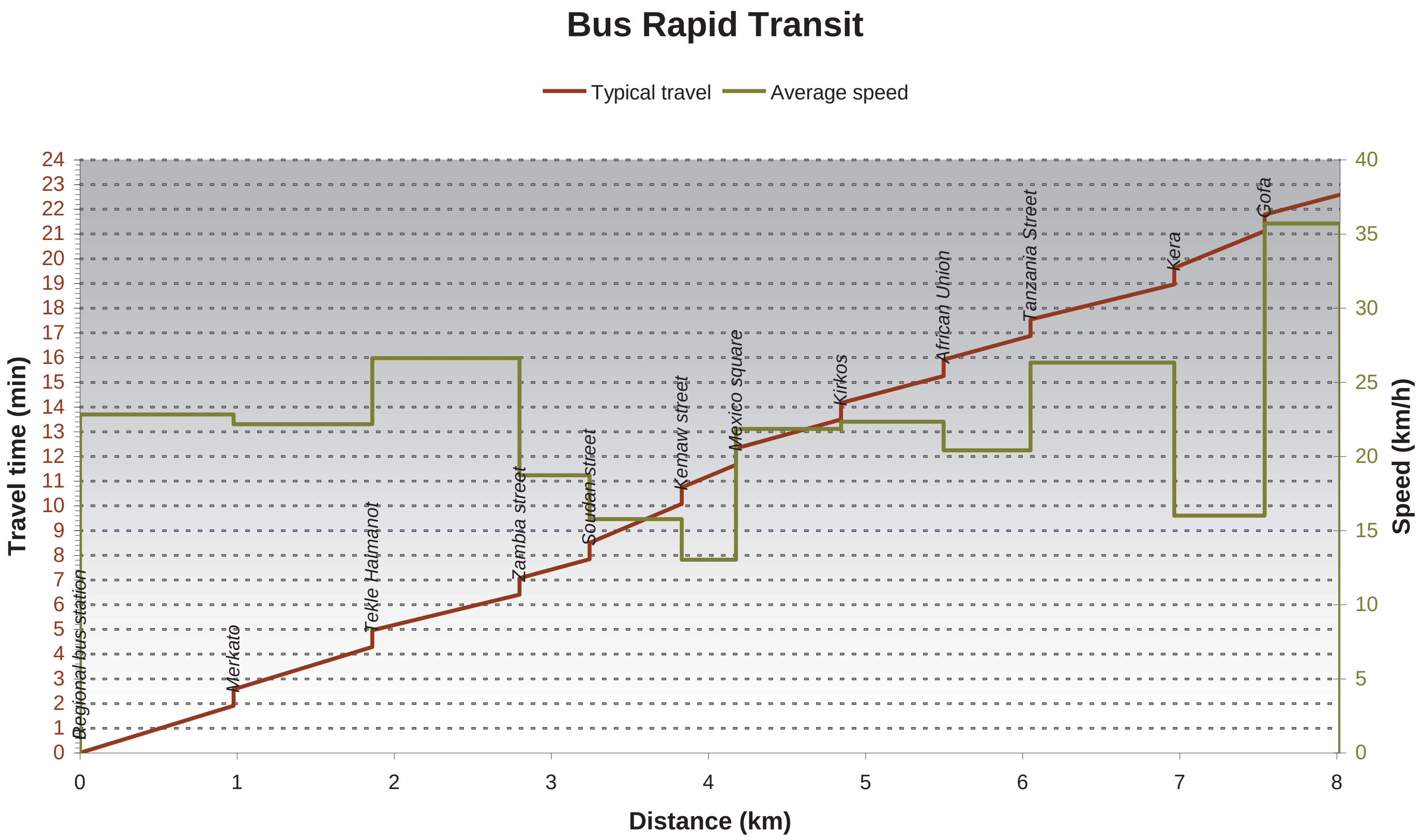


Illustration 43: Speed profile on the main section (Regional Bus Station – Gofa Gabriel)

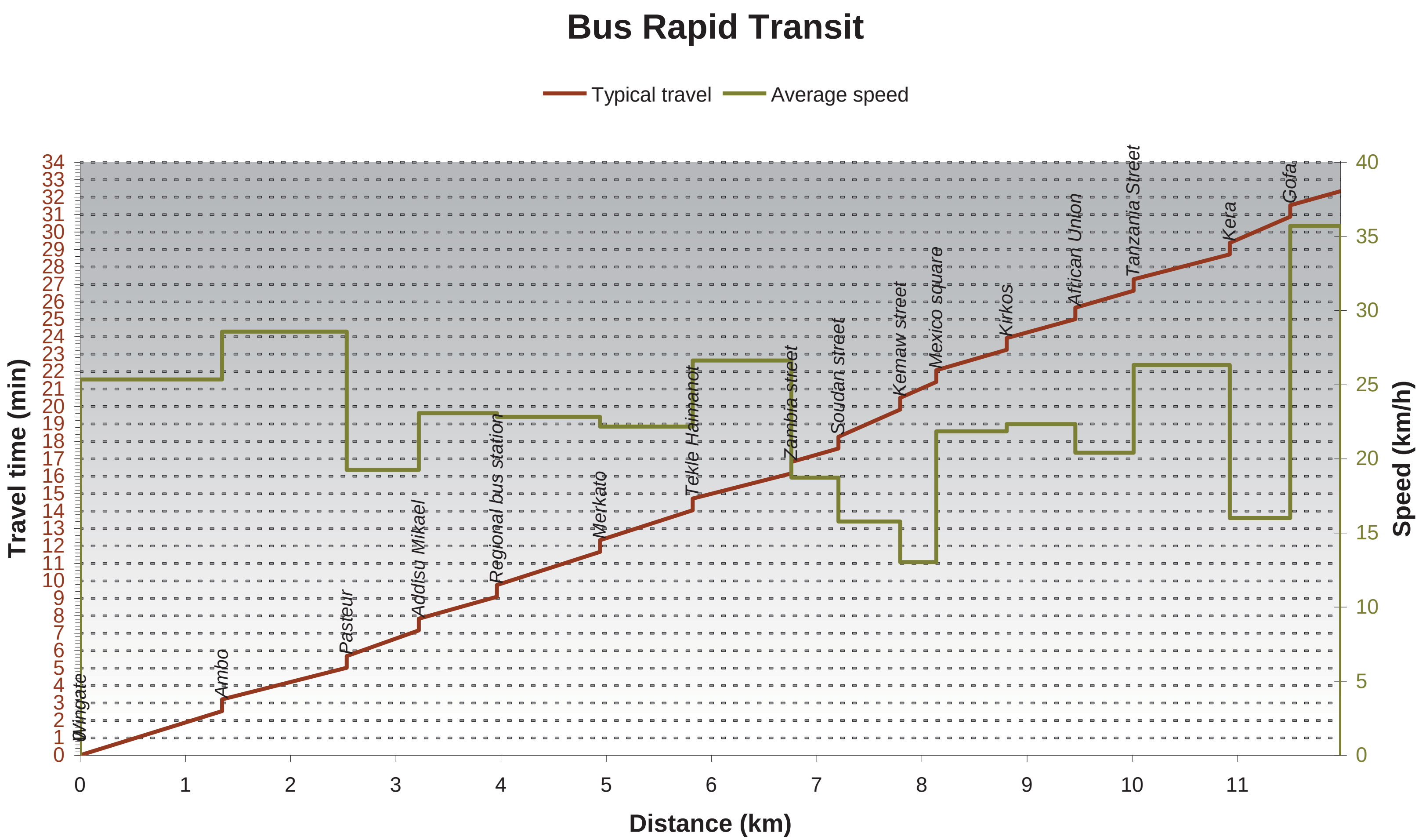


Illustration 44: Speed profile on the Wingate – Gofa Gabriel section

8.7. ROLLING STOCK FLEET

With the estimated travel time and the proposed headway (2 minutes) it is possible to compute the rolling stock fleet required to operate the BRT line.

With the hypothesis explained above, the results, taking into account the fleet at peak hour and the needs for maintenance, are the following:

	Fleet at peak hour	Fleet in maintenance	Total fleet
Regional Bus Station – Gofa Gabriel	27	4	31
Wingate – Gofa Gabriel	37	6	43

9. IMPLEMENTATION STRATEGY

To fit the quick win objective of Addis Ababa City Government, it is proposed to implement the project in 2 stages. Of course, the detailed design of the 1st stage will have to take into account the objectives and the available detailed design of the 2nd stage to insure coherence and cost efficiency for the project.

9.1. FIRST STAGE

The first stage could be operational on the Regional bus station – Gofa Gabriel section, and include the following basic features of the BRT system:

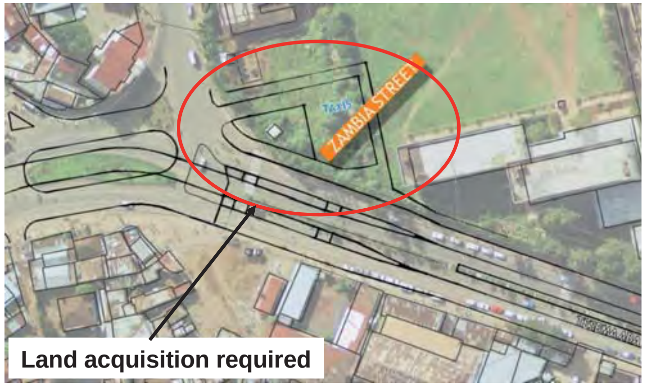
- Dedicated right of way delimitated only with paintings and/or curbstones on the existing streets;
- Street lights at junctions with dedicated systems to insure priority for the BRT buses at every crossroad;
- Station platforms to insure security and minimum comfort for passenger during waiting time, boarding and alighting from the buses;
- Depot/workshop upgrade to be able to maintain the new articulated buses

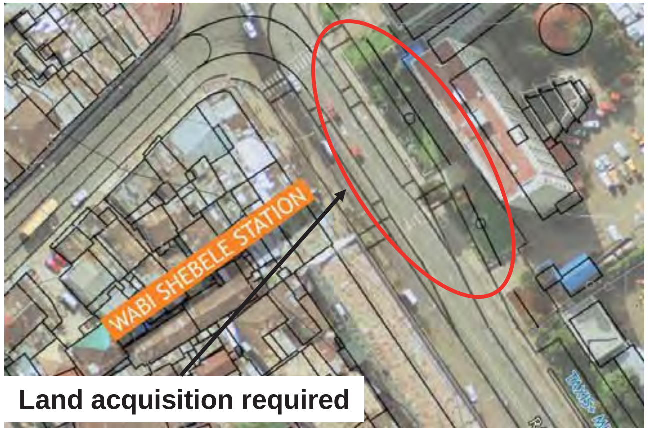
These features could allow the BRT system to run at its forecasted commercial speed, and to reach the expected peak hour capacity. However, this first stage would be very basic or inexistent on different items such as systems, street renewal, and stations equipments. This stage is thus not fully sustainable (especially for the road which will be subject to frequent and heavy loads on its structure) nor a complete BRT as it could be expected on its most modern version. Still, it would be a very good first step to implement a BRT in Addis Ababa.

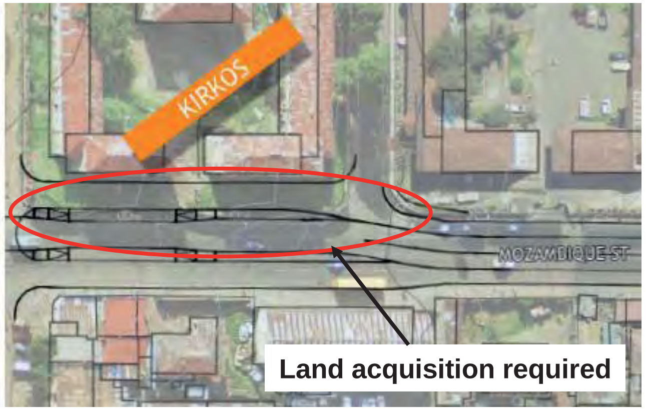
According to the discussions with AACG, the 1st stage could be operational for mid 2011.

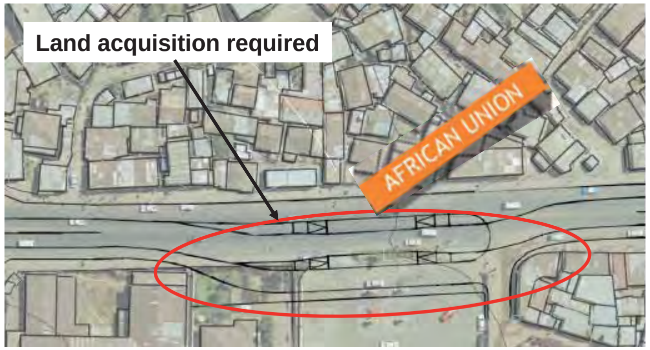
Still, there are some technical pinch points for the quick implementation to be overcome:

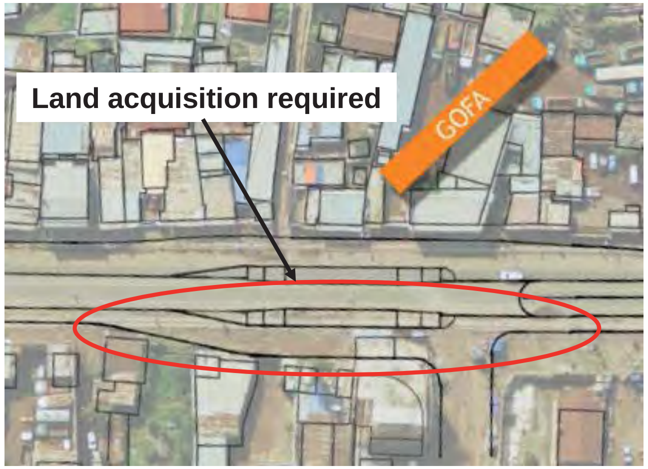
- The impacts on traffic that could be solved according to what is described on chapter 6.7 of the present report;
- Land acquisition on specific point which are underlined here below



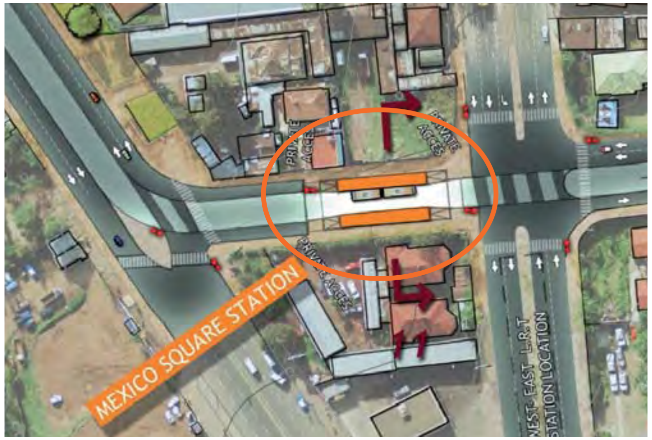








- The last pinch point is that major public works (more than just stations and right of way for buses) would have to be implemented in the three following areas:



Here below is a possible cross section of roads with the minimum 25 m right of way according to the widening defined by the structure plan of Addis Ababa.

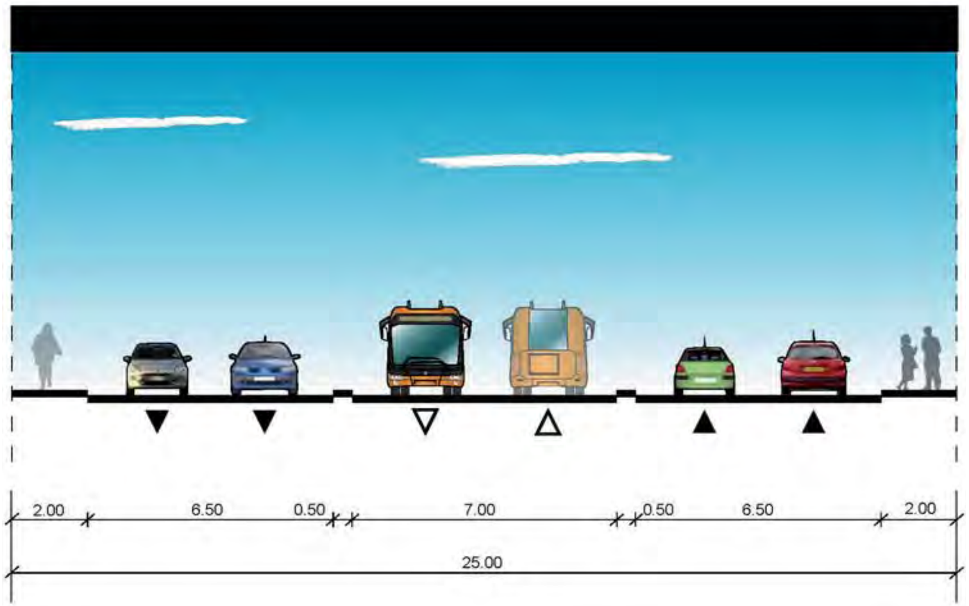


Illustration 45: Typical cross section of roads with 25 m right of way

9.2. SECOND STAGE

The 2nd stage would be an improvement of the BRT system and its extension to Wingate (and potentially to Jemo). It needs to be implemented section by section to allow the BRT to run continuously, and would comprise the following features:

- Widening of the right of ways to insure a minimum of 25 m (respecting structure plan of the city Master Plan) and 2*2 lanes for private vehicles;
- Whole street renewal;
- Implementation of landscaping and urban design strategy;
- Improvement of equipments at stations;

Technically and chronologically, the following steps will have to be respected:

- Utilities diversion;
- Works on the right of way (with buses running in the general traffic lanes);
- Works on stations (equipments);
- Works on the rest of the road and sidewalks, including widening on both sides (buses will be running on the final right of way, and cars will have to be diverted to alternative routes as much as possible);
- Systems, workshop improvement

This second phase could be operational for mid-2013.

10. FINANCIAL ANALYSIS

10.1. INVESTMENT COSTS

The following cost assessment is based on the data given by Addis Ababa Road Authority and on feedbacks from other public transport projects. It has been made for the Regional Bus Station – Gofa Gabriel section and for the Wingate extension.

The cost estimate of the Wingate – Regional Bus Station section takes into account the fact that the road is currently being widened to 30 meters.

It is only a first rough estimate excluding acquisitions, demolitions and taxes. The figures given here take as a hypothesis that the BRT, in both phases, will involve only basic systems and equipments, ie priority at traffic lights, but no CCTV, and no information for travellers at stations.

The estimate of the first stage includes the temporary BRT platform, the stations infrastructure, some works on the road around stations and at roundabouts, traffic lights at each junction, barriers along the BRT platform and stations, the implementation of bus interchanges and park and ride, the rolling stock and the depot upgrade.

The implementation of the first phase on the Regional Bus Station – Gofa Gabriel section (8km) amounts to about 298 M Birr.

The estimate of the second stage includes the final right of way on the whole line (12km), the stations and traffic lights on the extension to Wingate, the implementation of bus interchanges and park and ride, the rolling stock and the depot upgrade. It excludes the widening of the streets and their renewal which will be performed by ACCRA (for the estimate, only the perimeter of the BRT is taken into account).

The upgrading to the second phase on the Wingate – Gofa Gabriel section (12km) amounts to an additional cost of about 382 M Birr.

	First stage Regional Bus Station - Gofa Gabriel (estimated cost in M Birr)	Second Stage (excluding widening and street renewal) Wingate – Gofa Gabriel (estimated cost in M Birr)
Preparatory works	9.5	-
Public utilities	18.2	68.3
BRT platform	6.1	210.0
Stations infrastructure platforms	5.6	1.9
Stations equipments	7.1	1.8
Sidewalks, car lanes, car parks, roundabouts	36.5	-
Barriers	17.1	7.1
Traffic lights	25.9	5.2
Roadsigns and markings	3.4	-
Bus interchange / Park and ride	21.1	3.8
Rolling stock	96.1	37.2
Depot / maintenance area	30.0	10.0
Risks and uncertainties	21.7	37.0
Total	**298.3**	**382.3**

A benchmark with other trolley or diesel BRT systems in the world shows that infrastructure costs in Addis (with Birr / dollar conversion from October 2010) are quite cheap compared to other BRT in the world. The same can be said about rolling stock with articulated buses estimated for Addis case at around 3.1 M Birrs, which is just a bit more expensive than the cheapest normal Brazilian buses (see p 44).

Cities	Technology	Infrastructure costs (millions US$/km)[4]
Quito (Equator)	El *Trole* (Trolley)	5,1[5]
	Diesel (Ecovia way)	1,2
	Diesel	2,3
Bogota (Colombia)	Diesel	5
Lagos (Nigeria)	Diesel	1,7
Addis BRT (Ethiopia)	1st stage (diesel)	1,5
	2nd stage (diesel)	2,8

Illustration 46: Investment costs for infrastructure of some case studies in the world

[4] This covers busway, stations and other civil works
[5] This covers infrastructure costs with overhead wires, electrical infrastructure and rolling stock.

10.2. OPERATING COSTS

The assessment of the operating cost is based on data given by Anbessa in October 2010 and are updated in order to fit for articulated buses on a dedicated lane.

Unit operating cost in Birr/km

Item	Articulated bus on a dedicated lane (2010)
Operating Salaries	1.67
Administrative Salaries	0.37
Other Salaries& related	1.01
Oil & Lubricant	0.48
Fuel	7.94
Tyres &Tubes	0.62
Maintenance parts	2.72
Insurance	0.36
Miscellaneous& Administrative	0.12
Office Supplies & Printing	0.11
Total (excluding depreciation)	**15.39**

With the hypothesis described in chapter 8.5 “headways” and for the complete 12 km line, the operating costs will be about 49.3 M Birr per year.

10.3. OPERATING REVENUES

The operating revenues are difficult to asses as no traffic forecast figures are available. The assessment of the operating revenues has been made by using the following hypothesis:

- Bus services per direction per year: 126 630
- Bus capacity : 150 passengers
- Occupancy rate : 70%
- Number of passengers paying per occupied seat per service : 2.5
- Price per trip : 1.5 birr (the hypothesis is that there is no fare integration, i.e. the passengers pay each time they board the BRT regardless of the fact that they might have performed other trips on the Anbessa networks before boarding)

Please note that most of these hypothesis are highly sensitive and that the figures suggested above are only a first rough estimate. Further investigation with Anbessa and AACG is required in order to have a more robust operating revenue figure.

With the above hypothesis and for the complete 12 km line, the operating revenues will be about 99.7 M Birr per year.

These revenues are higher than the operating costs thus making the BRT line profitable. This will generate revenues for future lines or for compensating the deficit of other bus lines.

10.4. GENERAL BALANCE

The general balance presented below has been computed on the basis of the hypothesis and figures presented above, and takes into account the two implementation stages of the project. It should be considered only as indicative.

In addition of the previously elements, this balance takes into account the infrastructure maintenance costs (6 Million Birr / year) and the amounts needed to renew the rolling stock and the BRT platform after 15 years of operation (200 Million Birr in 2026).

This balance is computed over 30 years. All costs are expressed in million Birr of 2010.

As a result, the financial Internal Rate of Return (IRR) is computed. It amounts to 3.8% which is quite a good figure for a public transport project.

Million Birr 2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Revenues	33.2	66.5	83.1	99.7	99.7	99.7	99.7	99.7	99.7	99.7	99.7	99.7	99.7	99.7	99.7
Operating costs	16.5	33.0	41.2	49.3	49.3	49.3	49.3	49.3	49.3	49.3	49.3	49.3	49.3	49.3	49.3
Infrastructure maintenance costs	2.0	4.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0
Operating Profit	14.7	29.4	35.9	44.4	44.4	44.4	44.4	44.4	44.4	44.4	44.4	44.4	44.4	44.4	44.4
Investment	298.3		382.3												
Total	-283.6	29.4	-346.4	44.4	44.4	44.4	44.4	44.4	44.4	44.4	44.4	44.4	44.4	44.4	44.4

Million Birr 2010	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	Total
Revenues	99.7	99.7	99.7	99.7	99.7	99.7	99.7	99.7	99.7	99.7	99.7	99.7	99.7	99.7	99.7	2 875.3
Operating costs	49.3	49.3	49.3	49.3	49.3	49.3	49.3	49.3	49.3	49.3	49.3	49.3	49.3	49.3	49.3	1 423.0
Infrastructure maintenance costs	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	174.0
Operating Profit	44.4	44.4	44.4	44.4	44.4	44.4	44.4	44.4	44.4	44.4	44.4	44.4	44.4	44.4	44.4	1 278.3
Investment	200.0															880.6
Total	-155.6	44.4	44.4	44.4	44.4	44.4	44.4	44.4	44.4	44.4	44.4	44.4	44.4	44.4	44.4	397.7

Illustration 47: General balance

10.5. FUNDING STRATEGIES

10.5.1. General perspectives

Mr Menckhoff in his 2007 report gave the different options for funding a BRT project:

"The financing of a new BRT system can be grouped into five of activities: planning, operations, infrastructure, equipment (such as vehicles and fare equipment), and system maintenance. Each of these groups typically involves different sorts of financing or funding options.

- ***System planning and design:*** government budget - bilateral assistance agencies (e.g., AFD, GTZ, USAID, JICA) - United Nations agencies (e.g., UNDP, UNEP, UNCRD) - loans or grants through the World Bank or regional development banks (such as the AfDB) - private foundations (e.g. Hewlett, Clinton) - private sector (e.g. vehicle manufacturers, fuel suppliers)
- ***Operations:*** fare revenues – leasing of commercial space near stations – advertising – emissions trading – government subsidies
- ***Infrastructure:*** government budget – gasoline taxes or surcharges – land value taxation – sale or leasing of commercial space near stations – commercial banks – municipal bonds – loans from the World Bank or other development banks (e.g. AfDB, EIB, OPEC Fund, Kuwait Fund) – private investment options (PPPs)
- ***Equipment, such as buses, fare validation:*** bus operators – fare collection companies – credits from bus manufacturers – bilateral export banks - development banks, including IFC – commercial banks – government budget
- ***Infrastructure maintenance:*** government budget – gasoline taxes or surcharges – bus operators – fares"

10.5.2. Case of Addis

This overview is of much interest in the case of this BRT project. Indeed, the AACG and the Transport branch office should have a look at these diverse sources for funding four main activities:

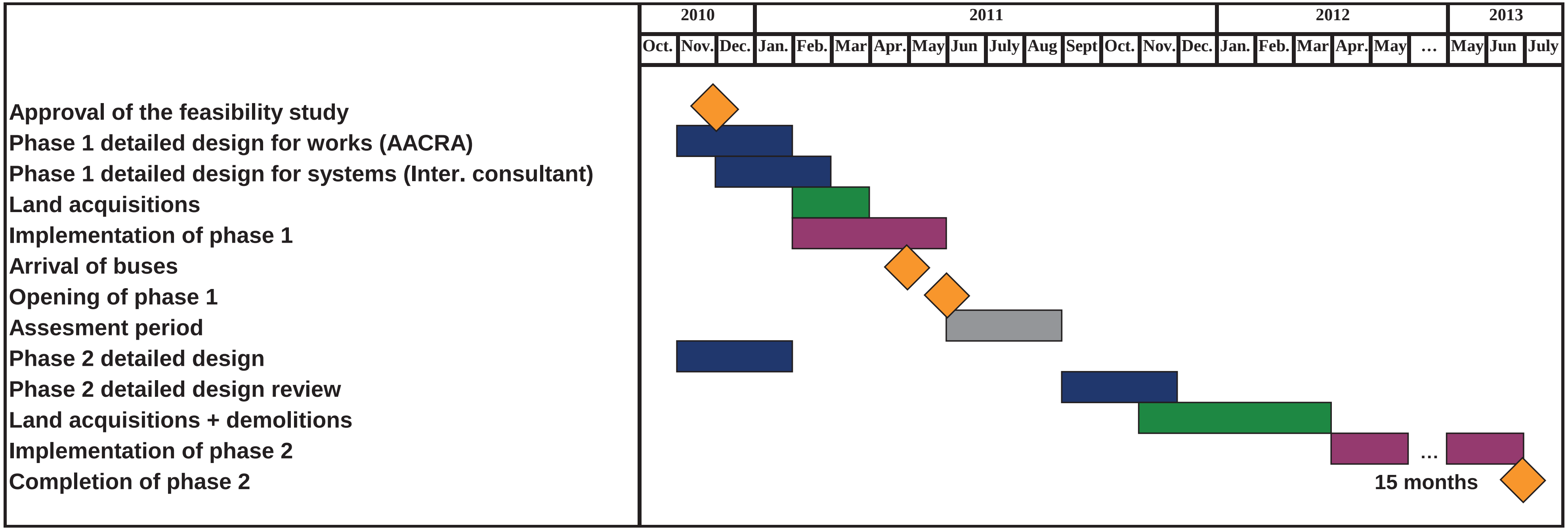
- The detail design of the BRT system: the AACG should probably be the main funder with some assistance from other sources, such as AFD;
- The infrastructure: again, AACG, in cooperation with Addis Ababa Road Authority, could finance a good part of this item, requiring optional complementary funding from other sources; a soft loan by AFD upon the fulfillment of all the requirements by the city administration is currently under examination.
- Operation: this item depends on how Anbessa will be integrated in the financing approach of the project, especially the contracting or institutional agreement between AACG or Transport Branch office, and Anbessa;
- Equipment, rolling stock, fare validation: it could either be joined with operation or not. In this case, as in Lagos, a PPP (public private partnership) could be an interesting option. As per today, an agreement has been found between AACG and Anbessa to buy new rolling stock of 500 buses, from which 200 would be articulated. The financing is expected to be 70 % from Anbessa, and 30 % from AACG, as a result the fare validation will be independent from the purchase of the rolling stock.

In any case, the debt will have to be limited and the financial options should remain reasonable, realistic, and sustainable.

11. SCHEDULE

The following schedule indicates the steps that have to be carried out in order to implement both phases of the BRT line. Those steps include:

- The feasibility study that will be approved in November 2010;
- The detailed design for phase 1 performed by ACCRA with the help of international consultants;
- The implementation of phase 1 including some land acquisitions;
- The buses ordered by Anbessa and AACG that are scheduled to arrive in April 2011;
- The opening of phase 1 by mid-2011 and the 3 months assessment period following it;
- The detailed design for phase 2 that will begin in November 2010 and its review after the opening of phase 1;
- The implementation of phase 2 including land acquisitions;
- The opening of phase 2 by mid-2013;



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12. CONCLUSION

The following steps for Addis Ababa City Government for implementing this BRT line project would have to be:

- Securing of funding, especially for the next step, e.g. the detailed design part;
- Launch the detailed design step with local consultants, but with an assistance from international experts;
- Organize institutional issue, and global funding strategy for the project;
- Implement the 1st phase.

13. APPENDIX 1: SOURCES DOCUMENTS

1. *City Development Plan 2001-2010, Executive Summary,* Office for the Revision of the Addis Ababa Master Plan, August 2002

2. *Addis Ababa Mass Transport System (high-capacity lines) – East-West Axis Feasibility Study of a Bus Corridor*, prepared by SEMALY in association with Cabinet Ilex and the Lyon Town Planning Agency for the City Government of Addis Ababa, with funding from the Foreign Ministry of France, May 2004.

3. *Urban Transport Study and Preparation of Pilot Project for Addis Ababa, Final Report,* prepared by Consulting Engineering Services (India) Pvt. Ltd. in association with Saba Engineering for Ethiopia Road Authority, with funding from the World Bank, December 2005.

4. *Some Comments about the Transport Master Plan and Preparation of Pilot Project for Addis Ababa,* presentation by Semaly at workshop in Lyon Town Planning Agency, July 2006.

5. *Expertise on Mass Transport technologies (BRT- LRT), Implementation strategies and institutional set up,* report from Mr. G. Menckhoff, consultant, in association with LTPA, Ethio French cooperation project, 2007

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Quito:

"*Case study of Quito Metrobus*", D. Hidalgo, 2006

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"*Os trolebuses na cidade de São Paulo: Uma Analise Preliminar*" Instituto de Politicas de Desenvolvimento e Transoporte (ITDP), February 2008

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"*Lagos BRT-Lite: Africa's first Bus Rapid Transit Transit Scheme – Scheme evaluation: Summary Report*" Integrated Transport Planning Ltd and IBIS Transport Consultants Ltd for LAMATA, January 2009

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"*Cities on the move: A world Bank urban transport strategy review*" the World Bank, 2002

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"*Trolleybus development in Ring Road of the Kathmandu Valley, a pre-feasibility report*" PREGA National Technical Expert from Winrock International Nepal, March 2004

Websites:

CERTU (Bhns) : http://www.bhns.fr/

Electric transport in Latin America: http://www.tramz.com/index.html

ISTED: http://www.isted.com/

ITDP:http://www.itdp.org/index.php/information_center/document_archive-program_area/developing_high_quality_low_cost_mass_transit/

Low-Tech Magazine: http://www.lowtechmagazine.com

Official website of Quito's trolleybus company: http://www.trolebus.gov.ec/

The Independent: Warning: Oil supplies are running out fast

The trolleybus system of Quito, Equator: http://www.tramz.com/ec/q/b1.html

UITP: http://www.uitp.org/

Urbamet: http://www.urbamet.com/

Pictures and maps

Egis Rail and LTPA, unless [exceptions]

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14. APPENDIX 2: PHOTOS OF THE BRT CORRIDOR

Addis Ababa Regional Bus Station

Fit Habte Giyorgis Street

Fit Habte Giyorgis Street

Fit Habte Giyorgis Street

Fit Habte Giyorgis Street, junction with Tesema Aba Kemaw Street

Tesema Aba Kemaw Street

Tesema Aba Kemaw Street


Tesema Aba Kemaw Street


Tesema Aba Kemaw Street, after Tekle Haymanot roundabout


Tesema Aba Kemaw Street, junction with Zambia Street


Tesema Aba Kemaw Street, junction with Sudan Street


Tesema Aba Kemaw Street

Kemaw Street


Kemaw Street


Ras Abebe Aregay Street


Mozambique Street, north of Ras Mekonen Street

Mozambique Street, south of Ras Mekonen Street

Mozambique Street

Mozambique Street

Mozambique Street

Mozambique Street at Kera

Mauritius Street from Gofa Gabriel roundabout


Overview of Anbessa depot in Mekanissa


Maintenance and workshop area in Anbessa depot

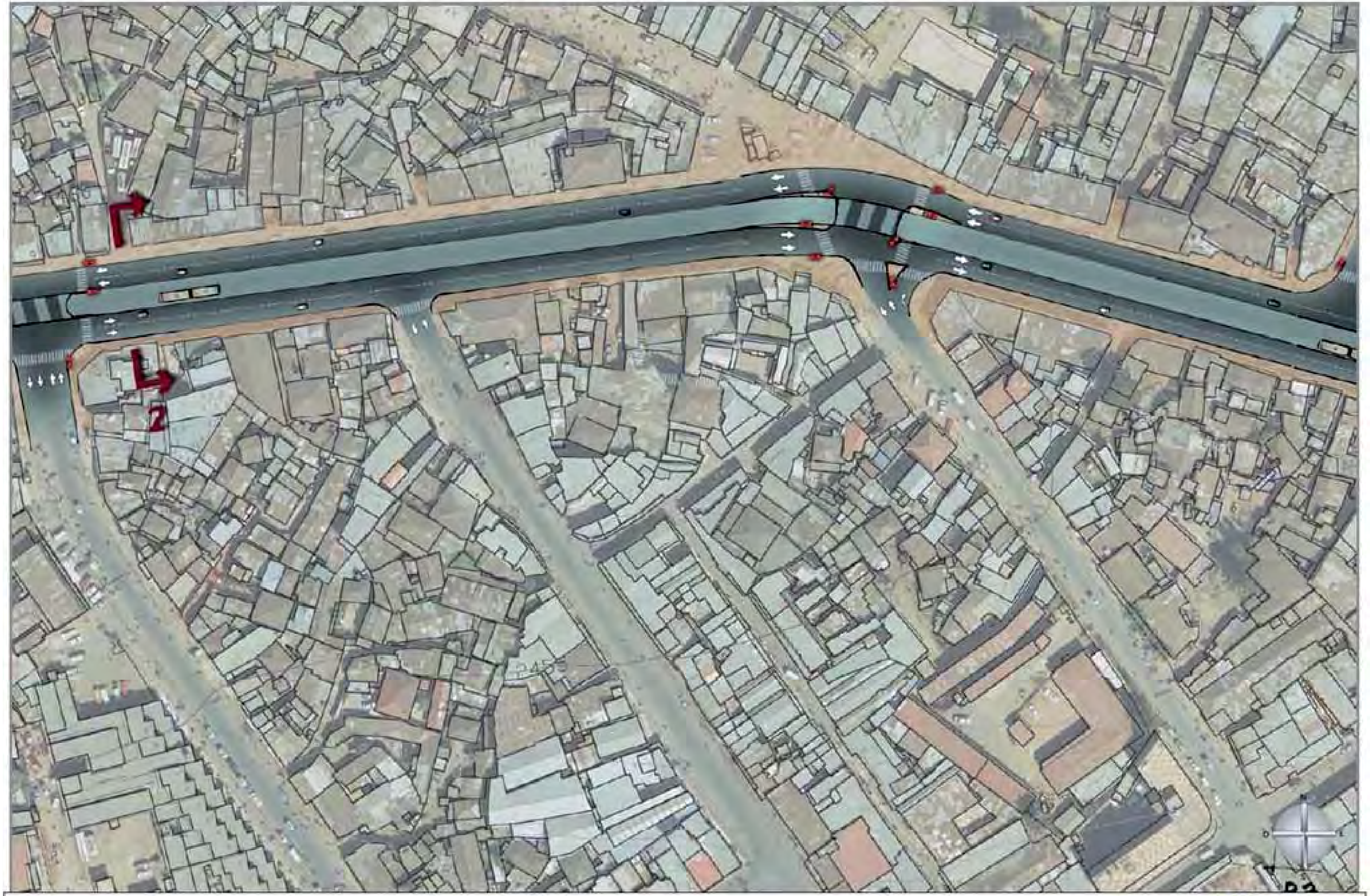
15. APPENDIX 3: MAPS OF THE BRT LINE

15.1. FIRST SECTION

See attached document

egis rail

BB2BJC_ADDIS ABEBA



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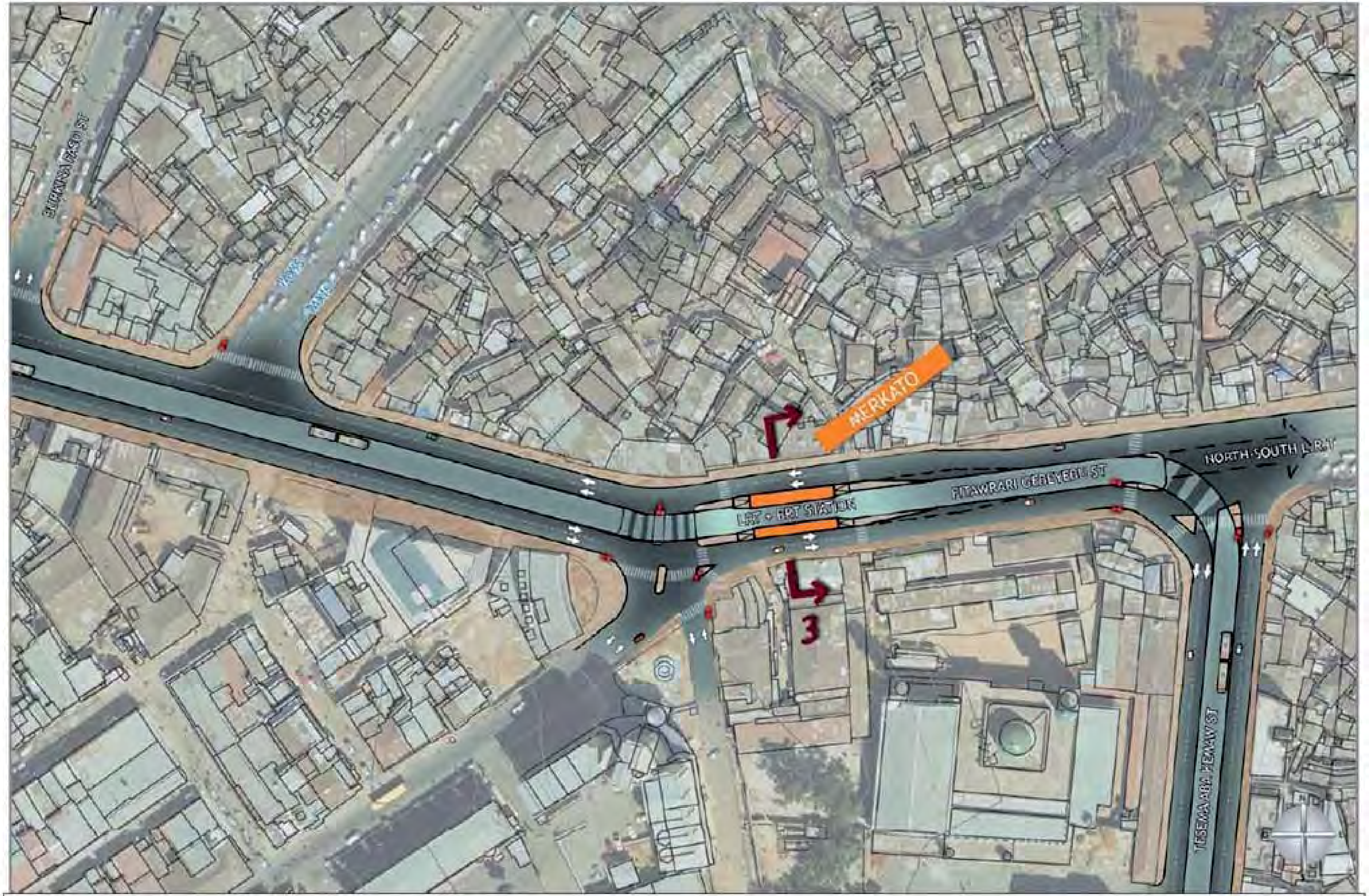
egis rail



0 25 50 100m

egis rail

8825JC_ADDIS ABEBA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TEKLE HAYMANOT
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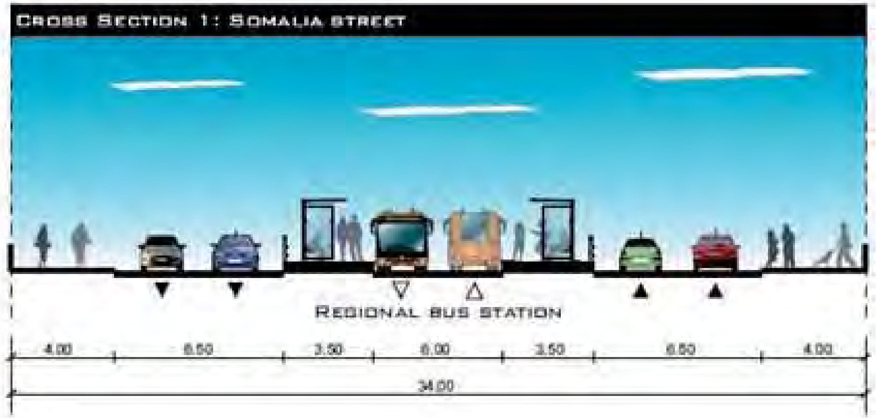

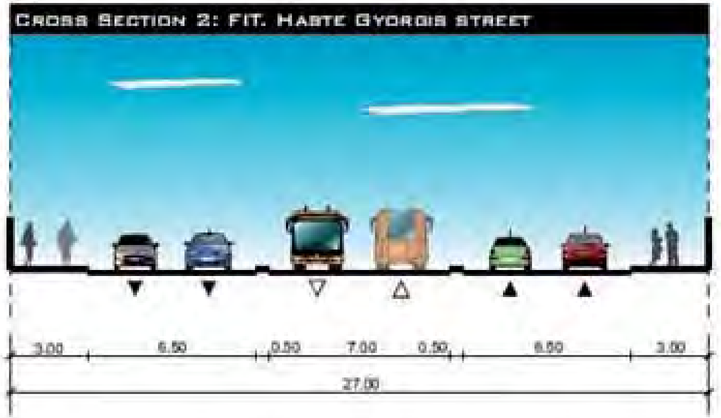

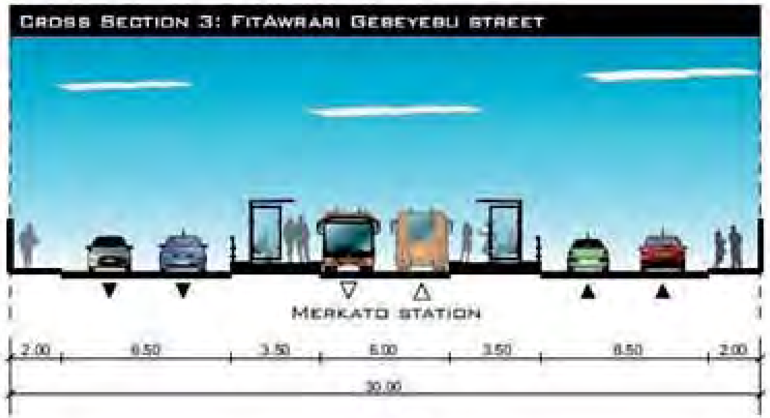

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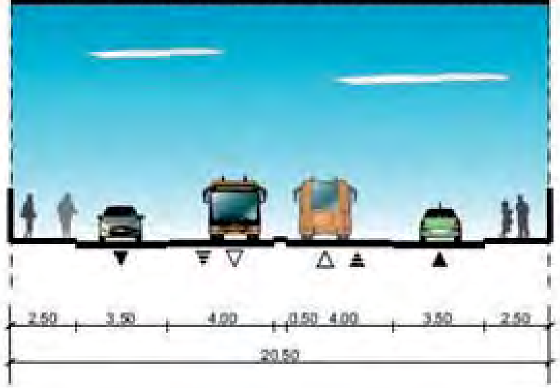
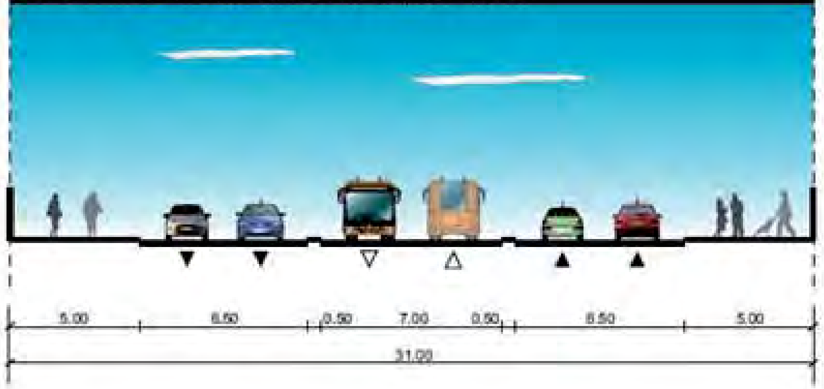
egis rail

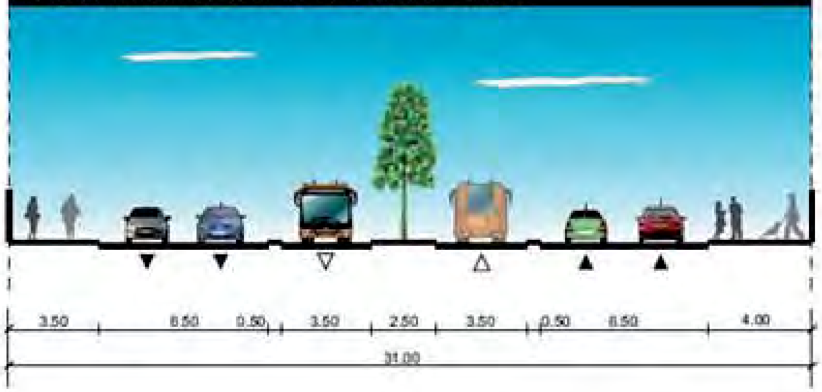
CROSS SECTION 4: TESEMA ABA KEMAN STREET

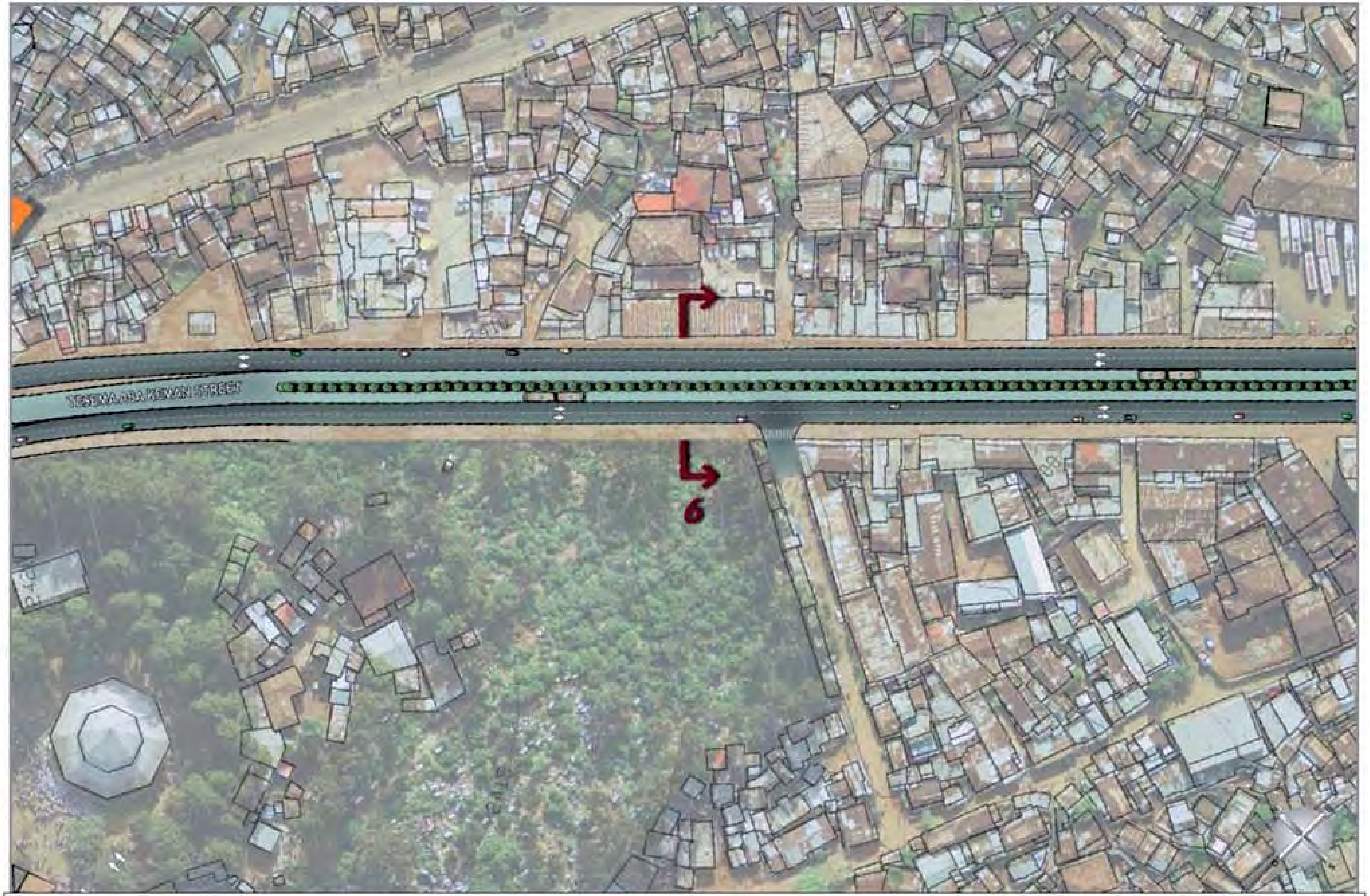


CROSS SECTION 5: TESEMA ABA KEMAW STREET



CROSS SECTION 6: TESEMA ABA KEMAW STREET





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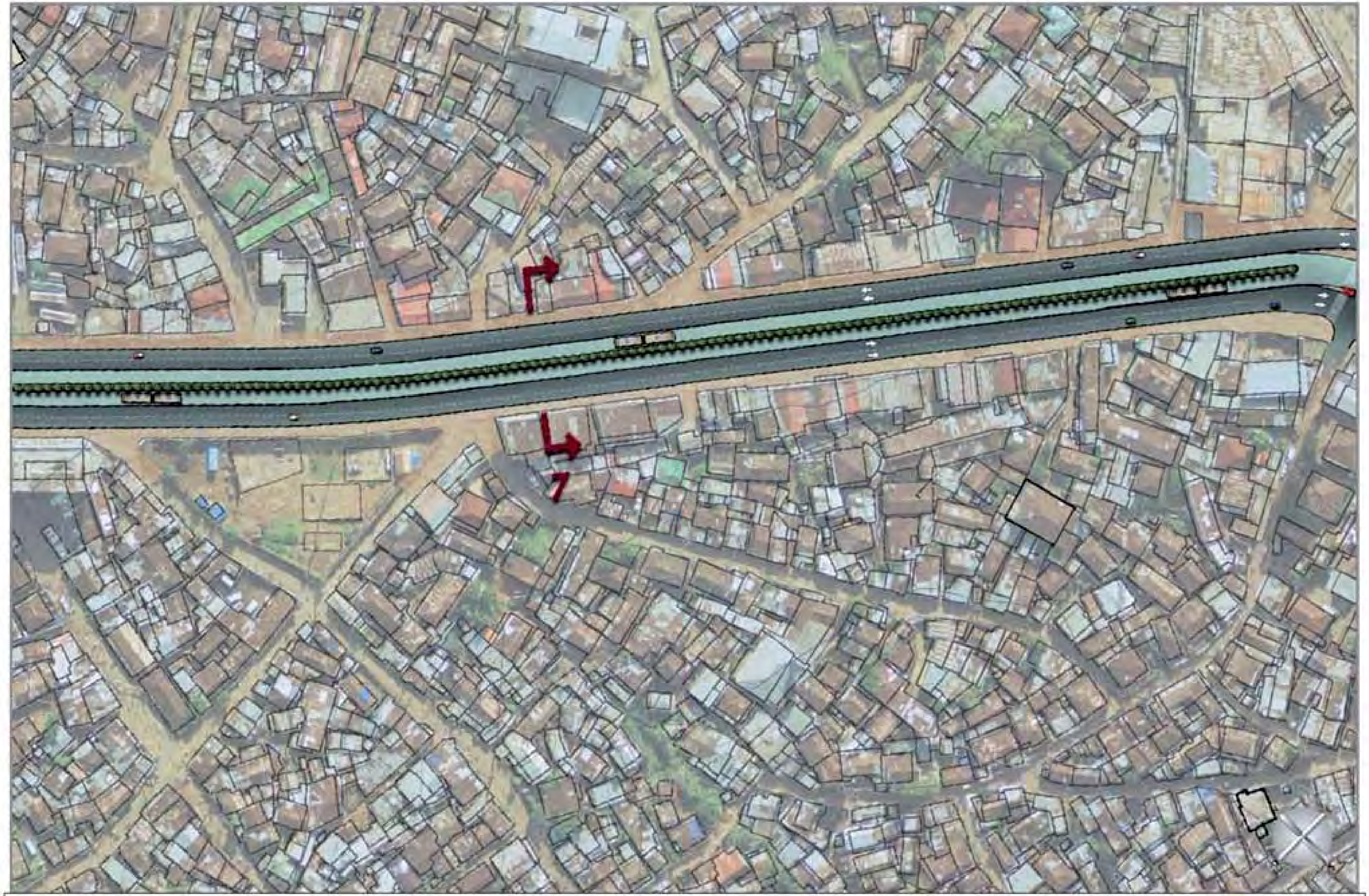

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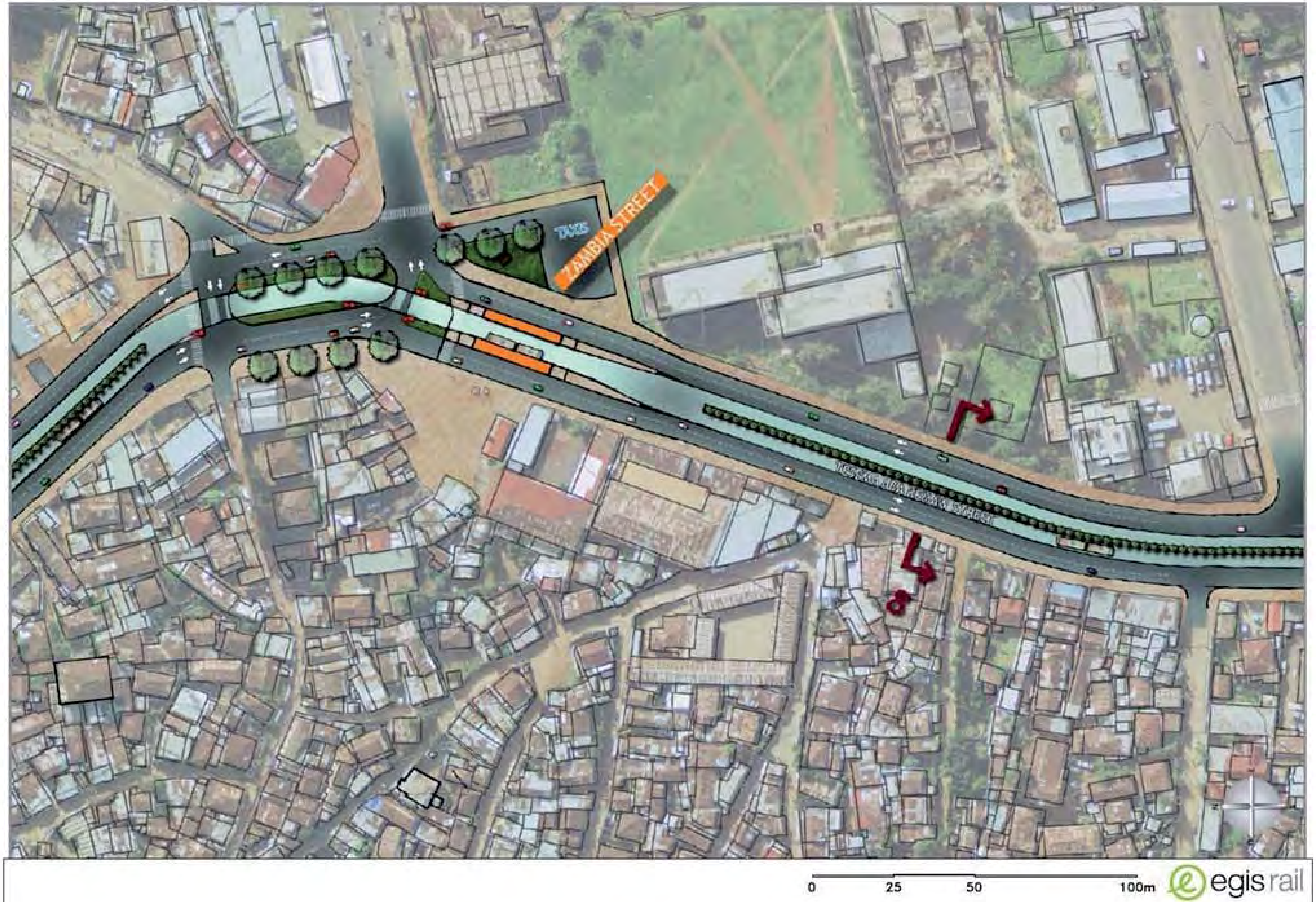
egis rail



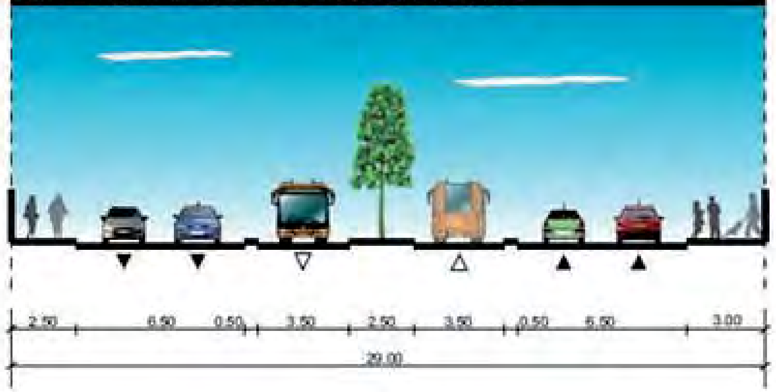
egis rail

0 25 50 100m

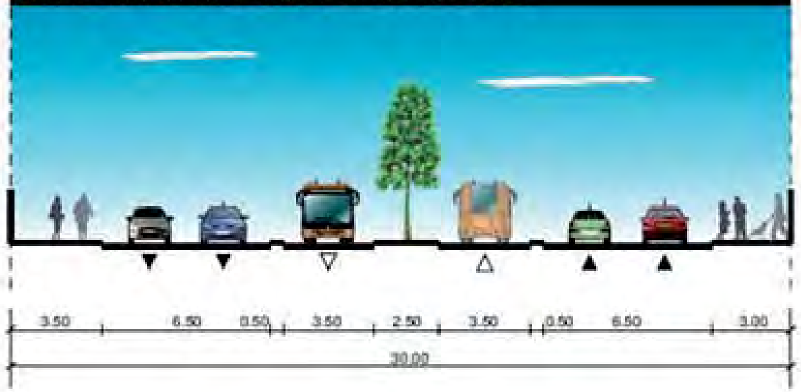
egis rail

egis rail

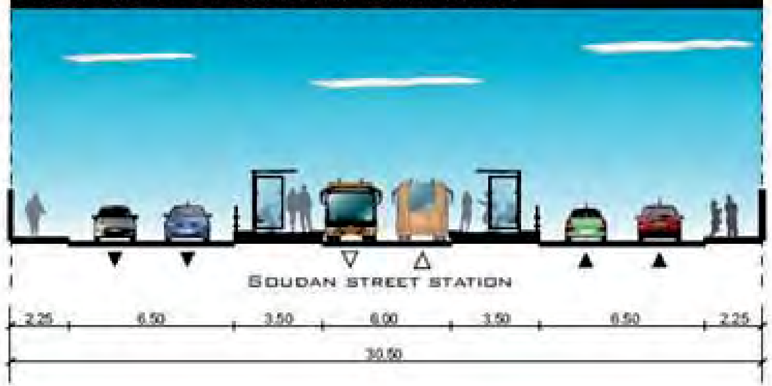
CROSS SECTION 7: TESEMA ABA KEMAW STREET



CROSS SECTION 8: TESEMA ABA KEMAW STREET



CROSS SECTION 9: TESEMA ABA KEMAW STREET



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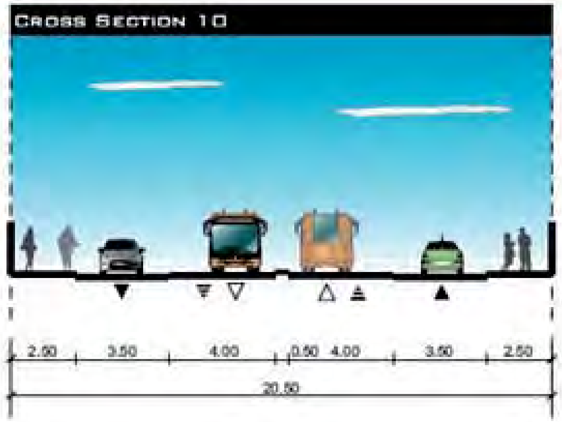
egis rail

BB28JC_ADDIS ABEBA


CROSS SECTION 10
2.50
3.50
4.00
0.50
4.00
3.50
2.50
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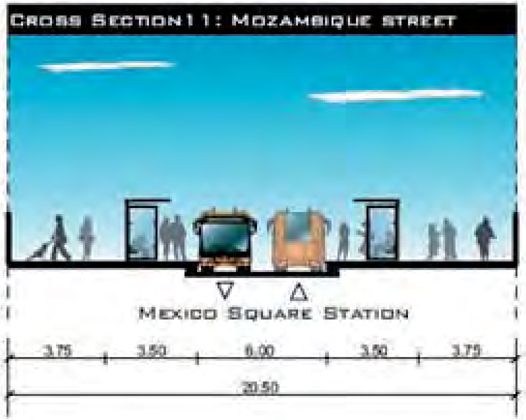
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MEXICO SQUARE STATION
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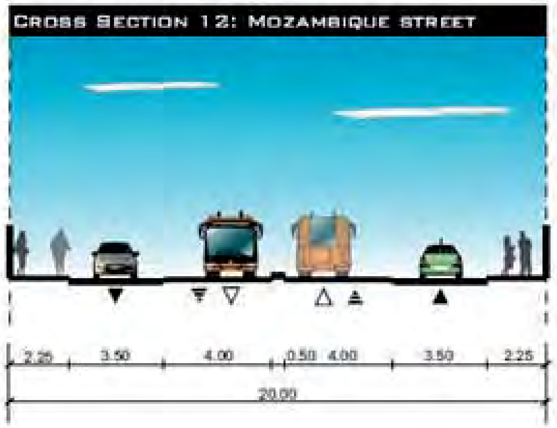
3.50
6.00
3.50
3.75
20.50


CROSS SECTION 12: MOZAMBIQUE STREET
2.25
3.50
4.00
0.50
4.00
3.50
2.25
20.00

0 25 50 100m

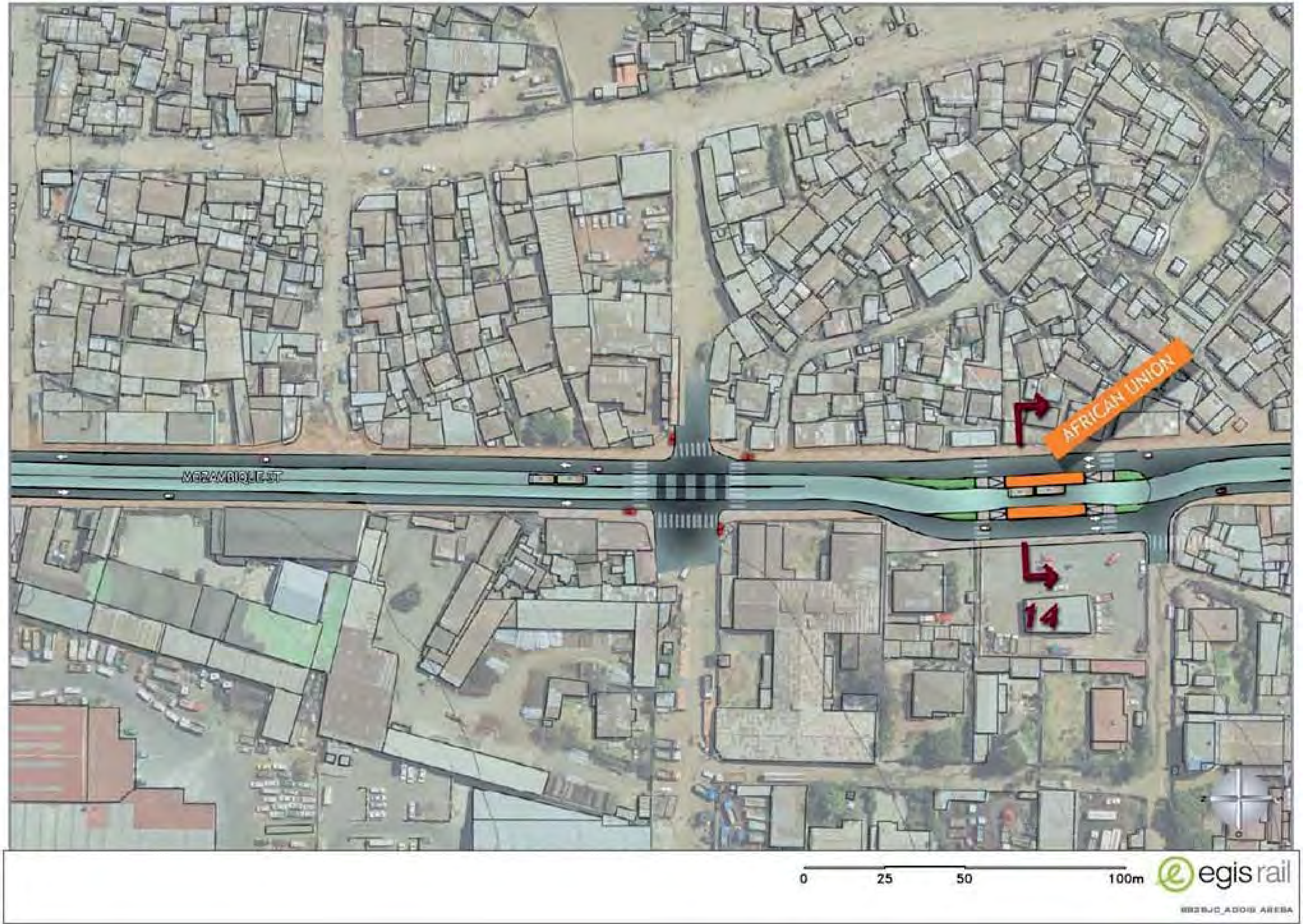
egis rail

0 25 50 100m

egis rail

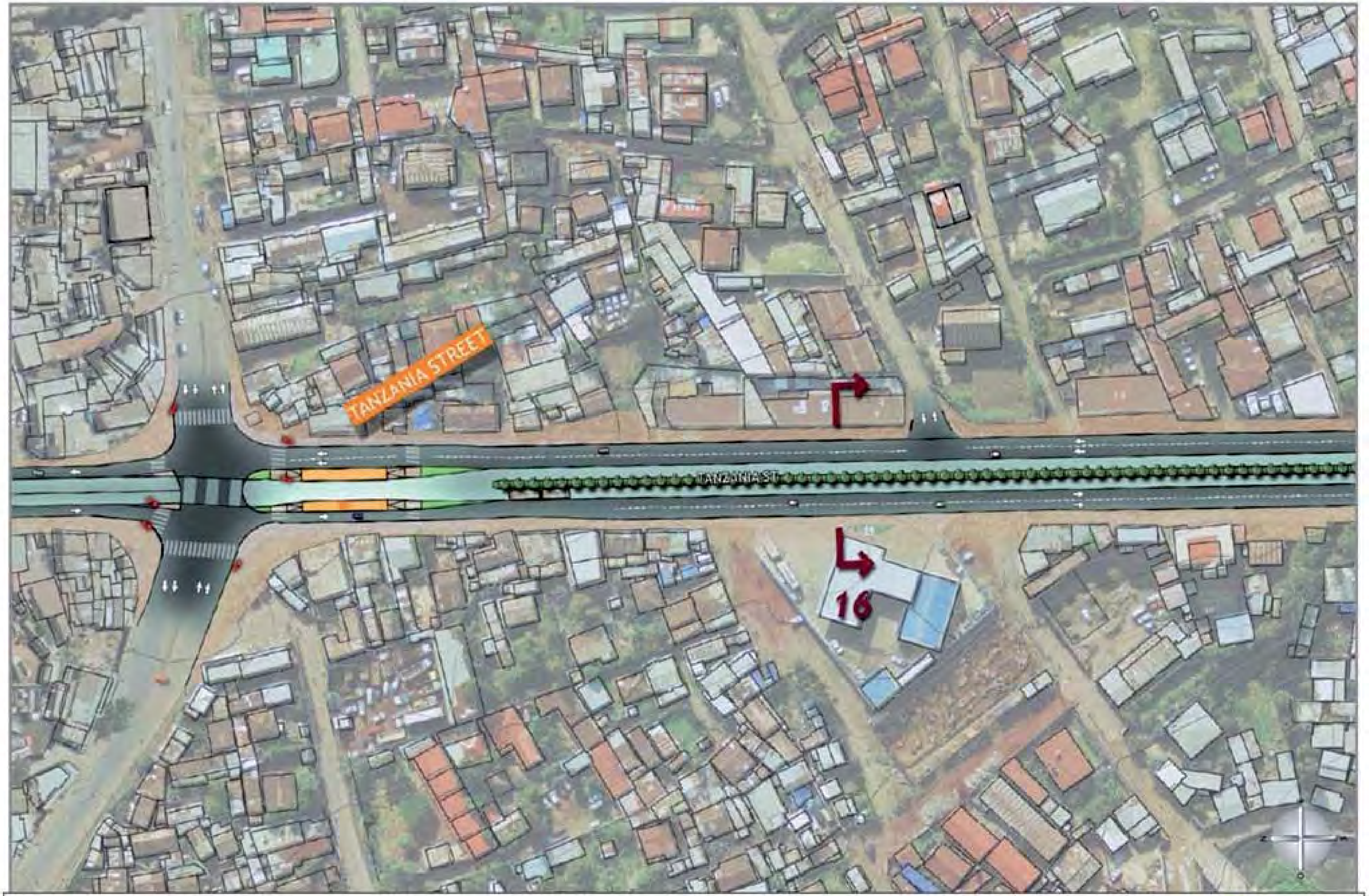
0 25 50 100m

egis rail


AFRICAN UNION
MOZAMBIQUE ST
14
0
25
50
100m
egis rail

egis rail

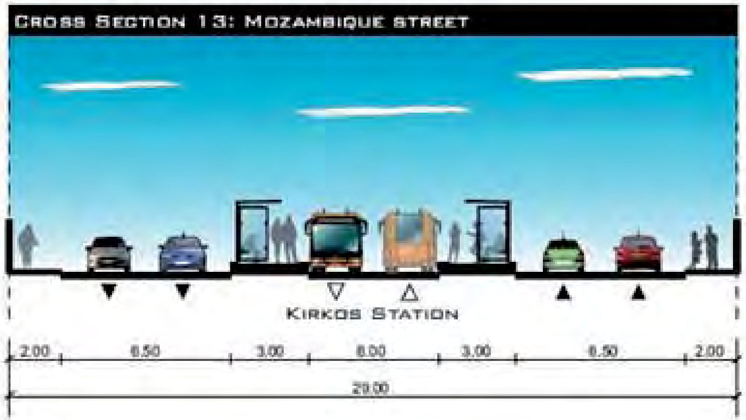
BRSAJC_ADDIS ABEBA

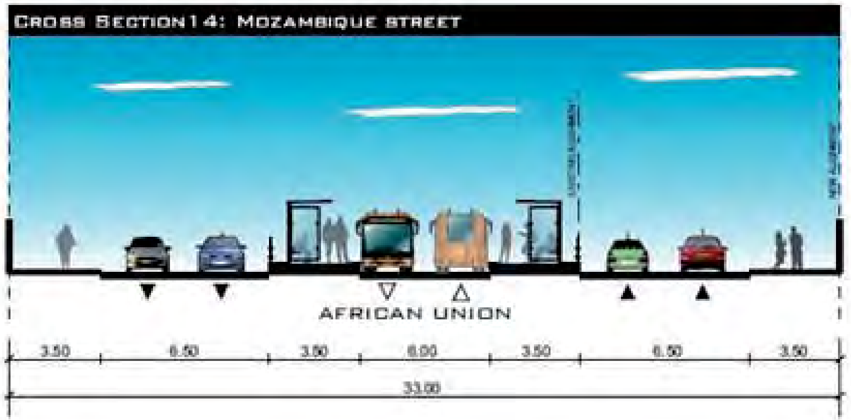


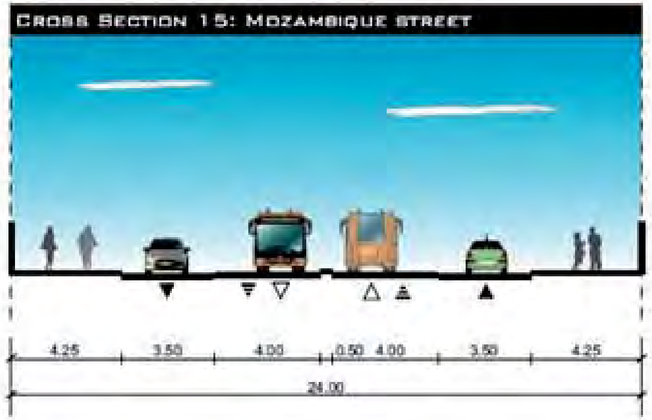
egis rail

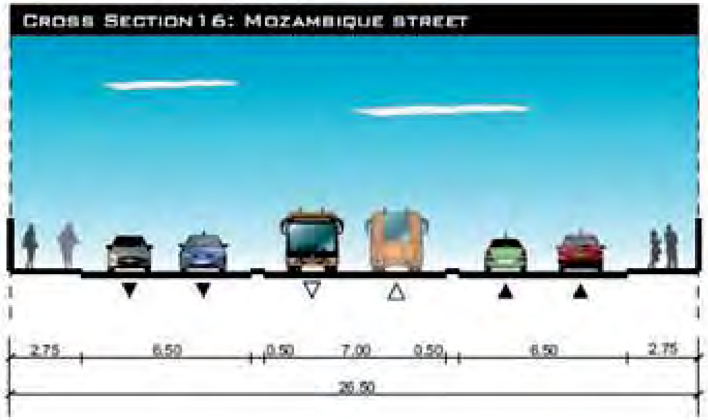
ADDIS ABEBA

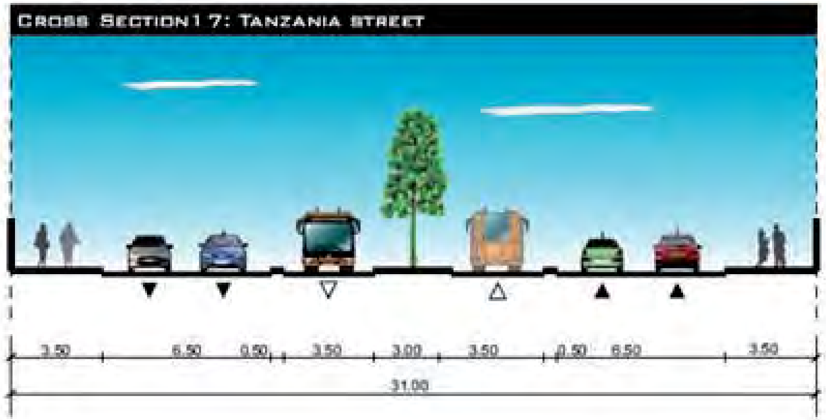
BB28JC_ADDIS ABEBA

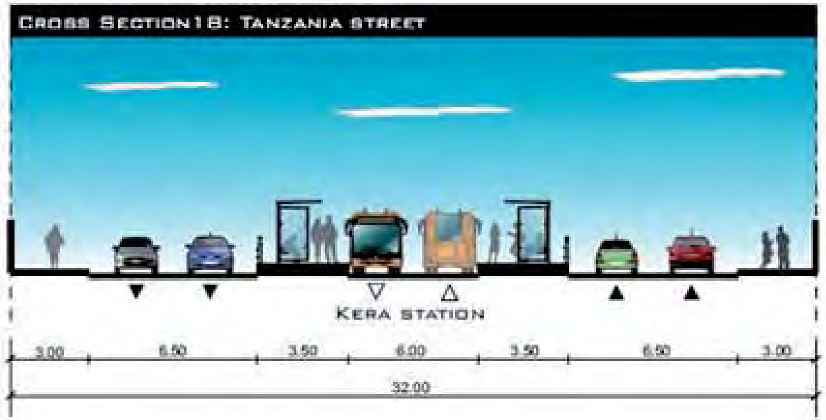

Cross Section 13: Mozambique street
Kirkos Station
2.00
6.50
3.00
6.00
3.00
6.50
2.00
29.00


Cross Section14: Mozambique street
African Union
3.50
6.50
3.50
6.00
3.50
6.50
3.50
33.00


Cross Section 15: Mozambique street
4.25
3.50
4.00
0.50
4.00
3.50
4.25
24.00



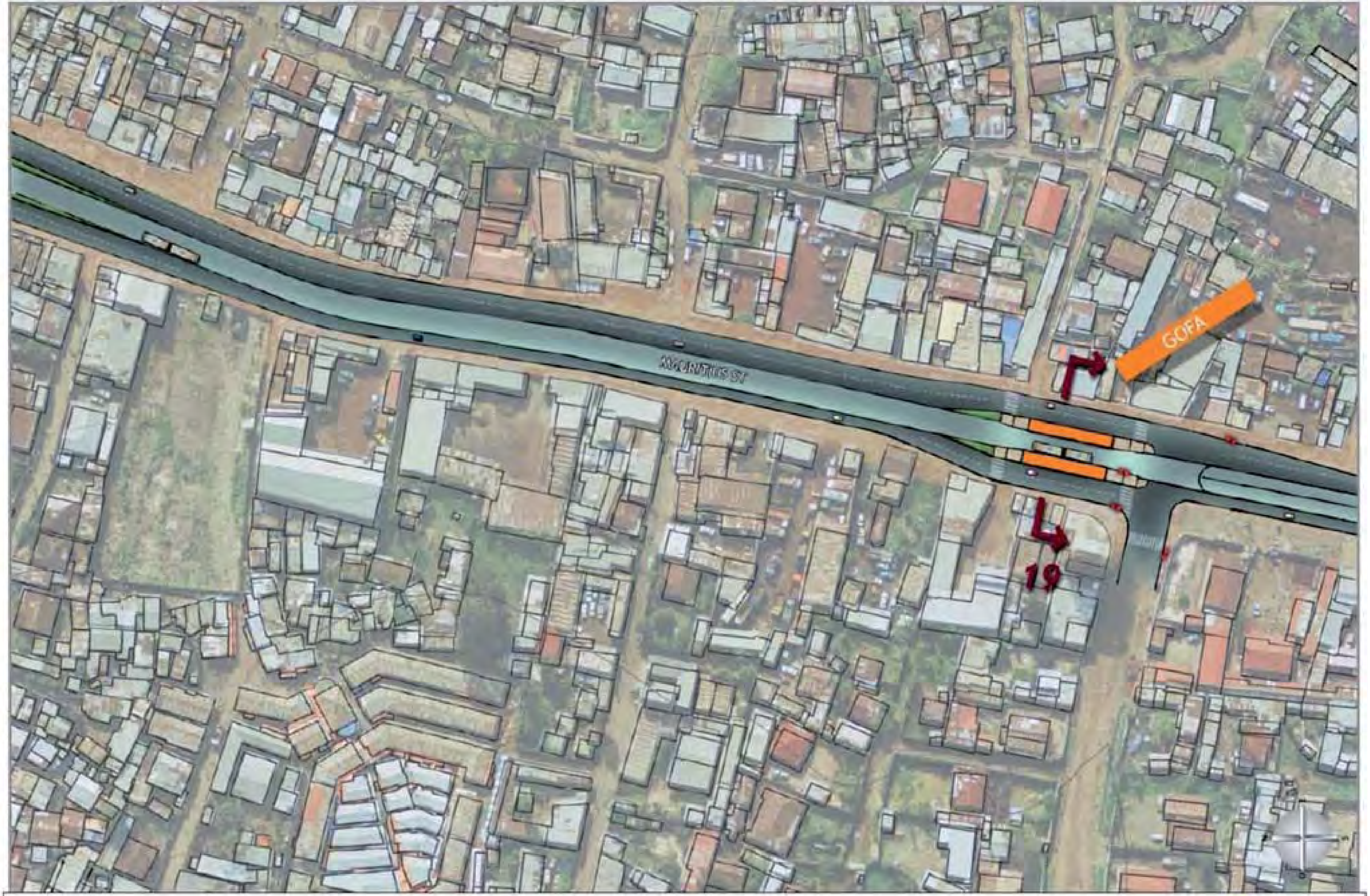




0 25 50 100m

egis rail

egis rail



0 25 50 100m

egis rail

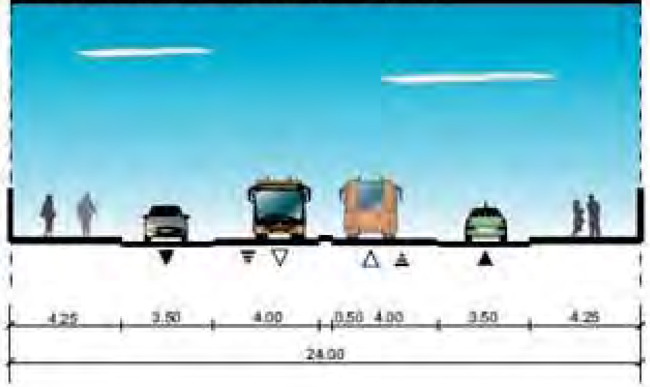
0 25 50 100m

egis rail

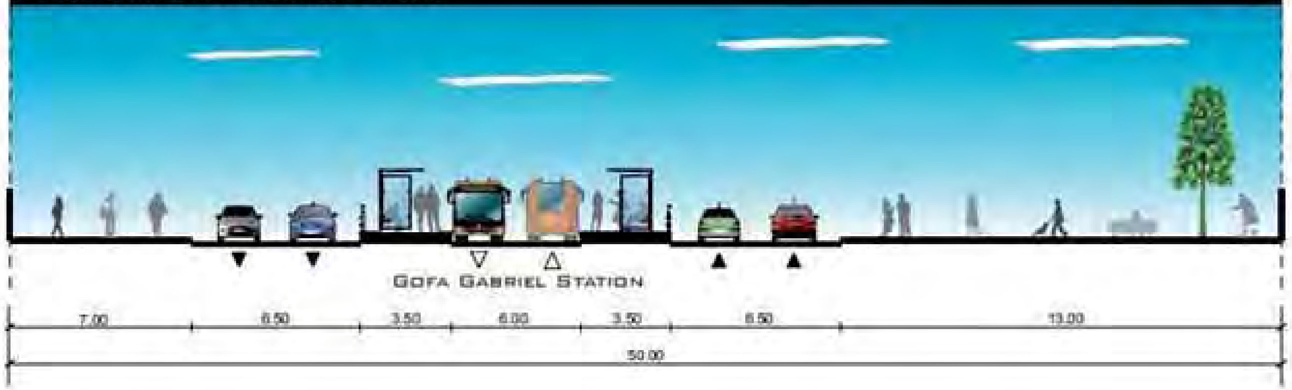
0 25 50 100m

Cross Section 19: Mauritius street

Cross Section 20: Mauritius street



Cross Section 21: Mauritius street




SOMALIA ST
REGIONAL BUS STATION
PERI-URBAN COACHES
+
CAR PARK
1
URBAN BUSES
MINI BUSES
TAXIS
NORTH-SOUTH LRT
STATION LOCATION
0
25
50
100m
egis rail


2
0
25
50
100m
egis rail
B93BJC_ADDIS ABEBA


MERKATO
NORTH-SOUTH LRT
LRT + BRT STATION
3
0
25
50
100m
egis rail

0 25 50 100m

egis rail

ADDIS ABEBA

0 25 50 100m

egis rail

ADDIS ABEBA

0 25 50 100m

egis rail

0 25 50 100m

egis rail

ADDIS ABEBA


ZAMBIA STREET
0
25
50
100m
egis rail

0 25 50 100m

ADDIS ABEBA

0 25 50 100m

egis rail


MEXICO SQUARE STATION
TAXIS - MINIBUSES
0
25
50
100m
egis rail

0 25 50 100m

0 25 50 100m

egis rail


MOZAMBIQUE ST
HUNGARY EMBASSY
0
25
50
100m
egis rail
8828JC_ADDIS ABEBA

0 25 50 100m

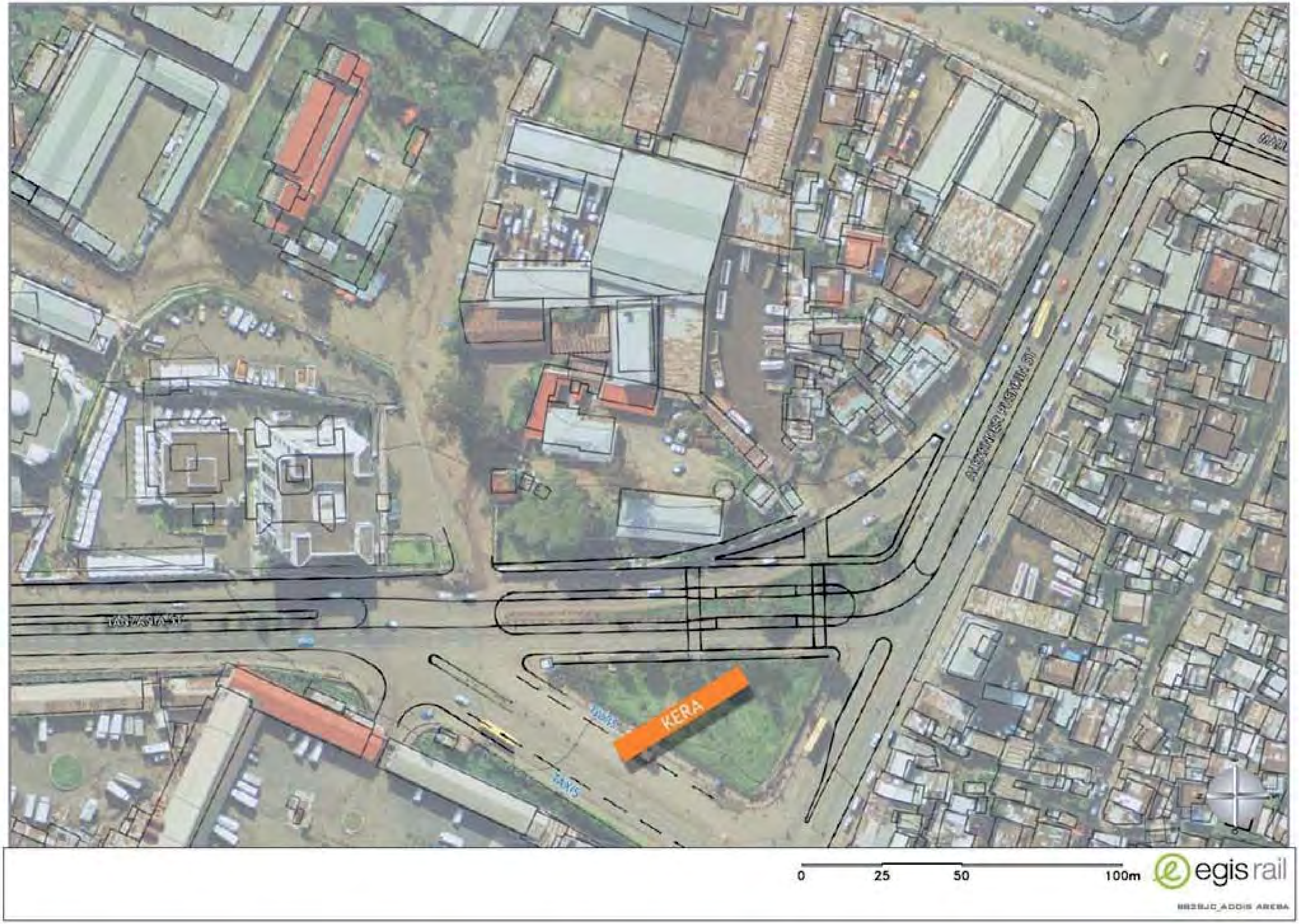
egis rail

0 25 50 100m

egis rail

882BJC_ADDIS ABEBA

0 25 50 100m


KERA
0
25
50
100m
egis rail

0 25 50 100m


GOFA
0
25
50
100m

0 25 50 100m

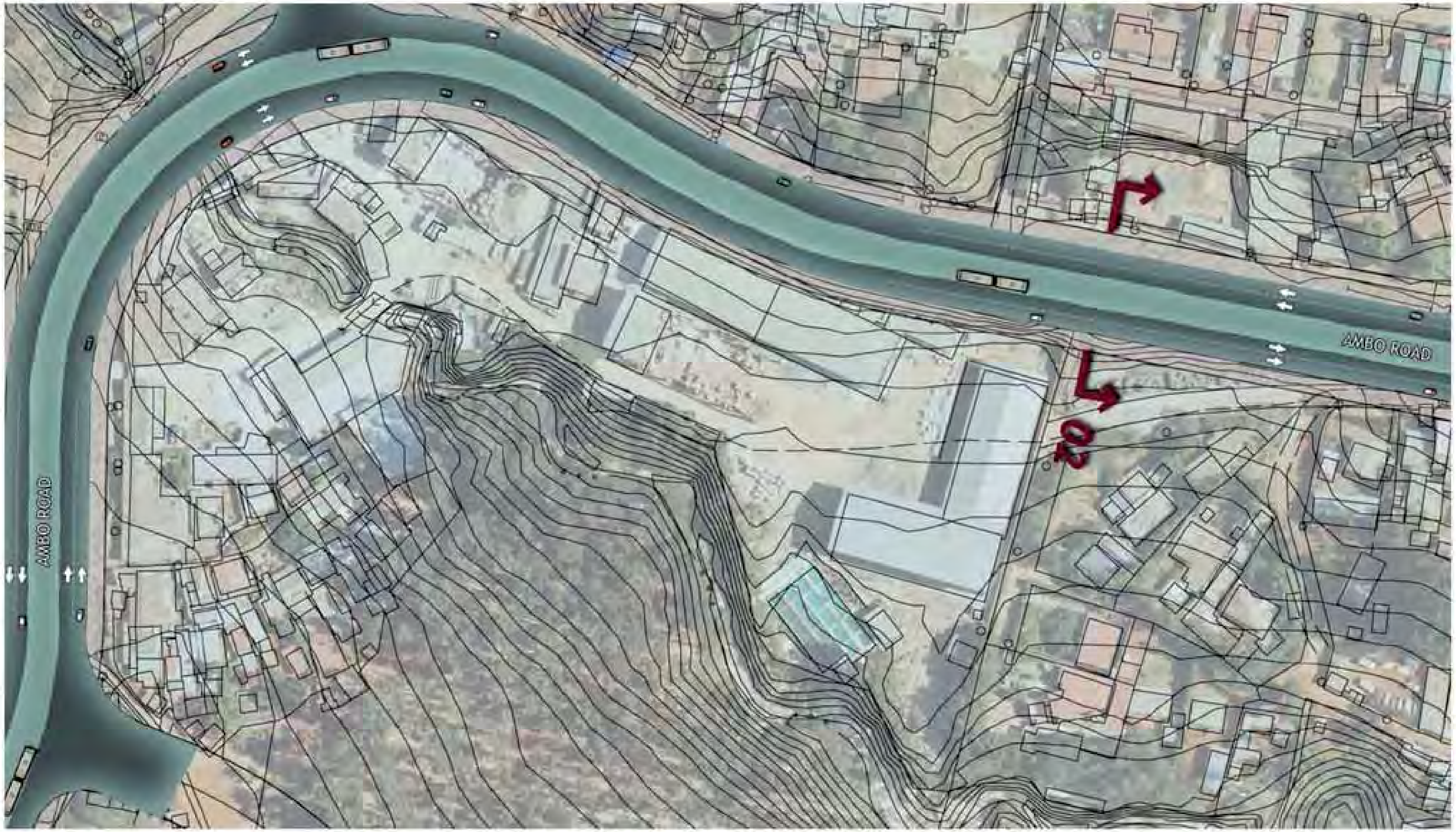
egis rail

ADDIS ABEBA

15.2. EXTENSION TO WINGATE

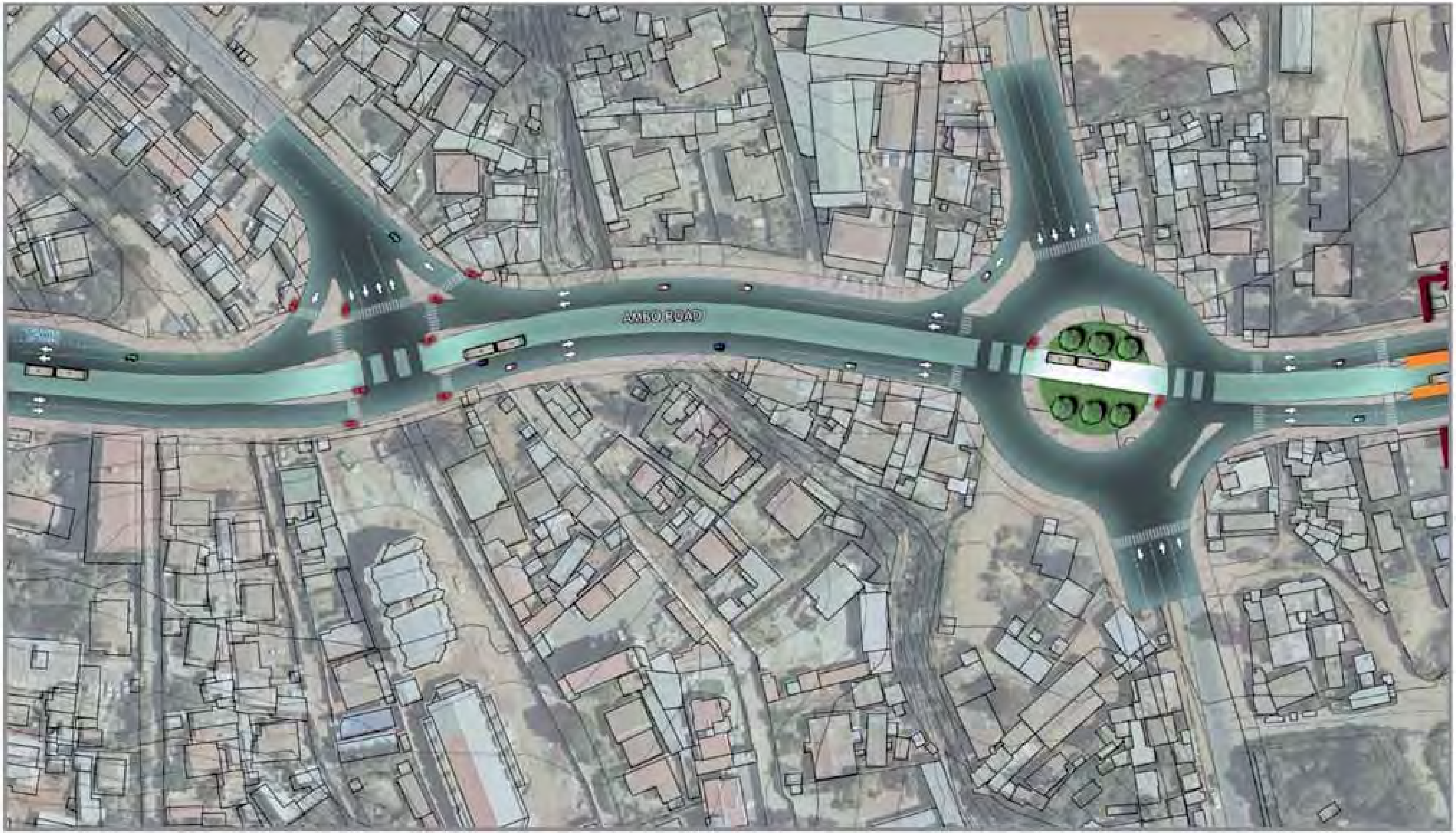
See attached document

WINGATE ROUNDABOUT
01
WINGATE
BUSES
BUSES
AMBO ROAD
0
25
50
100m
egis rail



0 25 50 100m

egis rail



0 25 50 100m

egis rail

0 25 50 100m

egis rail

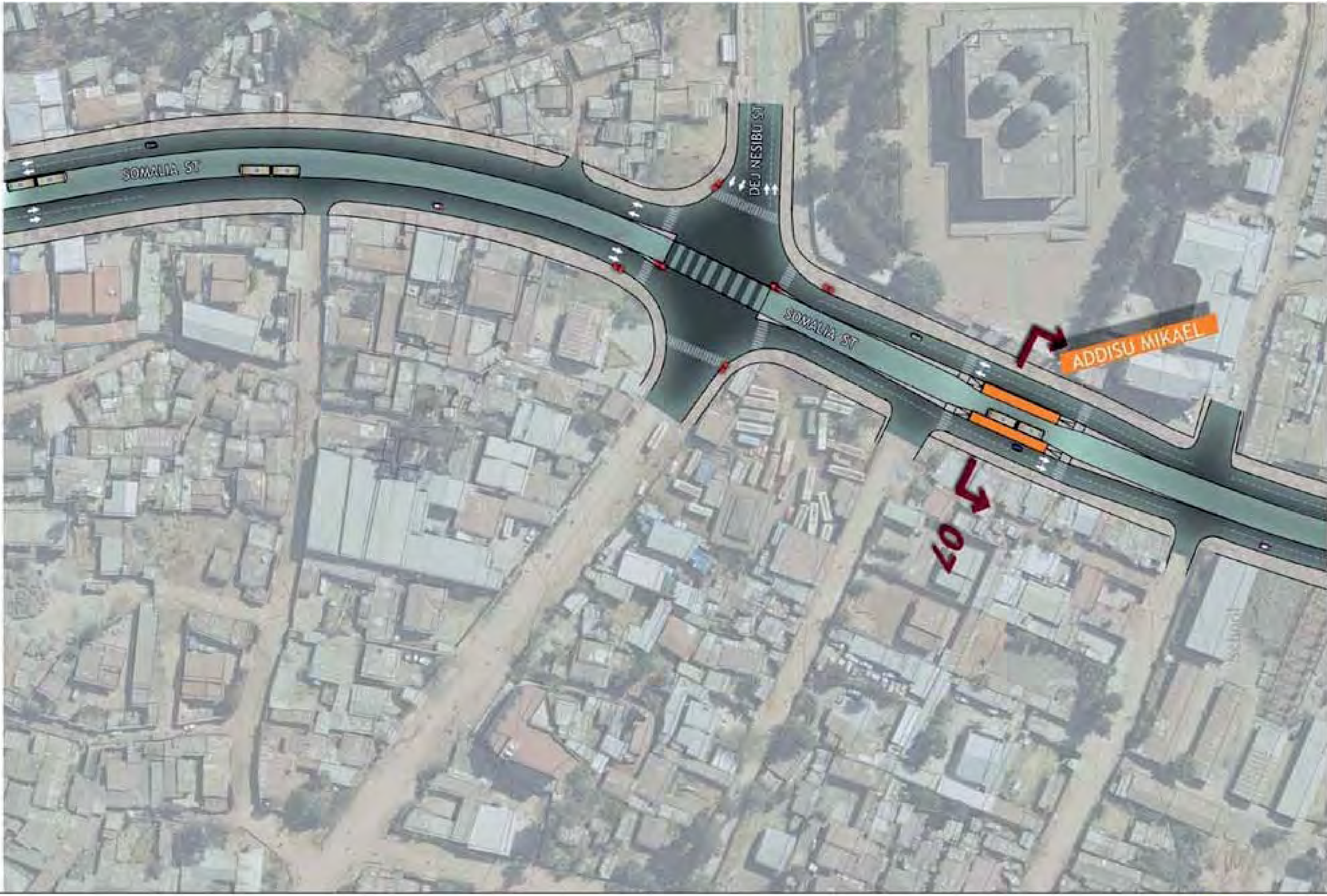
0 25 50 100m

ADDIS ABEBA

egis rail

0 25 50 100m

egis rail



0 25 50 100m

egis rail

SSCSJC_ADDIS ABEBA

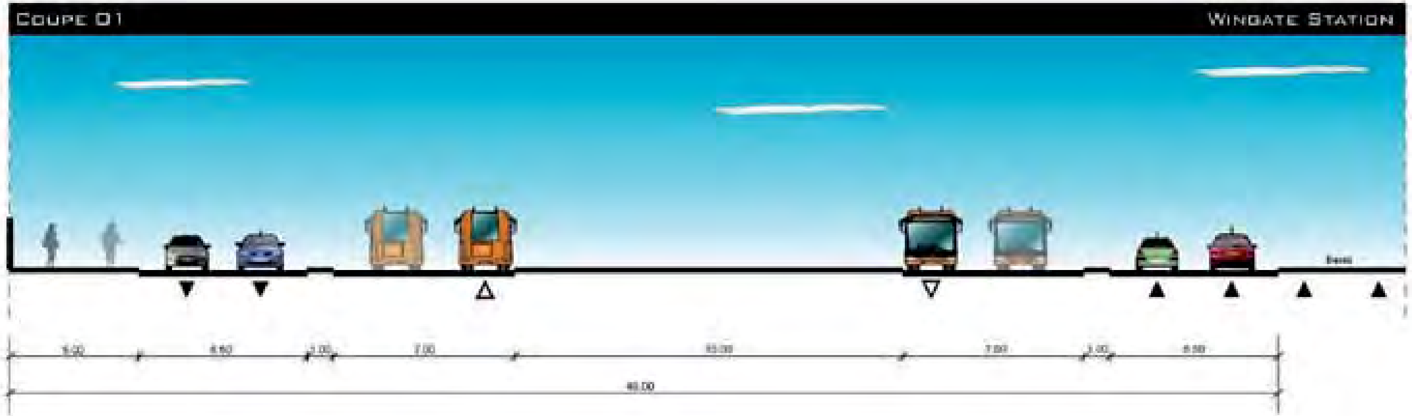
0 25 50 100m

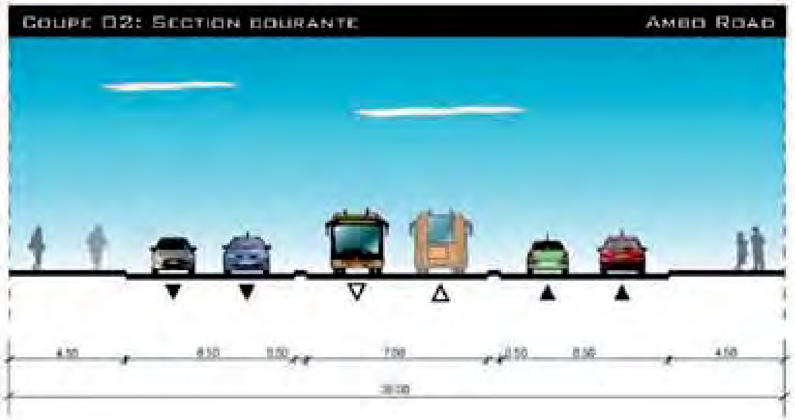
egis rail

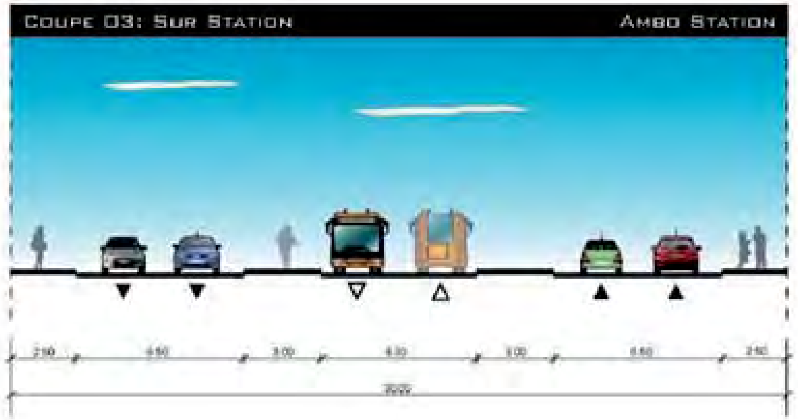
BBSBJC_ADDIS ABEBA

egis rail

BBDEJC_ADDIS ABEBA

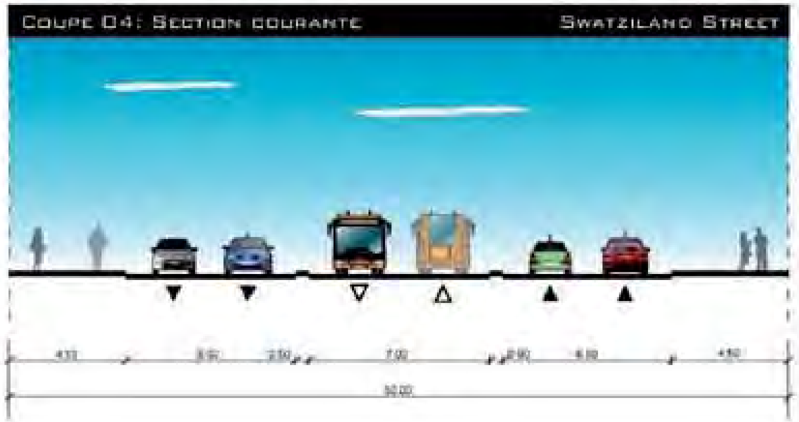


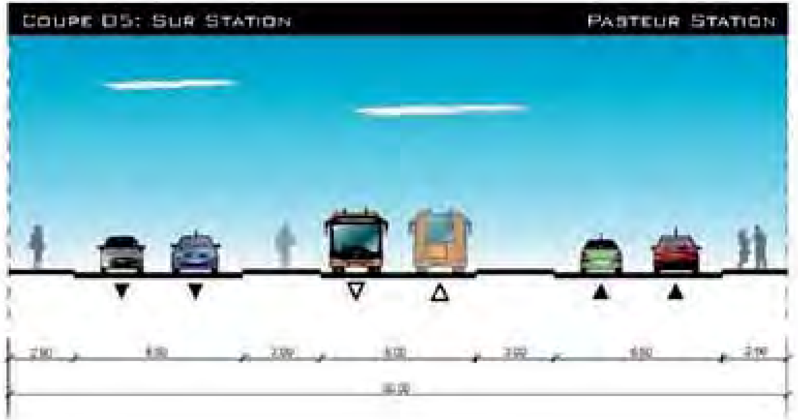


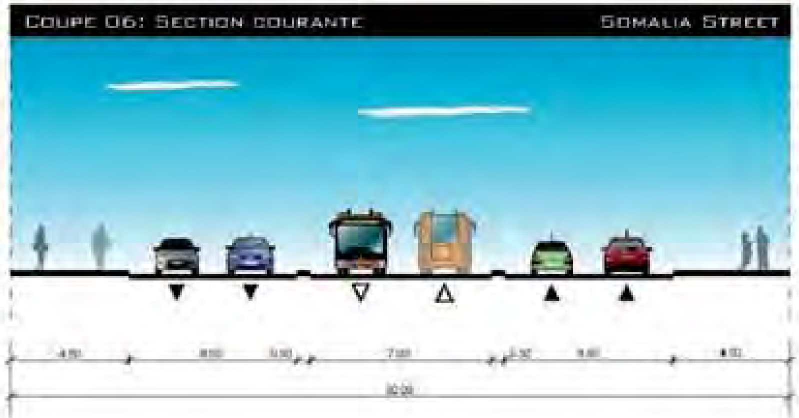


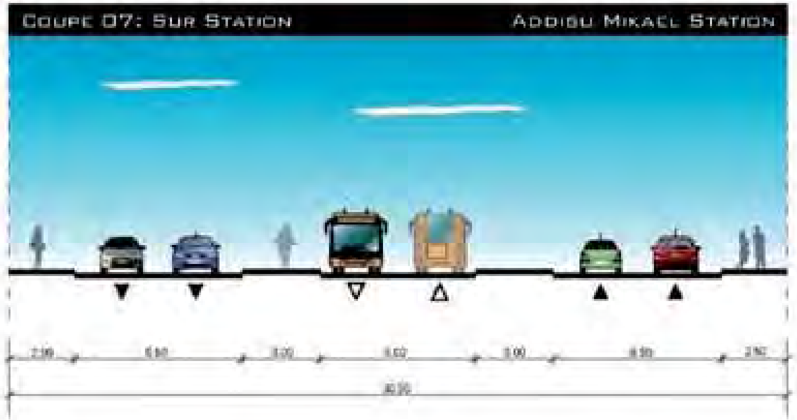
egis rail

_ADDIS ABEBA


Coupe 04: Section courante
Swatziland Street


Coupe 05: Sur Station
Pasteur Station


Coupe 06: Section courante
Somalia Street


Coupe 07: Sur Station
Addisu Mikael Station

0 25 50 100m