

Development of a Framework for Real-Time Transport Information Systems for Public Transport in the Greater Dhaka Area.

Technical Framework Report



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Technical Framework Report



Prepared by:

Korea National University of Transportation
Daehak-ro 50, Chungju-si,
Chungcheongbuk-do
Republic of Korea

Prepared for:

Department of Environment, Ministry of
Environment, Forest and Climate
Change
Population and Health Building, E/16,
Paribesh Bhavan, Sayed Mahbub
Morshed Rd, Dhaka 1207

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Executive Summary

Project Objective and Scope

This Project is a Technical Assistance (TA) project facilitated and funded by the UN Climate Technology Centre & Network (CTC-N) and is entitled: **Development of Framework for Real-Time Transport Information Systems for Public Transport in Greater Dhaka area.**

The objective of this technical assistance is, in consultation with the Dhaka and Bangladeshi colleagues, develop all the necessary technical and functional system details and other design considerations including potential locations to implement a real-time monitoring system for the Dhaka public transport buses (Bus Management System, BMS) including potentially digital signs at stops displaying arriving times and other information (Bus Information System, BIS).

1. **Establishing a baseline by collecting the information and data required:** Review previous plans for the urban public transport network and ITS in Dhaka. Collect data and analyze, summarize it, and present in an understandable fashion.
2. **Design of the Bus Management System (BMS)/Bus Information System (BIS) Architecture: Develop technical specifications for the following items.**
 - Bus Information Systems (BIS)
 - Bus Management Systems (BMS)
 - Communications and ICT architecture
 - Data and information review (BIS)
 - UX design, look and feel concepts.
 - Geographic review
 - Governance review
3. **Costing: Develop costs for the following items, under different scenarios:**
 - Equipment
 - Installation/construction
 - Software development/database maintenance
 - Operation, management, software maintenance

This report is divided into the following Chapters:

1. Introduction
2. Background & Geography
 - i. Future Networks
 - ii. Special Corridors
 - iii. Existing BMS systems
3. Hardware
 - i. On-Board Equipment
 - ii. Bus Stop Equipment
 - iii. Communications Networks
 - iv. Management Center
4. Software
5. Information Provision & UX
6. Estimated Costs
7. Benefits

8. Recommendations & Conclusions

1 Introduction

1.1 This Project is a Technical Assistance (TA) project facilitated and funded by the UN Climate Technology Centre & Network (CTC-N) and is entitled: Development of Framework for Real-Time Transport Information Systems for public transport in Greater Dhaka area.

1.2 **Please refer to the companion report: *Existing Conditions Report for this TA.***

Overview

1.3 This project is being undertaken in the capital city of the People’s Republic of Bangladesh (referred to as Bangladesh), Dhaka. Dhaka is a growing megacity with a metropolitan area with a population of over 21 million as of 2022 (9 million in the urban areas) in an area of 1,528 km².

1.4 Dhaka has experienced rapid urbanization since its independence from the rest of Pakistan in 1971. In part because of urbanization and demand for transport, Greenhouse Gas (GHG) emissions in Bangladesh from the transport sector have been increasing, according to the updated its Nationally Determined Contributions (NDCs) from August 2021. From the NDCs, the Government of Bangladesh has committed to reducing GHG emissions in the power, industry, and transport sectors by 5% by 2030, or by 15% if sufficient and appropriate support is received from developed countries. Transport-related plans include improving fuel efficiency (by +5%), tackling chronic road traffic congestion issues, and improving the public transport system. As such and in line with its national and local goals for transportation, Bangladesh has requested this Technical Assistance (TA) from the UN Climate Change Technology & Network (CTCN).

Issues in the Public Transport Network

1.5 According to a variety of records and reports (discussed later in this report), there are somewhere between 4,000 – 10,000 buses (including minibuses) that operate on Dhaka’s streets every day, in addition to millions of motorcycles, hundreds of thousands of cars and trucks, tens of thousands of autorickshaws (CNGs), and perhaps half a million rickshaws. The government realizes its need to incentivize the use of public transport system and control the permitted use of automobiles to materialize its mitigation goals and cater to the mobility needs of citizens. In particular, the service quality for public buses should be significantly improved by adopting information and digital technology in its operation and management. Encouraging use of the public transport system, over the use of a private transport, will require making the system more accessible, easier to use, and more convenient for users.

1.6 Against this backdrop, the government of Bangladesh has requested the CTCN to develop all the necessary technical and functional system details and other design considerations including potential locations to implement a real-time monitoring system for the Dhaka public transport buses (Bus Management System, BMS) including potentially digital signs at stops displaying arriving times and other information (Bus Information System, BIS).

Objective

- 1.7 The objective of this technical assistance is, in consultation with the Dhaka and Bangladeshi colleagues, develop all the necessary technical and functional system details and other design considerations including potential locations to implement a real-time monitoring system for the Dhaka public transport buses (Bus Management System or BMS) including potentially digital signs at stops displaying arriving times and other information (Bus Information System or BIS).

Outcomes

- 1.8 Upon completion, this technical assistance will allow Bangladesh to use the report and its details to develop documents for the acquisition. In addition, this TA, if implemented, the real-time monitoring system for buses will allow Bangladesh to increase the utility of its bus system, potentially increase its patronage, and potentially reduce its reliance on private fossil-fuel based transportation.?

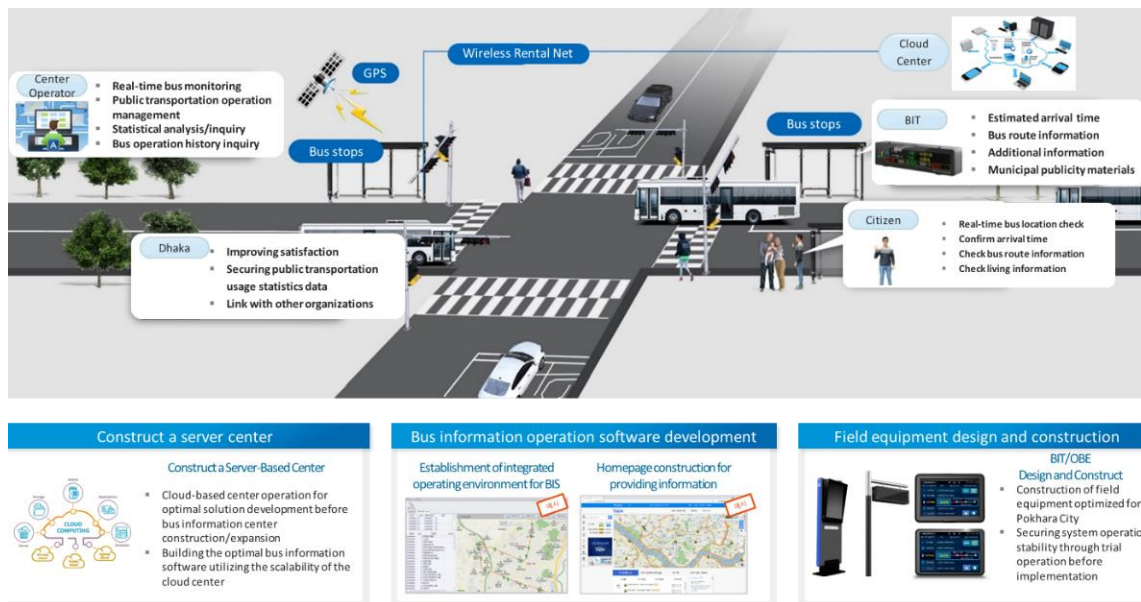
What is a Bus Information and Management System (BIMS)?

- 1.9 BIMS is a high-tech transportation system that collects and processes various information related to bus operation in real time and provides it to bus users, vehicle operators, and management companies or organizations.
- 1.10 BIMS can provide bus users with information such as estimated bus arrival time and bus location information using various media (Internet, SmartPhone, digital signs, etc.) while also providing vehicle operation management service by providing route information and operation information for bus drivers.

BIMS Ecosystem

- 1.11 BIMS is made up of two distinct but related technology systems, the Bus Management Systems (BMS) and Bus Information Systems (BIS). BMS are systems and technologies that are generally used by the bus operator. They include tracking devices, management systems, and software. BMS can be used by bus operators or government agencies to significantly improve efficiency in operation and manage headways, drivers, monitor for accidents and incidents and have many other benefits. BIS refers to the systems, technologies, and devices which communicate the location of buses to customers.
- 1.12 Examples of BIS include digital roadside signage which may state the expected arrival time of various buses which use the stop as well as systems, software and technologies that communicate with customers virtually include through mobile phone applications or websites. Together, BIS and BMS make up the real-time tracking system for public transport buses. BIMS can improve:
- public transport service, convenience, and information dissemination;
 - improve operation efficiency and therefore service quality; and
 - establish a basis for system expansions and new projects etc.

Figure 1: BIMS Ecosystem



Alternative Terminology

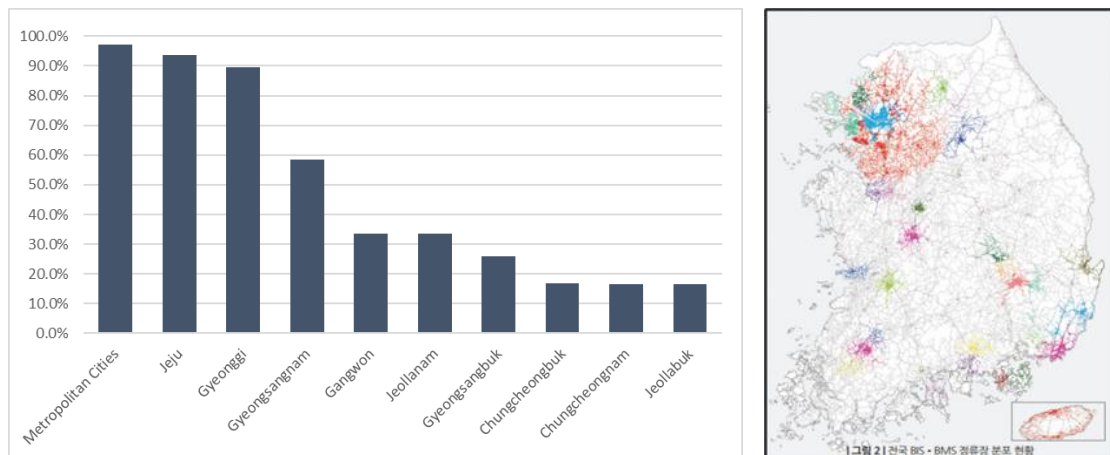
1.13 In other countries, BMS is usually referred to as Automatic Vehicle Location (AVL), Operations Control, and Computer-Aided Dispatch (CAD) systems while BIS is generally referred as Real-Time Passenger Information (RTPI) or passenger information. In this report the terms Bus Management System (BMS) refers to CAD and AVL while Bus Information Systems (BIS) refer to RTPI or similar passenger information systems, together these systems are referred to as the Bus Information and Management System (BIMS).

Korean Gold Standard

1.14 The basis for the technical specifications for BIMS systems in this report will be based on the Korean standards. Korean BIMS is an excellent technology recognized worldwide. Domestic surveys have shown that 96% of users are satisfied with Korean BIS, and its excellence has been recognized as a universal technology that has spread nationwide with a penetration rate of almost all agencies and with signage installed at 64.8% of bus stops nationwide (as of 2016). The technology has been exported to may other countries including Ulaanbaatar, Mongolia; Bogota, Colombia; Baku, Azerbaijan; Vietnam, and others.

1.15 Unlike systems in other countries, for example the United States, agencies use a large variety of AVL/CAD systems from several different manufacturers, each being distinct and non-interoperable. In Korea, 65 (39.9%) of a total of 163 local governments (39.9%) of a total of 163 cities and counties, centering on general buses (city buses, rural buses, village buses, airport buses, etc.), have established and managed BIMS system based on the same interoperable standard. The ratio of the number of routes operated by BIS/BMS to the total number of routes by local government is shown in Figure 2.

Figure 2: BIMS Systems in Korea



Data source: Government of Korea

Benefits of BIMS

1.16 BIMS provide many benefits to customers, operators, bus owners, city planners, local governments, and all others in the public transport provision space.

BIMS is considered an essential service for any modern public transport agency.

Main benefits

1. Improve information dissemination to the bus users – let them know where their bus is and when it will arrive at their stop.
2. Increase efficiency and punctuality.
3. Enable transparent and simple bus management of operators by a central authority.
4. Provide a way to gather crucial data for transport planning and improvements to the networks.

2 Background & Geography

Geography Review

Existing Bus Systems

- 2.1 **Note: A more fulsome summary of the existing public transport system in Dhaka are available in the Existing conditions Report.**
- 2.2 According to the Dhaka Transportation Coordination Authority (DTCA), Dhaka is currently served by 388 “routes”, many of which overlap with other “routes” of other operators. In part due to the profit-maximizing private sector component of the system, buses generally will only run on routes which the owners believe are profitable.
- 2.3 One of the only accessible ways of understanding the Dhaka public transport network is the General Transit Feed Specification (GTFS) database, which is utilized by a Google Maps to provide transit directions. Dhaka has had transit directions available in Google Maps since 2021. The GTFS database for Dhaka was developed by and maintained by a private company based in India. This database provides only a rough guide of the bus services that are available in Dhaka as in reality, services are not scheduled, and travel times are highly variable making any kind of scheduling virtually impossible anyways. The data in this section comes from the GTFS database and should therefore understood to be a rough guide of the service only, albeit the most accurate and up to date database available.

Dhaka Bus Stops

- 2.4 Note that in the Dhaka case, “bus stops” are generally not used. That is, passengers can and frequently do get on the bus essentially anywhere along its route. This practice is widespread in Dhaka as well as in other developing countries. The lack of bus stops in public transport networks is highly disruptive to traffic and while it may seem convenient for passengers, it is detrimental overall as it greatly increases the time it takes to drive the route. What’s more it encourages unsafe driving and behaviour as bus drivers swerve and drive slowly, looking for more passengers. That is not to say that bus stops are not in use, as there are many established areas where buses generally stop, as well as some official ones including at bus terminals.
- 2.5 According to this data, there are 1,306 bus tops in Dhaka. However, bus stops do not really exist as customers can and do flag down buses anywhere along its route.

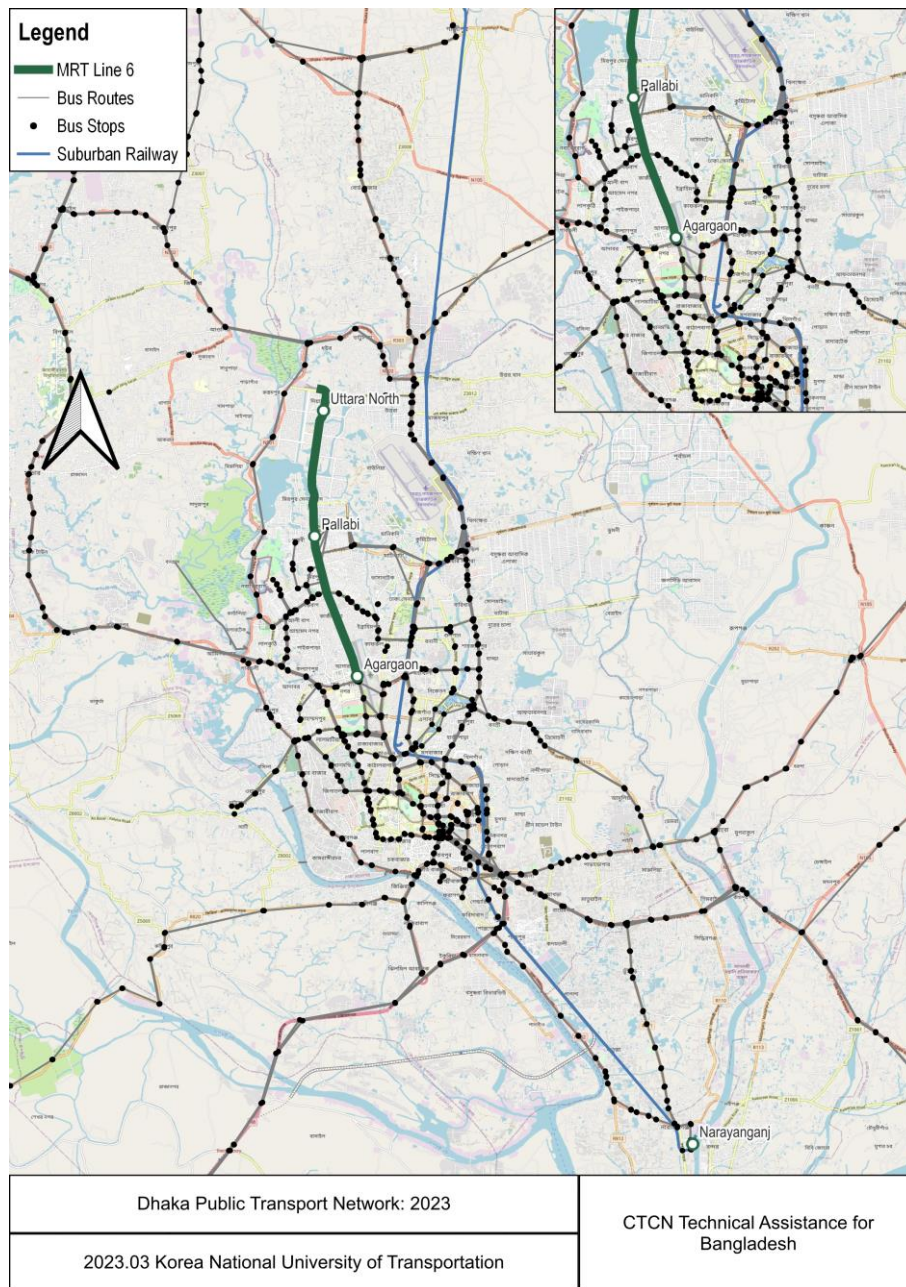
Figure 3: "Bus Stops" in Dhaka



Image sources: © 2023, Korea National University of Transportation or Creative Commons Licenses

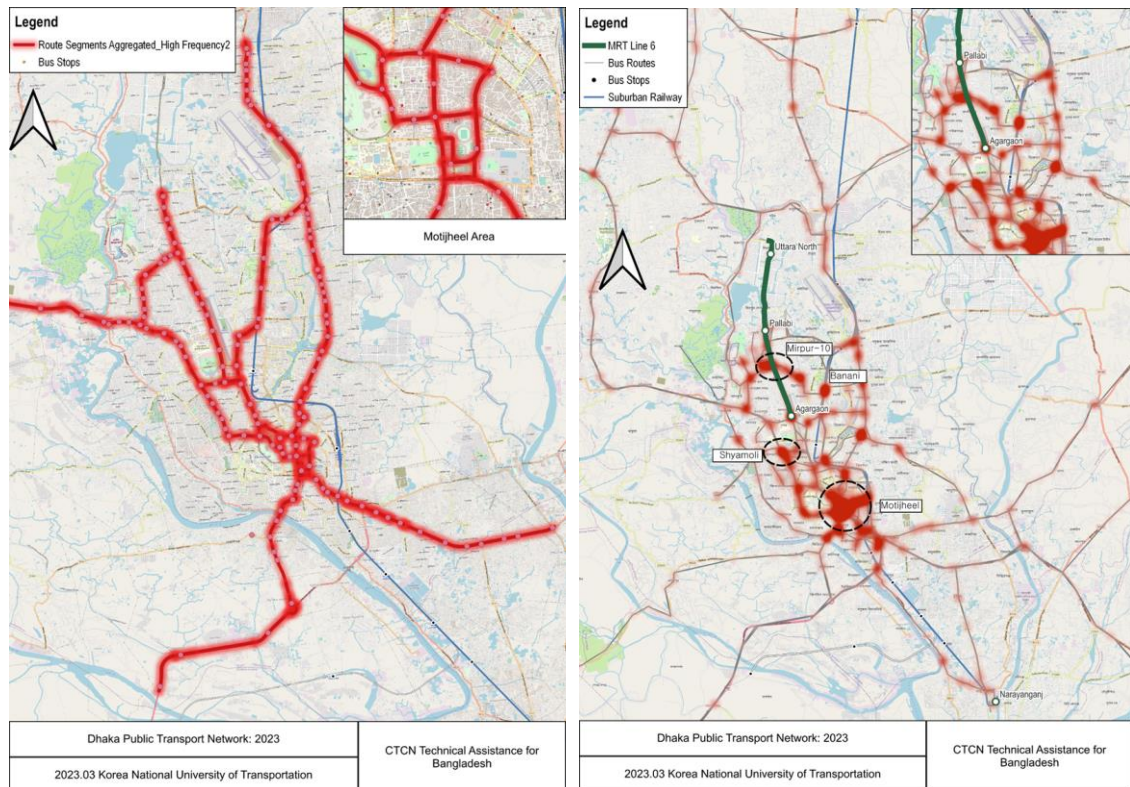
2.6 The map on the following page depicts the current bus and rail public transport network, including the bus routes and stops, as of March 2023. Bus routes connect most major areas of the Dhaka metropolitan area, also extending into neighbouring jurisdictions. On some corridors there exists quite high route frequency, with frequencies as high as 3,000 buses per day. According to the GTFS database, the majority of frequencies on specific corridors are lower than 1,200 per day (average of one bus every 1.5 minutes, higher during peak times).

Figure 4: Dhaka Public Transport Network (2023) – Routes and Coverage



Data source: General Transit Feed Specification (GTFS), licensed from private entity

Busiest Corridors



Fares

- 2.7 Fares in Dhaka are regulated and enforced by the Bangladesh Road Transport Authority (BRTA).

Bus Route Rationalization and Future

- 2.8 The bus system in Dhaka is set to change significantly in the coming years due to the rapid expansion of the MRT, BRT and the Bus Route Rationalization, which are all ongoing.

Overview

- 2.9 The regulation of bus services is rather complex in Dhaka. A Route Permit is required to operate buses on certain route and must be approved by a 21-member committee, called the Regional Transport Committee (RTC). Members of the RTC board include the commissioner of the Dhaka Metropolitan Police (DMP) and others. RTC has final say over whether the applicant is permitted to operate the route, or not, and must also meet certain minimum requirement for fleet and other items. In this manner routes were “planned” in a piecemeal/ad hoc fashion based on whichever operating company was interested in a new route.
- 2.10 However, other agencies which have some influence on the bus transport in Dhaka include the Dhaka Transportation Coordination Authority (DTCA) and the Bangladesh Road Transport Authority (BRTA). Recently, the DTCA has spearheaded the Bus Route Rationalization project, which aims to reform the Dhaka bus system. The purpose of the project, is to
- bring order to the public transport network; and
 - reduce congestion.

2.11 This will be accomplished by

- improving the management of the operating companies;
- updating the planned networks; and
- preparing an implementation plan for route rationalization and operation.

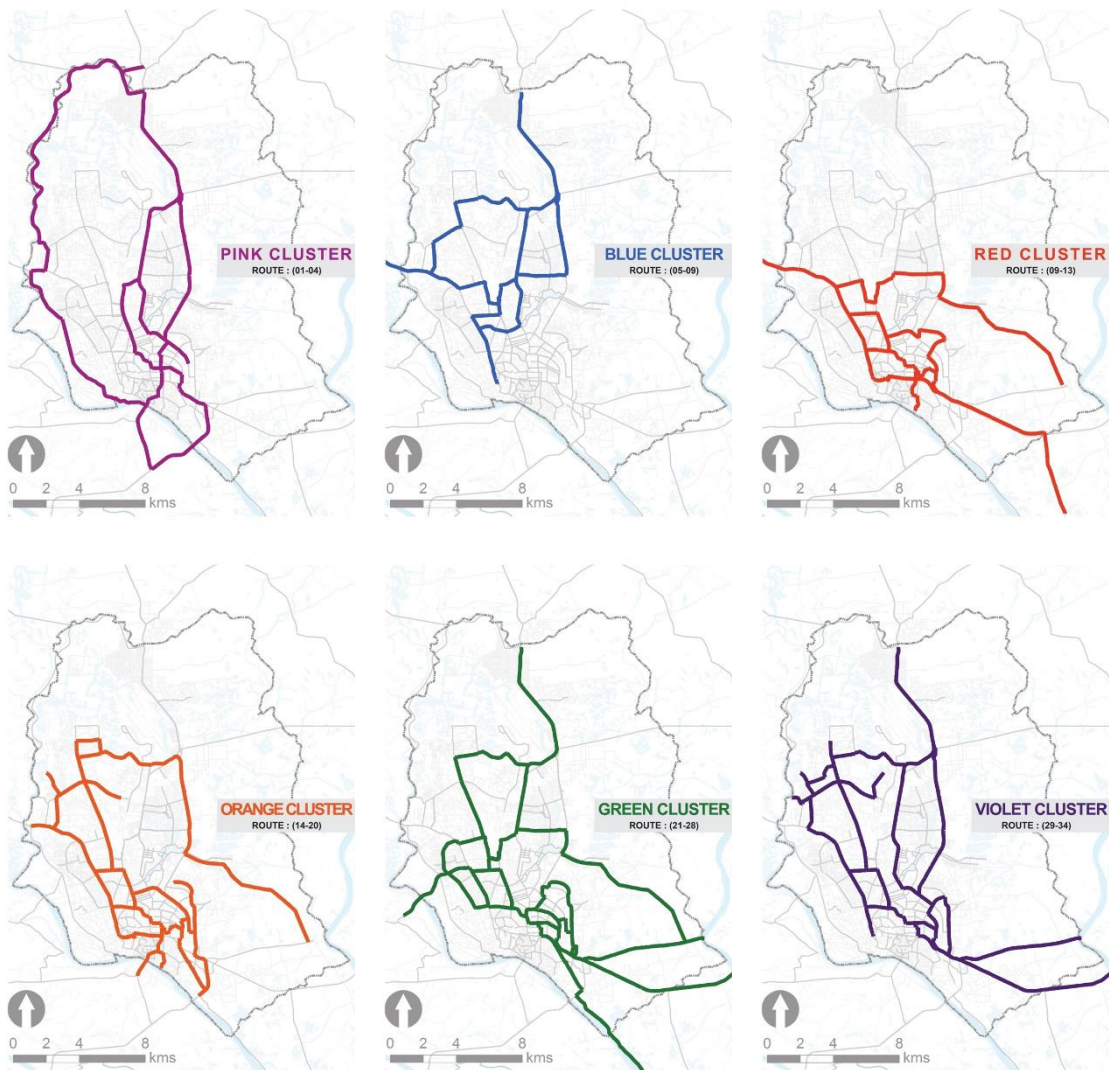
2.12 As such, a committee was formed to spearhead the project, which was started in 2018. This committee is made up of a variety of stakeholders including members from the City Corporations, BRTA, BRTC, Police, and crucially of the Bangladesh Road Transport Owners Association, and Workers Federation. So far, several new policy measures have been decided, including:

1. A move to centrally planned route arrangement, rather than ad hoc arrangements
2. Reduction of overlapping routes from 174 → 21 (now 42);
3. Reduction of bus companies to just 6 (now 22), based on partial ownership (shares) and based on market value of the buses;
4. Purchase of all minibuses by government
5. Vehicles older than 5 years old to be purchased by; the government;
6. Government to order buses on behalf of companies;
7. Provide government-backed loans at low interest rates for refabrication and purchase of new buses;
8. Repairs and purchase of new vehicles to be under management of government and the owners association
9. Try to implement an electronic fare collection system;
10. Take measures to construct bus stops with modern facilities
11. Construction of new bus depots, bus terminals, training centres, and other matters, under the supervision of the City Corporation;
12. Development of 4 new inter-district bus terminals;
13. Bus depots at Abdullahpur, Mirpur, Basila, Fulbaria, and Kachampur to be urgently constructed.
- 14. An agency or organization, to be established that will be responsible for the management and accountability of bus services in Dhaka – there should be participation of the Dhaka Road Transports Owners Association.**

Routes and Clusters

2.13 One of the main purposes of the rationalization project was to plan the future routes. DTCA has created groups of routes termed “clusters” which generally operate in a specific geographic area, and may operate out certain bus depots and terminals, or groups of bus depots. Six clusters (Pink, Blue, Red/Maroon, Orange, Green, and Violet), covering 42 (previously 34) routes, have been proposed, see below. **As the projects are still ongoing, these routes are not finalized.**

Figure 5 Six Proposed “Clusters” in Dhaka



These routes are subject to change, presented here for context only.

- 2.14 There are currently an estimated 1,306 “bus stops” in the Greater Dhaka Area (based on analysis of the GTFS dataset, which makes assumptions/guesses about bus pickup/drop-off locations). For most cross-regional trips, MRT or BRT will be used, and local bus services will be reduced. Based on our analysis of the GIS, we found there will be around 763 bus stops in the urban core of Dhaka in the future.

Bus Depots and Terminals

- 2.15 In 2021, DTCA had completed the Bus Depot Feasibility project. The main objective of the project was to find suitable locations for inter-district and city bus terminals in Dhaka and its surrounding areas. From this work, an initial 10 sites were considered:

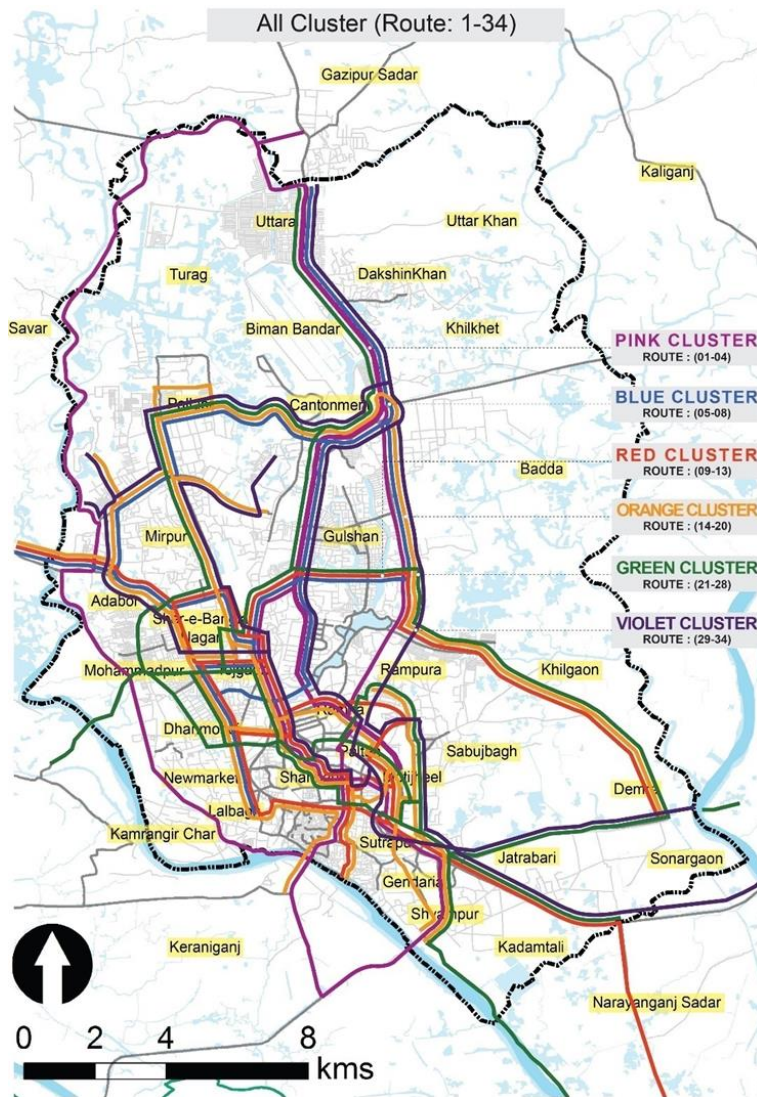
Table 1: Proposed Bus Terminals in Dhaka

| Terminal | Type | Major Connection | Phase |
|-----------|--------------------|------------------|----------|
| Gabtoli | Change to city bus | MRT-5 | Existing |
| Sayedabad | Change to city bus | | Existing |

| Terminal | Type | Major Connection | Phase |
|-------------------|-------------------------|---|-----------------|
| Baghair | New Interdistrict | - | Phase 1 (2025) |
| Kanchpur South | New Interdistrict | MRT-2 | Phase 1 (2025) |
| Gram Bhatulia | New Interdistrict | Circular Railway, Circular Waterway, MRT-6, MRT-4 | Phase 1 (2025) |
| Bhulta | New Interdistrict | MRT-1 | Phase 2 (2030+) |
| Hemayetpur | New Interdistrict | MRT-5 (North) | Phase 1 (2025) |
| Atibazar / Bhawal | City bus (depot) | | Phase 1 (2025) |
| Kanchan | City bus (depot) | MRT-1 | Phase 2 (2030+) |
| Gazipur | Future depot | BRT (3) | - |
| Baipali | Future depot | - | - |

- 2.16 In this report, it is described that in the future, bus terminals should have passenger information displays (including apps and web services) that “keeps track of arrival and departure time and also informs about the bays used by each bus route”, indicating that a Bus Information System (BIS) should eventually be implemented. Figure 6 below shows the locations of the rationalized routes as well as the bus terminal locations.

Figure 6: Map of Proposed Rationalized Routes & Major Bus Terminals



These routes are subject to change, presented here for context only.

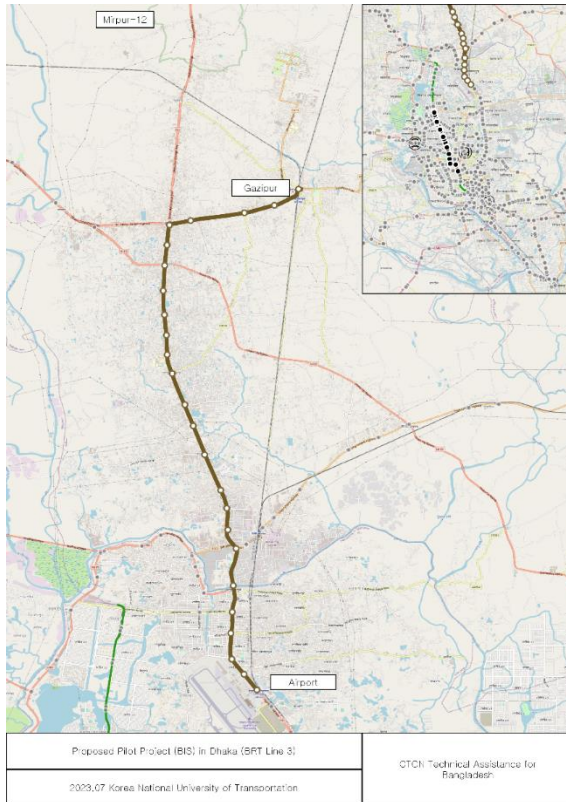
Special Corridors

2.17 Two corridors which are currently under construction will be especially advantageous for BIMS systems:

- BRT Line 3 corridor
- Begum Rokeya Avenue Corridor

BRT Line 3 Corridor

2.18 The BRT (Line 3) corridor makes an excellent project to test and implement a full-service BIS. Most modern BRT systems include BIS and BITs. Further, the BRT corridor should be equipped with good infrastructure and utilities which should make BIT installation simple. The BRT corridor is expected to be operation in 2024, or potentially later. BRT Line3 corridor is depicted below.



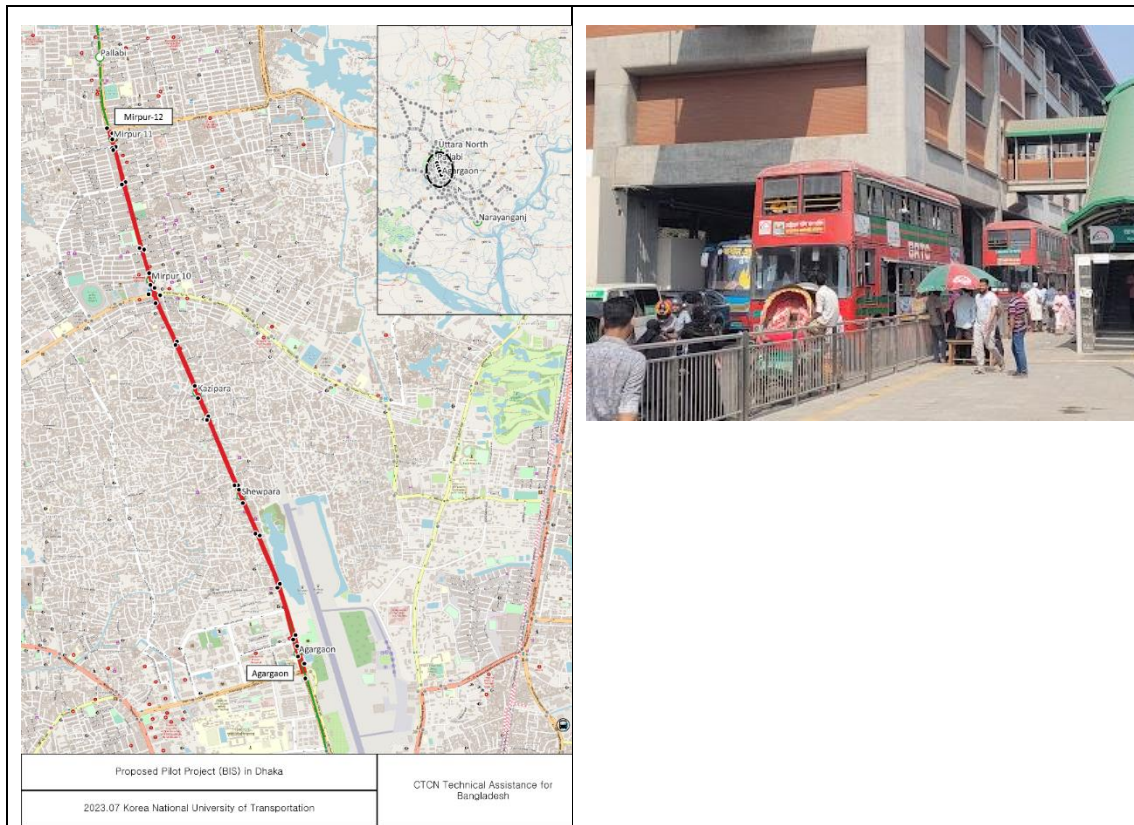
Begum Rokeya Avenue Corridor

- 2.19 This corridor is also the candidate for the Integrated Corridor Management (ICM) intervention project, which is being undertaken by the Dhaka North City Corporation¹. DNCC aims to move all wired utilities, including electrical, underground under this project by 2026 with \$150 million USD funding from the World Bank, which is a realistic time frame for a pilot project in Dhaka. Having underground utilities makes the installation of BITs significantly easier and cheaper. The corridor is shown below.

¹

http://www.dncc.gov.bd/sites/default/files/files/dncc.portal.gov.bd/tenders/bf7ab5e0_9773_49af_9948_bf0cd3de58b5/2022-07-27-10-31-d95c344b8c4e90028eedcb83858d4bd7.pdf

Figure 7: Begum Rokeya Corridor (Agargaon Station)



Summary

2.20 The following key points will be kept in mind for these technical framework:

- In the future there will be around 42 routes operating on six different clusters.
- There will be approximately 7000 vehicles
- There will be around 74 bus stops in the urban core of Dhaka in the future (directional)
- There will also be 25 stops associated with the BRT Line 3

Existing BMS Systems in Dhaka

2.21 There are no universally established automated vehicle locations (AVL), bus management systems (BMS), or other real-time passenger information (RTPI) systems that work across multiple operators in Dhaka. However, BRTC commissioned a Bangladeshi company called Impressive Securities, to develop an AVL for their fleet, which is referred to in Bangladesh as Vehicle Tracking System (VTS). The VTS is called the Safety GPS Tracker Service or just VTS.

2.22 The BRTC VTS tracks the location vehicle in real-time using GPS technology. For BRTC, it is a valuable tool for ensuring the safety and security of This service is provided by the BRTC in Bangladesh. BRTC has 239 buses in total and there is provision of this feature in every bus. For the operation of these buses there are 29 local routes and 197 intercity routes.

Figure 8: Realtime GPS Tracking

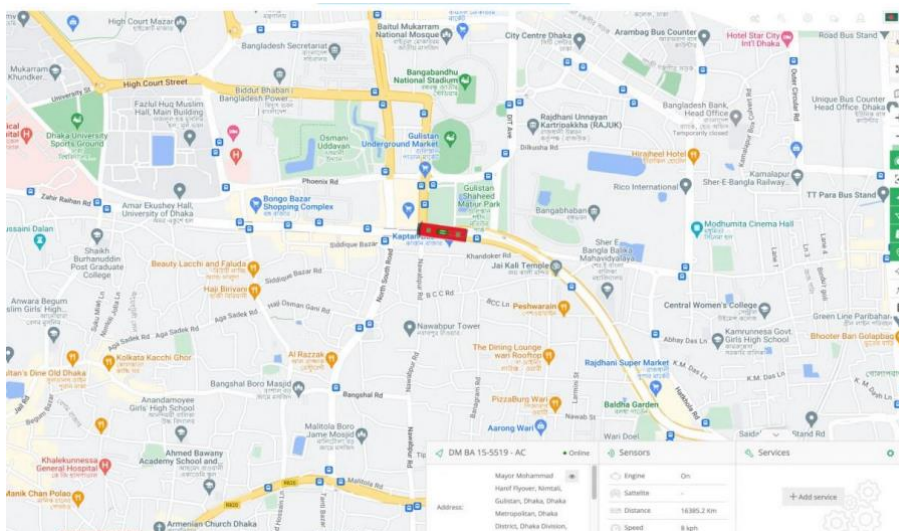


Source: Safety GPS Tracker Service

2.23 The main features of this service are:

2.24 **Realtime GNSS/GPS tracking:** With this feature, user can do tracking of their vehicle. Current speed of speed, engine status, address can be known from this service. User can monitor multiple vehicles from one account.

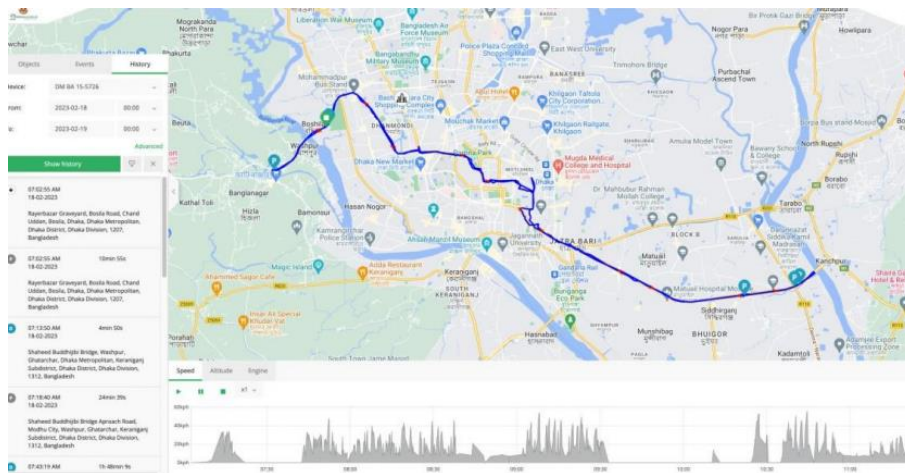
Figure 9: VTS Live Tracking



Source: Safety GPS Tracker Service

2.25 **History Map Replay:** previous route history on animated map of the vehicle can be observed. Use can select the specified time and view also. History can be backed up up-to 3 years.

Figure 10: VTS Daily Routes Logs Summary



Source: Safety GPS Tracker Service

- 2.26 **Data analysis:** all vehicle data, can be analyzed from the software and speed reports, drivers driving patterns can also be analyzed.
- 2.27 **Engine on/off:** engine on/off can be operated by using app or web application and engine on/off features can be provided.
- 2.28 **Violation alert:** This feature is related to the vehicle and passenger safety. If the driver crosses the limit of speed performs the harsh braking, harsh acceleration this event can be recorded with device, and time.
- 2.29 Other alerts like car maintenance BRTA paper renewal alert, Battery disconnection alert fuel filling alerts after certain duration are also provided.

| Device | Driver | Time | Event |
|---------------|--------|------------------------|--------------------|
| DM BA 11-6161 | | 18-02-2023 11:10:57 AM | Battery Disconnect |
| DM BA 11-6161 | | 18-02-2023 11:35:36 AM | Battery Disconnect |
| DM BA 11-6161 | | 18-02-2023 12:25:17 PM | Harsh Braking |
| DM BA 11-6161 | | 18-02-2023 12:26:20 PM | Harsh Braking |
| DM BA 11-6161 | | 18-02-2023 12:27:50 PM | Harsh Braking |
| | | | Battery Disconnect |
| | | | Harsh Braking |

Harsh Braking


| Device | Driver | Time | Event |
|---------------|--------|------------------------|--------------------|
| DM BA 11-6161 | | 11-02-2023 04:42:18 PM | Battery Disconnect |
| DM BA 11-6161 | | 12-02-2023 11:02:46 AM | Battery Disconnect |
| DM BA 11-6161 | | 12-02-2023 04:07:19 PM | Battery Disconnect |
| DM BA 11-6161 | | 12-02-2023 07:32:09 PM | Battery Disconnect |
| DM BA 11-6161 | | 12-02-2023 07:45:57 PM | Battery Disconnect |
| DM BA 11-6161 | | 12-02-2023 08:24:18 PM | Battery Disconnect |
| DM BA 11-6161 | | 12-02-2023 08:34:42 PM | Battery Disconnect |
| DM BA 11-6161 | | 12-02-2023 11:20:38 PM | Battery Disconnect |
| DM BA 11-6161 | | 12-02-2023 12:24:00 AM | Battery Disconnect |
| DM BA 11-6161 | | 12-02-2023 04:30:50 AM | Battery Disconnect |
| DM BA 11-6161 | | 12-02-2023 07:00:06 AM | Battery Disconnect |
| DM BA 11-6161 | | 12-02-2023 04:32:07 PM | Battery Disconnect |
| DM BA 11-6161 | | 12-02-2023 08:34:40 PM | Battery Disconnect |
| DM BA 11-6161 | | 12-02-2023 08:34:40 PM | Battery Disconnect |
| DM BA 11-6161 | | 12-02-2023 08:35:17 PM | Battery Disconnect |
| DM BA 11-6161 | | 12-02-2023 08:35:59 PM | Battery Disconnect |
| DM BA 11-6161 | | 12-02-2023 08:35:56 AM | Battery Disconnect |
| DM BA 11-6161 | | 12-02-2023 08:35:56 AM | Battery Disconnect |
| DM BA 11-6161 | | 12-02-2023 08:34:28 AM | Battery Disconnect |
| DM BA 11-6161 | | 12-02-2023 08:34:27 AM | Battery Disconnect |
| DM BA 11-6161 | | 12-02-2023 08:34:27 PM | Battery Disconnect |
| DM BA 11-6161 | | 12-02-2023 08:34:28 PM | Battery Disconnect |
| DM BA 11-6161 | | 12-02-2023 08:34:28 PM | Battery Disconnect |
| DM BA 11-6161 | | 12-02-2023 11:10:57 PM | Battery Disconnect |
| DM BA 11-6161 | | 12-02-2023 11:30:38 AM | Battery Disconnect |
| DM BA 11-6161 | | 12-02-2023 12:25:17 PM | Harsh Braking |
| DM BA 11-6161 | | 12-02-2023 12:26:20 PM | Harsh Braking |
| DM BA 11-6161 | | 12-02-2023 12:27:50 PM | Harsh Braking |
| DM BA 11-6161 | | 12-02-2023 12:27:50 PM | Battery Disconnect |
| DM BA 11-6161 | | | Harsh Braking |

Battery Disconnect

tracking device detects that the vehicle has entered that area, it sends an automatic notification to the fleet manager or driver. The notification can be delivered via email, text message, or a mobile app, depending on the preferences of the user.

- **Trip Report:** This feature provides the trip reports to the drivers or fleet manager including the trip length, trip time, start time, route taken, stops made, and any incidents or events that occurred during the trip etc. after finishing the particular trip.

Daily/Monthly Report



Report type: General information (merged) custom

Device: DM BA 15-4999 - DD

| Date | Stop duration | Idle duration | Engine work | Engine hours | Travel time | Overspeed | Distance travelled |
|------------|---------------|---------------|---------------|---------------|---------------|-----------|--------------------|
| 01-02-2023 | 5h 24min 42s | 6h 27min 41s | 7h 10min 24s | 13h 38min 5s | 11h 10min 42s | 0 | 92.48 Km |
| 02-02-2023 | 12h 43min 57s | 6h 54min 33s | 8h 24min 7s | 15h 18min 41s | 11h 16min 3s | 0 | 110.99 Km |
| 03-02-2023 | 10h 26min 44s | 17h 26min 53s | 6h 27min 48s | 23h 54min 41s | 13h 28min 46s | 0 | 93.4 Km |
| 04-02-2023 | 22h 58min 34s | 23h 19min 29s | 40min 21s | 24h 0s | 57min 20s | 0 | 4.63 Km |
| 05-02-2023 | 24h 0s | 7h 42min 46s | 0s | 7h 42min 46s | 0s | 0 | 107.54 Km |
| 06-02-2023 | 21h 52min 4s | 16min 37s | 1h 55min 15s | 2h 13min 48s | 2h 7min 56s | 0 | 149.32 Km |
| 07-02-2023 | 17h 45min 50s | 5h 54min 47s | 6h 3s | 11h 54min 52s | 6h 14min 10s | 0 | 103.35 Km |
| 08-02-2023 | 19h 20min 46s | 10h 16min 41s | 3h 50min 12s | 14h 7min 3s | 4h 35min 25s | 0 | 49.37 Km |
| 09-02-2023 | 24h 0s | 0s | 0s | 0s | 0s | 0 | 0.71 Km |
| 10-02-2023 | 24h 0s | 0s | 0s | 0s | 0s | 0 | 0.66 Km |
| 11-02-2023 | 24h 0s | 0s | 0s | 0s | 0s | 0 | 0.06 Km |
| 12-02-2023 | 24h 0s | 17min 24s | 0s | 17min 24s | 0s | 0 | 107.67 Km |
| 13-02-2023 | 15h 48min 22s | 18h 47min 28s | 4h 41min 42s | 23h 29min 20s | 6h 29min 50s | 0 | 94.76 Km |
| 14-02-2023 | 13h 10min 1s | 14h 8min 44s | 8h 43min 40s | 22h 52min 24s | 10h 48min 27s | 0 | 112.72 Km |
| 15-02-2023 | 9h 22min 49s | 10h 36min 25s | 10h 31min 18s | 21h 7min 53s | 14h 34min 22s | 0 | 137.99 Km |
| 16-02-2023 | 16h 5min 35s | 17h 18min 14s | 3h 43min 42s | 21h 2min 6s | 4h 58min 25s | 0 | 54.34 Km |
| 17-02-2023 | 14h 5min 38s | 12h 58min 45s | 4h 2min 28s | 17h 1min 23s | 4h 11min 36s | 0 | 49.15 Km |

Source: Safety GPS Tracker Service

- **API Access:** API stands for Application Programming Interface, which allows third-party developers to integrate the GPS tracking service with other software applications or systems. This feature helps to developers by providing real time vehicle tracking data, location history, event notifications, and trip reports through web protocol location history, event notifications, and trip reports through web protocols such as HTTP or HTTPS and the developers can use the programming language to develop the applications or tools.
- **Email Report:** With this feature user can get vehicle report by email automatically.

Information Dissemination

2.30 With the AVL installed and thus GPS data available, BRTC can supply some Real-Time Passenger Information (RTPI) for passengers, for an initial **6 routes**. These routes are all inter-city routes which are operated by BRTC. Customers can see the location of vehicles and their estimated arrival times along their route by utilization the BRTC Amader application (available for Android²). Although currently, six Dhaka intercity routes are available, BRTC plans to expand the service to all their routes, in the future. From the description

² In Bangladesh, iOS has a 95% mobile phone marketshare.

- Commuters can view all incoming or outgoing buses for a particular stop or his/her current location with this application. Users can also view all the buses operating on a particular route in real-time on map along with expected time of arrival (ETA).

2.31 The application has been downloaded between 5000 – 10000 times as of April 2023.

Table 2: BRTC Amader Application

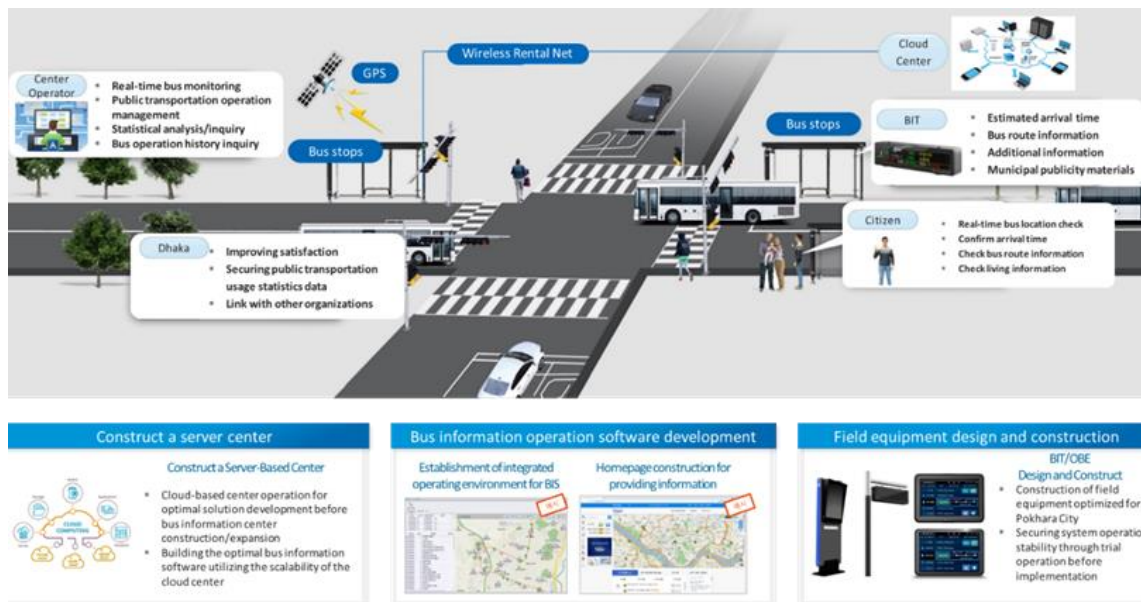


Source: Safety GPS Tracker Service

Overview of BIMS

2.32 Bus Information and Management System (BIMS) consists of Bus Information System (BIS) which loads On Board Equipment (OBE) and provides relevant information to bus users such as route/dispatch schedule, Estimated Time on Arrival, etc. through real time bus location tracking and wireless communication between bus and BMS center and BMS which manages the buses operation such as bus operation status/driver management etc. See Figure 11 below.

Figure 11: Overall BIMS Ecosystem



Definitions and Key Features

- **BIS (Bus Information System)** is a system designed to raise user efficiency by providing bus arrival time, routes, etc. via the Internet, mobile phone, and bus information terminal.
- **BMS (Bus Management System)** is designed to promote systematic operation and improve poor service quality caused by delays, by managing and sharing allocation time, operating routes, and illegal bus operation with bus service operators.

2.33 Technically, BMS systems and associated BIS do not both need to exist. BIS consist of optional equipment that is nonetheless commonly used. Construction order must be BIS after BMS. The key features of BIMS are detailed as follows.

Figure 12: Key Features of BIMS

| Category | BIS (Bus Information System) | BMS (Bus Management System) |
|-----------------------------|--|---|
| Purpose | <ul style="list-style-type: none"> • Providing information service | <ul style="list-style-type: none"> • Monitoring and controlling bus operation |
| Methods | <ul style="list-style-type: none"> • BIT and Displays at bus station • Internet, Mobile service | <ul style="list-style-type: none"> • Console of bus company, situation monitoring room, in-vehicle devices |
| Target object | <ul style="list-style-type: none"> • Bus users | <ul style="list-style-type: none"> • Bus drivers • Bus Companies • Local governments |
| Provided Information | <ul style="list-style-type: none"> • Previous station departure/arrival info (Event data) | <ul style="list-style-type: none"> • Operation status data (data transmitted regular interval) |
| In common | <ul style="list-style-type: none"> • GPS, Wireless communication, OBU • Center system (Computer equipment, network, additional facilities, etc.) • Operating unit (S'W application) | |

Image source: KDI

Table 3: BIMS Features Overview

| Item | | Features |
|------------------------|--------------------------------|--|
| Information collection | Location tracking | Wide location information collection, GPS |
| | Wireless communication | Wireless data network such as CDMA, WCDMA, GSM etc. |
| | Terminal | Integrated terminal (BMS terminal + transport card+ embedded terminal for passengers) or BMS terminal (BIS + transport card system) |
| Information provision | Users | Route/current location/ETA Bus stop/route guidance/arrival time |
| | Administrative | Route/current location /operation status history/statistics/demand |
| | Business | Operation interval/dispatch interval/current location Bus basic information/history/statistics |
| Operation management | Basic information management | City bus route, bus stops, integrated basic information management by DB and electric map |
| | Performance management | Comprehensive management of Repeat number as per route, company, numbers of operating vehicles, dispatch interval, deviation history, etc. |
| | Real time operation management | Real time comprehensive monitoring of current location, distance between vehicles, dispatch intervals, deviation status, etc. |

Information Provided

2.34 BIMS can provide information to many different groups: bus drivers, customers (passengers), bus operation companies, and management authorities, see below.

Figure 13: BIMS Information Provision Overview

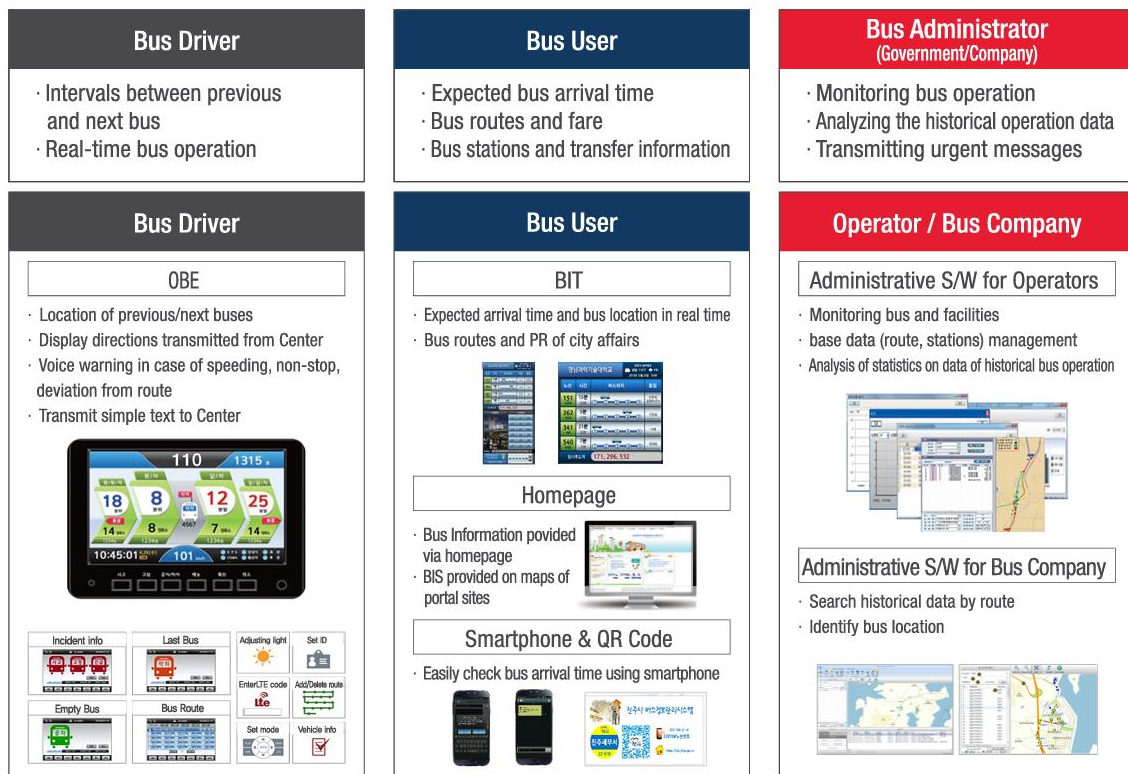


Image source: ITS Korea

Benefits of BIMS

- 2.35 By improving the immediacy, timeliness, convenience, and safety of public transportation, better and more competitive transportation service can be provided, and by overhauling the current bus route system and introducing a new bus information system, public transportation system can be provided in a more efficient way and passenger vehicle-based transportation can be converted to public transportation.
- 2.36 Many public transportation users in Dhaka are captive riders with limited transportation choices as they may be low-income earners, women, and children, and so the public transportation improvement plan can directly help these people have increased mobility and freedom, thus helping them access economic opportunity, jobs, and shopping etc.

Gender Considerations

- 2.37 Women and men in Bangladesh face different challenges when experiencing public transport, have different trip making habits, and have different access to ICT and the internet.

Challenges Women face on Public Transport in Bangladesh

- 2.38 According to some report, a staggering 94% of women commuters have experienced a sexual assault on the often-crowded buses of Dhaka ³. Overall, buses in Dhaka are incredibly unsafe for women.

³ <https://www.dhakatribune.com/opinion/op-ed/288324/is-public-transport-safe-for-women>

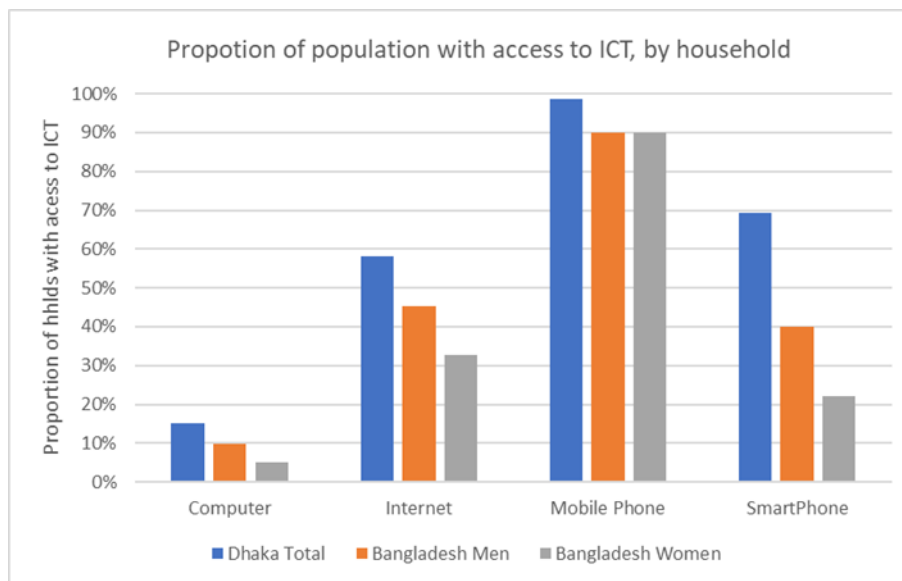
2.39 Speciality services for women in Dhaka are rare: the BRTC operates just two women-only routes per day. However, this may increase in the future.

Internet Access

Will services and technologies provided by the project/program be available and accessible to both women and men?

2.40 Countrywide, women tend to have less access and usage of Information and Communication Technology (ICT) than men. Around 40% of men in the country used a SmartPhone, while just over 20% of women reported using one. Similarly, overall, 45% of men had had access to internet, while just over 30% of women reported having access. Men (72%) are far more likely to own a mobile phone than women (51%) as well.

Figure 14: Internet Access of the Bangladeshi Population



2.41 A study from the Asia Development Bank (ADB) from 2018 confirmed there to be significant gender gaps with both internet access and smartphone ownership in Bangladesh, with women being significantly less likely to have access to a SmartPhone than men.

2.42 Its therefore critical to design a BIMS with this in mind and ensure that information of the real-time location of buses is accessible to those without a SmartPhone. **That means, that physical digital signage is a must-have.** Fixed digital bus stop signage is accessible to anyone who shows up to the bus stop who can therefore benefit from the real-time information provision.

2.43 This framework describes a system that will track and monitor buses in Dhaka, primarily to relay this information about timing to passengers. This by itself will not do anything to address the sexual assault and other unsafe conditions that women regularly must deal with on Dhaka’s crowded bus system. However, these systems could potentially be used in the future to address this issue with the following features:

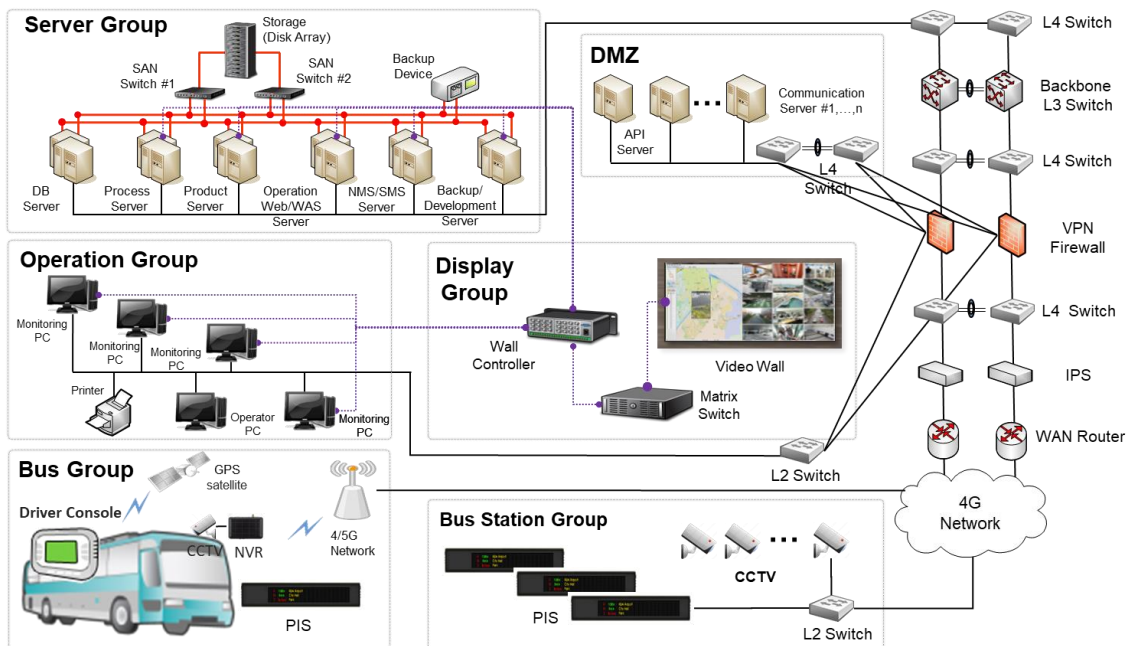
- Connect to CCTV systems installed on buses;
- Connect to CCTV systems installed at bus stops;
- Connect to future payment or card systems, which could be used to track how crowded buses are and provide this information to passengers;
- Display whether the next bus is for women-only or not.

3 Hardware

Overall System Architecture

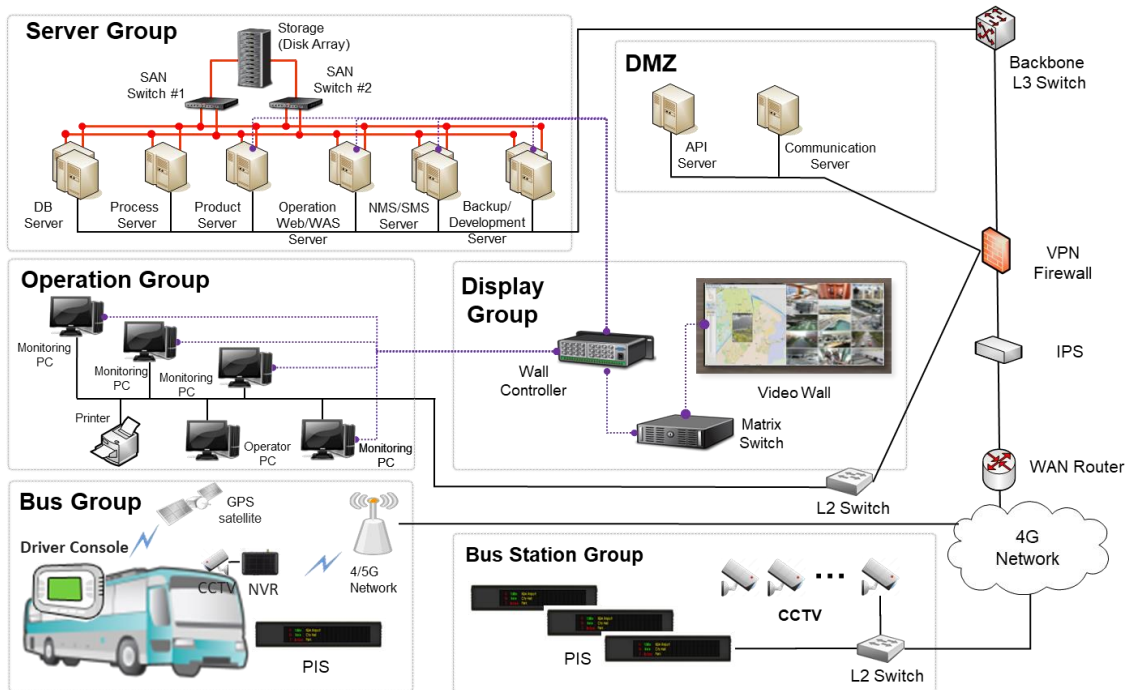
- 3.1 The following figure details the overall system architecture, for hardware, including the servers, storage, switches, monitoring videos, bus stop infrastructure, and On-Board Equipment (OBE). Two versions of the architecture are shown below. Figure 15 indicates a system with additional redundancy, while Figure 16 indicates a system without redundancy.
- 3.2 The hardware is configured into several groups. Namely, the server group, DMZ, and display group are all located at the management center, while the operation group is located at operating companies (which may or may not be located within the same building). The bus group (hardware located on moving buses), and bus station group (hardware located at bus stops) are remote, and communicate with the management center groups using wireless communications (existing 4G infrastructure). Within the management center, networking equipment including switches, VPN, routers etc. and configured as shown below.

Figure 15: Hardware Configuration (Detailed), with Redundancy



Source: Supplied courtesy of Neighbour Systems Korea

Figure 16: Hardware Configuration (Detailed), without Redundancy



Source: Supplied courtesy of Neighbour Systems Korea

On-Board Equipment (OBE)

3.3 Today's public transport bus operators have access to many different digital intelligent transport systems (ITS) that aid them in the safe and efficient operation of their vehicles, especially BIMS.

3.4 BIMS are customizable and flexible and offer many choices of equipment, each more advanced than the next. On-board units (OBUs) are the devices that are installed in vehicles to enable real-time tracking and monitoring of their location and other important parameters. OBUs may be small devices with no Human-Machine Interface (HMI), meaning there is no way for the driver to interact with it, to larger units with screens which can provide the operator with additional driving features, as well as the ability to receive messages from a central dispatch (known as Computer-Aided Dispatch, CAD).

3.5 The bus location tracking method uses Global Positioning System (GPS) and communication via existing wireless network infrastructure. The OBUs continuously measure longitude, latitude, and altitude generally reporting this information to a central management center every 20-30 seconds.

Figure 17: Transit Operator Cockpit Equipment

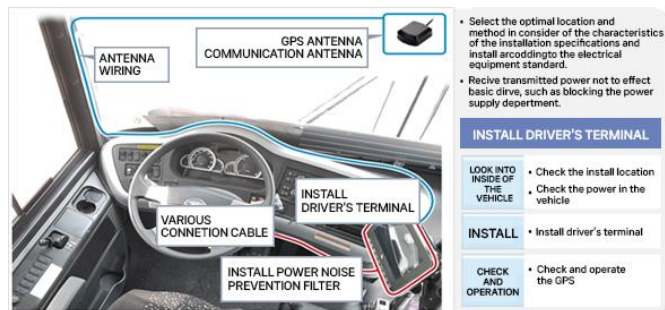


Figure 18: Overview of BMS AVL Communication

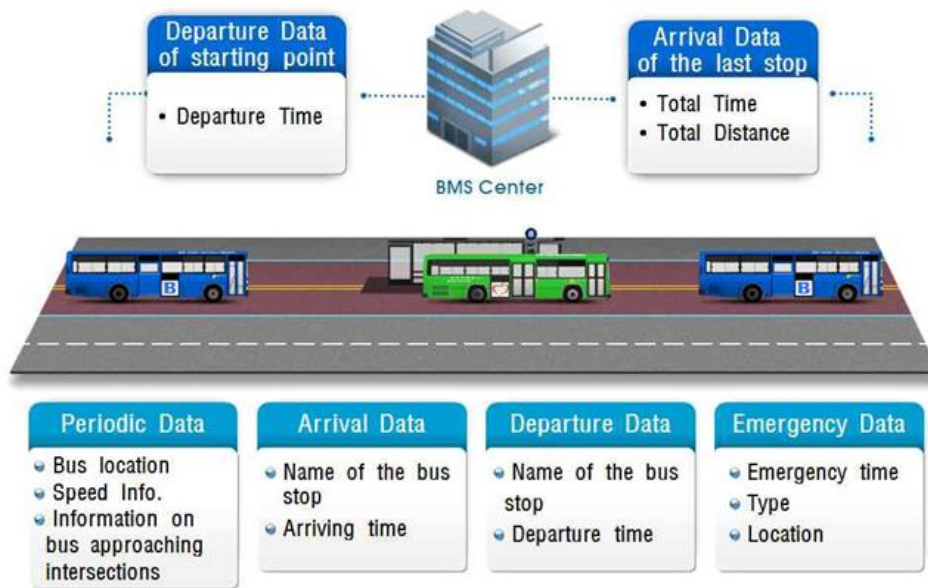





Image Source: Seoul Solution

- 3.6 In addition to GPS technology, OBUs may also include other sensors and communication capabilities. For example, they may be equipped with accelerometers to measure the vehicle's acceleration and deceleration. OBUs connect to the vehicle's OBD-II port, which may also give them access to additional data.
- 3.7 Other equipment installed in the operator cockpit can including dispatching screens, electronic fare collection (EFC)-related devices, and passenger information. A summary of the features and types of OBU is shown below in Table 4.

Table 4: Vehicle Operator Equipment – OBE Units

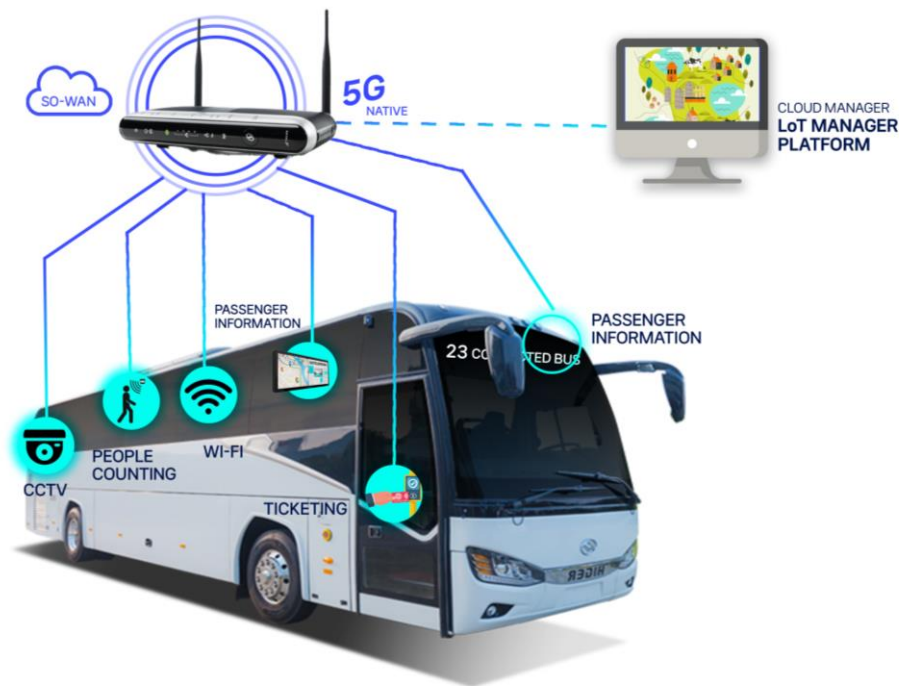
| Equipment | Description | Features | Example Image |
|--|--|---|---|
| OBD-II Port On-Board Unit (OBU) | Small device connects directly to OBD-II port or equivalent. 1-way communication connects to LTE networks. | AVL (GPS tracking), fuel monitoring, brake monitoring, geofence, engine on/off, acceleration monitoring |  |
| Operator Computer * | Larger device with screen. 2-way communication connects to LTE networks (may require separate modem). | AVL (GPS tracking), CAD (dispatch), route navigation, fuel monitoring, brake monitoring, geofence, engine on/off, acceleration monitoring |  |

| Equipment | Description | Features | Example Image |
|----------------------------|---|--|---|
| Integrated terminal | Larger device with other accessories screen. 2-way communication connects to LTE networks (may require separate modem). | AVL (GPS tracking), CAD (dispatch), route navigation, fuel monitoring, brake monitoring, geofence, engine on/off, acceleration monitoring, ability to control card readers and passenger displays |  <p>Source: TripSpark</p> |

* Recommended for Dhaka case

3.8 The existing bus tracking system currently utilized by BRTC utilizes a relatively simple OBD-II port-type OBU which does not have a driver display. However, in the case of a full system roll-out a system with a driver console could provide a huge upgrade to benefits and capability which we have considered in this report.

Figure 19: Integrated Terminal Ecosystem and Possibilities



3.9 Additionally, integrated terminals are available which can connect the operator unit not only to the BIMS but also to other on-board ITS systems. Given terms of reference for this project indicate that real-time passenger information display is the primarily goal of the research, integrated terminals will not be required. However, in some cases it may be beneficial to use an integrated terminal to ensure future compatibility if more ITS is desired later. In this report, integrated terminals nor simple OBD-II port type OBUs are not considered but information about integrated terminals and their associated equipment is listed in Appendix A.

OBU (Operator Computer / Main Controller & Modem)

- 3.10 Generally, it is preferably to use a combined unit which consists of controller/CPU, modem, and driver console (also referred to as a huma-machine interface HMI) rather than separate components. The specification for a combined unit is shown below.
- 3.11 A driver console (screen) while technically optional, is recommended in the case of the Dhaka system, and is the only way to maximize the benefits of the BIMS. The console should be designed to deliver optimized and reliable information easily and effectively to the vehicle operator and should be designed for driver to use embodied functions with ease by simplifying input.
- 3.12 A modem compatible with 3G (UMTS) and 4G (LTE) at minimum is recommended for communication between on board equipment and the management center.

Table 5: Combined Operator Computer/ On-Board Unit (OBU) Minimum Specifications

| Item | Specifications | Example Image |
|---------------|---|---|
| CPU | Octa Core |  |
| Memory | 512MB RAM/512M Flash More than 16-32GB External SD Memory | |
| Communication | WiFi: 802.11. b/g LAN: 10/100bps GPS RS232C: Default 3 ports USB: Host (2.0) Port (2 Port) | |
| Modem | Wireless Modem Type: GSM, EDGE, UMTS, HSPA, LTE, 5G Size: 95time; 54 time; Input voltage: 6V-32V The support of the SIM card : 3V/5V Interface Type: USB Transmission Rate: 2Mbps Style: External Serial Port, 1 USB, CAN, OBDII 12 – 34 V | |
| Screen | Display: 8 .0" TFT 800x480 350cd/m2 Touch Screen Control: 5-Button | |
| | | |

Display

- 3.13 An LCD touch panel larger than 8” should be used with the ability to communicate alerts and instruction messages directly to the console without transmission to a centre. The displayable content requirements are shown below in Table 6.

Table 6: Driver Console Display Requirements

| Item | Service content | Type of Display |
|------------------------------|---|---------------------------|
| Preceding/proceeding vehicle | Distance and time lap with foregoing/following car | Image or text |
| Present time | Standard time information received from GPS satellite | Text |
| Device status | Communication and operation of GPS, wireless communication devices | Image |
| Operation history | Operation time/distance/passed stops since departure | Text |
| Route traffic | Traffic status information per section of each route | Image (4 colors) |
| Centre/company message | Display message from BIS/BMS centre and bus company Audio announcement | Text, audio, sound effect |
| Urgent/caution message | Start with door open, dispatch interval modification, route deviation etc. Audio message | Text, audio, sound effect |

Bus Stop Equipment

- 3.14 Bus stop equipment generally consists of devices used to communicate information about the buses and their schedules to passengers who are waiting for the bus. The most important item is the Bus Information Terminals (BIT), which are electronic information displays that can provide real-time or scheduled information on bus schedules, routes, and arrival times at bus stops. While there are many ways to provide bus information to customers including with physical infrastructure at bus stops, equipment within the buses themselves, via the internet, websites, text message, or by ARS. However, the BIT is the most convenient and accessible way to provide information to public transport users, as it can easily be used by anyone, even if they do not have access to a SmartPhone or the internet.

Bus Information Terminals (BITs)

- 3.15 BITs do not make any sense under the current operating scenarios in Dhaka. For BITs to be used, **bus stops must properly be established in Dhaka** and used with great discipline. Bus operators must not stop to pick up passengers outside of official bus stops with few exceptions. In this report, we assume that bus stops will be established and used in the future.
- 3.16 BITs are commonly used at bus stops and transit hubs to provide passengers with up-to-date information on the location and estimated arrival time of buses. BIT displays typically show the

route number, destination, and expected arrival time of the next bus. Some BIT displays may also show additional information such as weather conditions, service disruptions, and special announcements. BIT displays can be found in many other cities around the world and are often displaying the same information that is available on mobile applications and other digital tools to provide passengers with a seamless and convenient travel experience.

- 3.17 Other types of bus stop equipment can include digital signage (displaying more information than a BIT), CCTV, audio-based passenger announcements and others. In this report, only BIT or digital signage for major terminals is considered. However, information about the technical specifications for other bus-stop based equipment can be found in Appendix A.

Table 7: Bus Stop Equipment

| Name | Details |
|---------------------------|---|
| BIT | Classified into LCD/LED type, provide ETA, operation information, public announcement, incident etc. |
| CCTV * | Installed inside shelter for 24 hours monitoring in order to prevent crime, burglar and to monitor system, and collected video is transmitted and stored in the management centre |
| Digital Signage (KIOSK) * | Installed at major bus stops with many tourists or spots with many floating populations to provide transit/transport/ entertainment info etc. |
| Speaker * | installed to provide audio information like incident and public announcement within shelter |

* Optional equipment

BIT Types

- 3.18 Currently there are several major types of BIT display on the Korean market, which can be classified according to their installation method: independent, unified, and embedded, see below.

Table 8: BIT Typologies

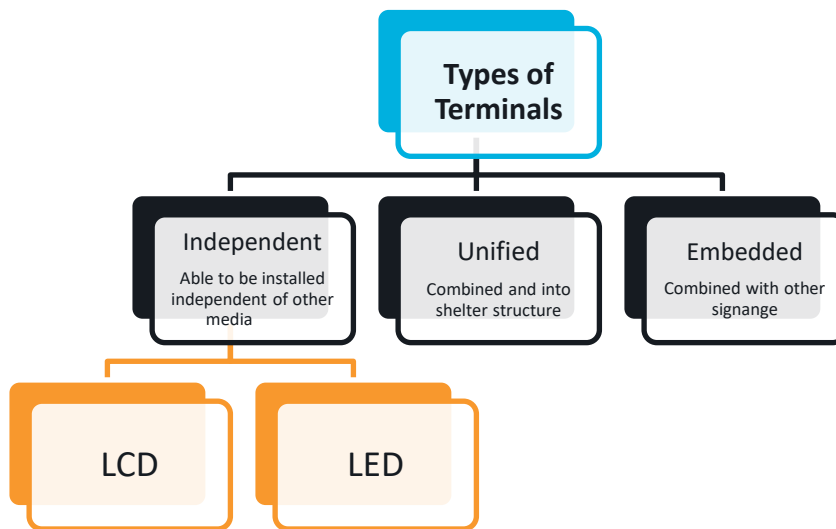


Figure 20: BIT Types



Unified

Embedded

Independent

- 3.19 BITs generally use two different display technologies: LED or LCD⁴. LCD-based displays are capable of additional information over LED displays due to their larger size and flexibility. In the Dhaka case, independent type is recommended for most purposes. In Dhaka, bus stops or bus shelters are generally not well established or used. Independent types give greater flexibility for installation. BITs are generally installed at bus stops with high demand for public transportation, supporting passenger convenience. A summary of the differences between LED and LCD BITs are shown below in
- 3.20 Table 9. LCD BITs carry a significantly higher cost than LED BITs but provide the ability to display more information. In the case of Dhaka, LED type displays are likely to be sufficient.

⁴ E-Ink has been used in some cases, although it is not commonly used.

Table 9: LED vs LED BIT (Information Display)

| Information | Sensors Req'd. | |
|--|------------------------------------|---|
| Route number | AVL (GPS) | LED (4-colour: White, Red, Green, Blue) |
| Estimated time of arrival | AVL (GPS) | |
| Current location | AVL (GPS) | |
| Imminent arrival announcement | AVL (GPS) | |
| Malfunction | - | |
| System announcement | - | |
| Crowding level | Integrated terminal & payment card | |
| Bus type (mini, articulated, double deck etc.) | AVL (GPS) | |
| Cost | \$5,400 - \$6,200 USD | |
| Bus stop name | - | |
| Bus stop ID | - | |
| Route number | AVL (GPS) | |
| Estimated time of arrival | AVL (GPS) | |
| Current location | AVL (GPS) | |
| Imminent arrival announcement | AVL (GPS) | |
| Malfunction | - | |
| System announcement | - | |
| Crowding level | Integrated terminal & payment card | |
| Bus type (mini, articulated, double deck etc.) | AVL (GPS) | |
| Air quality | Web access | |
| Weather | Web access | |
| Notices | Web access | |
| News | Web access | |
| Cost | \$10,750 – \$11,500 USD | |



3.21 The recommended minimum specifications for BITs are shown below in Table 10.

Table 10: LED BIT Specifications (LED Type)


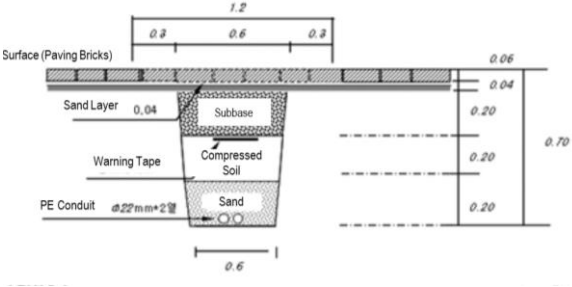

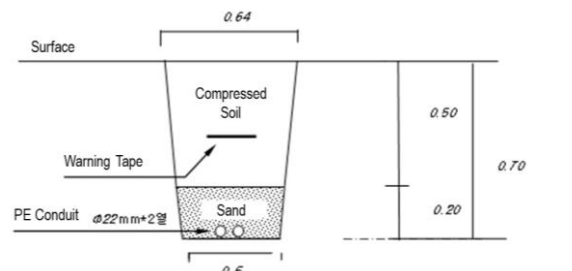

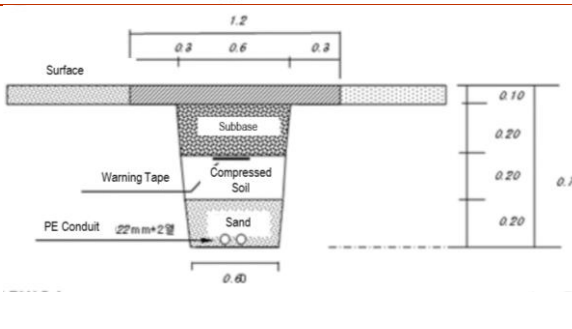
| Item | Minimum Specification |
|-------------------|---|
| Embedded software | BIT Program, Operating System Registration and Modification TTS Voice Engine Windows IoT 10 (embedded) x86 TTS BIOS |

| Item | Minimum Specification |
|---------------------------|--|
| Core computing components | Industrial Controller Intel Core i3 Quad Core 3.4 GHz (or higher) 4G DDR4 RAM 64 GB onboard SSD |
| Power | AC 220V, DC 12V (100W) AC 220V DC 5V (600W) UPS: 40 kA Short circuit protector: 2.5 kA 15A |
| Physical Hardware | Temperature/humidity sensor Door, heater, brightness control System reset |
| Screen | Full-colour LED 48mm, 4 line x 16 Brightness 3,500 cd/m ² (nits) or better |
| Other | On board fan Dust proofing, waterproofing, heat dissipation AR Coating 5T Powder coat body Stand-alone structure Foundation structure |

Installation

- 3.22 As previously discussed, we recommend that independent-type BITs be used and installed at to-be established bus stops in Dhaka, see Figure 22. Independent BITs can be installed relatively easily using existing infrastructure, such in sidewalks or on the sides of streets. Ideally, they would be installed on sidewalks or off-street.
- 3.23 The installation of BITs is relatively simple, and can be accomplished with a small crew, BITs are installed by digging a small hole in the ground, connecting a conduit to an electrical supply, and then installing the support on the surface above the hole.
- 3.24 Initial installation depends on the surface type and condition of the surface. See below for installation details, three surface types are considered:
- Soil/No Special Surface
 - Asphalt
 - Concrete Block
- 3.25 Finally, after the hole is complete, electrical conduit should be installed and connected to underground utilities, if available. BITs can also be installed in cases where underground electrical utilities are not available, and there are many such examples in Seoul.

Table 11: Surface Type and Installation

| Type | Image | Engineering Diagram |
|-----------------------------|--|---|
| Paving Bricks (Most Common) |  |  |
| Dirt or no surface |  |  |
| Concrete/ Asphalt |  |  |

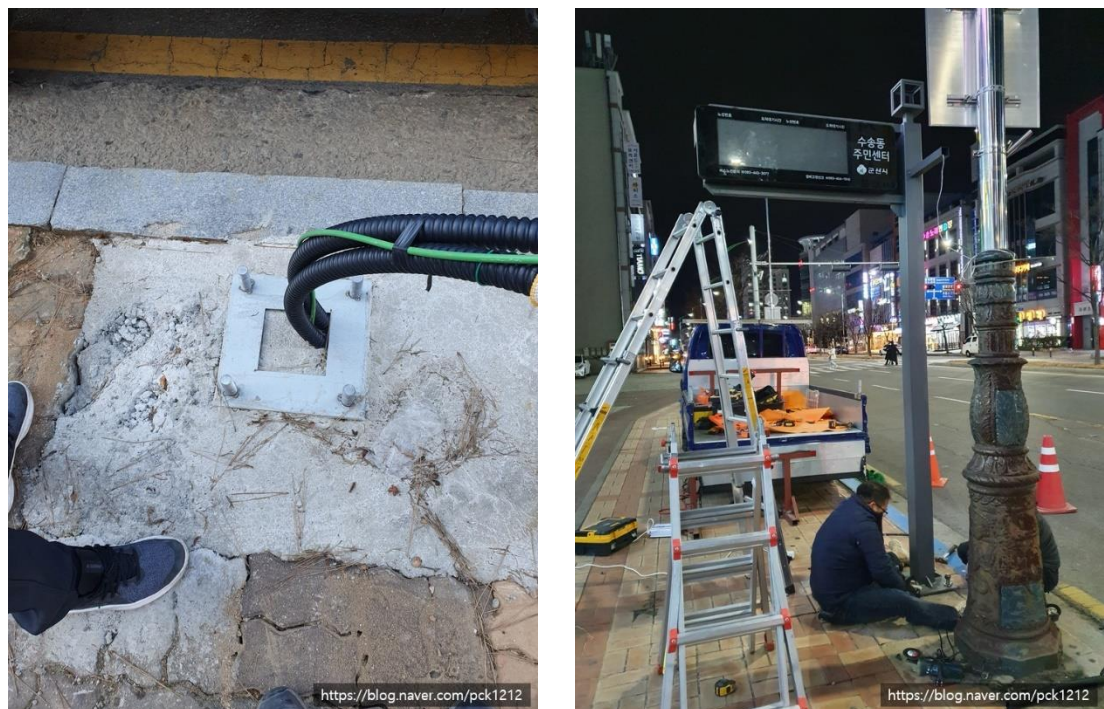
- 3.26 When there is no opportunity to connect to underground electrical utilities, additional installation of a mast can be used to connect to the overhead line. Mast should be located a short distance from the BIT, with conduit routed underground between the two, see Figure 21.
- 3.27 Additionally, it is possible to purchase compatible BITs which are strictly off-grid and use solar panels and batteries to power the signs. However, these installations are relatively rare and are more expensive than conventional on-grid installations.

Figure 21: Electrical Mast Installation Example



3.28 Finally, with conduit in place, the BIT and structural support stand can be installed and connected to the electrical system. A small crew can complete the installation within one working day, refer to Figure 22.

Figure 22: BIT Installation Process



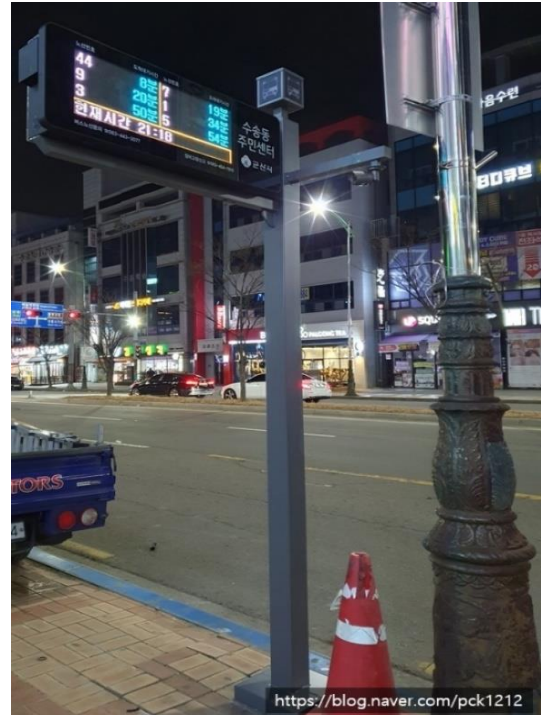


Image Sources Jitech Signage, SAIIn

Optional: Digital Signage (KIOSK)

- 3.29 Kiosks are commonly used around the world. They are often used in open space such as government offices, tourist site etc. and provides transport information/tourism/public announcement and transit information of bus/subway etc.
- 3.30 Digital kiosks generally cost more than BITs and are best suited for busy stations or transport hubs, like transfer points to the Mass Rapid Transit (MRT) or intercity bus hubs.

Figure 23: Example of a Digital Kiosk




Table 12: Specifications of the Digital Signage (Kiosk)

| Item | Configuration/function | Minimum Specifications |
|-----------------|---|---|
| Main Controller | Application operation and communication with center power, control, communication | Over Intel Core 2 duo RAM: over 2GB HDD: over 250GB |
| Display Panel | Interface for information users Touch screen providing various information. Panel type Reinforced glass for device stability | 46" DID LCD Panel Reinforced glass |
| Body | Fix and support display panel and main controller Consider beauty and durability | Slim design Silk screen print |

Optional: Loudspeaker

- 3.31 A loudspeaker should be located, fitting to shelter size (if applicable) and for optimum sound quality. The purpose of the loudspeaker is for announcement and in case of emergency and over IP65 is recommended. Installed linking with shelter environment to prevent howling and quality decline.

Table 13: Public Loudspeaker Specification

| Minimum Specifications | |
|--|--|
| 2-Way Speaker system (6" 2Way-2SPK) Waterproof: IP65 Hole: \varnothing 200(mm) ~ \varnothing 205(mm) Rated Power: 80W |  |

Communications Networks

- 3.32 Telecommunications, including mobile telecommunications in Bangladesh is regulated by the Bangladesh Telecommunications Regulation Committee (BTRC), based in Dhaka. According to the BTRC, their responsibilities include operating, regulating, maintaining telecommunication establishments, and providing various telecom services in the country are the major ones. Besides, fixing charges on the subscribers, ensuring the services for the subscribers and to ensure people's right are also tasks of BTRC. The social and economic behavioural pattern of the telecom service providers are also monitored by the BTRC to ensure that the users are not subjected to harassment and not indifferent in nature⁵.
- 3.33 Data is very cheap in Bangladesh, and as for retail, customers can expect to **pay an average of \$0.32 USD per Gigabyte**⁶. There are five main mobile telephony providers in Bangladesh using four separate networks:
- GrameenPhone
 - Banglalink
 - Robi/Airtel
 - Teletalk (fully state-owned)
- 3.34 Grameenphone is by far the largest operator by subscribers and market share with over 81 million subscribers, or a 45% market share, followed by Robi with 30%, Banglalink with 22%, and finally Teletalk with just over 4%.
- 3.35 In Bangladesh, 2G (GSM), 2.5 (GPRS), 3G (UMTS), 3.5 G (HSPA), and 4G (LTE) networks are available. We recommend 3G or LTE networks be used for communications. Data is inexpensive in Bangladesh and will not be a major concern for this project. **State-owned TeleTalk infrastructure may be used**, especially if a good deal can be made with the provider.
- 3.36 TeleTalk supports 900 MHz (E-GSM), GPRS, EDGE, HSPA/+ and 2100 MHz LTE bands. To ensure long-term compatibility, 3G or LTE networks are recommended.

⁵ <http://old.btrc.gov.bd/history-and-vision>

⁶ https://www.cable.co.uk/mobiles/worldwide-data-pricing/2022/2022_global_mobile_data_price_comparison.xlsx

Table 14: Bangladesh Frequency Bands

| 2G (GSM) | 2.5G | 3G (UMTS) | 3.5G | 4G (LTE) | 5G |
|------------------------------------|-------------------------|----------------------------------|--------------------------|----------------------------------|-------------------------------|
| 900 MHz (E-GSM) ^{1,2,3,4} | GPRS ^{1,2,3,4} | B1 (2100 MHz) ^{1,2,3,4} | HSPA ^{1,2,3,4} | B1 (2100 MHz) ^{1,2,3,4} | n78 (3600 MHz) ^{3,4} |
| 1800 MHz (DCS) ^{1,2,3} | EDGE ^{1,2,3,4} | B8 (900 GSM) ³ | HSPA+ ^{1,2,3,4} | B3 (1800+ MHz) ^{1,2,3} | |
| | | | | B8 (900 MHz) ^{1,2,3} | |
| | | | | B40 (2300 MHz) ^{1,4*} | |
| | | | | B7 (2600 MHz) ^{2*,3} | |

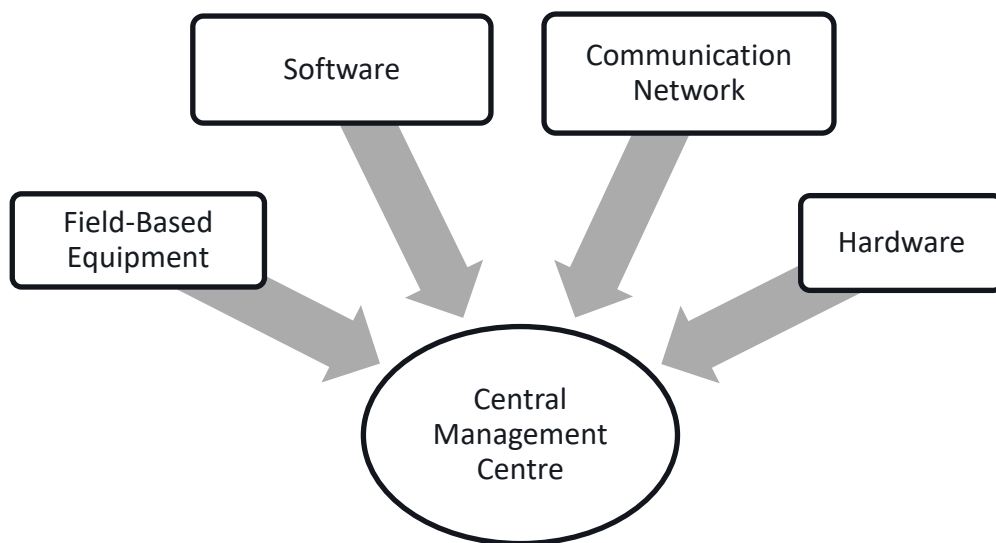
1=Bangalalink 2= Robi/Airtel, 3 = Grameenphone, 4 = TeleTalk

Management Center

Overview

- 3.37 A high-quality management center is crucial for a bus operating management company to efficiently oversee and coordinate their operations, and more importantly, for a central management authority to monitor bus companies’ performance in turn, as well as the entire network and undertake planning.

Figure 24: Four Pillars of a Central Management Centre



| Field-Based Equipment | Software | Communication Networks | Centre Hardware |
|--|---|---|--|
| <ul style="list-style-type: none"> Scalable Compatible Flexible | <ul style="list-style-type: none"> Standardized with national/international standards Links to other systems and agencies | <ul style="list-style-type: none"> Optimized for system operation Stable power supply | <ul style="list-style-type: none"> Scalable Compatible Flexible |





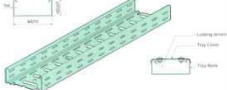

- 3.38 The benefits and normal activities of the management center are:

- **Improving Operational Efficiency:** A management center provides a centralized hub where supervisors and managers can monitor and control various aspects of bus operations. It allows them to streamline processes, optimize routes, track schedules, and make real-time adjustments when needed. This helps improve operational efficiency and ensures that buses run smoothly and on time.
- **Data Management and Analysis:** A management center equipped with advanced technology can collect and analyze data from various sources, such as GPS systems, ticketing systems, and passenger feedback if available. This data can provide valuable insights into passenger demand, route performance, maintenance requirements, and overall operational effectiveness. With this information, management can make data-driven decisions to optimize routes, allocate resources efficiently, and improve service quality.
- **Communication and Coordination:** In a bus operations center, effective communication and coordination are vital. A management center facilitates seamless communication among different stakeholders, including drivers, dispatchers, maintenance staff, and customer service representatives. It enables instant communication, relaying information about route changes, emergencies, vehicle breakdowns, and other important updates. This ensures that everyone involved is well-informed and can respond promptly to any situation.
- **Safety and Security:** Managing the safety and security of passengers and buses is of utmost importance for a bus operating management company. A management center can incorporate surveillance systems, access control, and alarm systems to monitor the premises and detect any potential security threats. It can also track bus locations in real-time and implement emergency protocols if needed, ensuring passenger safety and the protection of company assets.
- **Performance Monitoring and Improvement:** A management center provides tools and systems to monitor key performance indicators (KPIs) related to bus operations. This includes metrics such as on-time performance, passenger satisfaction, fuel consumption, maintenance costs, and more. By monitoring these KPIs, management can identify areas for improvement, implement corrective measures, and strive for continuous enhancement of the overall operation.

Equipment

- 3.39 The management center must be outfitted with high quality hardware and act as the central communication node to connect with the software, communication network, and hardware in the centre itself. The specifications listed in this report will ensure that the system is flexible, scalable, and capable with other ITS systems. Hardware in the management center should be selected for high performance and high reliability. Several hardware pieces will be required, especially including servers and operation/monitoring terminals. Hardware recommendations are shown below.

Table 15: Management Center Essential Features

| Item | Details | Image |
|------------------------------------|---|---|
| Electric supply | Must be a 100% reliable system with no load shedding, or backup generators will be required | - |
| Uninterruptible Power Supply (UPS) | Capacity should be suitable for the actual installed server capacity |  |
| Thermo-hygrostat / air conditioner | For maintenance of ideal temperature and humidity |  |
| Entrance control | Fingerprint, card-based or, passcode, secure entry |  |
| Automatic fire suppression | Automatic fire suppression system, based on automated |  |
| Console/desks | High quality for worker convenience |  |
| Power and cable trays | Separated for power and communications cables, considering height |  |
| Access panel / board | |  |
| Video wall | 46" 2 x 4 (total 8) video Commercial-grade monitors etc. with controller |  |

Servers








3.40 The server-specific functions are shown below in Table 16 and the specifications are shown in Table 17. A total of eight different servers within the management center would be required, each with specific functions.

Table 16: Server and Other Hardware Specific functions

| | System | Function | Quantity |
|---|--|--|-----------------|
| 1 | Main server (DB) | Syntagmatic ally store, manage all data within system | 2 |
| 2 | Communication Server | Collect bus location information by GPS receiver and status information through 4G LTE or 3G another wireless network. Provide ETA through wireless communication with BIT etc. | 2 |
| 3 | API Server (e.g. GTFS) | Dedicated server to host the GTFS and other API-related databases that describe the real-time and static transit schedules. | 1 |
| 4 | Location Processing Server | Major process like data analysis/processing, algorithm. Process collected real time bus operation data | 2 |
| 5 | Information Service Server | Monitor real time bus operation status, ETA, incidents, violation etc. Supports decision related to operation through operation history statistics and traffic data analysis/processing | 2 |
| 6 | Operation Server (WEB/WAS) | Host internet websites and provide information such as operation status, optimized route, ETA, route, bus company information etc. | 2 |
| 7 | Network Management Systems (NMS) & System Management System (SMS) Server | Dedicated server to remotely manage software, updates, and system configurations on client computers. Centralizes tasks like software distribution and inventory management to streamline IT management in large networks. | 2 |
| 8 | Backup / Development Server | Backup – store backup data as well as aid in development tasks. | 2 |
| | External/backup storage | External storage for massive database and backup data | 1 |
| | SAN Switch | Switch to connect main server, backup server and external/backup storage by FC | 1 |

Table 17: Server & Computing System Specifications

| Server | Minimum Requirements | | Quantity |
|---------------|-----------------------------|--------------|-----------------|
| DB | CPU | 3.2GHz 8Core | 2 |

| Server | Minimum Requirements | | Quantity |
|--|----------------------|---------------------------|----------|
|  | Memory | 64GB | |
| | Storage | 480GB*2EA, HDD : 1.2TB* 2 | |
| | NIC | 10/100/1000 Base-T 2port | |
| | O/S | Linux (e.g. RedHat) | |
| Communication  | CPU | 2.8GHz 8Core | 2 |
| | Memory | 64GB | |
| | Storage | 1.2TB*2EA | |
| | NIC | 10/100/1000 Ethernet x 4 | |
| | O/S | Linux (e.g. RedHat) | |
| API (GTFS)  | CPU | 2.8GHz 8Core | 1 |
| | Memory | 64GB | |
| | HDD | 1.2TB*2EA | |
| | NIC | 10/100/1000 Ethernet x 4 | |
| | O/S | Linux (e.g. RedHat) | |
| Process  | CPU | 2.8GHz 8Core | 2 |
| | Memory | 64GB | |
| | HDD | 1.2TB*2EA | |
| | NIC | 10/100/1000 Ethernet x 4 | |
| | O/S | Linux (e.g. RedHat) | |
| Information Service  | CPU | 2.8GHz 8Core | 2 |
| | Memory | 64GB | |
| | HDD | 1.2TB*2EA | |
| | NIC | 10/100/1000 Ethernet x 4 | |
| | O/S | Linux (e.g. RedHat) | |
| Operation Server (WEB/WAS)  | CPU | 2.8GHz 8Core | 2 |
| | Memory | 64GB | |
| | HDD | 1.2TB*2EA | |
| | NIC | 10/100/1000 Ethernet x 4 | |
| | O/S | Linux (e.g. RedHat) | |
| NMS/SMS  | CPU | 2.8GHz 8Core | 2 |
| | Memory | 64GB | |
| | HDD | 1.2TB*2EA | |








| Server | Minimum Requirements | | Quantity |
|---|----------------------|--|----------|
| | NIC | 10/100/1000 Ethernet x 4 | |
| | O/S | Linux (e.g. RedHat) | |
| Backup/Development Server  | CPU | 2.8GHz 8Core | 2 |
| | Memory | 64GB | |
| | HDD | 1.2TB*2EA | |
| | NIC | 10/100/1000 Ethernet x 4 | |
| | O/S | Linux (e.g. RedHat) | |
| | | | |
| External/backup Storage  | Storage | 150 TB (LTO-6) Compressed 2.5:1 Maximum Media : 24ea | 1 |
| | Controller | 2 * RAID controller | |
| | Cache | 4GB | |
| Centre operation Terminal  | CPU | i5 2.0 GHz or over | 4 |
| | Memory | 16 GB DDR4 | |
| | SSD | 250 GB | |
| | HDD | 1 TB | |
| | Other | Windows, 24" monitor x2 | |
| Bus company Terminal  | CPU | i5 2.0GHz or over | ~20 |
| | Memory | 16 GB DDR4 | |
| | SSD | 250 GB | |
| | HDD | 1 TB | |
| | Other | Windows, 24" monitor x2 | |
| Laptop  | CPU | i5 2.0GHz or over | 5 |
| | Memory | 16 GB DDR4 | |
| | SSD | 250 GB | |
| | HDD | 1 TB | |
| | Other | Windows | |

Table 18 lists the minimum requirements, where application, for additional management-center based hardware.

Table 18: Additional Management Center-Based Hardware

| Item | Minimum Requirements | Qty |
|--|---|-----|
|  SAN Switch | 16port SAN Switch Port embedded. Fiber Optic Path provided | 2 |
|  Laser printer | 1200dpi, 16PPM, 64MB | 1 |
|  Rack | Genuine product, standard Rack 42U, 19" | 3 |
| Backbone (L3) | | 1 |
| Firewall | | 1 |
| VPN | | 1 |
| IPS | | 1 |
| WAN Router | | 1 |
| L4 Switch | | 1 |
| L2 Switch | | 1 |
| Optical communication network | | 1 |
| KVM console | | 1 |

Interior & Architecture

3.41 The management center will consist of the following routes (at minimum):

1. Control/monitoring room
2. Situation room/office
3. Staff lounge
4. Equipment locker (server room)
5. Warehouse/storage room

3.42 The management center should completely block out the outer environment to protect the computing resources and equipment. Walls should be soundproof so that internal noise doesn't reach situation room. For the situation room/office, an environment friendly interior for workers is recommended.

Layout

3.43 The server room should be separated into various rooms for stable and efficient operation. It is necessary to equip a high-capacity uninterruptable power supply (UPS), emergency generator, and fire extinguishing. The management center should be secured, with access

limited to management personnel only. Total area of the office space is estimated to be approximately 120 m² or 1,290 ft².

Figure 25: Potential Management Center Layout

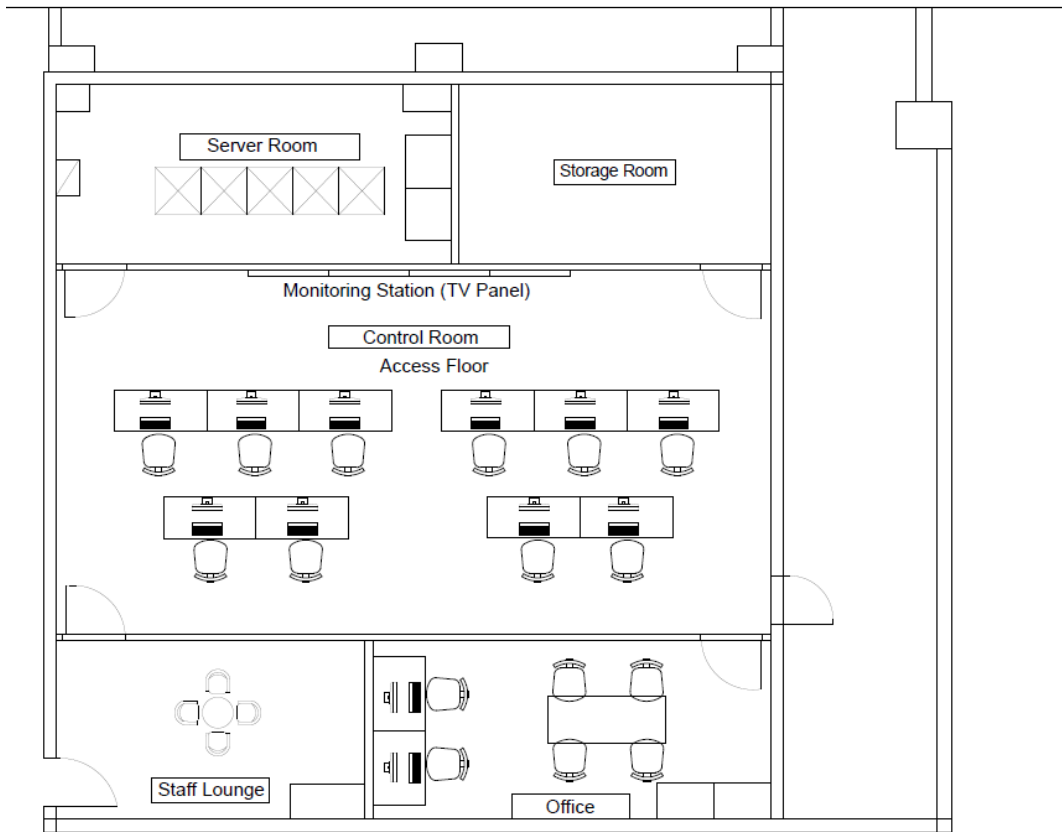


Figure 26: Images from Similar Management Center



Server rack



Operator Terminal (Office)



Monitoring room



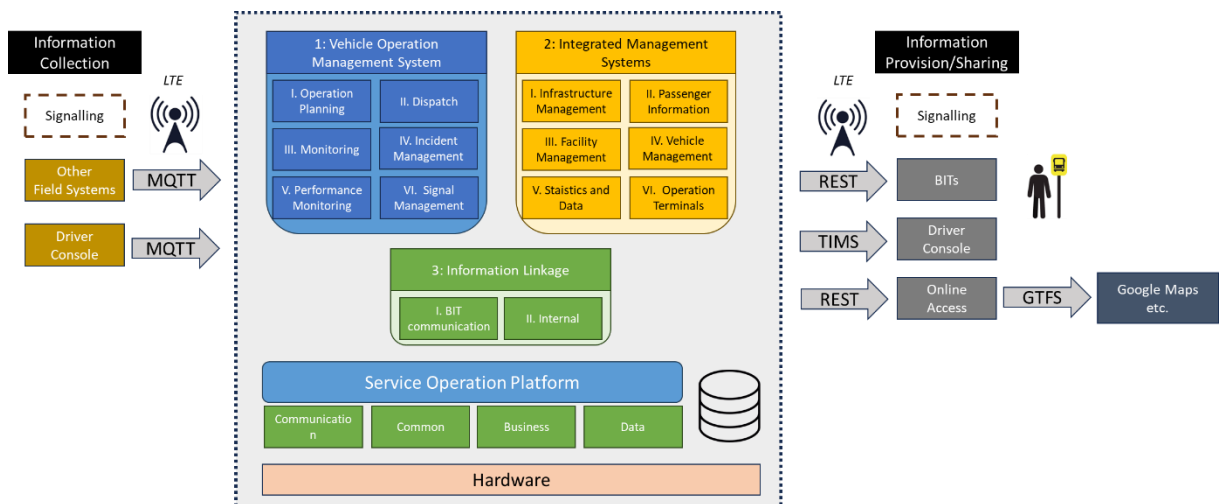
Break room / lounge

4 Software

Overview

- 4.1 Software for BIMS systems are complex and consists of numerous systems and subsystems including software for data collection, server operation, data processing and analysis in addition to the three most important functions are **dispatch** (for operations) and monitoring and **management** (for management/planning agencies), and **information provision** (for passengers and operators). The former is known as real-time passenger information (RTPI) or simply passenger information and the latter as computer-aided dispatch (CAD).
- 4.2 See Figure 27 for a general overview of the architecture, required interfaces and features of the BIMS software ecosystem. Below are indicated basic (which in our opinion are required for the Dhaka case) and optional functions.

Figure 27: BIMS Software (and Hardware) Architecture Overview



Software Requirements

- 4.3 The software systems that make up the overview bus management system can be disparate systems that perform their specific tasks but aren't necessarily designed to work as a full system. For example, commercial AVL products do not require or assume that commercial BIT is installed or even available. Other software and systems take care of the RTPI through online applications or BITs.
- 4.4 In some cases, integrated systems have been developed. A software package developed for Korea called S-BRT is a software system that takes care of several of the above-mentioned requirements (with additional capabilities) and such an integrated solution is recommended to be used in the Dhaka case. This system is ideal for very large and complex bus systems like Dhaka and Seoul.

- 4.5 The S-BRT software cover dispatch (computer-aided dispatch), communication with bus drivers, data collection, monitoring, tracking and history, BIT programming/data transfer, and performance tracking, external/internal communications and can also handle additional items like communication and control of facilities and even traffic signals.
- 4.6 While it may be possible to use other software systems, specific to whichever hardware and software systems are eventually chosen for Dhaka’s system, the following descriptions should be indicative of the overall structure and requirements for an integrated software package. The integrated software environment (or alternatively, discrete systems) should have the following capabilities:

Table 19: BMS Integrated Software Environment Capabilities

| Category/System | Function | Description |
|-------------------------------------|---------------------------|--|
| Bus Management System (BMS) | Dispatch Planning | Allows user to plan of operating hours and stop arrival times operation plan |
| | Communication with driver | Punctuality analysis message provided to the vehicle according to the rules |
| | | Analyze punctuality compared to the operation plan, generate operation adjustment instructions, and deliver them to the Dispatch service |
| | Management configuration | Management of vehicles, routes, and standard information required for system operation |
| | Track vehicles | Gather and manage GPS data from OBEs on vehicles |
| | Gather data | Data linkage through an interface between internal systems such as vehicles, facilities, and the management center operation system |
| | Performance Monitoring | Monitor driver/operator performance and ability to display statistics etc. |
| Bis Information System (BIS) | Share data | Collect and deliver data through standard linkage interfaces (REST |

| Category/System | Function | Description |
|--|-------------------------------|--|
| | | API, GTFS, etc.) and standard data formats (JSON, XML, etc.) |
| Contents Management Systems (CMS) | Manage data displayed on BITs | Manage the information displayed on passenger-accessible bus stop equipment |
| Facility Management System (FMS) | Manage other components | Management of installation information and status information of additional on-site facilities installed |

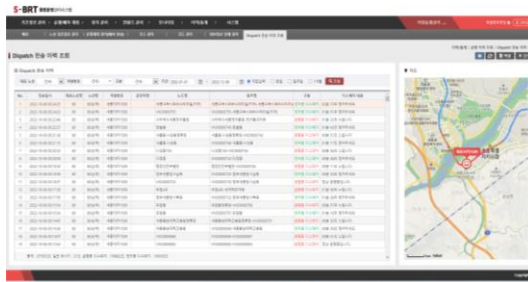
Bus Management Systems (Operations)

4.8 Dispatching and operations management is a critical aspect of ensuring that buses operate efficiently and effectively to provide transportation services to passengers. Operations management typically covers the following functions:

- **Scheduling:** Dispatchers are responsible for creating schedules for bus routes. This involves determining the timing and frequency of bus departures, considering factors like peak hours, passenger demand, and route distances. Schedules must be designed to minimize waiting times for passengers.
- **Assignment:** Dispatchers assign specific buses and drivers to routes and shifts according to the established schedule. They ensure that there are enough resources (buses and drivers) to cover all planned routes.
- **Communication:** Dispatchers maintain communication with bus drivers and other relevant personnel. They can provide drivers with updates, instructions, and information about route changes, delays, or other issues that may affect their routes. Effective communication is vital for keeping the bus system running smoothly.
- **Problem Resolution:** When issues or disruptions occur, such as traffic accidents, breakdowns, or service interruptions, dispatchers work to resolve these problems quickly. They may reroute buses, send replacement vehicles, or take other actions to minimize disruptions to passengers.

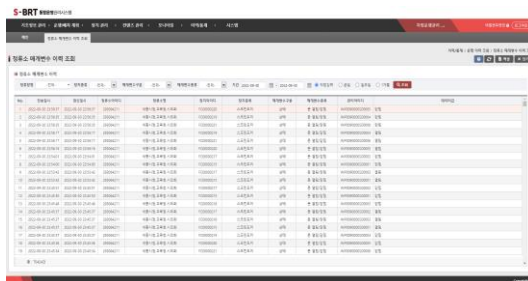
4.9 In addition, the program implemented should have a function to change the vehicle operation trajectory scheduled through real-time vehicle location control and have program to compare the vehicle scheduled route operation information with the actual operation information, in real time, and allow for historical review.

Figure 29: Dispatch History Software Screenshots



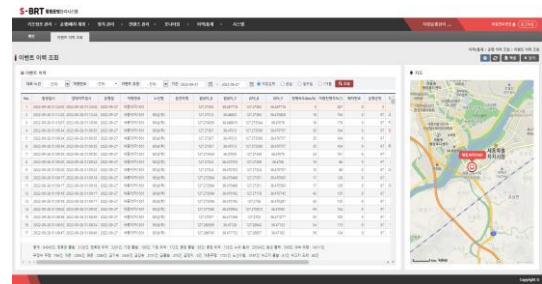
Added a map marker to check Dispatch location

View Dispatch transfer history



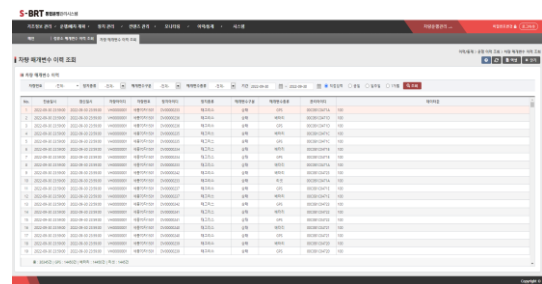
Added connection history for added stop facilities

Inquiry of bus stop facility connection history



Added a map marker so you can check the event location

Event history search



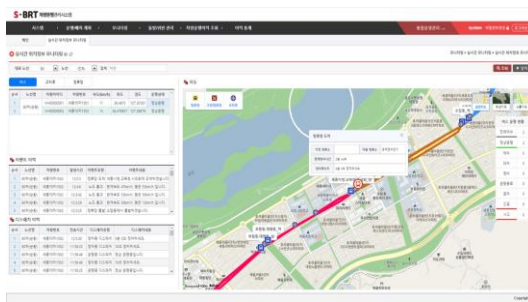
Added connection history for added self-devices

In-vehicle device connection history inquiry

Vehicle Tracking

- 4.10 The system should contain functions that can monitor real-time vehicle location and signals and provide information on the arrival of each stop by combining real-time vehicle location and real-time bus operation control information. The vehicle dispatch service should also control the driver's driving speed through real-time vehicle location control and provides stop waiting time information. Additionally, punctuality analysis service to secure stable and prompt punctuality, and real-time monitoring and stop monitoring.

Figure 30: Monitoring Software Screenshots

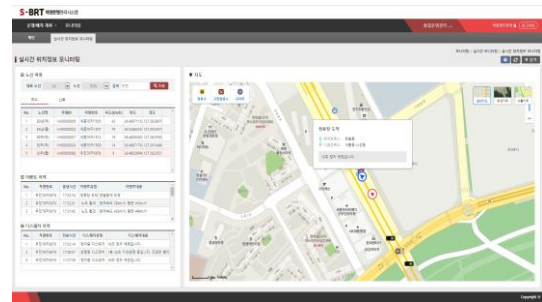


The screen display of multiple vehicles creates a requirement for direction judgment

Among the routes, it is necessary to distinguish between demonstration sections

In contrast to general messages, it is necessary to distinguish important messages for dispatch and priority signals.

e.g. space utilization is poor due to bus operation status display



Advanced to express the direction of bus operation

Adjust the curvature and color of the demonstration section

Modified design for priority signal and dispatch screen to increase contrast

Increased space utilization by removing the display of bus operation status

Performance Monitoring

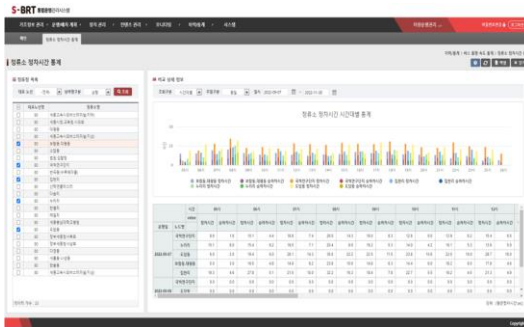
4.11

The system should have a function can monitor real-time vehicle location and provide information on the arrival of each stop by combining real-time vehicle location and real-time bus operation control information. In Seoul, the Transit Operations Performance Information System (TOPIS) organization uses this kind of performance data to closely monitor and manage bus operators by collecting and analyzing various operational metrics. Here's how it utilizes this data:

- **On-Time Performance:** TOPIS tracks the punctuality of buses, ensuring they adhere to their schedules. If a bus operator consistently runs behind schedule, this data allows authorities to address the issue and adjust routes or schedules as needed.
- **Passenger Load:** Performance data helps assess how full or empty buses are at different times and on specific routes. By analyzing passenger load data, Seoul's transit system can allocate resources more efficiently, adjusting services based on demand.
- **Fuel Consumption and Maintenance Records:** Monitoring fuel consumption and maintenance data can help identify maintenance needs and inefficient fuel usage. Regular maintenance can be scheduled based on data, reducing the risk of breakdowns, and improving overall fleet efficiency.
- **Driver Behavior:** Performance data can also track driver behavior, such as speeding, sudden stops, or excessive idling. By identifying problematic driving patterns, Seoul TOPIS can provide feedback and training to bus operators to enhance safety and fuel efficiency.
- **Service Quality Metrics:** TOPIS assesses service quality through passenger feedback and complaint data. By tracking this information, transit authorities can address issues promptly and ensure a higher standard of service.

- **Route Optimization:** Performance data allows Seoul TOPIS to identify underperforming routes and potentially adjust or optimize them. This can lead to cost savings and improved service quality.
- **Resource Allocation:** By analyzing performance data, the system can allocate resources, such as buses and personnel, more effectively. This ensures that bus operators are deployed where and when they are needed most.

Figure 31: Performance Monitoring (Bus Stops)



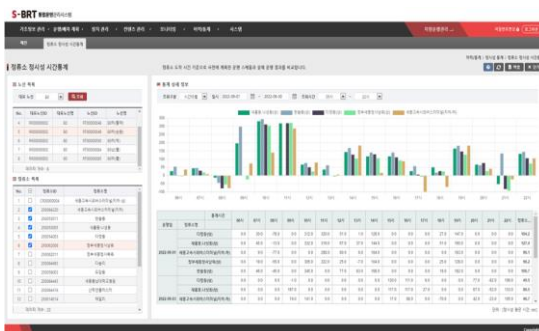
Hourly/daily/monthly average stopping time statistics for the bus stop

Bus stop time statistics



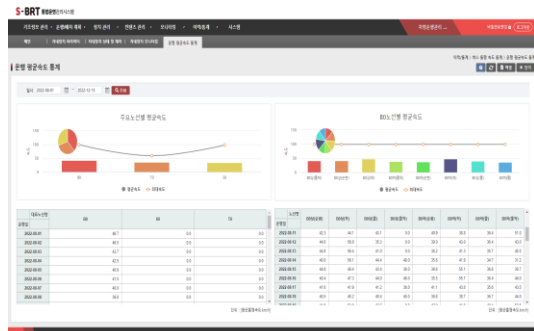
Hourly/daily/monthly average speed statistics for the section of the stop

Average speed statistics for each stop section



Stop punctuality observance/number of delays Average statistics by time slot

Bus stop punctuality time statistics



Daily average speed, maximum speed statistics for routes

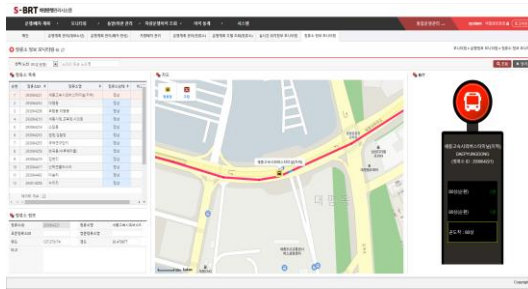
Driving average speed statistics

Contents Management Systems (CMS)

4.12

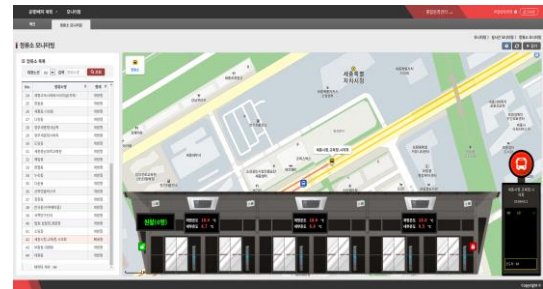
Information provision systems provide the stationary and real-time information to users and shall be designed, to comply with the purpose of service offer to create web page conceptualizing user friendliness and establish push type information provision system by my bus setting.

Figure 32: Bus Stop Monitoring Software Example Screenshots



Poor space utilization with stop list and stop details

Absence of display of status information of bus stop facilities other than BIT information



Redesigned the stop list to increase space utilization

Advanced to display bus stop facility images and status information such as bus stop congestion, temperature, door open/closed, etc.

Stop monitoring

Advancement of station monitoring

Table 21: Detailed Contents Management Systems Applications and Functions

| Division | Name | Function |
|----------|----------------------|--|
| Internet | ETA processing | Provide current location, departure time at previous stops and ETA |
| | Traffic condition | Incident, delay, and service suspend |
| | Shortest route | Search shortest route considering transit |
| BIT | Operation per route | Search operation route and provide route info |
| | Operation per stops | Search stops and bus info per stops, major facility |
| | Route bus basic info | Route/stop/vehicle/company/fare/transit info |
| KIOSK | Operation per route | Search operation route and provide route info |
| | Operation per stops | Search stops and bus info per stops, major facility |
| | Other | News/weather/public announcement etc. |
| | Shortest route | Search shortest route considering transit |

Facility Management System (FMS)

- 4.13 Remote update about field facility, equipment etc. using wireless/wired communication network shall be possible, and this software shall be designed guarantee maintenance easiness by pattern search through addition of integrated facility management function which can simultaneously manage field facility at centre.

Table 22: Facility Management Application Software

| Division | Process | Function |
|-------------------------|----------------------------|---|
| Basic info management. | Information management | Facility basic info register/modify/delete/search |
| Status man. | Fac. Status collection | Store real time status information of facility Notify operator and store logs in case of failure |
| | Status monitor | Monitor message from BIT |
| Control management | Control management | Real time/periodic control of BIT on/off |
| | Rem. update man | BIT remote update management |
| History info management | Maintenance management | Manage maintenance information, person in charge per facility and company data |
| Stats info management | Gen. fac. stats | Generate facility status/failure statistics by period |
| | Search facility statistics | Systematic failure readiness through statistics including history management per failure types |

Other Commercial Software

4.14 Commercial software will be required in several instances, to be installed on a variety of hardware/servers. Table 23 is a summary of commercial software requirements.

Table 23: Commercial Software Requirements

| Machine | Feature/Description |
|---|--|
| RDBMS | Integrated database storage |
| Backup software | Central intensive management. Capable of various reporting |
| SMS/NMS | Server/network/breakdown/security/management and Analysis generates various statistics analysis and report |
| Operation systems | O/S systems for servers, terminals, and laptops |
| GIS software | GIS engine (can be open source) |
| Anti-virus etc. | System virus vaccine |
| GTFS/API building /maintenance software | See below |

General Transit Feed Specification

4.15 Database standards for static scheduling and real-time information are used to provide information about the location and arrival times of buses to either operator provider websites,

or more commonly, third-party application developers. In Korea, Kakao and Naver Maps are two popular navigation applications that utilize public transport data to provide users with real-time information about transit options. In Korea, the Ministry of Land, Infrastructure and Transport (MOLIT) and Seoul Metropolitan Governments (through TOPIS) have developed an XML and JSON based domestic standard and open API to provide real-time public transportation data to third-party applications, such as Kakao and Naver Maps, based on REST.

- 4.16 Both Kakao and Naver Maps use the domestically developed API to access real-time data on public transportation schedules, routes, and fares. This data is updated regularly and includes information on buses, subways, trains, and taxis. Users can use these applications to plan their trips, check real-time arrivals and departures, and view route maps.
- 4.17 Outside of Korea, the General Transit Feed Specification (GTFS) static and real-time are the international standards for open data access for public transport data, most notably used by Google Maps as well as Transit, CityMapper, Apple Maps, and OpenTripPlanner. The use of standardized data formats such as GTFS have made it easier for transportation companies and third-party applications to access and use public transportation data.
- 4.18 Real-time information can be provided to third parties through an open data standard, specifically the General Transit Feed Specification -Real-Time (GTFS RT). GTFS-RT is a standard format developed by Google for exchanging real-time public transit data. It is designed to provide up-to-date information about public transit routes, schedules, and service status, allowing applications and services to display accurate and timely information to users.

5 Information Provision & UX

Overview of Sensors and Data

- 5.1 To ensure reliability of location indicator, detect the location based on GPS value per second. If GPS operation is abnormal, indicate the location by revising previous locations and average speed in terms of software. Highly reliable GPS module should be used to ensure the accuracy of location indicator and the accuracy of location should be enhanced based on precise algorithm.

Table 24: Information Collected from Sensors

| Category | Information collected | Collection method |
|------------------------|--|---|
| Location data | Bus location and time | Receive location coordinates from GPS receiver Determine bus stop, intersection ID, etc. based on location coordinates collected |
| Bus information | Operation speed/ operating time/distance | Collect bus operation data generated by bus operation record generator |
| | Not stopping at station/ driving with door open / failure to reverse direction at a terminus/route deviation | Collect non-compliance with operating rules generated by operation non-compliance data generator |
| Unexpected events | vehicle accident/ breakdown and on-board emergency | Collect information related to emergency such as vehicle breakdown, accident, and on-board emergency via driver |
| Device status | Device status data | Collect information related to communication equipment status generated by self-diagnosis function |
| Cash/ card information | Collect card & cash data | Collect card & cash information gathered by Validator and Farebox and send all of it from the garage |
| Passenger counter | Number of passengers boarding/deboarding | Collect the number of passengers boarding/ deboarding recorded in passenger counting system and in card data |

Data Review

- 5.2 In this section of the report, we will review of information which can be provided to customers, vehicle operations, and management staff through various BIS media (including BITs and on mobile applications, or websites). As an information provision system, BIS

provides information to all users of the system, provide the following types of information to each user. In all cases, the BMS is the source of the information.

Table 25: Information Review

| Division | Medium | Information | Period | | |
|-----------------|--------------------|---------------------------|---|--|---------|
| General users | BIT | Bus operation information | ETA, travel time to destination | 30~60 sec | |
| | | | Approach to bus stop | Event | |
| | | Additional | Public announcement, event information, weather | Occurrence | |
| | Internet | Bus operation information | location, ETA per stops passing time per stops, bus type | Request | |
| | | | Dispatch schedule, first/last bus | Request | |
| | | Incident | Incident | Request | |
| | | Route search | Route, bus stop, transit, required time | Request | |
| | | Additional | Public announcement, event information, weather | Request | |
| | Mobile /web | Bus operation information | location, ETA per stops passing time per stops, bus type | Request | |
| | | | Dispatch schedule, first/last bus | Request | |
| | | incident | incident | Request | |
| | | Route search | Route, bus stop, transit, required | Request | |
| | Vehicle Operator | OBU | Other buses operation information | Location, ETA, # stops behind (up to 2 buses each direction) | Request |
| | | | This bus | Dispatch schedule, first/last bus | Request |
| Incident | | | incident | Request | |
| Route search | | | Route, bus stop, transit, required | Request | |
| Center operator | Board and terminal | Bus operation information | Bus location on entire routes, | Occurrence | |
| | | | Abnormality of collected information | Occurrence | |
| | | incident | Incident situation | Occurrence | |
| | | Device status | BIT status/display | Request | |

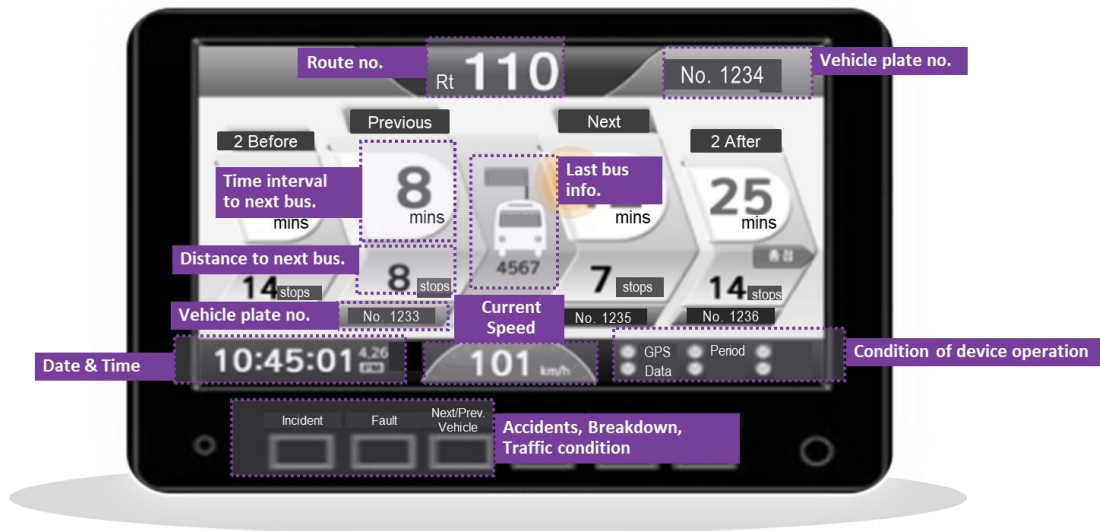
Bus Operator

- 5.3 The operator terminal, or OBU will be used to communicate with the operator. The main screen typically shows route number, ID, speed, and information about preceding and proceeding buses on the same route. This information will indicate to the vehicle operator if

they on time, or late. Typically, these devices also can easily access other information screens with additional information, including communication with dispatch.

5.4 The following user interface, or similar, is recommended for the Dhaka case.

Figure 33: OBU User Interface



Bus Information Terminals (BITs)

BITs are the physical digital signs that are installed at bus stops. As programmable interfaces, there are several options for what type of information to display. BITs can provide quite a bit of different information, including current location of bus, ETA, route information, incident information, see Table 26.

Table 26: BIT Information to be Provided

| Division | Provided information | Display | Language | Interval |
|----------------------|---|----------------------|--|------------|
| Bus location | Estimated Time of Arrival (ETA) - Estimated time on arrival - Notice in case of delay by incident | Text/graphic & audio | Text: Bangla / English (Arabic numerals) Audio: Bangla | ~1 min |
| Route number or name | Route search - Bus stops, first bus, last bus, dispatch interval Bus stop search - Departure/destination, required time to stop, transit | Graphic & audio | Graphic: Bangla (Bangla numerals) / English (Arabic numerals) Audio: Bangla | On request |
| Incident | Incident display Congestion, traffic accident, construction | Text graphic & audio | Bangla | Occurrence |

| Division | Provided information | Display | Language | Interval |
|----------|------------------------|----------------------|---|-----------|
| Other | - Public announcements | Text graphic & audio | Text: Bangla (Bangla numerals) / English (Arabic numerals) Audio: Bangla | Real-time |

Language

- 5.5 LED BITs have the capability to display text in almost any written language, including Bangla or Latin/Roman characters, Arabic numerals etc. We recommend that the BIT displays “cycle” between Bangla and English while displaying the same information in each language/script. Displaying the information in Bangla script including numerals is essential given that a large majority of population may not be familiar with Latin/Roman characters and Arabic numerals. At the same time, any foreign visitors will appreciate the ability to read the signs.

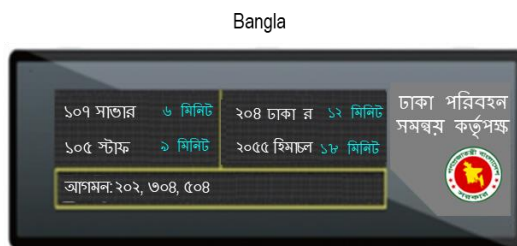
Design and Mock-Ups

- 5.6 We recommend that the standard, off-the-shelf BIT that is used everywhere in Korea be used in Dhaka case. The standard BIT design means a lower cost, while still providing the ability for basic customization including a small area for logos and text.
- 5.7 The following images show examples of designs of the BITs displaying information, in the Dhaka case. Currently, Dhaka bus routes are operated by a variety of private operators and generally do not use route numbers. Generally, the destination of the route is written on the side of the bus, as well as the operator in many cases. However, this is not ideal since BITs generally work better with route numbers. Three options for displaying routes and their related information are shown below.
- **Option A:** Operator & Route Destination
 - **Option B:** Route Number & Route Destination
 - **Option C:** Route Numbers Only
- 5.8 In cases where the working does not fit on the screen, the route destination or name can “scroll” across the screen. Descriptions on the BITs should cycle between Bangla and English.

Figure 34: BIT - BIT Display - Routes & ETA (Option A)



Figure 35: BIT Display - Routes & ETA (Option B and C)



5.9 The BITS may also be used to display additional information including the time, and alerts, see below.

Figure 36: BIT Displays - Time and Date or Alerts



Online/Application-Based

- 5.10 Information about buses and their locations can be communicated to customers online through a variety of means including by SMS, smartphone app, website, or other method. For the Dhaka case we recommend using an open standard (**GTFS-RT**) for data sharing and then become a Google Transit partner, thereby using Google Maps as the de facto standard for public transport planning in Dhaka. The relatively advantages of disadvantages of this approach are discussed below

Advantages:

- Standardized, internationally used and recognized format
- Free and open-source software is available for database maintenance and creation
- Easy to share with major mapping applications like Google Maps, Transit etc.
- Free to upload data into Google Maps
- Google Maps supports Bangla language

Disadvantages:

- No ability to customize applications for customers
- Limited to the open standard
- May be time consuming to (this applies to locally developed application too)

General Transit Feed Specification (GTFS)

- 5.11 Information about transit routes in the **Dhaka area is already available in Google Maps, however it is based on static schedules** (with no real-time information). The GTFS database utilized in the Dhaka case was developed and is owned by a private company based in India. We recommend that the regional authorities in Dhaka purchase the database from this company and take over management of the database in addition to the real-time database.
- 5.12 As Google Maps (and other applications) are third-party developed, the agency has little control in the look and feel of the application. However, given the advanced resources of a

major corporation like Google, user interfaces are typically extremely well thought out and usable.

5.13 It is recommended that the management center staff manage and produce the GTFS-RT database and keep it up to date. However, there are commercial partners available who can undertake the upkeep of the database. The management agency should eventually become a partner with Google Transit, to allow the database to be utilized in Google Maps. The application process is simple with support from Google.

5.14 In development the GTFS and GTFS-RT databases, some customization is possible, namely with the name of the routes and display colours. We recommend that in conjunction with the general bus system reform, a colour-coding scheme is implemented and consistently used across the system. For Dhaka case, this appears to be the “clusters” which have colours. For example, bus routes on the Purple/Pink cluster can be coloured Purple/Pink in Google Maps. Currently, all buses in Dhaka are the standard light blue colour.

Figure 37: Example of Google Maps Transit Directions for Purple/Pink Cluster (PC View)

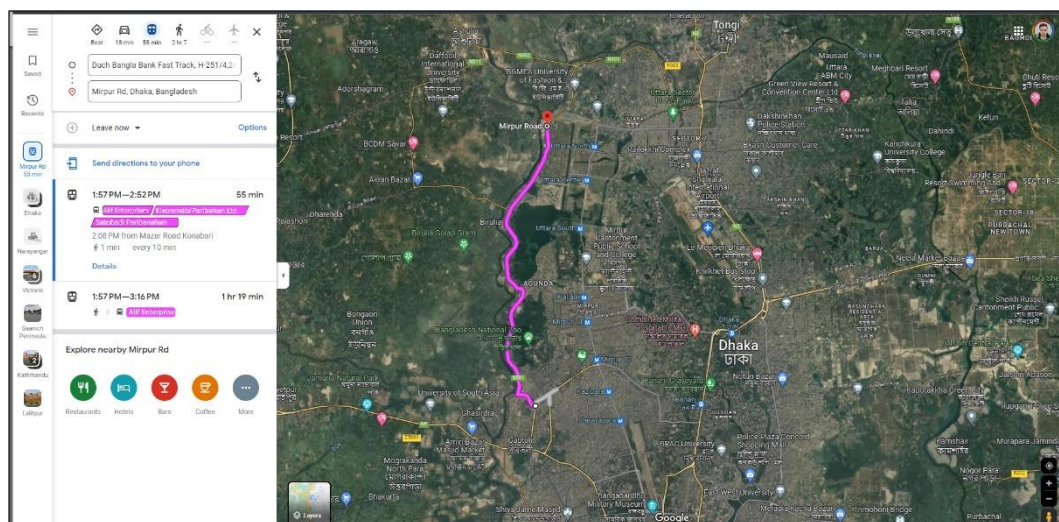


Figure 38: Example of Google Maps Transit Directions for Green Clusters (Mobile View)

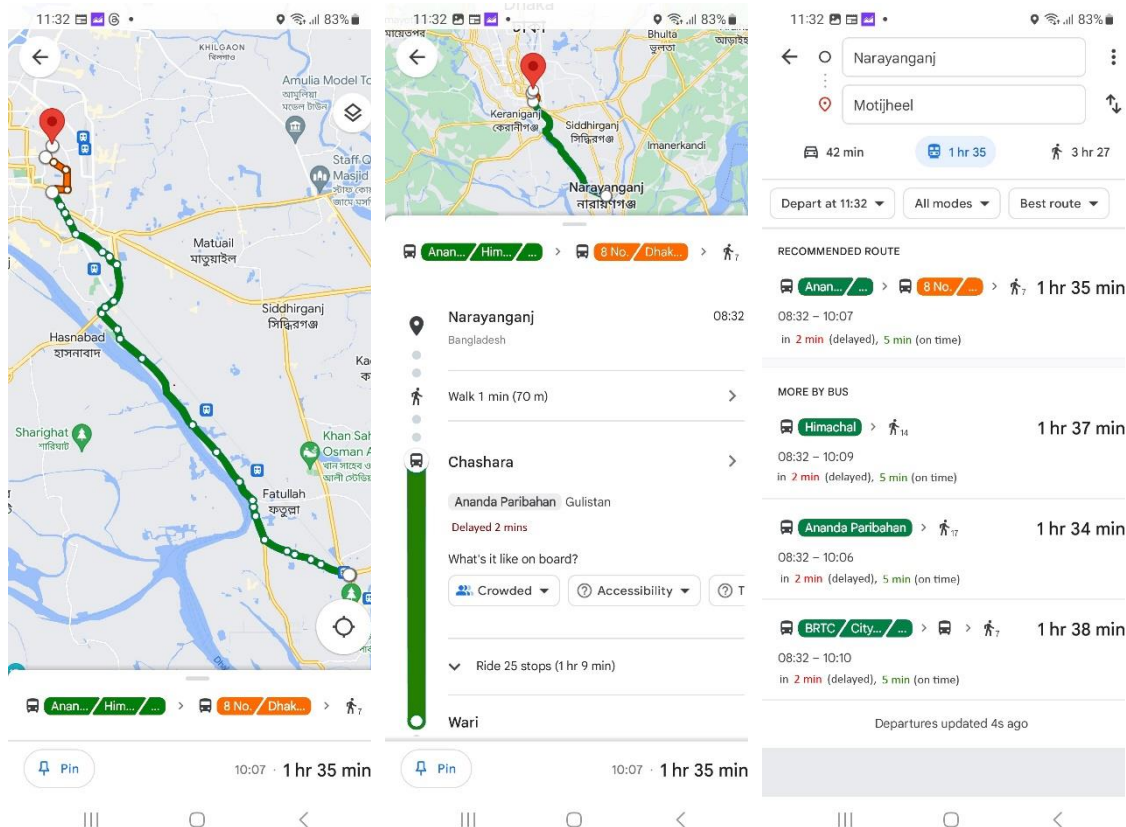


Image Source: Google Maps

Language

- 5.15 The existing GTFS static database for Dhaka supports the English language only. However, through the translations.txt dataset, support for other languages including Bangla, is possible. The translations.txt file should be used and maintained by the management center staff to ensure accurate translations.

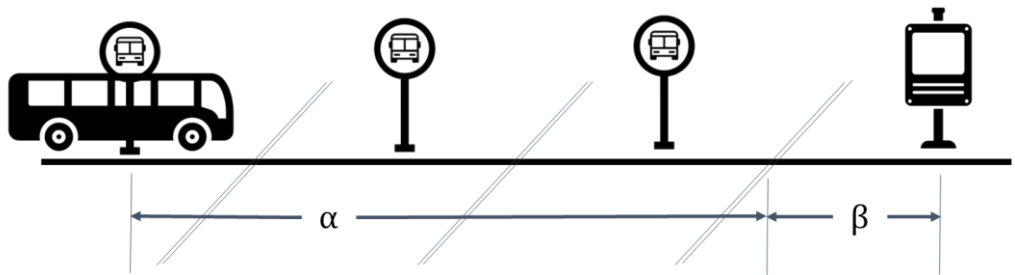
Estimated Time of Arrival (ETA)

- 5.16 To accurately estimated the estimated time of arrival (ETA) on Dhaka’s roads, an accurate **digitalized map** of the routes and network **must first be made**. This is known as the ‘Link and Node Network’. The link and node network may be made from a variety of existing maps and systems.
- 5.17 There are numerous estimation algorithms for ETA such as weighted moving average method, Kalman filtering technique, neural network models, Markov chain, regression model etc. ETA information is calculated based on passing time of each sector, estimates bus’s passing time applying movement average method which uses recent past information of collected information as event to estimate, and predicts future sector passing time by differentially applying past data utilization number per route and section based on present time.
- 5.18 The following equations detail one example of how to calculate ETA:

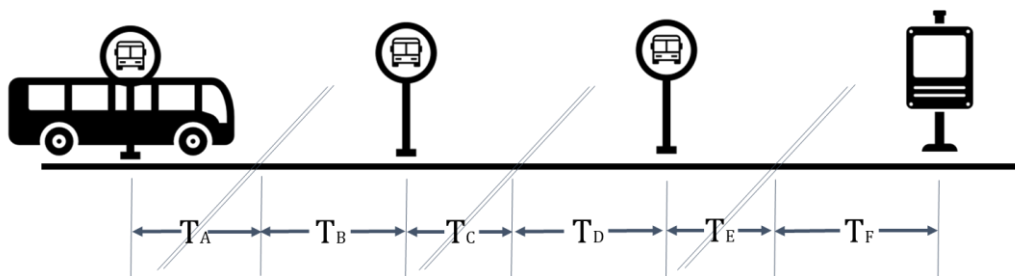
- $T_{link} = \left(\frac{1}{2}\right) * (S_{n-1} + T_n)$ (Equation Set 4)
- $S_2 = \left(\frac{1}{2}\right) * (T_1 + T_2)$
- $S_3 = \left(\frac{1}{2}\right) * (S_3 + T_4)$
- $S_4 = \left(\frac{1}{2}\right) * (S_3 + T_4)$
- ...
- $S_{n-1} = \left(\frac{1}{2}\right) * (S_{n-2} + T_{n-1})$

5.19 ETA is updated according to every event such as bus stops/crossroads, number of bus stops is according to bus stops event. ‘About-to-arrive’ information is provided when departure event occurs at previous bus stop.

Table 27: ETA Overview



- α : Plan for arrival time and station number supply section
- β : Almost arrived



| Estimated Arrival Time Provide Users | Time to End Point |
|--|---|
| - Location of the vehicle upstream stop. Each section based on travel time to estimate arrival time and provide. | - Processing cycle is when an event occurs, and we must estimate the distance to the -- bus stop at the end point of arrival. Time to stop predicting the end point service. |

5.20 Basic concept of calculating ETA and estimated time to final stop is as above. ETA provided to users (T_u) estimates and provides ETA based on passing time per section provided that current location of vehicle is before previous stop. In case of calculating required time to final stop, processing period is now bus stops event occurs, it estimates required travel time to final stop by calculating distance from arriving stop to final stop.

Table 28: Display of Time Remaining

| Vehicle Location | ETA | Stops |
|------------------|-------------------------------------|-------|
| A | $T_a + T_b + T_c + T_d + T_e + T_f$ | 2 |

| Vehicle Location | ETA | Stops |
|------------------|-------------------------------|-------|
| B | $T_b + T_c + T_d + T_e + T_f$ | 2 |
| C | $T_c + T_d + T_e + T_f$ | 1 |
| D | $T_d + T_e + T_f$ | 1 |
| E | momentarily | 0 |
| F | momentarily | 0 |

6 Estimated Costs

- 6.1 This section aims to provide a comprehensive overview of the costing aspects associated with various transport technologies. It is crucial to note that the cost figures presented in this chapter are high-level estimates intended to give a broad understanding of the financial implications involved. These estimates are based on available data, industry research, and expert opinions, but they should be treated as indicative rather than precise figures.
- 6.2 The costing encompasses various components, including infrastructure, equipment procurement, operational expenses, and the potential for future upgrades. These elements interconnect and influence each other, creating a complex web of cost considerations. Each component comes with its unique set of cost drivers, making it essential to approach cost estimation with caution. Additionally, skilled negotiators should get a good deal when it comes time to implement the project.
- 6.3 While efforts have been made to provide reliable estimates, it is crucial to understand the limitations and uncertainties associated with costing transport technologies. Factors such as market conditions, regulatory frameworks, technological advancements, and geographical variations can significantly impact the actual costs incurred. Additionally, project-specific factors, such as site conditions, scale, and the integration of existing infrastructure, can introduce further complexities and cost implications.
- 6.4 The high-level estimates presented in this chapter serve as a starting point for understanding the financial dimensions of various transport technologies. They offer insights into the major cost drivers, trends, and key considerations for decision-makers. However, it is important to note that these estimates should be treated as indicative rather than definitive figures, and detailed feasibility studies and project-specific assessments should be undertaken before making final investment decisions.

Management Center

- 6.5 The management center represents the largest fixed cost. Total cost for all management center components, hardware, and software will amount to approximately \$2.4 million USD (2023). Note that this cost is independent of which corridors are used and how many BITs are installed, in all cases this set up cost will be required to have a good system 'base'. Beyond this fixed cost, the system can be scaled up (or down) appropriately.

Figure 39: Costs – Hardware for the Management Center (Including Redundancy)

| Item | Cost/Unit | Units | Total |
|-----------------------------------|-----------|-------|------------------|
| Hardware | | | |
| DB Server | \$53,800 | 2 | \$107,600 |
| Communication Server | \$23,100 | 2 | \$46,200 |
| API Server | \$23,100 | 1 | \$23,100 |
| Process Server | \$23,100 | 2 | \$46,200 |
| Information Service Server | \$23,100 | 2 | \$46,200 |
| Operation Server | \$23,100 | 2 | \$46,200 |
| BMS/SMS Server | \$15,400 | 2 | \$30,800 |
| Backup/Development Server | \$23,100 | 2 | \$46,200 |
| Data storage | \$30,800 | 1 | \$30,800 |
| SAN Switch | \$42,300 | 2 | \$84,600 |
| Backup LTO | \$26,400 | 1 | \$26,400 |
| KVM Console | \$9,200 | 1 | \$9,200 |
| Wall DID | \$2,300 | 1 | \$2,300 |
| Wall Controller | \$69,200 | 1 | \$69,200 |
| Server Rack | \$2,300 | 2 | \$4,600 |
| Workstations | \$2,000 | 4 | \$8,000 |
| Operator Workstations | \$2,000 | 20 | \$40,000 |
| Laptop | \$2,500 | 2 | \$5,000 |
| Printer | \$500 | 1 | \$500 |
| Generator | \$46,200 | 1 | \$46,200 |
| UPS | \$26,900 | 1 | \$26,900 |
| Temp/Humidity Sensors | \$38,500 | 1 | \$38,500 |
| Sub Total (\$ USD) | | | \$785,000 |
| Software | | | |
| Database Management System (DBMS) | \$192,308 | 2 | \$384,600 |
| Backup S/W | \$115,385 | 1 | \$230,800 |

| Item | Cost/Unit | Units | Total |
|--|-----------|--------|--------------------|
| SMS/NMS | \$115,384 | 1 | \$115,400 |
| Development Tool | \$0 | 1 | \$0 |
| Window O/S | \$200 | 30 | \$2,000 |
| Vaccine (server) | \$423 | 1 | \$8,000 |
| Vaccine (client) | \$21 | 30 | \$0 |
| MS Office/Productivity Software | \$250 | 30 | \$3,000 |
| GTFS manipulation software | \$28,000 | 1 | \$28,000 |
| BMS - Bus (BRT) Management System S/W | \$615,400 | 1 | \$615,400 |
| BMS Licenses | \$461,500 | ~1,000 | \$461,500 |
| FMS - Facility Management System S/W | \$184,600 | 1 | \$184,600 |
| Bus routes / station management system S/W | \$230,800 | 1 | \$230,800 |
| Contents Management Systems (CMS) S/W | \$153,800 | 1 | \$153,800 |
| Sub Total (\$ USD) | | | \$2,420,000 |
| Network Components | | | |
| Backbone | \$53,800 | 1 | \$53,800 |
| Firewall | \$25,400 | 1 | \$25,400 |
| VPN | \$25,400 | 1 | \$25,400 |
| IPS | \$42,300 | 1 | \$42,300 |
| WAN Router | \$34,600 | 1 | \$34,600 |
| L4 Switch | \$34,600 | 1 | \$34,600 |
| L2 Switch | \$3,800 | 1 | \$3,800 |
| Rack | \$2,300 | 1 | \$2,300 |
| Sub Total (\$ USD) | | | \$220,000 |
| Grand Total (\$ USD) | | | \$3,420,000 |

Property and Operation

- 6.6 A management center site must be procured. We recommend that a secure office space in the Motijheel area be procured and purchased (leasing is also possible). According to latest figures, commercial office space in the Motijheel area is relatively inexpensive for a mega city and comes out to an average rate of **Tk 1.17 lakh/m²**. The management center requires an approximately 120 m² space given a purchase price of **Tk 1.56 crore** including fees or approximately \$144,000 USD (2023).

Table 29: Property Related Expenses

| | Unit | Cost (TK) | Cost (\$ USD) |
|----------------|--------------------|------------|---------------|
| Property | 120 m ² | 1.42 crore | |
| Taxes and Fees | ~10% | 14.2 lakh | |

| | Unit | Cost (TK) | Cost (\$ USD) |
|--------------------|------|-------------------|------------------|
| Sub Total | | 1.56 crore | \$144,000 |
| Renovation cost | | 32.5 lakh | |
| Grand Total | | 1.88 crore | \$175,000 |

6.7 Including renovations, we estimate the total cost of the property to be approximately Tk 1.88 crore or \$175,000 USD.

6.8 However, using existing office space in a state-owned corporations head office, such as at the Dhaka Transportation Coordination Authority (DTCA), would be ideal as this would reduce capital and operating expenses and allow for DIMS operation to better engage with DTCA planners/staff.

GTFS & Open Data

6.9 The costs to build and operate the GTFS-RT and GTFS Static databases, based on the APIs, are shown below. These values include building the database and continuing to host and maintain it once it is complete. Cooperation with management center staff would be required.

6.10 Currently, the GTFS Static database is maintained by a company based in Delhi, India called **Nand Imperial Consulting**. They have provided the following estimates for the GTFS database development and maintenance. Server costs could be eliminated by utilizing inhouse dedicated API server.

Table 30: GTFS-Related Database Costs

| Item | Cost | |
|--|----------|-----------|
| Cost to purchase the GTFS static database | \$5,500 | |
| Cost to build GTFS-RT database (Requires AVL data access) | \$22,500 | |
| Monitoring/maintenance | \$2,800 | per month |
| Server costs | \$500 | per month |

On-Board Equipment

6.11 On-board equipment (OBE) consists primarily of the OBE unit itself. One unit is required for each bus. Given the enormous number of buses in Dhaka, the costs may stack up considerably. Again, while OBD-II ports are possible if simple tracking is all that is required, more expensive operator control units provide significant benefits to overall system operation.

Table 31: On-Board Equipment Costs

| Item | Cost/Unit |
|---------------------------------------|-----------|
| On-board Unit (OBU) / Integrated Unit | \$2,700 |
| Rear display * | \$2,700 |
| Inside display * | \$2,300 |
| CCTV * | \$1,500 |
| NVR * | \$1,900 |
| L2 Switch * | \$1,150 |

| Item | Cost/Unit |
|------------------------|-----------|
| Announcement speaker * | \$1,500 |

* Optional equipment, for reference only

Bus Stop Equipment

6.12 Bus stop equipment consists primarily of the BIT unit. One unit is required for each stop, per direction.

Table 32: Bus Stop Equipment Costs

| Item | Cost/Unit |
|--------------------------------|-----------|
| Bus Information Terminal (BIT) | \$11,500 |
| CCTV * | \$2,200 |
| Digital Signage (Kiosk) * | \$30,000 |

* Optional equipment, for reference only

Other Costs

6.13 Other costs including electricity, data, and labour for the management center staff are shown below. Data and energy costs are relatively low in Bangladesh. Overhead for the management center is assumed to be an additional Tk 10 lakh/year.

Electricity & Data

Figure 40: Assumptions

| Item | Value | Source | |
|-----------------------|----------------------|-------------------|----------------------|
| Cost of data | Tk 32/ Gigabyte | \$0.31 / Gigabyte | Link |
| Cost of electricity | Tk 8.53 / kWh | \$0.076 / kW-hr | Link |
| Server operation time | 24 hours/day | - | |
| Server avg. load | 50% | | |
| Server power supply | 120 W | - | Link |
| PC operation time | 16 hours/day | - | |
| PC avg. load | 60% | | |
| PC power supply | 250 W | - | Link |
| Air conditioner | 3500 W | - | |
| BIT operation | 24 hours | | |
| BIT power consumption | 200 W/m ² | | |
| BIT data usage | Negligible* | | |
| OBU data usage | Negligible* | | |

* Due to the incredibly low average cost of data in Bangladesh, we assume costs associated with each BIT and OBU are essentially negligible, compared to the other costs associated with this system.

$$P_{Server,daily} = 24 \text{ hr} * 50\% * 120W * 2 = 2.88 \text{ kWh}$$

$$P_{PC,daily} = 16 \text{ hr} * 60\% * 250W = 2.4 \text{ kWh}$$

$$P_{AC,daily} = 16 \text{ hr} * 50\% * 3500W = 28 \text{ kWh}$$

$$P_{BIT,daily} = 24 \text{ hr} * 200 \frac{W}{m^2} * (0.661m * 0.24 m) = 0.76 \text{ kWh}$$

Table 33: Daily/Annual Ongoing Costs

| | kWh (day) | kWh (year) | Cost (Tk /year) | Qty. | Tk /year | \$USD/year |
|-------------|------------|------------|-----------------|------|----------|------------|
| Servers | 2.88 | 1,051 | 9,000 | 5 | 44,800 | \$400 |
| PCs | 2.40 | 876 | 7,500 | 4 | 29,900 | \$300 |
| A/C & Other | 30.0 | 10,950 | 93,000 | 1 | 93,400 | \$870 |
| Per BIT | 0.8 | 277 | 2,400 | 1 | 2,400 | \$25 |
| Per OBU | Negligible | - | | - | - | |
| Overhead | | | | | 10 lakh | \$9,000 |

Labour / Staff

- 6.14 In this section, we present the estimated cost for staffing of the management center. Note, these full-time employees will consist of public employees, primarily tasked with monitoring the system, performing maintenance if required, solving issues, and overall system monitoring and management. They may also monitor and develop performance reports, rating and comparing the performance of various operators. These staff are NOT involved in dispatch, which is normally the responsibility of each of the different

Table 34: Labour Costs

| Staff for management Center | Number | Annual Cost (salary + add'l) | Tk/year | \$USD/year |
|--|--------|------------------------------|------------------|-----------------|
| Manager (6 th Grade) | 2 | 8.6 lakh | 17.3 lakh | \$16,000 |
| Technical operator (9 th grade) | 10 | 5.4 lakh | 54.0 lakh | \$50,000 |
| Cleaning/maintenance etc. (20 th grade) | 2 | 2.0 lakh | 4.0 lakh | \$4,000 |
| Total | | | 35.8 lakh | \$70,000 |

7 Benefits

Overview

- 7.1 Investments in projects like a bus management system have numerous benefits to operators and customers and for the environment including:
- **Reduced Fuel Consumption:** BMS allow for more efficient route planning and vehicle dispatching. By minimizing idle times and reducing unnecessary detours, these systems help vehicles use less fuel. Reduced fuel consumption not only translates to cost savings but also contributes to lower greenhouse gas emissions, which is a significant environmental benefit.
 - **Less Congestion and Traffic (direct):** By using the data it produces to optimize routes, BMS systems help reduce traffic congestion from bus routes. This not only saves time but also decreases the environmental impact of idling vehicles stuck in traffic. Reduced congestion also means less wear and tear on roads, leading to fewer road maintenance activities, which can be resource intensive.
 - **Less Congestion and Traffic (indirect):** Additionally, by increasing the efficiency and convenience of public transport, it will encourage more Dhakabashis to continue to use public transport, refrain from switching to private transport, and to even switch to public transport from using private transport.
 - **More reliable transport and access to information.** This results in more reliable and efficient public transportation services, encouraging people to choose buses and trains over personal vehicles. As a result, it can lead to a reduction in the number of cars on the road, contributing to lower emissions and less traffic congestion.
 - **Optimized Urban Planning:** The data generated by BMS systems can be valuable for urban/transport planners and policymakers. It allows them to make informed decisions about transportation infrastructure development, including the placement of public transit routes and the implementation of green and sustainable initiatives.
 - **Positive Public Image:** Organizations that invest in technologies like CAD AVL can enhance their public image, since bus schedules and information is now readily available and much more convenient to use.
- 7.2 Some of these benefits can be quantified, and although not the purpose of this Technical Framework report, we discuss these quantified benefits in this section including the Greenhouse Gas (GHG) reductions.

Benefits (Quantified)

- 7.3 The main benefit for customers is an increase in information and convenience which causes them to experience better, more enjoyable, and more reliable journey. Individuals who have used passengers information actually or perceive that they save an average of 2.5 minutes per journey on average (the average bus journey length is 43 minutes in Dhaka according to reported values). Therefore, the time savings is significant (5-6% on average). Using the

following formulae (and assumptions listed in Table 36), we calculated the potential time “saved”, annually in hours, see below.

$$T_{ave} = \frac{L_{ave}}{Speed_{ave}} * 60$$

$$D_{new} = E * \frac{S}{T_{ave}} * D_u$$

$$B \text{ (mins)} = S * D_u + \frac{1}{2} * S * D_{new} * \left(\frac{1}{60}\right)^7 * \text{rule of half} - \text{Equation Set 1}$$

$$B \text{ (Taka)} = B \text{ (mins)} * \text{VOT (300 taka/hour)}$$

- 7.4 Due to enormous daily ridership on the Dhaka bus system, if fully implemented, the system could save an equally enormous amount of time and therefore have a large benefit, with knock-on economic effects as individuals have more time to put towards other economic activity. The following table shows the potential perceived/actual savings in hours, Taka, and USD. The implementation of a BMS could potentially have a hypothetical socioeconomic value of around \$210m USD annually. **This is likely to far outweigh the costs associated with implementation. Innate assumptions of this value are that it is fully implemented, in working order, and all potential users have access to it.**

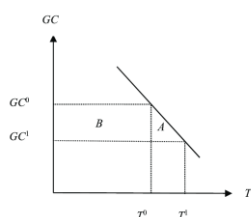
Table 35: Estimated Passenger Benefits

| Item | Hours | Taka | USD |
|-----------------------------|---------------------|-------------------|-------------------|
| Time savings, daily | 256,536 | 7.7 crore | \$0.7m USD |
| Time savings, annual | 76.7 million | 2300 crore | \$210m USD |
| Time savings, 10-year | 769 million | 23000 crore | \$2.1b USD |

GHG Reductions

- 7.5 The above-described benefits may result in a reduction in Greenhouse Gases (GHGs). Specifically, GHG reductions may come from (1) a modal shift, that is, people who previously used fossil fuel powered private vehicles will instead switch to public transport, thus reducing the overall vehicle-kilometres travelled (VKT) in the region and consequently the amount of fuel burned, which in turn produces GHGs. And (2) a reduction in operating miles due to an increase in operating efficiency (and therefore fuel burn).
- 7.6 These equations involve numerous assumptions, due to a lack of overall data in the Dhaka area. In this report, the focus was on technical specifications rather than on an obtaining

⁷ Where total benefits (B) = savings/user * # existing Users + 1/2 * savings/user * # new users. The Rule of half is a commonly-employed approximation for the integral of the demand curve which is used to determine the change of **consumer surplus** (and therefore user-benefits).



accurate ridership data. Estimating actual usage of the transport network in Dhaka has never been done and would be a tremendously large and arduous undertaking requiring perhaps years of work and huge budget. In this desktop-based project, we could accurately estimate daily ridership and therefore use a commonly accepted assumption, based on available literature. Please refer to the existing conditions report.

7.7 The equations and assumptions are shown below. The baseline for the country of Bangladesh in 2021 was 169.05 MTonnes CO₂e of which 17 MTonnes CO₂e are from transport. Bangladesh’s forecasted transport reductions were determined to be 32.89 MTonnes CO₂e in the conditional scenario⁸.

Equation Set 2 (calculate change in demand)

$$T_{ave} = \frac{L_{ave}}{Speed_{ave}} * 60$$

$$\Delta D = E * \frac{S}{T_{ave}} * D_u$$

$$CO2_e(\text{kg}) = \left(\left(\frac{L_{ave}/100 * MC_{mc}}{OCC_{mc}} * FE_{mc} \right) + \left(\frac{L_{ave}/100 * MC_{car}}{OCC_{car}} * FE_{car} \right) \right) * \Delta D * CE$$

Table 36: Assumptions for GHG Reductions (Passenger)

| Description | | Value | Unit | Source |
|---|-------------------|-----------|--|--|
| Perceived travel time savings for a presence of Bus Information System (RTPI) | S | -2.52 | Minutes/pax | De Gruyter, 2018 Link |
| Value of time, middle income, Dhaka | VOT | ~300 | Taka/hour | Rahman et al. Link |
| Average trip length | Lave | 5.6 | Km | 2035 Structure Plan for Dhaka (RDP) (2015 value) |
| Existing demand | D _u | 6,000,000 | Daily passengers | 2035 Structure Plan for Dhaka (RDP) (2015 value) |
| Average road speed of buses in Dhaka | Speed | 8 | Km/hr | 2035 Structure Plan for Dhaka (RDP) (2015 value) & Google Maps API |
| Ave trip time | Tave | Varies | Minutes | Calculated |
| Elasticity of demand (time WRT demand) | E | -0.06 | % change in travel time/% change in demand | Reported elasticity for Jakarta, Indonesia |
| Change in demand | ΔD | Varies | people | Calculated |
| Occupancy, motorcycle | OCC _{mc} | 1.5 | people | Assumption based on similar cities |

⁸ https://unfccc.int/sites/default/files/NDC/2022-06/NDC_submission_20210826revised.pdf

| Description | | Value | Unit | Source |
|----------------------------------|--------------------|------------|---|--|
| Occupancy, car | OCC _{car} | 2.2 | people | Assumption based on similar cities |
| Fuel economy motorcycle | FE _{MC} | 1.76 | L gas/100 km | Global Fuel Economy Initiative (2022), for Vietnam |
| Fuel economy light vehicle (car) | FE _{car} | 12.1 | L gas/100 km | South Korean government target for average fuel economy, light vehicle |
| Mode choice car | MC _{car} | 7.5% (75%) | Portion of all journeys (portion of motorized journeys) | 2035 Structure Plan for Dhaka estimates |
| Mode choice motorcycle | MC _{mc} | 2.5% (25%) | Portion of all journeys (portion of motorized journeys) | 2035 Structure Plan for Dhaka estimates |
| Carbon equivalent of gasoline | CE | 2.32 | Kg CO ₂ / L gas | U.S. Energy Information Administration |

Equation Set 3 (calculate operation savings in demand)

$$Op\ Savings = Red * Op_{hours} * Speed$$

$$CO2_e(kg) = \frac{Red}{100} * FE_{bus} * CE_d$$

Table 37: Assumptions for GHG Reductions (Operation)

| Description | | Value | Unit | Source |
|---|---------------------|------------|-------------------------------|--|
| Reduction in operation distance from BMS | Red. | 10% | % of distance | De Gruyter, 2018 Link |
| Total daily operation hours | Op _{hours} | 60,291 | hours | 2023 GTFS Database |
| Average road speed of buses in Dhaka | Speed | 8 | Km/hr | 2035 Structure Plan for Dhaka (RDP) (2015 value) & Google Maps API |
| Total daily operation distance | Op _{dist} | Calculated | Km | Calculated |
| Fuel economy bus | FE _{bus} | 24 | L diesel/100 km | Global Fuel Economy Initiative |
| Carbon equivalent of diesel | CE _d | 2.68 | Kg CO ₂ / L diesel | U.S. Energy Information Administration |

Results of GHG Reductions

- 7.8 The total GHG reductions are summarized in the table below. Total GHG reductions could amount to just over 200 tonnes of CO₂e per **day** of operation.

Table 38: Results of GHG Reductions

| Description | Daily | | Annual | | 10-Year Total* | |
|------------------------------------|------------|-------------------------------|---------------|-------------------------------|----------------|-----------------------------------|
| Reductions from passenger activity | 180 | <i>Tonnes CO₂e</i> | 54,000 | <i>Tonnes CO₂e</i> | 0.54 | <i>MegaTonnes CO₂e</i> |
| Reductions from operator activity | 30 | <i>Tonnes CO₂e</i> | 9,000 | <i>Tonnes CO₂e</i> | 0.09 | <i>MegaTonnes CO₂e</i> |
| Total | 210 | <i>Tonnes CO₂e</i> | 63,000 | <i>Tonnes CO₂e</i> | 0.63 | <i>MegaTonnes CO₂e</i> |

- 7.9 Total reductions could amount to 63,000 tonnes annually or 0.63 MTonnes CO₂e over a 10 - year period. This could account for approximately 1.9% of the required total 32.89 MTonne CO₂e (conditional) reduction in emissions from transport identified as NDC.

8 Recommendations & Conclusions

8.1 In this section, we will review the requirements for the proposed BIMS system and let the reader know of the steps that first must be taken if such as system is to be implemented.

Preliminary Requirements

8.2 BIMS systems can be used most effectively under the specific circumstances. If these requirements are not met, investment in BIMS is not warranted.

8.3 While buses can be tracked and displayed on a map, for example, how BRTC’s current system works, to unlock enormously more benefits, a proper bus system must be established and respected with bus stops exclusively being used and routes clearly numbered in a logical way.

Table 39: Basic Requirements for BIMS to be Implemented

| Item | Requirement | Dhaka |
|--------------------------------------|---|----------------|
| Governance/planning | Managed by central authority | No |
| Operator(s) | Monopoly (1 operator) or managed by central authority | No |
| Bus stops | Numbered, established at regular intervals, stopping outside of bus stops is prohibited | No |
| Bus routes | Numbered and standardized, assigned | Reform ongoing |
| Vehicle | Relatively modern, with OBD-II port available | Mostly |
| Electrical infrastructure (for BITs) | Available either underground or overhead | Yes |
| Communications network | 100% coverage | Yes |

8.4 While Dhaka’s electrical and communications infrastructure is adequate, as of today, Dhaka does not fully meet the criteria for governance, operators, and bus stops. However, with political support, BIMS can be one tool which is used to reform a bus system and eventually meet the above criteria.

8.5 It is especially critical that a central overarching management authority be established. Individual operators cannot be expected to purchase, manage, and use the BIMS system on their own. BIMS systems can and are used in situations where there are multiple private operators, but always with a central management authority in place.

8.6 It is equally critical that bus stops be established and used exclusively to pick up passengers. Without bus stops, any BITs or online information becomes useless and nonsensical.

8.7 Finally, it is critical that buses assigned to specific routes and only operate on those routes when their dispatch (assigned by central dispatch) matches their vehicle. Otherwise, the dispatch system will not be useful.

Scenarios / Geography

8.8 To develop scenarios, we assume that all the above-described preliminary requirements are satisfied. Our other basic assumptions are as follows:

- There are at least 7000 vehicles in the Greater Dhaka area now, but in the future, there will be 4500 vehicles operating on 42 routes in the Greater Dhaka area (by 2030).
- There will be 42 routes operating on six different clusters.
- There will be around 74 (150 bidirectional) bus stops in the urban core of Dhaka in the future. However, some bus stops may be added and some stops will require more than one BIT, **so we assume a full rollout of 200 BITs.**

8.9 For the Dhaka case, we recommend two potential pilot projects and three further options for system roll out to cover a total of an estimated 7,000 buses and 150 (bi-directional) bus stops.

Table 40: Implementation Scenarios

| | Description | Vehicles | BITs | Kiosks |
|-----------------|--|----------|------|--------|
| Pilot A | Pilot project – BRT Corridor 340 vehicles 50 stops (BRT system only) Online system established with GTFS-RT | 340 | 50 | 0 |
| Pilot B | Begum Rokeya Corridor | | 25 | 0 |
| Pilot Expansion | Pilot Expansion Green cluster routes and buses BITs on BRT system + Begum Rokeya corridor Online system established with GTFS-RT | ~850 | 74 | 0 |
| Full Rollout | All buses covered. BITs at all planned stops (200 total) Online system established with GTFS-RT | 7700 | 200 | 20 |

* Not recommended

Pilot Projects and System Expansion

8.10 We recommend the project be undertaken in two parts: BMS and later the BIS. BMS is arguably more important than BIS since it can lead to enormous increases in efficiency.

Table 41: System Expansion Timeline

| | | 2024 | 2025 | 2026 | 2027 | 2028 | 2029 | 2030 |
|------|----------------------|------|-------|------|------|------|------|------|
| BMS: | Management center | | | | | | | |
| | Initial 340 Vehicles | | Pilot | | | | | |
| | Green cluster | | | | | | | |
| | Other clusters | | | | | | | |
| BIS: | Online with GTFS-RT | | | | | | | |

| | | 2024 | 2025 | 2026 | 2027 | 2028 | 2029 | 2030 |
|--|---------------------------------|------|------|-------|------|------|------|------|
| | BRT corridor (50 BITs) | | | | | | | |
| | Begum Rokeya Corridor (36 BITs) | | | Pilot | | | | |
| | Additional corridors | | | | | | | |
| | Kiosks at major terminals | | | | | | | |

8.11 Scenario 3, which would involve a BMS system with only an online system in use for bus information provision (i.e. no BITs) is not recommended for Dhaka. While SmartPhones are becoming very popular and common and data is cheap, there remains a large portion of captive bus riders who do not have a SmartPhone, especially older people, or women. This would create an unjust inequity in information provision; therefore, we cannot recommend that BITs are not used.

Bus Management System (BMS)

8.12 BMS can be established sooner than BIS. Currently, there is an ongoing order from the BRTC for 340 electric buses from Korea, which is supported partially through loans from the Korean EDCF. This gives a good opportunity to start install on these brand new and modern buses, which will undoubtedly be compatible with Korean-manufactured OBUs.

8.13 We recommend that the BMS center be established in 2024/2025 and the order of 340 electric buses from Korea be the first to have OBUs installed. System can be scaled from there starting with the green cluster⁹.

Bus Information System (BIS)

8.14 Firstly, the GTFS-RT database should be built and maintained as soon as the BMS system is operational, regardless of any corridor. While initially only covering a small portion of routes, the BMS will be expanded later.

8.15 A pilot project should first be undertaken for BIT installation, across a small area. We recommend the following two corridors for BIT installation/pilot projects:

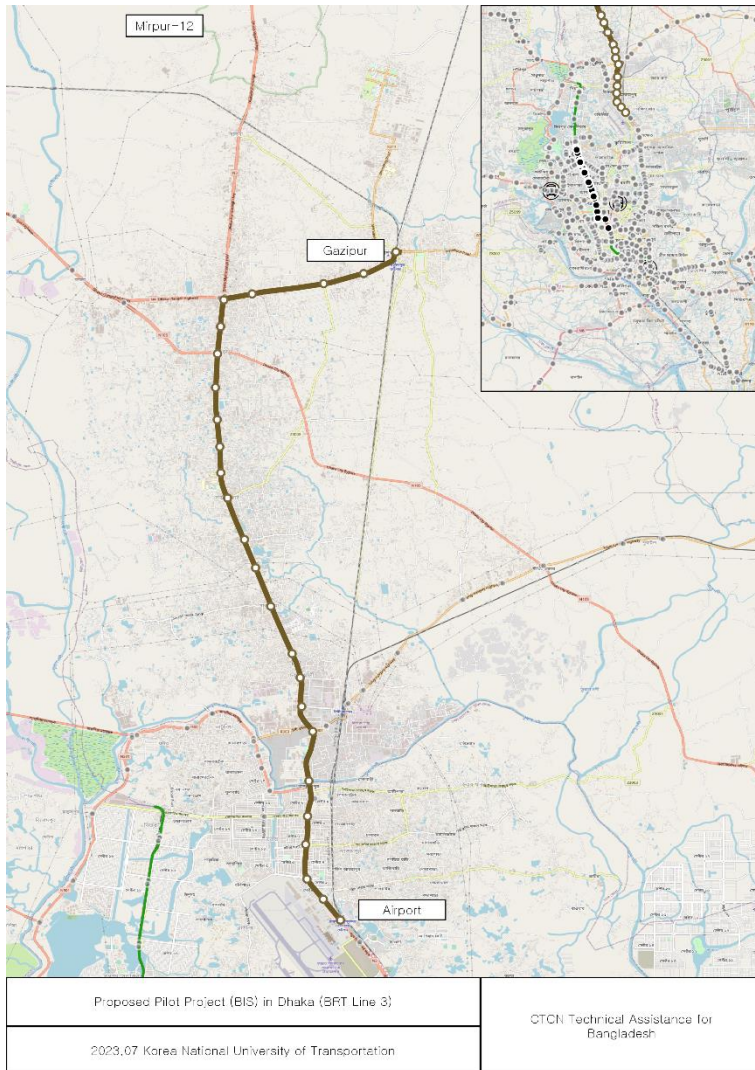
- **Pilot A:** BRT Line 3 Corridor (20 kilometres).
 - **Requires 50 BITs** (one BIT per direction per BRT station)
- **Pilot B:** Begum Rokeya Avenue corridor, between Mirpur-12 and Bangla Motors (about 10 kilometres).
 - **Requires 25 BITs** (one BIT per direction per stop)
 - This corridor exactly correlates with the existing MRT Line 6 and will have at least four

BRT Line 3 Corridor

8.16 The BRT (Line 3) corridor makes an excellent project to test and implement a full-service BIS. Most modern BRT systems include BIS and BITs. Further, the BRT corridor should be equipped with good infrastructure and utilities which should make BIT installation simple. The BRT

⁹ Actual ridership values are not available in Dhaka, especially no by bus stop. However, green cluster is likely to be the busiest, based on the analysis of the existing bus schedules (based on supply rather than demand)

corridor is expected to be operation in 2024, or potentially later. BRT Line3 corridor is depicted below.



Begum Rokeya Avenue Corridor

- 8.17 This corridor is also the candidate for the Integrated Corridor Management (ICM) intervention project, which is being undertaken by the Dhaka North City Corporation¹⁰. DNCC aims to move all wired utilities, including electrical, underground under this project by 2026 with \$150 million USD funding from the World Bank, which is a realistic time frame for a pilot project in Dhaka. The corridor is shown below. Having underground utilities makes the installation of BITs significantly easier and cheaper.

¹⁰ http://www.dncc.gov.bd/sites/default/files/files/dncc.portal.gov.bd/tenders/bf7ab5e0_9773_49af_9948_bf0cd3de58b5/2022-07-27-10-31-d95c344b8c4e90028eedcb83858d4bd7.pdf

Figure 41: Begum Rokeya Pilot Project Corridor



Project Total Costs

- 8.18 The total costs for the project will vary, depending on the options chosen. The table below summarizes the costs and options for full rollout and two different pilot projects. A 20% contingency is applied to develop ranges.

Table 42: Summary of Project Costs

| Cost (\$ USD) | |
|--|----------------------------|
| Full Rollout (7000 buses, 200 BITs) | |
| Management center* includes software | \$3.6-4.3 million |
| On-board equipment | \$22.9-27.4 million |
| Bus stop equipment | \$2.4-2.8 million |
| Total | \$28.8-34.6 million |
| Annual expenses | \$0.13 million |
| Annual maintenance | \$1.16 million |
| Pilot A (BRT Corridor) | |
| Management center * includes software | \$3.6-4.3 million |
| On-board equipment | \$1.0-1.2 million |
| Bus stop equipment | \$0.6-0.7 million |
| Total | \$5.2-6.2 million |
| Annual expense | \$0.12 million |
| Annual maintenance | \$0.08 million |
| Pilot B (Begum Rokeya Corridor) | |
| Management center * includes software | \$3.6-4.3 million |
| On-board equipment | \$1.5-1.8 million |
| Bus stop equipment | \$0.3-0.4 million |
| Total | \$5.4-6.5 million |
| Annual expense | \$0.12 million |
| Annual maintenance | \$0.08 million |

Information Provision

- 8.19 We recommend that a combination of online information (by creating and maintaining open data using the GTFS-RT and GTFS standards) and physical location information (BITs installed at stops) be used.
- 8.20 **Online information** will follow the GTFS standard and include routing, route numbers, scheduled times, difference from scheduled time (i.e., real-time information) and travel times. Schedules will be based on route numbers and bus stops which have been established, standardized, and exclusively used for passenger pick up and drop off.
- 8.21 **Physical location time** (at BITs) will consist of bus route, bus number, estimated time of arrival, current time, system announcements, and system alerts.

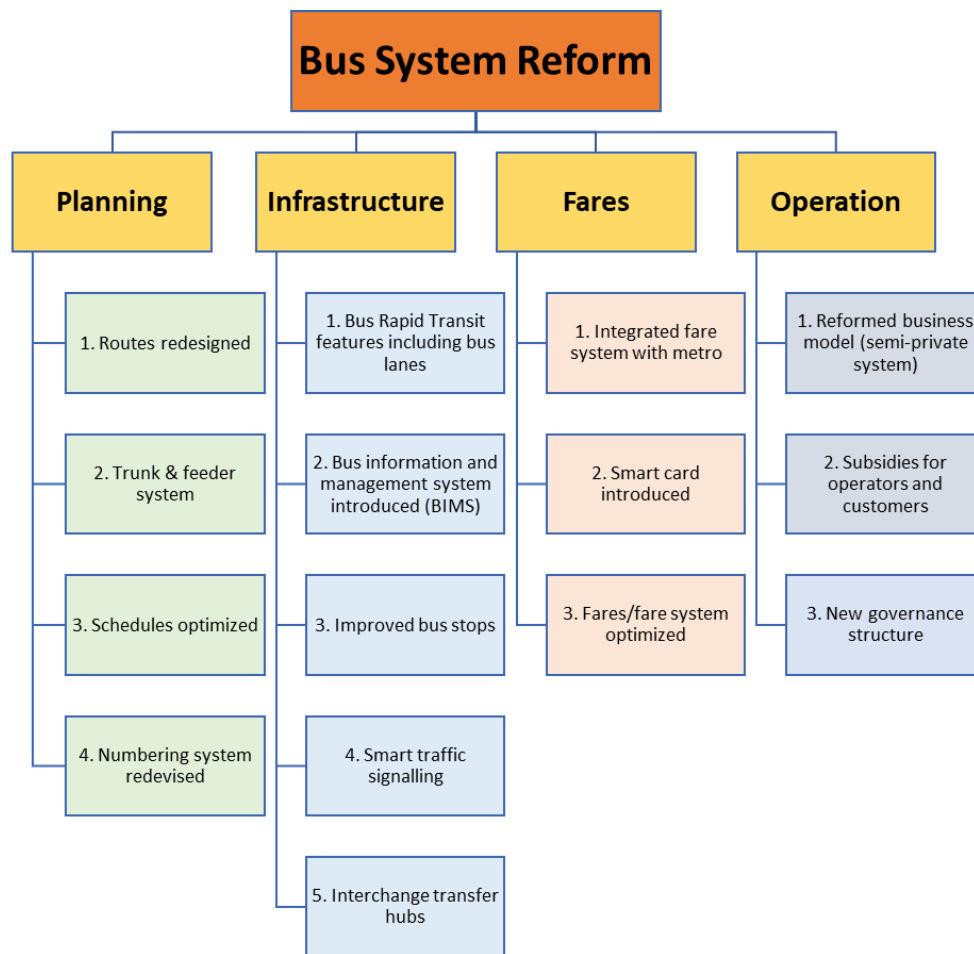
Governance & Lessons from Korea

- 8.22 As of now, it is unclear which organization should be responsible for investing in, supporting, and operating the proposed system. Under the current system in Dhaka, where almost all buses are run private operators, we believe **there will be a very low probability of successfully implementing this proposed system which requires oversight from a central governing authority.** We believe that there are no examples in the world of a common BIMS system being used by a variety of private operators, without a clear governing authority, as is the case in Dhaka. In Seoul for example, private operators of buses are used but they are overseen by a central authority which also controls, funds, and monitors the BIMS.
- 8.23 The most logical entity for this role is currently the DTCA. As the leader in the ongoing efforts to reform the public transport system in Dhaka, they are the best positioned to correctly implement this technology tool, which has proven to be one critical for successful bus reform. The ongoing efforts to reform the public transport system in Dhaka **MUST be completed before a city-wide BIMS system is implemented.**

Korean Case

- 8.24 The Seoul bus reform of 2003-2004 is viewed as a crucial move to help Seoul maintain its competitive advantage and address the growing challenges it faced. This overhaul was driven by Mayor Lee Myung-Bak, who later became the President of South Korea before his eventual arrest and imprisonment. The Seoul Metropolitan Government initiated a broad array of reforms across the entire public transportation system in response to a mounting financial crisis, rising citizen dissatisfaction, and increasing subsidies for bus operations. These reforms encompassed a complete revamp of bus operations, the introduction of the first Bus Rapid Transit (BRT) corridors, enhanced coordination between bus and metro services, improvements in the quality of the bus fleet, the incorporation of natural gas (CNG) buses to enhance air quality, and the establishment of a fully integrated fare structure and ticketing system that spanned routes and modes, and crucially, the introduction of the BIM for operations and passenger convenience. The reforms in Seoul led to improvements to traffic safety, bus speed, operating expenses, passenger volume, and overall customer satisfaction. The bus reform was multi-faceted, see Figure 42 below.

Figure 42: Seoul Bus Reform Overview



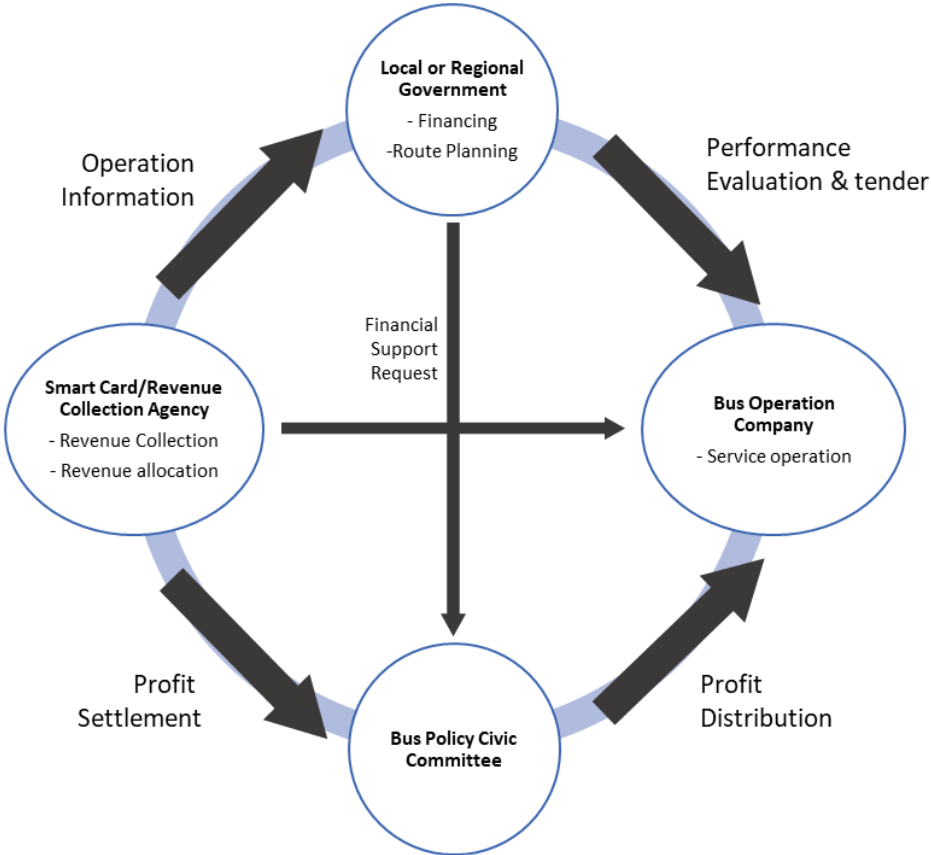
8.25 This comprehensive reform approach commenced with the bus sector but extended to encompass institutional and organizational modifications in transportation, innovative technological advancements, and infrastructure development, although not all these aspects are explored in depth within this paper. Seoul stands out as one of the few cities to have executed such an all-encompassing bus reform, which included changes in institutional frameworks, major operational system adjustments, infrastructure construction, and the introduction of integrated electronic ticketing, and implemented other ITS features, all within a relatively brief timeframe.

8.26 Pre-reform, Seoul had an almost 100% privately operated and managed bus system which was inefficient and unsafe. Post-reform, Seoul moved to a “semi-private system” of operation and governance meaning that private operators (bus companies) are used to run the services, but they are strictly controlled by a central authority (in this case, the Seoul Metropolitan Government). The system is depicted in the figure below.

8.27 Individual bus companies are not involved with fare collection since they do not control or are not even involved with the fare media collection (an RFID card system). Instead, the third party collects and pools revenues from all operators for all routes across the system. Revenue is distributed evenly, and in the case of Seoul, the central government provides subsidies to the bus operation companies to ensure profitability. Bus companies can increase their overall share of profit compared to other operators by a small amount by performing well including

not engaging in dangerous driving. The BIMS allows tracking of vehicles and gathering other data, such as acceleration, which allows the creation of performance measures used in this process.

Figure 43: Operation Scheme for Semi-Private System (Seoul)



| Pre-Reform | Post-Reform |
|--|---|
| Bus operator fare revenue depends on passengers picked up | Local government pools revenues from all operators and provides subsidies in case of losses |
| Bus operators compete with other companies for customers and drive recklessly | Bus operators are paid on service provided rather than passengers and are penalized for dangerous driving |
| Operators prefer busy routes and avoid routes they perceive to not be profitable | Routes are managed by the local government exclusively |

BIMS in the Bus Reform and Governance

8.28 In case of Korea BIMS systems have been constructed and managed by local governments initially (Seoul Metropolitan Government). However, the Seoul BIMS is now being developed with the central government initiative as administrative boundaries are often blurred in many cases, and the same systems have been exported country-wide. Consequently, funding also has been provided by the central governments partially. In the recent example of the Korea

Gongju-Sejong integrated BIMS, the central government provided 80% of the cost while local government provided 20%. This policy case could be replicated in Dhaka.

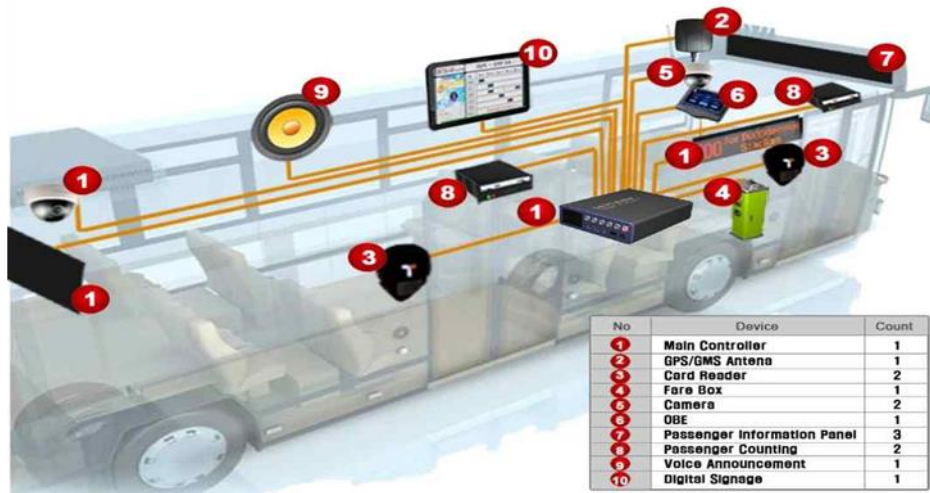
- 8.29 As previously discussed, considering the intertwined nature of bus networks in Dhaka, a central authority or institution is essential for providing and managing a comprehensive BIMS system. Central government intervention can also be justified due to the benefits resulting from BIS including user convenience, reduced energy consumption and environmental benefits as BIS increases competitiveness of environmentally friendly mode of public transit.

Appendix A: Integrated Terminals

Integrated Terminals

- 8.30 Vehicle Design is relevant to BMS and e-Ticketing, consists of ten systems in total and will be installed in 1,100 buses running BRT corridor and downtown section.

Figure 44: Vehicle-based ITS Equipment




- 8.31 Integrated controller collects operation/status information inside bus such as driver console, card reader, CCTV, destination indicator, passenger announcement terminal etc. and transmits to BMS centre.
- 8.32 Also, it shall stably communicate with centre through external Dual Band modem, collect GPS
- 8.33 location information through WGS84 coordinate system and renew location information per second through NEMA Protocol.

CCTV

It is installed rear/front side and inside of vehicle to monitor passengers, accidents, driving behavior etc.


Table 43: CCTV Minimum Specifications

| Image | Minimum Specification | |
|---|-----------------------|----------------------------|
|  | input | NTSC, PAL |
| | Video input | Max 4ch |
| | resolution | Over 720*480 |
| | compression | H.264, MPEG4, MJPEG etc |
| | recording | Any time |
| | search | time/date, calendar, event |
| | power | 10~40v |

LED Destination Indicator

- 8.34 LED destination indicator is a device which displays bus information through LED (Light Emitting Diode) on the top of bus so that users can easily recognize bus number and destination from long distance. Destination display method installed more than 80% of city buses operating in Addis Ababa city due to difficulty in recognition due to low visibility in case of bad weather and night as it displays only fixed English
- 8.35 An LED destination indicator is a highly responded system as users can easily recognize bus information such as route number, destination, first/final station etc. Also, it can help foreign tourists use buses as it can present English complying with internationalization rambled destination indicator shall present data on screen received from integrated terminal.
- 8.36 The requirements for LED destination indicator are as below. It should be manufactured to normally operate under -40~40°C environment, and to prevent malfunction by vibration and shock caused during operation. It should provide stable power against unstable voltage change of bus, and should provide power consistently during operation. Rear LED destination indicator shall display bus information through electricity and communication wiring Light Emitting Diode (LED) of letter display unit shall use red and green, viewing angle of LED shall be ±60°C horizontal, ±30°C vertical using wide angle LED.

Table 44: LED Indicator Specifications

| Image | Minimum Specifications |
|---|---|
| | External front : LED 128mm 2Line 12 Row External side : LED 96mm 2Line 10 Row Internal front : LED 64mm 2Line 8 Row |
|  | Voltage : 24VDC(17~32VDC) Data communication : RS 485 or IBIS standard EMC : 89/336/EEC, CE and e mark Temperature range : -25 to +70 oC Relative humidity : <95% RH at+40 oC |

<LED destination indicator Specifications> Source: Mobicom Corporation(Sweden)


Digital Signage (passenger information)

- 8.37 This is a kind of PIS (Passenger Information System) which provides various information related to passenger movement. It can promote improvement of user convenience and internal environment by presenting bus use information (ETA etc.) through digital medium, LCD

Figure 45: Digital Signage for Bus Passenger Examples



Table 45: Digital Signage for Passenger Specifications


| Image | Specifications |
|---|--|
|  | <p>Operating voltage : 24VDC(18~32VDC) Operating temperature : -20~ 30o Lifetime : CCFL backlight : approx. 10,000hours Interfaces : Standard- IBIS, RS 485, ISB, stop signal, Ethernet, RS232 Editing software : Mobitec Content Editor Display : 19", 16:9, 1366x 768 Brightness : min 500cd/m2 Operating system : LINUX Data formats : MPEG, MOV, AVI, BMP, JPG, PNG, GIF</p> |

Bus Speakers

- 8.38 This device announces, connected with integrated terminal, arriving bus stop and next stop. And, also, it provides public announcement and other announcement stored in integrated terminal.

- 8.39 - Speaker should be located considering bus size and offer optimum sound.
- 8.40 - It is installed in order to announce received from integrated terminal, over ip-65 is recommended.
- 8.41 - It should be installed to prevent howling and sound quality decline considering bus environment.
- 8.42 - Product suitable for bus size, considering bus environment, should be selected and proposed, and the most suitable audio system for project size should be constructed.
- 8.43 - It should be installed to deliver sound evenly inside shelter

Table 46: Loudspeaker for Bus Passengers Specifications

| Image | Specifications |
|---|--|
|  | Impedance : 4Ω Sensitivity : 91DB Normal power : 100w Max power : 200w Frequency : 45hz -20khz Audio coil : 25mm asv Magnet : 38oz |

Source: FI-Pk(china)<Bus speaker Specifications>

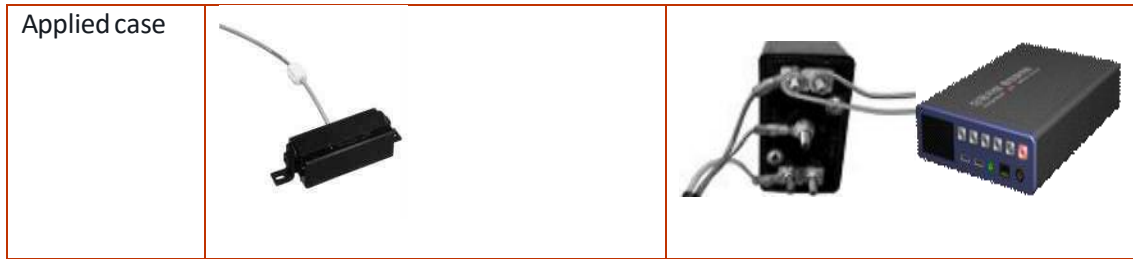
Source: Cube(Korea)

Door Sensor

- 8.44 There are two check methods for door open/close. One is to install individual door sensor and the other is to link with existing door open/close switch. After reviewing both methods, team designed to check door open/close through link with existing door open/close switch.

Table 47: Door Sensor Specifications

| Division | Door sensor installation | Door switch link |
|----------|---|--|
| Method | Install physical sensor to check door open/close | Check using contact signal of switch |
| Merit | No need to link with electric devices of bus | Voluntary measure about malfunction by company Wiring simplification by direct connect from switch(shorten process) |
| Demerit | Additional maintenance is needed in case of malfunction | Circuit for signal input/interpretation is should be configured at terminal |



CCTV

- 8.45 CCTV is installed to ensure perfect security system and safe space within shelter. CCTV can be classified into shooting part and control part. Shooting part consists of camera, lens, housing, pan/tilt etc., stability, durability, maintenance suitability is considered. Control part receives control signal and conducts control function of lens, pan/tilt, and camera. Proposal team considered passenger safety within shelter, easiness of maintenance and climate of Addis Ababa, and recommend PTZ(Pan Tilt Zoom) camera which can support pan/tilt/zoom and provide not only wide range surveillance but excellent detail video footage in case of zoom in.
- 8.46 PTZ camera has two motors for Pan(horizontal) and Tilt(vertical) except motor for Zoom, Focus and Iris. It is a characteristics of PTZ camera to rotate camera fast, silently, smoothly and accurately using these two motors. Also, it is capable of 360degree rotation while sending signals such as communication, video, power etc. without noise and distortion.

Table 48: CCTV Specifications

| Division | Specifications |
|---|--|
|  | <p>Image pickup device : 1/4" color EX-View PS CCD, 410,000 pixel Total pixel 811(H)*508(V) Horizontal resolution over 600TV, minimum brightness 0,0001 Lux Max 37 times zoom camera(f3.5 ~ 129.5mm) SSNR(noise remove), 126X WDR wide backlight adjustment IP level : IP66 Power consumption : Max.60W size(WxHxD) : 248(Ø) X 316.5(H)mm remote control : RS-485, COAXIAL CONTROL temperature/humidity : -50~+50/ under 90% RH</p> |

Control Information

| | |
|--|---|
| Prepared by | Prepared for |
| KNUT Daehak-ro 50, Chungju-si, Chungcheongbuk-do Republic of Korea | Korea National University of Transportation (KNUT) Population and Health Building, E/16, Paribesh Bhavan, Sayed Mahbub Morshed Rd, Dhaka 1207 |
| Author/originator | Reviewer/approver |
| Devon Farmer | Hyun Kim |
| Other contributors | Distribution |
| | |
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