CTCN Technical Assistance
December 2023

Planning the Urban Public Transport System in Vientiane, Lao PDR (CTCN Technical Assistance)

Feasibility Studies Final Report

Korea National University of Transportation (KNUT)

CTCN Technical Assistance
December 2023

Planning the Urban Public Transport System in Vientiane, Lao PDR (CTCN Technical Assistance)

Feasibility Studies Final Report

CTCN Ref: Technical Capacity Enhancement for Planning Urban Public Transport System in Vientiane, Lao PDR

Prepared by:

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

Prepared for:

Korea National University of Transportation (KNUT)

Lan Xang Avenue, Vientiane Capital, Lao PDR

Contents

Figures

Tables

Executive Summary

Project Objective and Scope

This Project is a Technical Assistance (TA) pro bono modality project facilitated by the UN Climate Technology Centre & network (CTCN) and funded by the Korean National Research Foundation (NRF) and is entitled: **Technical Capacity Enhancement for Planning Urban Public Transport System in Vientiane, Lao PDR.**

The main objective of the TA is to provide the Lao PDR assistance in planning their future urban public transport network including the use of advanced technologies (ITS) and enable knowledge transfer from Korea.

1. **Urban Public Transport Network for Vientiane**: Review of the ongoing plan for the urban public transport network in Vientiane. Based on previous studies, network planning concepts, and experience in Korea, review the network concepts and proposed policies and provide additional commentary and recommendations. The special focus will be paid the BRT expansion plans.
2. **Smart Public Transport**: Develop conceptual scenarios for Smart Public Transport, with a focus on ITS solutions including:
    - Electronic payment cards (T-money)
    - Bus management systems (real-time tracking of buses)
    - Bus information systems to provide real-time information and predicted arrival times of buses including physical terminals, web-based, app-based, and third-party data
    - Data management center (TOPIS), big data tracking of public transport data
    - Real-time road condition monitoring (used by the data management center)
    - Third-party data sharing (Kakao, Naver, Google, etc.)
    - Smart bus stops
    - Demand-Responsive Transit (DRT)
    - Autonomous vehicle shuttles (AV)
    - Mobility as a Service (MaaS) Applications
    - Taxi-hailing
    - Wi-Fi on buses
    - CCTV

    i. Pre-Feasibility Study for One Intervention (e.g. DRT): Choose and implement a pilot project based on one of the short or medium-term interventions developed in the above studies

3. **Capacity Enhancement for Lao PDR Urban Public Transport:** Strengthening the capacity of the Lao PDR to undertake public transport projects including planning and operations (focus on BRT

Purpose of this Report

This report details a review of the proposed future public transport network for Vientiane. It can be considered a peer review of the works undertaken. This report is divided into the following Chapters:

1. Introduction
2. Summary of Other Works
3. Baseline/Existing Conditions

4. Review of the Vientiane Transport Master Plan (JICA)
5. Recommendations for Changes to the VTMP
6. Smart Transport Scenarios
7. Pre-Feasibility Study

1 Introduction

Project Details and Objective

1.1 This Project is a Technical Assistance (TA) under the pro bono modality project facilitated by the UN Climate Technology Centre & Network (CTCN) and funded by the Korean National Research Foundation (NRF) and it is entitled: Technical Capacity Enhancement for Planning Urban Public Transport System in Vientiane, Lao PDR.

Overview

1.2 This project is being undertaken in the capital city of the Lao People's Democratic Republic (Lao PDR), Vientiane. While Vientiane has slower population growth than other Asian metropolitan cities such as Bangkok, Jakarta, and Manila and does not yet suffer from the chronic large-scale traffic congestion that affect huge cities, for a city of its size it is developing more traffic issues and there is an increasing trend of more fossil-fuel-based private car ownership. The Lao PDR has ambitions targets related to Greenhouse Gas (GHG) emissions and will need to see large-scale reductions in GHG emissions across all sectors, including transport.

1.3 Much has been done in the way of planning the transport network in Vientiane over the last few years, especially on the development of a Bus Rapid Transit (BRT) system first proposed by the Japan International Cooperation Agency (JICA) and developed by the Asian Development Bank (ADB). This BRT project will benefit the people of Vientiane and will importantly help the Lao PDR on its quest to achieve its goals of reducing GHG emissions from transport by targeting a switch from privately operated, fossil-fuel based, transport modes to more environmentally friendly and efficient high-capacity electric buses.

1.4 The Lao PDR cannot currently complete transport-related studies including their detailed planning, feasibility studies, financial arrangements, and institutional arrangements for planning and operation of a modern public transport system. As such, the Lao PDR requested Technical Assistance (TA) for planning their future public transport system through the United Nations (UN) Climate Technology Centre and Network (CTCN) program which "provides technology solutions, capacity building and advice on policy, legal and regulatory frameworks tailored to the needs of individual countries by harnessing the expertise of a global network of technology companies and institutions.[1]"

Objective

1.5 The urban public transport system best suitable to Vientiane Capital with the projected population growth and increased visitors (tourists) will be planned, surveyed, assessed, and implemented, based on the enhanced capacity for the urban public transport system

[1] https://www.ctc-n.org/

development in Lao PDR. Based on this, GHG emission reduction in the transport sector will be achieved by promoting a modal shift from private vehicle-based land transportation using fossil fuels (gasoline and/or diesel) to an urban public transport system (potentially mass passenger transport mode). In addition, traffic accidents due to heavy dependency upon private vehicle-based road transportation could be decreased, and air quality could be improved, to contribute to the security of human health and lives and the conservation of tourism resources in Vientiane the historic city.

1.6 The details of the steps of The Project are as follows:

1. **Urban Public Transport Network for Vientiane**: Review of the ongoing plan for the urban public transport network in Vientiane. Based on previous studies, network planning concepts, and experience in Korea, review the network concepts and proposed policies and provide additional commentary and recommendations. The special focus will be paid the BRT expansion plans.
2. **Smart Public Transport**: Develop conceptual scenarios for Smart Public Transport, with a focus on ITS solutions including:
    - Electronic payment cards
    - Bus management systems (real-time tracking of buses)
    - Bus information systems to provide real-time information and predicted arrival times of buses including physical terminals, web-based, app-based, and third-party data
    - Data management center (TOPIS), big data tracking of public transport data
    - Real-time road condition monitoring (used by the data management centre)
    - Third-party data sharing (Kakao, Naver, Google, etc.)
    - Smart bus stops
    - Demand-Responsive Transit (DRT)
    - Autonomous vehicle shuttles (AV)
    - Mobility as a Service (MaaS) Applications
    - Taxi-hailing
    - Wi-Fi on buses
    - CCTV

    i. Pre-Feasibility Study for One Intervention (e.g. DRT): Choose and implement a pilot project based on one of the short or medium-term interventions developed in the above studies

3. **Capacity Enhancement for Urban Public Transport:** Strengthening the capacity of the Lao PDR to undertake public transport projects including planning and operations (focus on BRT, DRT, and bus reform.)

Outcomes

1.7 Upon completion of this TA, the Lao PDR can focus on implementing public transportation service improvement projects that apply information and communication technology (ICT), modern transport planning standards, and modern administration based on knowledge transfer from Korea. This will allow them to cope with their increasing traffic congestion and air pollution problems, set-up expanded BRT, BIMS (Bus Information and Management System), or DRT and, as a result, improve the public transportation mode share.

1.8 As part of this TA, we will also identify funding opportunities and develop a pre-feasibility study for one intervention, to be determined during this study. This TA will also identify the

GHG emission reduction potential of several identified public transport network types, and the GHG emissions reduction potential of the chosen pre-feasibility study intervention. As such, this TA will aid the Lao PDR in understanding how its investment will aid in their NDCs and other goals, such as their goal of becoming a net zero country by 2050.

This Report

1.9 JICA in coordination with Katahira & Engineer International, International Development Center of Japan Inc., and Oriental Consultants Global, has been undertaking the Vientiane Transport Master Plan Project (VTMP). This project kicked off in June 2019 and is ongoing. The scheduled end date is December 2022. The VTMP covers all transport modes (road, public transport, taxi, private vehicles, urban rail etc.

1.10 This report details a review of the above-described proposed future public transport network for Vientiane. It can be considered a peer review of the works undertaken.

1.11 This report is divided into the following Chapters:

1. Introduction
2. Summary of Other Works
3. Baseline/Existing Conditions
4. Review of the VTMP
5. Recommendations

Vientiane, Capital of the Lao People's Democratic Republic (PDR)

General Overview

1.12 The sovereign state of the Lao People's Democratic Republic (Lao PDR) has a long history dating back to at least 1353 with the establishment of the Lan Xang Hom Khao (Lan Xang kingdom). Laos most recently achieved its independence from France in 1953, with the Kingdom of Laos transitioning into the modern Socialist Republic upon abolishment of the Royal Lao Government in 1975. A landlocked country located in Southeast Asia; the population of the Lao PDR is currently estimated to be around 7.3m people [1]. The country is contained within an area of 286,000 km^2 making it larger than neighbouring SEA counties of Cambodia, Brunei, East Timor, and Singapore, but smaller than other Southeast Asian countries. In terms of population, Laos is only more populous than Singapore, East Timor, and Brunei.

Figure 1: Lan Xang Avenue, the Main Boulevard in Vientiane

1.13 Vientiane is the capital city of the Lao PDR and has been the capital of Laos since its independence from France in 1953. Vientiane Capital is a growing city of approximately 0.97 million residents (as of 2021) which is projected to grow to over 1.4 million by 2045. Between 2000 – 2020, the average population growth rate of Vientiane Capital was approximately 2.9% annually. However, this is projected to reduce to an annual rate of approximately 1.85% from 2020 to 2045[1]. The metropolitan area of the Vientiane Capital also includes parts of neighboring Vientiane province, in total the metropolitan area of Vientiane is estimated to be around 1.0 million – 1.2 million people as of 2021.

1.14 The Lao PDR is bordered by Thailand to the west and south, Vietnam to the east, China to the north, Cambodia to the south, and Myanmar to the northwest (see Figure 2).

Figure 2: Map of Lao PDR in Indochina

Economy Overview

- Pre-pandemic, the Lao economy experienced significant growth. Year over year, the economy has grown by around 6-8% every year since 2000, making it one of the fastest-growing economies on earth during this period. This economic growth was driven in part by tourism, but Laos also exports some goods, including wood products, coffee, tin, copper, gold, and electricity to its neighbors, mainly Thailand, China, and Vietnam.
- The Lao economy has suffered greatly from the effects of the COVID-19 pandemic. The year-over-year GDP growth rate dropped by approximately 90% from 2019 to 2020, at the height of the economic crisis caused by the pandemic. However, the economy did not contract, but only grew by approximately 2.7% in 2021, according to the World Bank.
- At the same time, the Lao government had undertaken, and partnered with China, the Lao-China railway which cost approximately $6 billion USD, a significant portion of which was paid for through Lao debt to China. Due to the shock of the pandemic, there was a risk of default on this debt in 2020 and a subsequent economic crisis.
- However, the Lao economy managed to stave off default and is indeed forecasted to increase in 2022 once more, by around 3.5% over 2021. This is driven in part by a revival of tourism[2] and cross border trade, mostly through China. Overall, the Lao economy is the smallest in Southeast Asia (ASEAN), being worth approximately USD 19 billion in 2019, which is around $2,670 per capita according to IMF estimates

Transport Overview

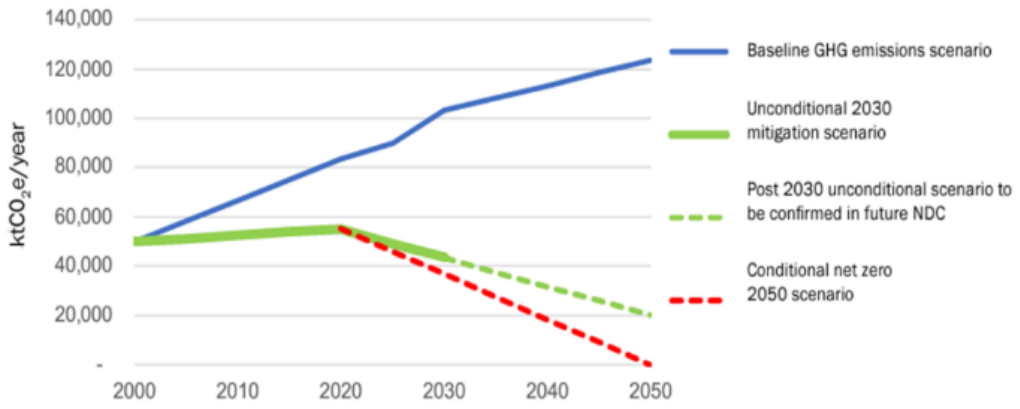
- A growing economy means a growing demand for services, vehicles, and transport. Transport demand, and especially car ownership, has significantly increased in recent years.
- Mobility in Vientiane largely depends on personally owned transportation: motorcycles and cars. This is supplemented by on semi-public transportation options such as bicycles, jumbo, songthaew, and taxis. Vientiane citizens prefer motorized means of transportation such as motorcycles and tuk-tuks, and the use of formalized public transport such as buses is relatively low at under 1%.
- Transport demand, and especially car ownership, has significantly increased in recent years. As of 2018, Vientiane's vehicles accounted for 43% of the 900,000 registered vehicles (of which 610,000 are motorcycles) in the country. The number of motor vehicle registrations in Vientiane is growing at a high annual average of 13%, especially the number of motorcycles, which accounts for a large proportion of the supply.
- Vientiane's public transport system has secured more than USD 105 million in funding for the construction of 11.5km of busways to operate a BRT system with three routes, from 2024 or 2025 onwards.

[2] Economist Intelligence Unit https://country.eiu.com/laos

Environmental Goals Overview

- The rapid increase in personal transportation has led to various urban problems such as various air pollution, traffic accidents, and vehicle congestion, and, it has caused social issues such as various environmental problems such as increased Greenhouse Gas (GHG) emissions and air pollution caused by exhaust gases.
- The Lao PDR was the first ASEAN member to join the Paris Agreement in 2016 and is striving to reduce GHG emissions in the transportation sector by increasing the penetration rate of two-wheeled and passenger electric vehicles by 30% by 2050 and reorganizing the public transportation system. The Lao PDR government has taken steps to achieve its targets, including asking for assistance to develop plans and pre-feasibility studies to improve the urban public transport network in Vientiane from other international organizations.
- Past plans for transport in Vientiane have focused on the public transportation network to cope with extreme traffic congestion, traffic accidents, and air pollution problems. Additionally, a BRT system that can transport large amounts of passengers at relatively low construction costs has been identified as a key project to improve the public transport system.
- **Lao PDR's vision is for net zero GHG emissions by 2050.**
- Following the GHG reduction scenario, financial investment in climate change will be expanded by 2030 and applied to future Laos Green Urban Transport projects from the Vientiane Sustainable Urban Transport Project (VSUTP) and ADB.
    - Bus lanes and station construction and BRT Corridor, 2022.04 ~ May 2022
    - BRT depots and warehouses and control center, 2022. Q1

Figure 3: Greenhouse Gas Reduction Scenarios for All Sectors



Source: Lao PDR Government (Ministry of Natural Resources and Environment), 2021

- To reduce GHG emissions in the transportation sector, the Lao PDR made several proposals, including the introduction of a new high-speed rail system, BRT system, and other improvements to non-motorized transport, with a target of an average reduction of 25-300 ktCO2e/y between 2020 and 2030.
- Additionally, the Lao PDR intends to achieve a 30% penetration rate of electric vehicles including two-wheelers and passenger cars, and secondly, a switch to biofuels for 10% of transportation fuels. Together, these policies are targeted to reduce GHG emissions by 30 ktCO2e/y - 29 ktCO2e/y.

- Together, these policies are not enough for the Lao PDR to achieve its targets; additional policies are needed.

2 Smart Public Transport Scenarios

Introduction

2.1 Planning Vientiane's public transport may include the installation of Intelligent Transportation System (ITS) technologies, also known as *Smart Transport.* ITS can contribute to the transition from personal transport to bus by providing an improved convenience for the end-user.

2.2 In the ongoing Vientiane Transportation Master Plan (VTMP) being produced by JICA, the focus is on traditional infrastructure with some exceptions like TSP (on BRT corridors) and an IC card-based payment system. In this Chapter, we will provide a recommendation for Smart Public Transport components that will enhance and improve both the existing, and proposed, public transport systems in Vientiane. Three scenarios, based on investment values and should be considered for future implementation in Vientiane:

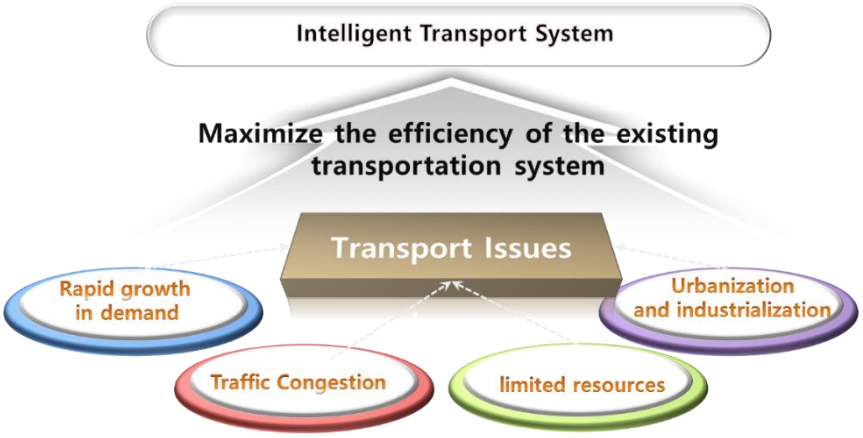
1. Short Term (complements 2024 ADB BRT plan)
2. Medium Term (complements 2027+ BRT plan)
3. Long investment (complements 2032+ BRT plan)

Definitions of Intelligent Transport Systems (ITS)

2.3 Intelligent Transportation Systems (ITS) are advanced technologies that are used to manage and optimize traffic flow and improve transportation efficiency. These systems are designed to make transportation safer, faster, more efficient, and more environmentally friendly.

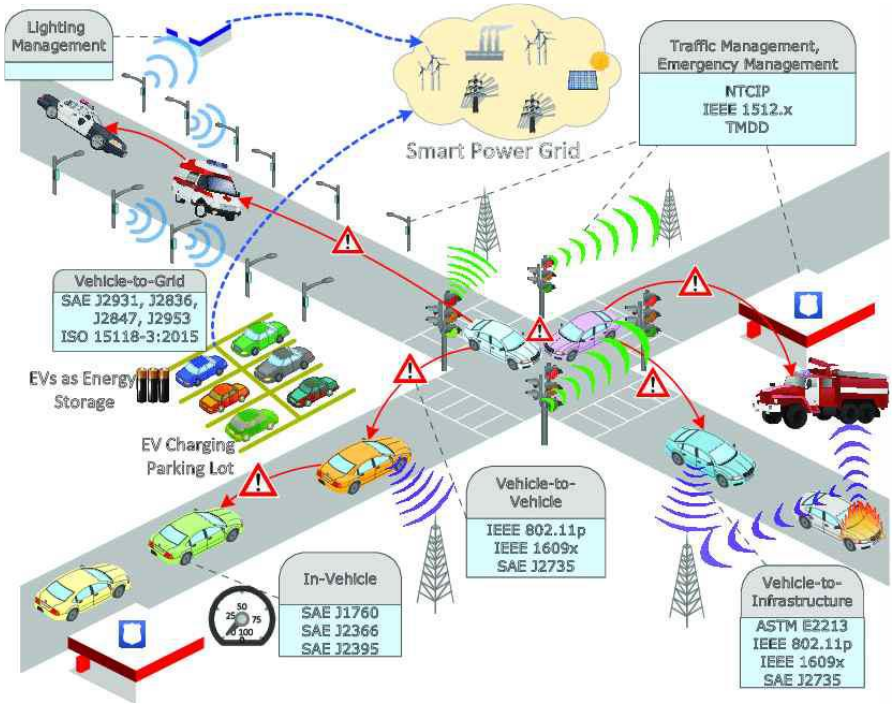
ITS is designed to maximize the efficiency of the existing (or proposed) fixed transport systems.

Table 1: Overview of Intelligent Transportation System (ITS)



2.4 ITS systems are available for road (traffic) networks and public transport networks. The image in Figure 4 below illustrates the general concept and possible components of ITS for a hypothetical road network.

Figure 4: ITS Conceptual Diagram



2.5 Some examples of ITS, for road systems, include the following:

- Smart traffic signal control systems
- Automated vehicle registration number registration
- Speed cameras
- Traffic monitoring cameras/video-based traffic sensing
- In-road inductive loop sensors
- Automated road tolling
- Variable speed limits

2.6 Examples of ITS systems for public transport could include:

- Bus Management and Information System (BMS) – real-time tracking and management of public transport fleets
- Real-time bus arrival and departure information for passengers
- Electronic fare payment/fare integration
- Traffic signal optimization for public transport vehicles;
- And many others.

2.7 Many counties have implemented ITS systems to **better manage their existing transport infrastructure.** ITS systems can have benefits for road users (increased efficiency, less congestion), governments, and road network operators, the local economy & businesses, and transport operators too.

2.8 In classic transportation planning and engineering, new infrastructure is designed and constructed, but other solutions are available to reduce congestion and improve transport for cars, see Table 2 below.

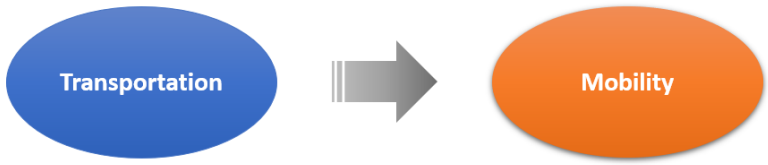
Table 2: Classical Transportation Solutions

Item	Components
New construction	Capacity expansions
	Network, stations, & facilities
Pricing policies	Congestion pricing
	Fuel taxes
Efficiency improvements	Bus passenger optimization *
	Traffic optimization *
Restrictions	Auto restriction zones
	High occupancy vehicle (HOV) lanes
	Bus-only lanes

* Solutions that are ideal for ITS

2.24 As a result, ITS can be part of the ongoing paradigm shift in the transport planning world which looks at transforming from Transportation Planning to Mobility Planning.

Table 3: Transition from Transportation to Mobility



Facilities	People
By planning, designing and optimizing facilities (Physically)	By meeting people's needs (Why and how do people travel?)

2.25 ITS solutions offer benefits over traditional "dumb" transport. These benefits include:

1. **Improved Safety**: One of the major benefits of ITS is improved safety. ITS technologies such as collision avoidance systems, adaptive cruise control, and lane departure warning systems help prevent accidents and save lives. Additionally, ITS can help emergency responders reach accident sites more quickly, reducing the risk of injury and fatalities.

2. **Reduced Congestion**: Another benefit of ITS is reduced congestion. By using real-time traffic data and intelligent routing, ITS can help drivers avoid traffic jams and reduce travel time. This not only improves productivity and saves time, but also reduces air pollution and fuel consumption, resulting in significant cost savings.
3. **Enhanced Mobility**: ITS technologies can also enhance mobility by providing real-time information about traffic conditions, transit schedules, and parking availability. This helps travelers make more informed decisions and choose the most efficient mode of transportation, reducing travel time and improving overall mobility.
4. **Environmental Benefits**: ITS can also have significant environmental benefits. By reducing congestion and improving traffic flow, ITS helps reduce fuel consumption and emissions, resulting in a cleaner and healthier environment. Additionally, ITS technologies such as electric vehicle charging stations and smart traffic lights that optimize energy usage can help reduce energy consumption and promote sustainable transportation.
5. **Economic Benefits**: Finally, ITS can have significant economic benefits. By improving transportation efficiency, ITS can help reduce transportation costs for businesses and individuals. Additionally, ITS technologies can create new business opportunities in areas such as data analytics, software development, and hardware manufacturing, resulting in job creation and economic growth.

ITS in Korea for Public Transport

2.26 In this section of the report, we summarize the existing types of ITS features that are present in Korean bus systems. In Korea, many ITS features are available for public transport users. Essentially every ITS feature for public transport users that is used or discussed around the world is in use in Korea. The following ITS features can be found on Korean buses and bus infrastructure:

Table 4: Public Transport ITS in Korea

ITS Feature	Locations in Korea	Owner/Provider
Electronic payment card system	Country-wide	T-money corporation, jointly owned by Korean government agencies Link.
Bus Management System (BMS) & Data Management centre	Seoul, Incheon, Sejong, Daejeon, Busan, Gwangju, Daegu, Gangneung, Suwon/Gyeonggi etc.	In Seoul, managed through TOPIS (Seoul Metropolitan Government) Link.
Bus information provision online, applications, & for third parties including GTFS	Country-wide	Data is managed by local agencies, including the Seoul Metropolitan Agencies Link. Websites are available, but popular applications from Naver Corporation and Kakao Corporation are generally used.
Bus information provision by SMS text message or ARS	Country-wide (however, no longer widely used)	In Seoul, managed by the Seoul Metropolitan Government Link.
Next-stop signs and announcements on buses	Most bus systems country wide	In Seoul, managed by the Seoul Metropolitan Government and bus operation companies
Bus Information Terminals (BITs) - Real-time bus location information and crowding information	85% of bus terminals in Seoul, common in Sejong, Busan, Daegu, Gwangju, Jeju-do	In Seoul, managed by the Seoul Metropolitan Government (TOPIS) Link.

ITS Feature	Locations in Korea	Owner/Provider
		Crowding data managed by the Seoul Metropolitan Government (TOPIS) with data from T-money corporation Link.
Larger scale Bus Information Terminals (BITs) - real-time bus information at CBS	All major intercity bus terminals in country, major Seoul bus stops, Sejong BRT stops	Managed by express terminals (municipal governments, Seoul Metropolitan Governments) **Link**.
Transit service priority (TSP) at traffic lights in central Vientiane	BRT corridors in Seoul, BRT corridors in Busan, BRT corridors in Jeju	In Seoul, the Seoul Metropolitan Government.
Demand-Responsive Transit (DRT) Technologies	Seoul (Eungpyeong-dong), Gyeonggi-do (Paju), Incheon (Songdo, Gyeyang, Geomdan, Yeongjeong, Namdong), Sejong, Cheongju (Osong)	MOD (Ciel corporation) **Link** in Incheon. Schucle in Sejong, Paju, Eungpyeong-dong, & Daebu-do **Link** Sejong City government **Link** Varo DRT in Cheongju (Osong) **Link**
Wi-Fi on buses	Seoul, Busan	Seoul Metropolitan Government, Busan Metropolitan Government
Wi-Fi at CBS (bus terminal)	Some stops in Busan, some stops in Seoul, most major bus terminals country-wide	Seoul Metropolitan Government, Busan Metropolitan Government, Ministry of Science & ICT
Closed-Circuit Television Cameras (CCTV) at Central Bus Station (CBS)	Country wide	May operators/owners.
CCTV on buses	Country wide	Seoul Metropolitan Government, Busan Metropolitan Government etc.
Demand-responsive taxi-hailing (car, tuktuk, songthaew)	Country wide (for registered taxis only). Several applications are available.	KakaoT **Link**. TADA/Uber **Link**. Tmoney Onda **Link**.
Autonomous shuttle services	Seoul (Cheonggyecheon), Sejong (Osong-Sejong), Chungju (KNUT)	Some early autonomous shuttle demonstration projects are being developed by private companies in Seoul (**42dot**) and Sejong (Autonomous **a2Z**) with strong government support. A government-sponsored autonomous shuttle project is currently underway including Ciel corporation, ETRI and other government/private entities which will be completed by 2027.
E-Ticketing for intercity transport	Country-wide	For intercity buses T-Money, T-Map, and KakaoT provide e-ticketing applications and websites, the most popular of which is T-Money Tx **Link**. Country-wide for rail service using the Korail app or website **link** and SRT app or website **Link**.
Mobility as a Service (Maas)	Country-wide	While not fully integrated, there are several applications available for purchasing tickets for intercity buses,

ITS Feature	Locations in Korea	Owner/Provider
		taxis, kick-board rentals etc. Examples included the KakaoT application and T-Money Go applications, Ddokta app from Hyundai, among others. These applications integrate ticketing for different modes, directions, and different accounts in one convenient application. Other mapping applications like Kakao Maps and Naver Maps offer country-wide transport directors.

Benefits and Overview of Smart Public Transport

Electronic Fare Collection (EFC) using Integrated Circuit (IC) Cards

2.27 Electronic fare collection (EFC) systems generally use integrated circuit (IC) cards combined with a form of contactless technology, like RFID to facilitate automatic fare payment simply by briefly tapping a card against a reader machine on board a bus or other transit vehicle or station.

Figure 5: EFC Reader in Seoul (T-Money)

2.28 In Korea, the most widely used contactless SmartCard for public transport is T-money[3]. It was launched in 2004 by the Korea Smart Card Company and has since become widely used throughout the country. The T-money card can be used on various modes of transportation, including buses, subways, and taxis. It can also be used for some convenience stores, vending machines, and parking lots. The card works by using radio-frequency identification (RFID) technology to communicate with card readers at the point of service.

2.29 To use the T-money card, users first need to purchase and load money onto the card. This can be done at designated T-money card vendors, convenience stores, or online. Once the card is loaded with money, users simply need to tap the card on the card reader when entering and exiting public transportation or using other services. Since its launch the T-money chip system has been integrated into Korean credit cards. Many Koreans are therefore able to use their normal credit card to pay for public transport fares directly. With the rise of digital wallets, including Samsung Pay (also known as Samsung Wallet), public transport fares can be paid for by using a SmartPhone with such software installed and set up. The Europay MasterCard and Visa (EMV) standard is not widely accepted in Korea and cannot be used onboard Korean buses.

[3] A competitor to T-money, CashBee, also exists but is primarily only used outside of the Seoul Metropolitan Area

2.30 Outside of Korea, SmartCard systems are also very popular being used in hundreds of cities across the world. In some places, regular credit cards can be used to pay for transit fares, but they universally use a different contactless system than Korea does. The global standard for contactless payment is the Europay Mastercard Visa (EMV) and many commercial IC card readers will be compatible with EMV. Major companies that produce SmartCards include:

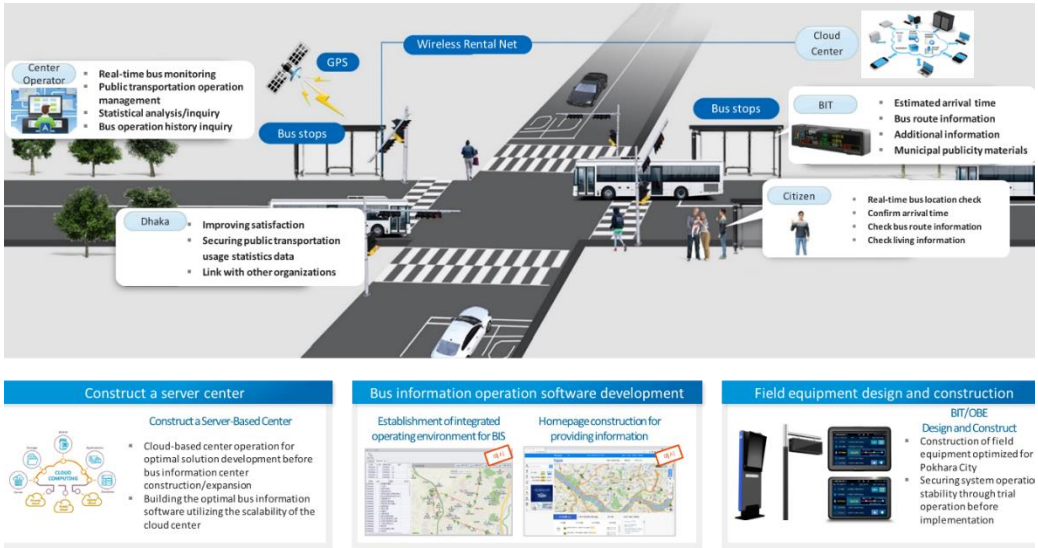
Figure 6: EFC Reader and Compatible Media

- Cubic corporation: London, Hong Kong, Chicago, Vancouver, San Diego, Brisbane, Sydney, New Jersey
- Octopus: Hong Kong, Shenzen, China
- Japanese PASMO & SUICA

Bus Management System (BMS) and Bus Information Systems (BIS)

2.31 One of the most effective ITS systems in the BIMS, which are two different and related technologies, 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 mange 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.

Figure 7: BIMS Ecosystem



2.32 In other countries, BMS systems are sometimes 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. Many private companies develop BMS software, systems, and equipment including:

- Tracom (Korea)
- Sign Telecom (Korea)
- Trapeze Corporation (Canada)

- INIT (USA)
- TransLoc (USA)

2.33 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.

On-Board Units (OBU)

Figure 8: Transit Operator with OBU

2.34 OBU (On-Board Unit) units are devices that are installed in vehicles to enable real-time tracking and monitoring of their location and other important parameters. These units use GPS technology to determine the vehicle's location and transmit this data to a central server, where it can be used to provide real-time location information, route planning, and other useful insights.

2.35 In addition to GPS technology, OBU units may also include other sensors and communication capabilities. For example, they may be equipped with accelerometers to measure the vehicle's acceleration and deceleration, or with cellular or satellite communication capabilities to transmit location data and other information to the central server.

2.36 OBU units for AVL systems are commonly used in fleet management, logistics, and transportation industries to track the location and movement of vehicles, optimize routes and schedules, monitor driver behavior, and improve overall efficiency and safety.

Bus Information Terminals

2.37 Bus Information Terminals (BIT) are electronic information displays that provide real-time information on bus schedules, routes, and arrival times at bus stops. They 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.

2.38 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. In addition to providing information to passengers, BIT displays can also be used by transit agencies to monitor the performance of their bus fleets and improve overall system efficiency. By collecting data on bus arrival times and passenger usage, transit agencies can identify areas of the system that need improvement and make changes to improve service quality.

2.39 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.

Figure 9: Bus Information Terminals

Standardization for Data Sharing

2.40 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, called REST.

2.41 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.

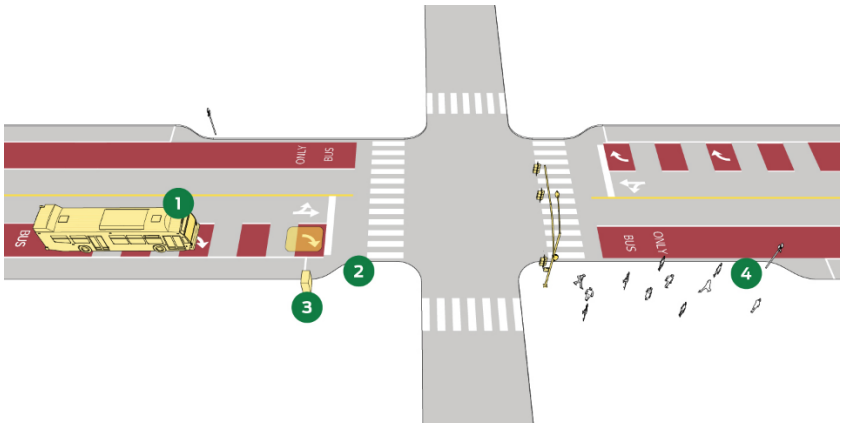
2.42 Outside of Korea, the General Transit Feed Specification (GTFS) static and real-time are the international standards for open data access for public transport data, most notably used by Google Maps as well as Transit, CityMapper, Apple Maps, and OpenTripPlanner. The use of standardized data formats such as GTFS have made it easier for transportation companies and third-party applications to access and use public transportation data.

Transit Service Priority (TSP) For Traffic Lights

2.43 Transit service priority (TSP) at traffic lights is a system designed to improve the speed and reliability of public transportation by giving buses and other transit vehicles priority at intersections.

2.44 Traffic lights are equipped with sensors that detect approaching buses and give them priority when they approach an intersection. This can include extending the green light time for buses, shortening the red-light time, or even changing the light to green as the bus approaches. This helps to reduce delays and improve the reliability of bus service.

Figure 10: TSP Overview



On-Board Bus Information Systems (Next-Stop Announcements)

2.45 On-board bus announcement technologies are systems designed to provide automated audio announcements on public transit vehicles, such as buses and trains. These systems typically use pre-recorded messages or text-to-speech software to announce upcoming stops, transfer points, and other important information to passengers.

2.46 There are several types of on-board bus announcement technologies available, including:

- GPS-based systems - These systems use GPS technology to track the location of the vehicle and trigger announcements when the vehicle approaches a designated stop.
- Route-based systems - These systems use information about the route, such as a pre-programmed list of stops, to trigger announcements as the vehicle passes each stop.
- User-activated systems - These systems allow passengers to request specific announcements or information, such as upcoming stops or transfer points, by pressing a button or using a touch screen display.

2.47 On-board bus announcement technologies are becoming increasingly common on public transit vehicles around the world, as they provide a convenient and accessible way to communicate important information to passengers, particularly those with visual or hearing impairments.

2.48 In addition to improving passenger experience and accessibility, on-board bus announcement technologies can also help to improve safety and reduce operator workload by automating the announcement process. Many transit agencies also use these systems to deliver important service announcements, such as changes to routes or schedules, to passengers in real-time.

2.49 Generally, these systems are purchased from the bus manufacturer and come installed and ready to be used. Aftermarket solutions are available, though not as common.

Demand-Responsive Technologies (DRT)

2.50 Demand-Responsive Transit (DRT) is a type of public transportation system that provides flexible, on-demand service to passengers. Unlike fixed-route transit lines, which operate on a pre-determined schedule and route, DRT systems are designed to respond to the specific needs and requests of passengers in real-time. DRT systems tend to use smaller vehicles, typically vans, such as the one pictured (in use in Korea). DRT is becoming increasingly common, especially being used by transport providers in low-demand situations like suburban or peri-urban areas.

Figure 11: Schucle (셔클) DRT Van

2.51 One of the key benefits of DRT is its flexibility. Because the system can adapt to passenger demand, it can provide more efficient and effective service, especially in areas with lower population densities or during off-peak hours when fixed-route transit lines may not be as cost-effective. Other benefits of DRT include:

- Improved accessibility: DRT systems can be designed to provide door-to-door service for passengers with mobility issues or disabilities, making it easier for them to access public transportation.
- Reduced travel time: Because DRT vehicles operate on a flexible route, they can often take more direct routes to passengers' destinations, reducing travel time and increasing efficiency.
- Cost-effectiveness: DRT systems can be more cost-effective than fixed-route transit lines, especially in areas with low demand or during off-peak hours when operating fixed-route transit lines may not be financially feasible.
- Reduced environmental impact: By providing more efficient and effective service, DRT systems can help to reduce the environmental impact of public transportation.

2.52 DRT platforms and vehicles are available. In Korea, two major companies have produced DRT systems which are being used. Both companies have enjoyed strong governmental support. These companies are

- MOD (Ciel Corporation)
- Shucle (셔클)
- Varo (바로) DRT

2.53 These services use advanced AI algorithms to determine optimal route alignments pick-up-/drop-off orders to maximize efficient. DRT systems are used around the world having been introduced by private ventures and public transport providers around the world.

Taxi-Hailing/Ridesharing

2.54 There is numerous ridesharing (also referred to a transportation network companies, TNCs, or simply Uber) platforms in use around the world. The best known include Uber, Lyft, Grab, Pathao etc. In Korea, the main operation model for ridesharing is different than in most other countries, as unlicensed taxi vehicles (including all ridesharing) are illegal. Therefore, ridesharing/hailing is known as taxi-hailing since only licenses taxis may respond to these calls. Developed by the Kakao Corporation, the most popular Taxi-Hailing application in Kakao T. In 2022, Kakao announced their intention to enter the Lao market, with local partner LVMC Holdings.

Figure 12: Example of a Taxi that can be Hailed by App

2.55 Korean taxis accept the T-money card and it is therefore possible and relatively easy to combine this mode with public transport trips, making taxi-hailing a candidate for future Mobility-as-a-Service like integration.

Mobility as a Service and Online Ticketing

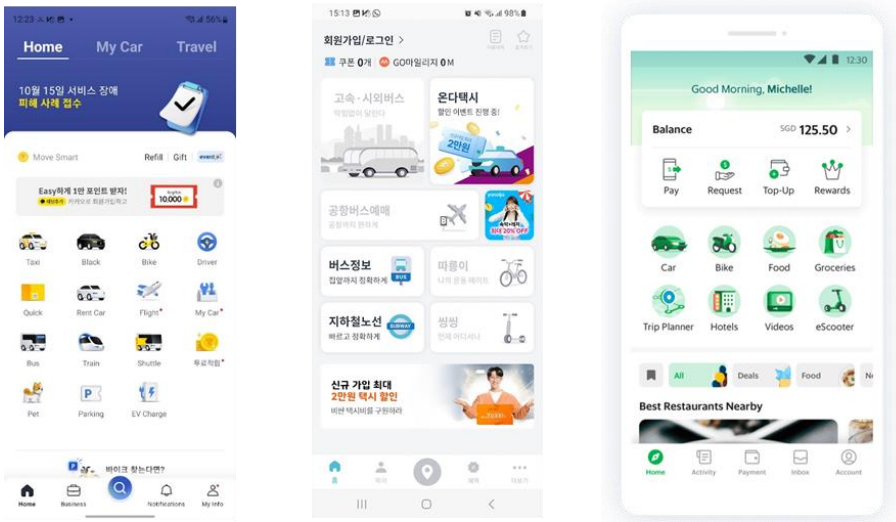
2.56 Mobility as a Service (MaaS) is an emerging concept in the transport indsutry that aims to provide seamless, convenient, and integrated mobility solutions to individuals and communities. MaaS envisions a future where various modes of transportation, such as public transit, ridesharing, bike-sharing, car-sharing, and more, are seamlessly interconnected through digital platforms and accessible to users through a single, user-friendly interface like a mobile app.

2.57 With MaaS, individuals can plan, book, and pay for their entire journey, from door to door, using a combination of transportation services. This approach prioritizes user convenience and efficiency, reducing the reliance on private car ownership, alleviating traffic congestion, and contributing to sustainability goals by promoting the use of more eco-friendly modes of transportation when appropriate.

2.58 MaaS has the potential to transform the way people move around cities and regions, making transportation more accessible, cost-effective, and environmentally friendly. By integrating various transportation options and leveraging advanced technologies like real-time data and smart routing algorithms, MaaS offers the promise of improving urban mobility while reducing the negative impacts associated with traditional car-centric transportation systems.

2.59 Examples of applications and companies in the MaaS space include Kakao Mobility, Grab, or TMoney, among others.

Figure 13: Examples of Mobile MaaS Applications



KakaoT TMoney Grab

Other Smart Amenities (CCTV & Wi-Fi)

2.60 In Korea and in other countries, closed-circuit television (CCTV) and Wi-Fi are becoming more commonly available on public transport buses sand trains, and other vehicles. These features offer many benefits to passengers including:

- Increased safety: CCTV cameras on public transit can help prevent crime by serving as a deterrent to potential criminals. In case of any criminal activity, CCTV footage can be used as evidence to identify and prosecute the perpetrators.
- Improved passenger experience: Wi-Fi on public transit can provide passengers with internet access, allowing them to browse the web, check emails, and stay connected while on the move. This can make the commuting experience more enjoyable and productive for passengers.
- Real-time monitoring: CCTV cameras can provide real-time monitoring of public transit vehicles, allowing operators to detect any issues and respond quickly. This can help improve the efficiency and reliability of public transit systems.
- Better management: CCTV footage can also be used to monitor operations and identify areas for improvement. This can help transit agencies better manage their resources and improve their service.
- Data collection: Wi-Fi can also be used to collect data on passenger usage patterns, which can be used to inform decision-making and improve service planning. This can help transit agencies optimize their resources and provide better service to passengers.

Existing Smart Public Transit in Vientiane

There are several existing ITS features in Vientiane, however most are not well-developed or widely available. However, through various plans, Vientiane and the Lao government as expressed interest in developing a further smart public transport system with ITS. The few ITS features related to public transport that do exist in Vientiane are:

- Taxi ride-hailing
- QR-code payment system for public transport
- CCTV in some cases

Taxi/Ride-Hailing

2.61 Various ride-sharing startups operate in Laos. These services are accessed through a mobile app that allows users to book a ride and track the driver's location in real-time. These companies' services include both car and motorbike rides, with options for both private and shared rides. Ridesharing aims to provide safe and reliable transportation while also promoting sustainability by reducing the number of vehicles on the road. Some companies have also partnered with local businesses to provide promotional discounts and benefits for users. As of 2021, ridesharing to covers multiple cities in Laos, including Vientiane, Luang Prabang, and Pakse..

2.62 The benefits ride sharing versus other traditional taxi services include that

- fares are calculated automatically so that passengers are not cheated;
- It is possible to call a taxi from anywhere in the city; and
- there are flexible payment methods: Cash, Mastercard, JCB through QRCode and UnionPay.

2.63 Various products are offered by these companies including

- General cars, sedans, air-conditioned cars
- Motorcycles
- Plus (large multi-seater sedan)
- Express delivery service
- Small cars without air conditioning
- Pickup truck for many people or carrying a lot of things

QR Code Payment System

2.64 In Laos and in other countries (including China) payment using QR codes for bank-to-bank transfers is becoming increasingly common. These solutions are passive and low-tech, as the user simply needs to scan the QR code while using their banking app to transfer money relatively quickly. The Vientiane Capital State Bus Enterprise (VCSBE) accepts payment via QR Code bank transfer, since signing a Memorandum of Understanding (MoU) in January 2020, and fully implementing the program as of last year. Additionally, there are many other transportation companies or individual vehicle operators who accept such payments. In the future, the company or organization operating the Bus Rapid Transit system may also accept QR code baking transactions.

CCTV

2.65 CCTV is installed in several places in the capital Vientiane including at the CBS, however it is monitored by the police only, who currently only use it for security purposes.

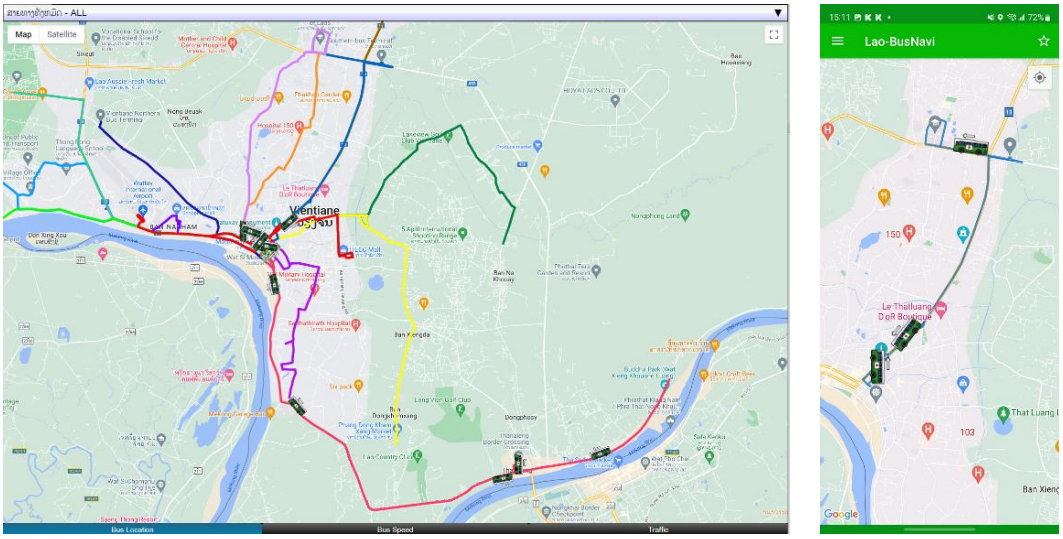
Digital Tachometry

2.66 All Vientiane Capital State Bus Enterprise (VCSBE) buses have digital tachometers installed, which are used for maintenance purpose of the buses.

Bus Management System (BMS) and Real-Time Passenger Information (RTPI)

2.67 A system that allows for the provision RTPI using a BMS-like system has been operational since 2017. Developed through funding by the Japan International Cooperation Agency (JICA) and the Japan Research Institute for Social Systems (JRISS), technically all buses in Vientiane are tracked in real-time and that information is available to users through a website (lao.busnavi.asia) or SmartPhone app, which is available for Android or iOS users. The user interfaces for the website and application are shown below.

Figure 14: Lao Bus Navi Interface



Source: Lao Bus Navi website and application, screenshots taken in 2023

2.68 The real-time data from this service is not currently being shared with any third-party applications, for example Google Maps. This RTPI system is a very basic system, which uses simple SmartPhone as the On-Board Units (OBU), used by drivers. By using essentially standard off-the-shelf SmartPhones instead of more traditional and expensive OBUs, the costs for using and maintaining the system are reduced significantly. Additionally, the data centre is made up of standard PC computers installed in a building in Vientiane.

2.69 However, the system is limited. The SmartPhones can only track the locations in real-time. They cannot automatically provide real-time information from the OBU port of the buses to provide, for example, digital tachometry information or provide alerts to drivers etc.

Figure 15: SmartPhone OBU Unit Example

Source: JICA/JRISS Report, October 2015

2.70 Separate driver and passenger applications were developed to create and access the data. The SmartPhone simply sits next to the driver when in use (it is secured to the steering column to prevent theft). Additionally, at the Vientiane Capital State Bus Enterprise Control room, there are monitoring centres which can monitor the bus systems in real-time. However, information provided is relatively basic. As part of this project, Wi-Fi packet sensors were installed roadside on bus corridors which measure the speeds of the buses as they pass by certain sections. This information is available for monitoring by various parties, including the public. The left side shows the location of the bus, and clicking on the bus displays the route and fare. The right side shows the traffic condition of the route obtained from the bus operation data, and the locations with running speeds of 20 km/h or less are displayed in red.

Figure 16: System Monitoring Dashboard at the VCSBE

Source: JICA/JRISS Report, October 2015

2.71 At the Central Bus Station permanent monitors were installed to allow public access to the information, at the busiest stop on the system, even if they did not have their own SmartPhone.

Figure 17: Customer-Facing Monitors at the CBS

Source: JICA/JRISS Report, October 2015

2.72 As of 2023, the utility of these systems is questionable, as the user interface has not been updated and as a result is outdated. With no third-party data sharing, the data is not being used by other applications (like Google Maps). Additionally, on multiple observations in 2023 the navigation apps are only displaying a maximum of 3 -4 vehicles at any one time, which may imply that many drivers are not using the SmartPhone OBUs, or that they are otherwise not functioning.

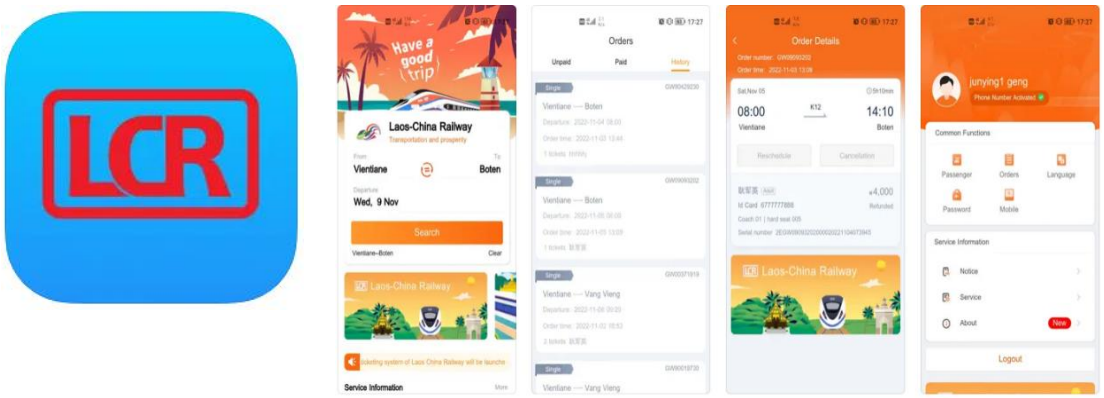
WiFi

2.73 Several buses do have free WiFi on them. These include only the Airport Route and Lao-ITECC shuttles, which were set up by JICA as part of their major project to modernize the VCSBE. These two routes also feature GTFS availability in Google Maps, quality schedules, and other nicer amenities, as well as higher fares than most other routes.

E-Ticketing

2.74 E-ticketing, or making a reservation for a transportation service online, is a very new concept in Laos. As of 2023, the only service that you can book online in Laos is the new Lao-China Railway (LCR). The LCR app was only launched in March 2023, before that, people wanting to use the train needed to physically travel to the train station, which is located far outside the city centre, a day or so before the train departure time to purchase a ticket from a vendor.

Figure 18: E-Ticketing System for the LCR



Source: LCR Railway application (App Store)

For intercity buses, options are more limited, but Bangkok-based startup 12go offers the ability to book bus transfers on major tourist routes only. This service is primarily used by tourists.

Next-Stop Announcements

2.75 As with the free WiFi, next stop announcements are available on select Vientiane routes, specifically the airport and Lao-ITECC Shuttle routes, which were set up by JICA. As shown below in Figure 19.

Figure 19: Next-Stop Announcement on Vientiane Buses

Evaluation Methodology

Multiple Account Evaluation (MAE)

2.76 The multiple account evaluation (MAE) framework is a tool that can be used to evaluate the costs and benefits of different transportation projects. It does this by considering the different perspectives of different stakeholders, or groups of people who have an interest in the project.

2.77 The framework identifies five different accounts that should be considered when evaluating a transportation project:

- **Transport:** This account considers the ability of the items to affect the convenience and attractiveness of transport, in Vientiane.
- **Environment**: This account considers the items that affect the environment.

- **Financial**: This account considers the costs of the project that can be measured in monetary terms.
- **Social**: This account considers the costs and benefits of the project that affect society.
- **Policy Alignment**: This account considers the costs and benefits of the project that affect the economy.
- **Deliverability**. This account considers the costs and benefits of the project that affect the economy.

2.78 For each account, the framework identifies a set of criteria that can be used to measure the costs and benefits of the project. The criteria are then used to develop a set of indicators that can be used to measure the project's performance.

2.79 The multiple account evaluation framework is a valuable tool for making informed decisions about transportation projects. By considering the different perspectives of different stakeholders, the framework can help to ensure that all the costs and benefits of a project are considered.

Table 5: Methodology for Evaluation Measurements

Category	Criteria	Calculation method
Transport	Increase attractiveness	Scale 1 - 5
	Increase convenience	Scale 1 - 5
	Provide benefits to customers	See Equations 1
	Provide benefits to operator	See Equations 2
Environment	Reduce emissions from motor vehicles	See Equations 3
Financial	Capital Cost (CapEx)	Based on similar projects (Discounted value in 2023 $ USD used)
	Operating Cost (OpEx)	Based on similar projects (Discounted value in 2023 $ USD used)
	Benefit-Cost Ratio (BCR) *	**Equation 4**
Social	Neighborhood impacts	Scale 1 -5
	Access for vulnerable groups	Scale 1 -5
Policy Alignment	Land-use planning alignment	Scale 1 -5
	Transport plan alignment	Scale 1 -5
Deliverability	Ease-of-implementation	Scale 1 -5

Category	Criteria	Calculation method
	Public acceptance	Scale 1 -5

* Go /No-Go requirement that the BCR meet the minimal acceptable ratio for investment (>1.0)

Discussion of the Strategic Benefits

2.80 The purpose of implementing ITS in a public transport system is to increase convenience for passengers and provide a benefit to them as well as to attract future customers. As previously discussed, ITS can be a cost-effective way to increase efficiency and convenience. In the following table to strategic benefits of each type of ITS discussed in this report to summarized, and its overall benefit to cost is presented at a high level, refer to Appendix B.

Calculations

2.81 The following equations and assumptions were used to calculate the above-mentioned values, where applicable.

Assumptions

Table 6: Assumptions and Values for Calculations of Benefits and Costs

Description		Value	Unit	Source
Users	D_u	Varies	*people*	KNUT-developed Emme-based model
Perceived travel time savings	S	Varies	*minutes*	Based on varies sources generally UK - see Table 30.
Total change in perceived travel time	ΔTT	Varies	*minutes*	Calculated
New Users	ΔD	Varies	*people*	Calculated
Elasticity of demand (time WRT demand)	E	-0.6	*% change in travel time/% change in demand*	Reported elasticity for Jakarta, Indonesia and other ASEAN bus systems
Value of Time (Vientiane)	VOT	30,576	*kip/hour*	Calculated from Vongpraseuth et al., 2022 **Link**
Benefit (user)	B	Varies	*mins/$*	Calculated
Benefit (operator)	B_{op}		*km/$*	Calculated
Occupancy, motorcycle	OCC_{mc}	1.5	*people*	Assumption based on similar cities
Occupancy, car	$OCCc_{ar}$	2.2	*people*	Assumption based on similar cities
AM Peak – Daily factor	F_{am}	~2.80	*unitless, varies by OD*	Calculated from 2021 OD survey
Operation cost, VCSBE	VOC	8,813	*kip/km*	JICA Report from 2011 **Link**
Exchange Rate *kip to USD*	Ex	16,949	*kip/USD*	Market Rate (2023)

Description		Value	Unit	Source
BMS Efficiency Improvement	EI	15%	*%*	Evidence from Daegu, Korea
Daily service km	DS	5k-95k	*km*	Proposed from JICA VTMP
Daily – annual factor	F_{Daily}	~300	*unitless*	Assumption
AM Peak – Daily factor	F_{am}	2.80	*unitless*	2021 OD survey (JICA)
Average travel distance (motorcycle)	$Dist_{avg,mc}$	7.74	*km*	KNUT-developed Emme-based model
Average travel distance (car)	$Dist_{avg,car}$	12.14	*km*	KNUT-developed Emme-based model
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
Carbon equivalent of gasoline	CE	2.32	*Kg CO_2 / L gas*	U.S. Energy Information Administration
Occupancy, motorcycle	OCC_{mc}	1.5	*people*	Assumption based on similar cities
Occupancy, car	OCC_{car}	2.2	*people*	Assumption based on similar cities
Mode choice car	MC_{car}	74.4%	*%*	2021 OD survey (JICA)
Mode choice motorcycle	MC_{mc}	26.6%	*%*	2021 OD survey (JICA)

Table 7: Perceived Benefits of ITS Solutions

ITS Item	Perceived Benefit	Additional Benefit	Unit	Source
QR-code payment system	1.52	-0.17 (s)	Mins/pax	Chen et al, 2022 **Link**
Electronic payment card system	2.00	1.2 (s)	Mins/pax	Welde, 2012 **Link**
RTPI - Online/web	2.20		Mins/pax	Lui et al., 2018 **Link**
RTPI - SMS/ARS	0.85		Mins/pax	UK TfL Transport Analysis Guidelines (TAG) Data Book, January 2023
RTPI – Bus Information Terminals (Physical)	2.52		Mins/pax	De Gruyter, 2018 **Link**
Next-stop signs and announcements on buses	3.12		Mins/pax	Wardman (ITF), 2014 **Link**
Free WiFi	0.80		Mins/pax	UK TfL, **Link**
Transit service priority (TSP) at traffic lights in central Vientiane	0.60*		Mins/pax	Lin, 2002 **Link**

ITS Item	Perceived Benefit	Additional Benefit	Unit	Source
CCTV (terminal)	3.70		Mins/pax	UK TfL Transport Analysis Guidelines (TAG) Data Book, January 2023
CCTV (on buses)	1.66		Mins/pax	UK TfL Transport Analysis Guidelines (TAG) Data Book, January 2023

* Based on improvement delay, calculated from average delay in Vientiane network

Equations 1:

$$\boldsymbol{\Delta TT} = S * D_u$$

$$\boldsymbol{\Delta D} = E * \Delta TT * D_u$$

$$\boldsymbol{B\ (mins)} = \Delta TT * D_u + \frac{1}{2} * \Delta TT * \Delta D \ ^{4} \quad * \textit{rule of half}$$

$$\boldsymbol{B\ (\$\ USD)} = \frac{VOT}{60} * B * Ex$$

Equations 2:

$$\boldsymbol{B_{op}\ (km)} = DS * 15\%$$

$$\boldsymbol{B_{op}\ (\$\ USD)} = VOC * B_{op} * Ex$$

Equations 3:

$$\boldsymbol{CO2_e(kg)} = \Delta D \left(\frac{Dist_{avg,mc} * MC_{mc}}{OCC_{mc}} * \left(\frac{1}{100} \right) * F_{am} * F_{daily} * FE_{mc} + \frac{Dist_{avg,car} * MC_{car}}{OCC_{car}} * \left(\frac{1}{100} \right) * F_{am} * F_{daily} * FE_{car} \right)$$

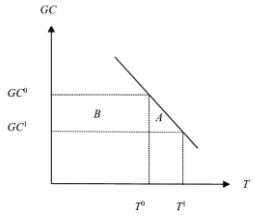
Equation 4:

$$\boldsymbol{BCR} = \frac{\sum Benefits\ (discounted), USD\$}{\sum Costs\ (discounted), USD\$}$$

If this value is not greater than 1.0, than the investment should not be considered.

---

[4] 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).



2.82 Based on the above-described assumptions and calculations, the following evaluation was completed. Table 10 is the evaluation using forecasts which include future growth in transit service and customers. While in both cases some investment may be worthwhile, some projects become unsustainable due to BCR of less than 1.0, see Table 9 below.

Evaluation Results

Projects Not to be Pursued by Government Directly

2.83 Among Smart Mobility features considered, we found that several were not worth pursuing at this time or were otherwise not suited to be government capital project, these are briefly discussed here.

Ridesharing/taxi hailing (Includes cars and tuk-tuks etc.)

2.84 **Reason: Best left for private sector**. In other countries, namely Korea, the private has developed this sector quite effectively. Government should pursue legalization of ridesharing and encourage Tuk-Tuks to use services. In neighbouring countries (i.e. Thailand and Vietnam) Grab specifically allows Tuk-Tuks to use service.

E-Ticketing and Mobility as a Service (Maas)

2.85 **Reason: Best left for private sector**. In other countries, namely Korea, the private has developed this sector quite effectively. Government may support private sector with studies and choose a partner to develop MaaS applications (e.g. Loca, Grab, etc.). Government may support private sector with studies and choose a partner to develop MaaS applications.

Autonomous Public Transport

2.86 **Reason: The technology is not yet developed enough**. In other countries, some autonomous public transport services have been implemented but these are mainly for research and/or demonstration purposes and are not proper. Lao PDR may wish to wait until such a time when the technology is sufficiently developed so that it can be used efficiently.

Recommended Project List

2.87 In this section, evaluation results are summarized and presented and are summarized as a series of "projects", which may consist of multiple ITS or Smart Mobility components, or missing policies. Each specific project is discussed in more detail later. The list of projects is as follows:

Table 8: Smart Mobility Projects – Recommended Projcts and Policies

Project		Description	Responsible Organization
Short-term (Highest Priority)			
1	Upgrades to Existing Bus Information Systems (BIS)	Upgrade the existing BIS, and switch to an open data standard (GTFS-RT).	Bus Operators VCSBE, or BRT[5]
2	Development of policies to legalize ridesharing	Develop policies to finally legalize ridesharing and taxi-hailing in Lao	MPWT DOT

[5] Currently, the Vientiane Capital State Bus Enterprise (VCSBE) is the only full-size bus operator. In the future, other operators may operate convention bus services and the Bus Rapid Transit (BRT) line which is expected to be open within the next few years (2024-2025).

Project		Description	Responsible Organization
		PDR based on Lao-government developed standards.	
3	Development of policies to support foreign and local investment in E-Ticketing, micro mobility, & Mobility as a Service (Maas)	Develop policies support and encourage private industry to develop standard ticketing systems for online ticketing of bus and train systems.	MPWT DOT
4	CCTV on buses	Vehicle-based ITS/Smart Mobility **capital project**	Bus Operators VCSBE, or BRT
5a,b	Upgrades to the Central Bus Station (minor)	Major project to focus on the CBS, the busiest bus stop/terminal in Vientiane with improved passenger amenities and information	Vientiane City/MPWT DOT
	Upgrades to the Central Bus Station (major)		
6a,b,c	a. Full replacement of the Bus Management System (BMS)	Replace the existing JICA-developed system with a completely new and "proper" BIMS system.	MPWT DOT/VCSBE
	b. Next-stop signs and announcements on buses	Invest in equipment and software to announce stops on buses including visually and with sound.	MPWT DOT/VCSBE
	c. Bus Information Terminals (BITs)	When BMS system is replaced, BITs can be pursued, eventually target 30% of stops.	Vientiane City/MPWT DOT
7	Electronic Fare Collection by RFID Card	IC card will significantly reduce the time to board buses. Target 100% of VCSBE fleet and BRT.	Bus Operators VCSBE, or BRT
8	Transit service priority (TSP)	Traffic congestion does not yet warrant TSP, perhaps, but by 2035 it might.	Vientiane City/MPWT DOT
9	WiFi on buses	IC card will significantly reduce the time to board buses. Target 100% of VCSBE fleet and BRT.	Bus Operators VCSBE, or BRT
10	*Demand-Responsive Transit (DRT) - Project to Enhance Songthaew Capability*	*See Chapter 3 in this report.*	*MPWT DOT*

Socioeconomic Cost-Benefit Analysis

2.89 A crucial component of the evaluation is a socioeconomic cost-benefit analysis (CBA). It is a method to evaluate the economic and social impacts of a proposed project, policy, or intervention. It involves assessing both the costs and benefits associated with the project and comparing them to determine its overall feasibility and desirability. Cost inputs should include operating and capital expenses, for a set evaluation period (say 15 years), additionally benefits

should be identified and monetized for direct comparison to the costs. In Table 9 below, the benefit cost ratio (BCR)[6] and the net present value (NPV)[7].

Table 9: BCR and NPV

Project		BCR	NPV
4	CCTV on buses	8.28	$2.8m
5b	Upgrades at CBS	High	$4.8m
6a	Bus Management System (BMS)	**1.17**	**$0.96m**
6b	Next-stop signs and announcements on buses	High	$7.3m
6c	Bus Information Terminals (BITs) targeted for 10% of bus stops	1.39	$1.4m
7	Electronic Fare Collection - Card System	**0.69**	**-$1.8m**
8	Transit service priority (TSP) at traffic lights in central Vientiane	**0.90**	**-$50,000**
9	WiFi on buses	1.98	$0.53m
10	See Next Chapter in this report		

2.90 On the following pages, the resulting evaluation matrices is presented. Individual ITS items are scored according to the multiple-account evaluation criteria. No weighting is applied. Based on this scoring, individual projects can be compared against each other.

[6] Ratio of the total benefits divided by the total costs, a value over 1.0 is desirable

[7] Net present value,

Evaluation

Table 10: Resulting Evaluation

	Transport			Environmental	Financial		Social		Policy Alignment		Deliverability		
	Increase Attractiveness	Increase Convenience	Provide Benefits to Customers	Reduce Emissions from Vehicles	Capital Cost	BCR	Neighbour-hood Impacts	Access for Vulnerable Groups	Land-use Planning Alignment	Transport Plan Alignment	Ease-of-Implemen-tation	Public Acceptance	Total Score
Next-stop signs and annoucement on buses	●	●	●	●	●	●	●	●	●	●	●	●	59
Upgrades at CBS	◕	◕	◕	○	●	●	●	●	●	●	●	●	51
Bus Management System (BMS)	●	●	●	●	○	◔	◑	●	●	●	◑	●	46
Bus Management System (BMS) - Online Only	◕	◕	◕	◕	◔	◔	◑	◔	●	●	◕	◑	39
CCTV on buses	◔	◑	◔	◑	●	●	●	◑	◕	◑	●	◕	43
Electronic Fare Collection - Card System	◕	●	◑	◑	○	○	●	◑	●	●	◑	◑	38
Transit service priority (TSP) at traffic lights in central Vientiane	◑	●	○	○	●	○	◕	●	●	●	◔	●	40
WiFi on buses	◕	●	○	◔	●	◔	●	◕	●	◑	◑	◕	41
BCA<1.0 long term	◑ 4	● 5	○ 3	○ 2	◔ 3	○ 2	◕ 4	◕ 4	● 5	● 5	◑ 4	◕ 4	

GHG Reductions

2.91 The above-mentioned recommendations may result in a reduction in Greenhouse Gases (GHGs), due to a modal shift, that is, people who previously used fossil fuel powered 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. Total estimated GHG reductions are shown below in Table 11.

2.92 We estimate up to 163,000 Tonnes of CO2e could be reduced (15-year total).

Table 11: Estimated GHG Reductions for Smart Transport Evaluation

Project		Total
4	CCTV on buses	19,000
5a/5b	Upgrades at CBS – WiFi, CCTV, Upgraded Screens, and BITS	700
6a	Bus Management System (BMS)	41,000
6b	Next-stop signs and announcements on buses	35,000
7	Electronic Fare Collection - Card System	23,000
8	Transit service priority (TSP) at traffic lights in central Vientiane	6,000
9	WiFi on buses	9,000
	Grand Total (Tonnes CO2e)	**163,000**

Costs and Financing

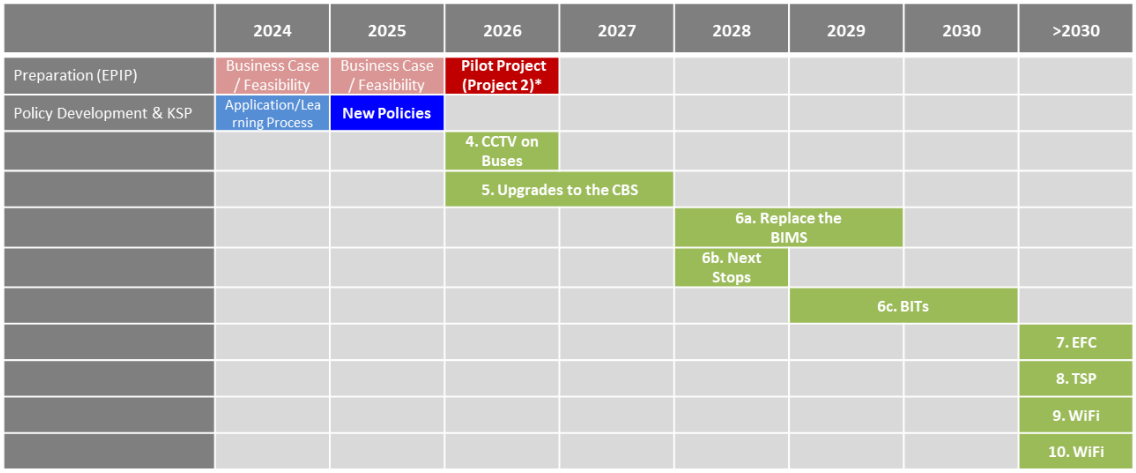
2.93 The project descriptions **are available in tables in Appendix C**. The following items are to be included in the recommended future scenarios. The highlights of our recommendations are as follows in Table 12 and timelines are shown in Table 13.

Table 12: Summary of Major Smart Mobility Projects

No.	Major Item	Year	Cost ($2023 USD)
Short Term			
1	Upgrades to Existing Bus Information Systems (BIS)	2024-2025	$150k
2	Development of policies to legalize ridesharing	2024-2025	$200-$300k
3	Development of policies to support foreign and local investment in E-Ticketing, micro mobility, & Mobility as a Service (Maas)	2024-2025	$200-$300k
4	CCTV on buses	2025-2026	$600-$700k
5a	Upgrades to the Central Bus Station (minor)	2025-2026	$400-$500k
5b	Upgrades to the Central Bus Station (minor)	2025-2027	$3-$4m
Medium Term			
6a	Full Replacement of Bus Management System (BMS) and BIS	2028	$7-$10m
6b	Next-stop announcements on buses	2028	$0.75-$1m
6c	Bus Information Terminals (BITs) targeted for 10% of bus stops	2028	$3-4m
Long Term			
7	Electronic Fare Collection by RFID Card	*2030+*	$8-10m
8	Transit service priority (TSP)	*2030+*	$1-2m
9	WiFi on buses	*2030+*	$50-75k

No.	Major Item	Year	Cost ($2023 USD)
10	*Demand Responsive Transit (DRT) Project to Enhance Songthaew Capability*	*2030+*	*See Chapter 7*

Table 13: Timeline of Implementation



Financing

2.94 As a next step, a Business Case for ITS (Smart Public Transport) in the Lao PDR should be developed. In this Business Case, detailed costs should be developed. In this report, detailed estimates for funding (i.e. costs) were not calculated.

2.95 However, the cost estimations for ITS services could be up to approximately 10x the annual revenue of the current bus operator, the VCSBE ,and carry significant annual operating costs. Most projects would provide a benefit but may not provide directly attributable revenue gains. Therefore, its is would be impossible for the VCSBE to self-fund these projects, and therefore outside funding will be required. In the future, the VCBSE or other bus operator in Vientiane (such as the operator of soon to be constructed BRT,

2.96 The Korean Government chooses to fund various projects in the developing world through their ODA fund, including through the programs described below.

Knowledge Sharing Program (KSP)

2.97 This program is best suited for small studies or capacity building. The focus of this program is on knowledge transfer from Korea to the developing nation. The Korean Knowledge Sharing Program (KSP) is an initiative developed by the Korea Development Institute (KDI) to facilitate the sharing of knowledge and experiences accumulated by the Republic of Korea in its development journey. The program aims to support partner countries in their efforts to achieve sustainable socio-economic development by leveraging the lessons and best practices learned by Korea.

2.98 The KSP focuses on providing technical assistance and capacity building to partner countries in various areas such as economic development, governance, public administration, and social policy. It aims to transfer Korea's expertise and know-how in these fields to help partner countries address their specific development challenges.

2.99 Under the KSP, Korean experts and practitioners are deployed to partner countries to work closely with local counterparts. They engage in knowledge exchange activities such as training

programs, workshops, seminars, policy dialogues, and on-the-ground project implementation. Through these activities, the KSP aims to promote knowledge sharing, foster institutional capacity building, and facilitate policy reforms in partner countries.

2.100 The KSP is based on the belief that sharing Korea's development experiences can provide valuable insights and practical solutions for other countries facing similar development issues. By fostering cooperation and collaboration, the program aims to contribute to inclusive and sustainable development globally. Through these activities, the KSP aims to promote knowledge sharing, foster institutional capacity building, and facilitate policy reforms in partner countries.

Economic Innovation Partnership Program (EIPP)

2.101 Recognizing the increasing global need for development cooperation, the Ministry of Economy and Finance of Korea introduced the Economic Innovation Partnership Program (EIPP) in 2020. The primary objective of this program is to promote sustainable growth and enhance economic relationships between nations.

2.102 The EIPP program is designed to foster economic collaboration between the Republic of Korea and a partner country, to promote sustainable economic growth in the partner nation. It encompasses policy and technical consultations to strengthen economic cooperation and facilitate mutual benefits.

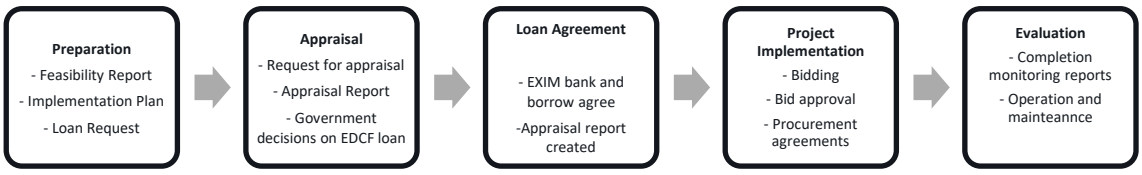
2.103 The 2024/2025 EIPP for the Lao PDR consists of 6 studies, including the following.

- **Study #6:** Feasibility study for the establishment of a smart public transportation implementation plan based on electric vehicle. Includes the Introduction of intelligent traffic control system, plans to build electrified public transportation charging stations, and management facilities, etc.

Economic Development Cooperation Fund (EDCF) via KOICA or K-EXIM Bank

2.104 The EDCH is the ODA funding mechanism of the Korea Export-Import Bank (K-Exim). The EDCF was established in 1987 and is set up to provide loans to developing countries at extremely low interest rates with long repayment period. The main targets of the funds are for human resources, including educational equipment and for economic infrastructure. Generally, EDCF projects go through a fairly large number of steps before implementation, shown graphically below.

Figure 20: EDCF Process



2.105 The main objective of the EDCF is to promote sustainable socio-economic development and poverty reduction in partner countries. It aims to enhance their capacity for self-help and foster long-term economic growth. The fund primarily targets developing countries and emerging economies that require financial resources to implement development projects.

2.106 The EDCF offers concessional loans, which are loans with favorable terms such as low interest rates, extended repayment periods, and flexible repayment terms. These loans are meant to

provide affordable financing options for partner countries, enabling them to invest in critical infrastructure projects and other development priorities.

2.107 In addition to loans, the EDCF also provides grants to support specific projects or technical assistance programs. Grants are non-repayable funds that are used to cover project costs, capacity building activities, feasibility studies, and knowledge sharing initiatives. The EDCF operates through partnerships and collaboration between the government of Korea and recipient countries. The fund aims to align its assistance with the development priorities of partner countries, ensuring that projects supported by the EDCF contribute to their sustainable development goals.

Funding for Recommended Projects

2.108 Recommended funded for each of the projects is listed below in Table 14.

Table 14: Recommended Sources of Funding

No.	Major Item		Funding Source for Next Steps
Short Term			
1	Upgrades to Existing Bus Information Systems (BIS)	2024-2025	Internal Lao PDR or KSP Program (Korea)
2	Development of policies to legalize ridesharing	2024-2025	Internal Lao PDR or KSP Program (Korea)
3	Development of policies to support foreign and local investment in E-Ticketing, micro mobility, & Mobility as a Service (Maas)	2024-2025	Internal Lao PDR or KSP Program (Korea)
4	CCTV on buses	2025-2026	KOTRA EIPP 2024/2025 Program
5a	Upgrades to the Central Bus Station (minor)	2025-2026	KOTRA EIPP 2024/2025 Program
5b	Upgrades to the Central Bus Station (minor)	2025-2027	KOTRA EIPP 2024/2025 Program
Medium Term			
6a	Full Replacement of Bus Management System (BMS) and BIS	2028	KOTRA EIPP 2024/2025 Program
6b	Next-stop announcements on buses	2028	KOTRA EIPP 2024/2025 Program
6c	Bus Information Terminals (BITs) targeted for 10% of bus stops	2028	KOTRA EIPP 2024/2025 Program
Long Term			
7	Electronic Fare Collection by RFID Card	*2030+*	KOTRA EIPP 2024/2025 Program
8	Transit service priority (TSP)	*2030+*	KOTRA EIPP 2024/2025 Program
9	WiFi on buses	*2030+*	KOTRA EIPP 2024/2025 Program
10	*Demand Responsive Transit (DRT) Project to Enhance Songthaew Capability*	*2030+*	*See Chapter 7*

3 Pre-Feasibility Study for Demand-Responsive Transit (DRT)

Introduction

3.1 The purpose of this Chapter is to present the findings of a pre-feasibility study on Demand-Responsive Transport (DRT) in Vientiane, the capital city of Laos. The report provides an overview of the current transportation system in the city, highlighting the challenges faced by commuters and the potential benefits of implementing a DRT system.

3.2 Vientiane has experienced rapid urbanization and population growth in recent years, which has put a strain on the existing transportation infrastructure. The city's public transportation system is currently limited, and many commuters rely on private vehicles or motorcycles, leading to traffic congestion, pollution, and safety concerns. While traditional fixed-route transit has been explored and used in the past, it is difficult to effectively serve suburban or peri-urban areas with infrequent, fixed-route services. Songthaews, TukTuk, and Jumbos have traditionally served this role in the past. However, new technologies for demand-responsive transit (DRT) are available which can allow for flexible routing and more efficient services for these kinds of low-demand areas.

3.3 DRT is a flexible, on-demand transportation service that uses technology to optimize routes and provide efficient and convenient transport options for commuters. It has been successful in many cities worldwide, and its implementation in Vientiane could significantly improve the city's transportation system.

3.4 This report includes an analysis of the current transportation demand in Vientiane, a review of existing DRT models, and an assessment of the feasibility of implementing a DRT system in the city. The report also examines the potential socio-economic impacts of a DRT system, including job creation, improved access to healthcare, education, and employment opportunities.

3.5 The findings of this pre-feasibility study suggest that DRT could be a viable and effective transportation solution for Vientiane. The report provides a roadmap for the next steps in the feasibility study, including a more detailed analysis of the financial, technical, and operational requirements for implementing a DRT system in the city.

Overview of Demand-Responsive Transit (DRT)

Operating Models

3.6 Demand-Responsive Transit (DRT) is a transportation service that operates on a flexible schedule and route based on real-time demand from passengers. DRT systems are typically designed to provide public transportation services in areas where fixed-route services are not viable due to low ridership or limited infrastructure.

3.7 One of the earliest DRT systems was the Dial-a-Ride program, which was launched in 1973 in Beloit, Wisconsin. The system allowed passengers to call a central dispatch center to request a

ride, and the system would dispatch a vehicle to pick them up and take them to their destination. This approach proved to be effective, and Dial-a-Ride programs quickly spread to other cities in the US and around the world.

3.8 Over the years, DRT systems have evolved and become more sophisticated, with the development of new technologies such as mobile apps, GPS, and vehicle tracking systems. Today, DRT services are widely used in urban, suburban, and rural areas to provide transportation options for individuals who are unable to access or afford traditional public transit services.

3.9 The following figure depicts the operating models that are available and used for a modern DRT system.

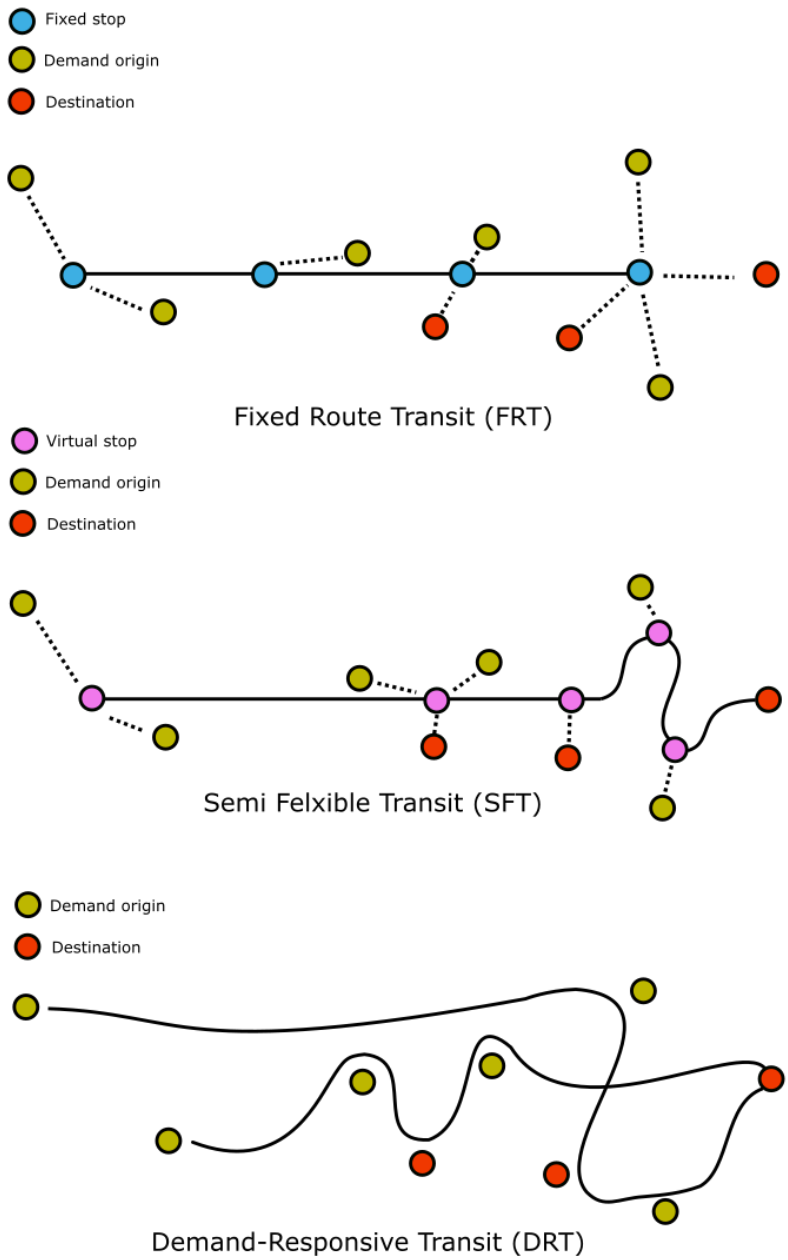
Figure 21: Fixed and Flexible Shared Transit Operation models

	Traditional Bus	Semi-Flexible Transit[8]	DRT	Shared Taxi/ Songthaew	Traditional Taxi	Taxi Hailing or Ridesharing
Stops	Fixed stops	Flexible virtual stops	May use flexible virtual stops	Flexible virtual stops	No stops	No stops
Passenger Load	10+	< 12	< 12	1-4	1-2	1-2
Schedule	Fixed, scheduled	Semi-scheduled/ on-demand	On-demand	When filled/on-demand	On-demand	On-demand
Requires SmartPhone	No	Yes	Yes	Some	No	Yes
Booking system	Wait at bus stop	Booked at time of need, requires SmartPhone	Booked at time of need, requires SmartPhone	Booked at time of need, requires SmartPhone	Hailed by road	Booked at time of need, requires SmartPhone
Routing	Fixed routes	Route-based but partially flexible	Flexible	Route- based but partially flexible	Partial point-to-point	True point-to-point
Operation cost/ passenger	Lowest	Low	Medium	Medium	High	High
Example	VCSBE, Some Songthaew, Seoul bus system	Uber Bus/Shuttle in Cairo, Didi minibus	Shucle, MOD, Others	Uber Pool, Songthaew, Marshrutka, Matatus etc.	Traditional taxi, TukTuks/Jumbo	Loca, Uber Lyft, Grab

3.10 Many cities, countries, and the private sector are now exploring the use of autonomous vehicles (AV) and other advanced technologies to enhance DRT services further. These innovations have the potential to revolutionize public transportation by providing highly flexible, efficient, and affordable transportation options that can adapt to the needs of passengers in real-time. However, for now, AV technologies are still in development, and there are no turn-key demand responsive and autonomous platforms yet available.

[8] Refer to: Lin, P, Pei, M, Liu, R et al. (2019) Flexible transit routing model considering passengers' willingness to Pay. IET Intelligent Transport Systems, 13 (5). pp. 841-850.

Figure 22: DRT Operation Models



Examples/Case Study

Korea: Shucle (셔클) Sejong City & Paju (Unjeong)

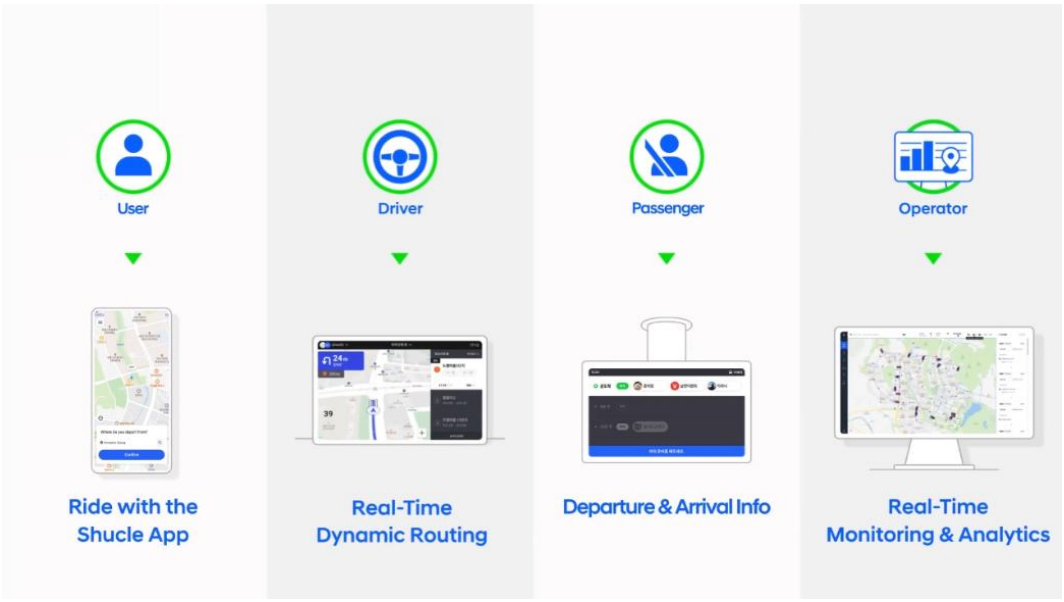
3.11 In Korea, there are several competing services for DRT. MOD (Ciel corporation), Shucle (backed by Hyundai corporation), and Varo are some examples. These companies enjoy strong governmental support at the regional, local, and federal level.

3.12 Shucle operate their DRT shuttles in several locations including Paju, which is part of Gyeonggi province and normally part of the Seoul Metropolitan area as well as across the Sejong area, and in several places in Incheon (also near Seoul). The Shucle service in Paju and Sejong operates on behalf of the local transit operator, in effect is a part of the local bus services.

Figure 23: Shucle DRT Vehicle in Paju

3.13 To use Shucle, users must download and use the Ddokta (똑타) application to their SmartPhone, which was developed by Hyundai Mobility and is a part of their integrated mobility platform (MaaS). As a MaaS app, the Ddokta app also recommends other potential rides and travel possibilities, if the Shucle is not available.

Figure 24: Shucle DRT Ecosystem



3.14 These services operate true demand-responsive point-to-point rides anywhere within a set service area. That is, it is more like taxi than a bus. Users input their destination while their origin location is measured by the SmartPhone's GPS. in some cases, users are asked to walk to a 'virtual stop' on a major corridor to get picked up. By monitoring the app, the user can see where the vehicle is and the estimated time until it arrives at the pick-up location. The services use advanced algorithms to respond to new demand requests in real-time, therefore the actual arrival time is flexible, although predicted in the app it is constantly updated. The overall goal of the algorithms is to move as many people as possible in the shortest overall time as possible. The service area of Shucle is shown below in Figure 25.

Figure 25: Shucle Service Area in Sejong

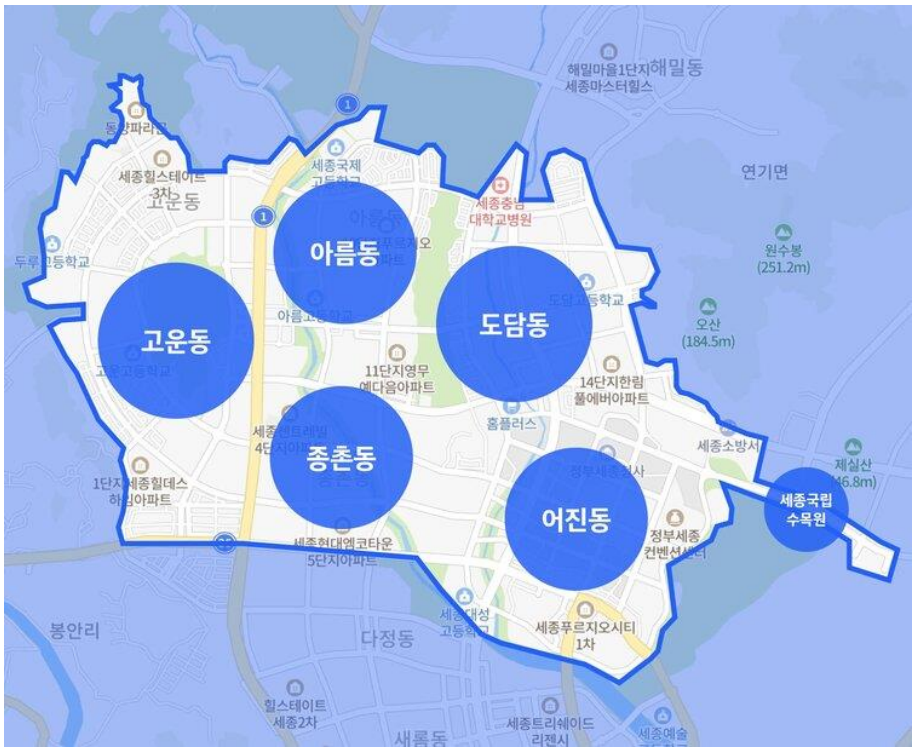


Image source: Shucle Website

3.15 Operating since 2021, the Shucle service in Sejong has been considered a success. With four vehicles operating, the Shucle services had an average occupancy of 2 – 4 person at any given time, average walking time to a virtual stop was 2.3 minutes, average travel time was short, at just 7-12 minutes, generally under 10 minutes. While waiting time was generally within 5 – 10 minutes, at peak times when demand was highest, waiting times increased accordingly. Between 8AM-9AM, the majority (>55%) of wait times were more than 10 minutes, with 10% of users having to wait more than 20 minutes to use it [9].

3.16 Several other DRT programmes have been implemented in Korea, with varying levels of success. Several DRT programmes have shut down, notably the Yeongjeong-do example produced by Shucle. These DRT programmes have suffered from peak demand problems since they have served areas for last-mile first-mile services. However, since they are demand responsive, the waiting time increase significantly depending on the demand (unlike fix0edroute services, which have similar waiting times but are much more crowded). In off-peak times they have excess capacity. In areas where there is more consistent and off-peak demand, the service might see better success.

Developing World: Uber Bus, Swvl, Shuttl & Bus hailing Apps

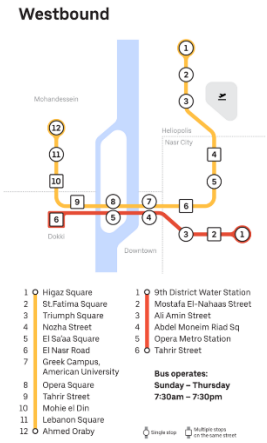
3.17 The Uber Corporation operates a unique DRT public transport service in the Cairo metropolitan area which is called Uber Bus. A fully private venture, Uber Bus operates their

[9] An Yongjun (2022) Policy Recommendation for DRT Adoption to Urbanized Areas: Based on the 'Shucle' Project in Sejong City, Transportation Technology and Policy Vol.19 No.3, June 2022

DRT services on a semi-fixed flexible service. That is, the vans operate on two pre-programmed routes, and is thus an example of semi-flexible transit (SFT) or partial DRT.

3.18 Like the Korean examples, Uber Bus operates new, air-conditioned, and comfortable 10-passenger vans. Vans only pick up enough passengers to fill the seats, and users must use the Uber app on a SmartPhone.

Figure 26: Uber Bus DRT Vehicle in Cairo



Source: Uber Corporation, MENA

3.19 Another similar service, Swvl, is an Egyptian/Dubia-based startup that provides a technology platform to enable shared transportation services for intercity and intracity trips, mostly in developing nations. Swvl's platform is designed to either replace or modernize and digitize existing paratransit services that are already common in many developing nations. Swvl is active in the following markets:

- Egypt
- Jordan
- Kenya
- Latin America
- Pakistan
- Saudi Arabia
- UAE
- Mexico
- Turkey

3.20 They market to a more upscale client, who still uses public transport, and generally require drivers (or "captains") to have modern vans with a good state or repair, versus the local versions which use various vehicles of questionable safety where fares must be negotiated, cannot be pre-booked and are slow due to constant picking up passengers along the route. However, like many other technology companies Swvl continues to lose money and their stock value has dropped considerably in recent months and years.

3.21 Another similar application and technology company is Shuttl, which was founded in India in 2015. Their business model is identical to that of Swvl, offering higher quality, air-conditioned vanpools that can be pre-booked with the application. Both these offerings, and others like

them, are examples of Semi-Flexible Transit (SFT) that can be pre-booked using an online application.

Figure 27: Bus-Hailing Company Vehicles (Emerging Markets)

Image Source: Creative Commons License

3.22 Finally, according to research from Sri Lanka[10], DRT users in developing nations would be willing to wait, up to 11.65 minutes for DRT services. Therefore, DRT may be a good option for Vientiane in the short term (2024 – 2027) in addition to, or instead of, non-BRT fixed feeder routes.

Issues and Drawbacks

3.23 DRT and/or SFT is not a panacea, and while in many cases in can be more efficient than fixed-route transit, it is not always. Some drawbacks of DRT services include:

- Necessarily, limited coverage: DRT is often limited to certain areas, which means that some passengers may not have access to this service.
- Possible longer wait times: Since DRT vehicles need to be scheduled and dispatched on an on-demand basis, passengers may experience longer wait times than they would with fixed-route transit.
- Increased costs: DRT services, that is the vehicles themselves and the software, can be more expensive than traditional fixed-route transit vehicles and systems due to the need for more flexible scheduling and dispatching systems. In addition, some annual maintenance costs for cloud-computing and server costs will be required.
- Unequal access: DRT services may not be accessible to everyone, especially those with disabilities or mobility impairments, as some vehicles may not be equipped with wheelchair ramps or lifts. Additionally, they typically require the user to own a SmartPhone and a data plan, which can limit (especially in developing nations) the types of users that can access the services.
- Less flexibility for the operator: DRT vehicles are generally purpose built with equipment designed for operating DRT, and may not be able to be moved to other routes easily. Additionally, some technical knowledge is required to use operate the services and maintain the servers etc.
- Lower capacity: DRT vehicles often have lower passenger capacity than traditional transit vehicles, which may result in more trips being required to transport the same number of passengers.

[10] A. Anburuvel, W.U.L.D.P Perera, R.D.S.S. Randeniya (2022)

Planning DRT in Vientiane

Existing Paratransit: Songthaew and TukTuks

3.24 Songthaews are a type of shared taxi or minibus commonly found in Thailand and Laos. The word "songthaew" means "two rows" in Thai, referring to the two benches that run along the sides of the vehicle's rear cargo area. Songthaews are generally pickup trucks (such as the Hyundai Porter pictured below) that have been converted to bus-like vehicles capable of carrying up to 10 or so passengers at a time. Fares are handled in cash and are paid to the driver, or fare handler if there is one.

Figure 28: Songthaew Examples

Songthaew Interior

Songthaew Exterior in Vientiane (2010)

Image Source: Wikimedia Commons

3.25 Songthaews can be found in both urban and rural areas and are often used as a cheap and convenient mode of transportation for both locals and sometimes tourists. They typically operate on fixed routes, like a bus, and will pick up and drop off passengers along the way, with fares usually being negotiated between the driver and passengers before the journey begins. While songthaews can be a convenient way to get around, they are often cramped and uncomfortable, and may not be the best option for travelers with large amounts of luggage. However, they are a popular and affordable way to travel in Laos.

3.26 Outside Laos and Thailand, these kinds of transit systems are referred to as paratransit. Other forms of paratransit available in Laos includes TukTuks, which typically operate as point-to-point taxis and jumbos which are larger TukTuks that can handle more passengers. Jumbos may be used as shared taxis, or as point-to-point taxis in the same ways as TukTuks. These vehicles are almost always three-wheeled vehicles powered by a 2-stroke motorcycle engine. In Luang Prabang, a small fleet of 14 E-TukTuks were used and initially supported by local drivers and JICA. However, they were not repaired or maintained as there was a lack of

knowledge of EV maintenance as well as a lack of spare parts in the country. One by one, the EVs broke down and stopped being used[11].

Figure 29: Examples of TukTuks in Laos

TukTuk

Jumbo TukTuk

Image Source: Wikimedia Commons

3.27 As of data received for 2021, there were about **512 TukTuks or Jumbos**, and **136** registered **Songthaews** in Vientiane.

Paratransit Demand and Service

3.28 Currently, Songthaew vehicles operate on at least 15 routes in the Vientiane metropolitan areas, according to data gathered in 2023. All these routes operate to areas outside the city centre, including some routes that can be considered intercity, for example up to Vang Vieng or Nonehai.

Table 15: Songthaew Routes in Vientiane

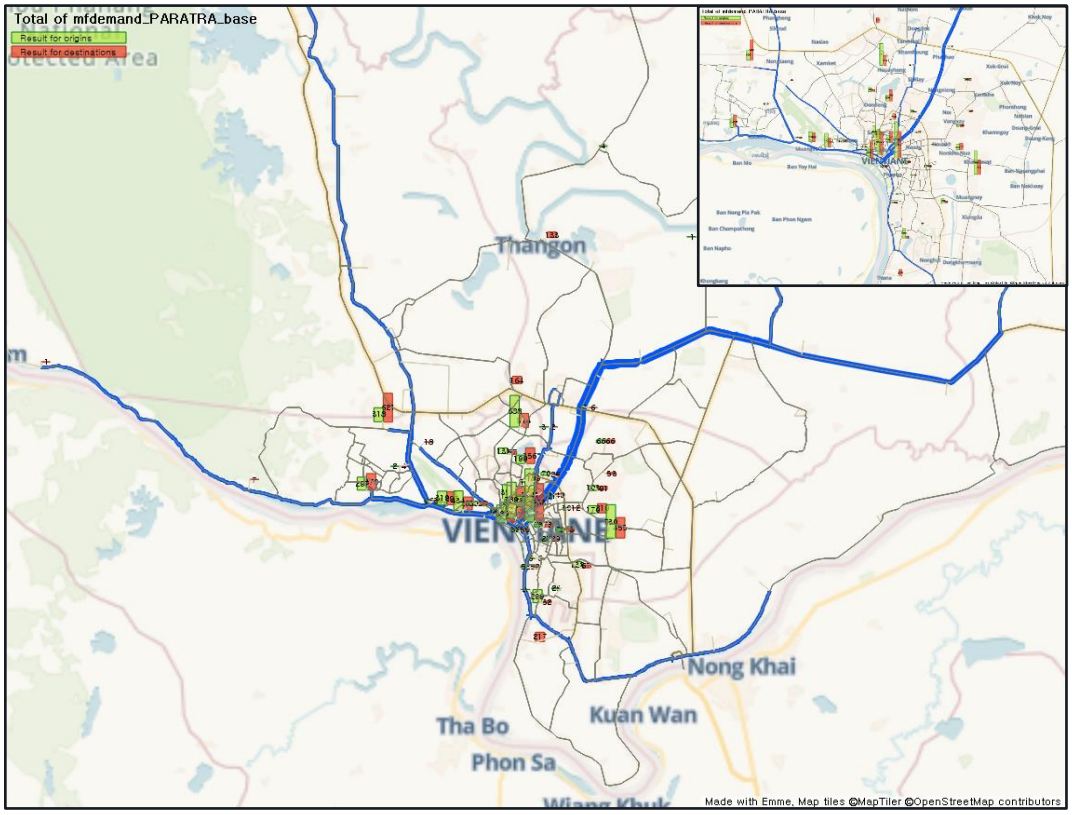
No.	Start	Destination	Fare	Distance
2	Songthaew Station, Central Bus	Nabong	50,000Kip	
3	Songthaew Station, Central Bus	Thakokhai	50,000Kip	
4	Songthaew Station, Central Bus	Lingsun	40,000Kip	
6	Songthaew Station, Central Bus	Thadoue	30,000Kip	
7	Songthaew Station, Central Bus	Chansavang	15,000Kip	
8	Songthaew Station, Central Bus	Naxaythong	30,000Kip	
9	Songthaew Station, Central Bus	Luke36	30,000Kip	
10	Songthaew Station, Central Bus	Thardthong	15,000Kip	
11	Songthaew Station, Central Bus	Thadindaeng	30,000Kip	
12	Songthaew Station, Central Bus	Parkzarp	30,000Kip	
13	Songthaew Station, Central Bus	Dongdok	10,000Kip	
14	Songthaew Station, Central Bus	Lao-China Railway station	10,000Kip	
15	Songthaew Station, Central Bus	Lao Friendship Bridge	10,000Kip	

[11] Miki Namba (2021) Material Itineraries of Electric Tuk-Tuks: The Challenges of Green Urban Development in Laos, East Asian Science, Technology and Society: An International Journal, 15:2, 173-191, DOI: 10.1080/18752160.2021.1897737

No.	Start	Destination	Fare	Distance
16	Sikhai	Nonehai	120,000Kip	
17	Sikhai	Barndone	80,000Kip	
18	Sikhai	Vangvieng	100,000Kip	
19	Sikhai	Talard	50,000Kip	
20	Sikhai	Nasa	40,000Kip	
21	Sikhai	Peerlard	50,000Kip	

3.29 Today, demand for paratransit trips is limited to a few key areas, on western, central, eastern, and southeastern corridors. In total, paratransit commands a low mode share (<2%). When the first BRT systems open in 2024, BRT may compete the existing songthaew routes.

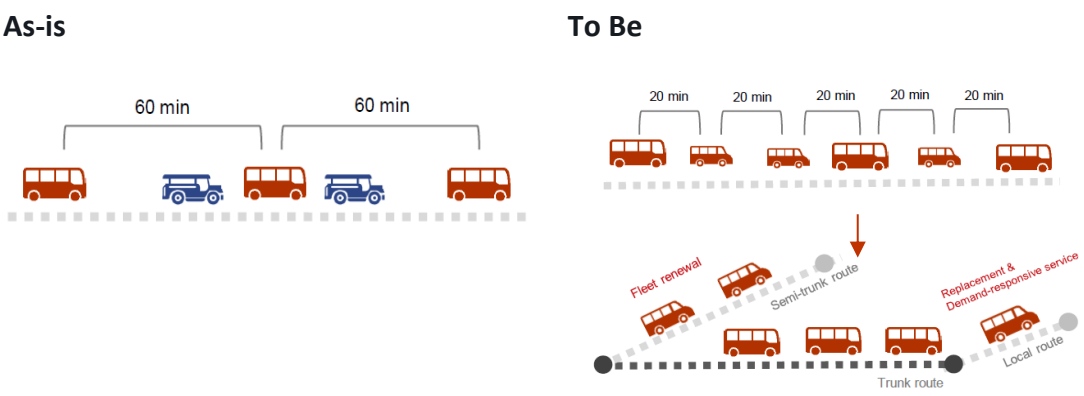
Figure 30: Paratransit OD Demand (OD Survey) & Paratransit Routes



3.30 Thes existing songthaew routes are long and are serving under-development or low-density areas. Today, songthaew operates as fixed-routes services on various routes throughout the capital, some of which correspond to VCSBE fixed-operation routes as well.

3.31 In some cases, the songthaew are not scheduled well, and **sometimes directly compete with VCSBE buses, leading to an inefficient transport network.** This issue was recognized by JICA in their recent planning work, and the issues and solutions are illustrated below in Figure 31.

Figure 31: Process for Formalizing the Songthaew Operators (JICA)



- Bus and songthaew are operated independently, and most routes needlessly compete

- Bus and songtheaw launch operation cooperation on, and songthaew services are officially integrated based on concession (contract) agreements.
- Some songtheaw routes are converted to demand-responsive services
- Old/deteriorated vehicles are replaced with new songthaew vehicles (e.g. e-songthaew or vans) through lease or concession programs.

3.32 JICA's 2023 Vientiane Transportation master Plan, recognizes that in the future, songthaews may be fixed-route feeder services, or DRT if possible.

Proposed DRT Service

3.33 DRT could be run in several areas that do not compete with BRT or the existing bus service (VCSBE). To determine if a DRT service could be appropriate for the context of the Laos Vientiane network, a simulation was run using the existing and future estimated demand profiles (for paratransit demand) in Vientiane.

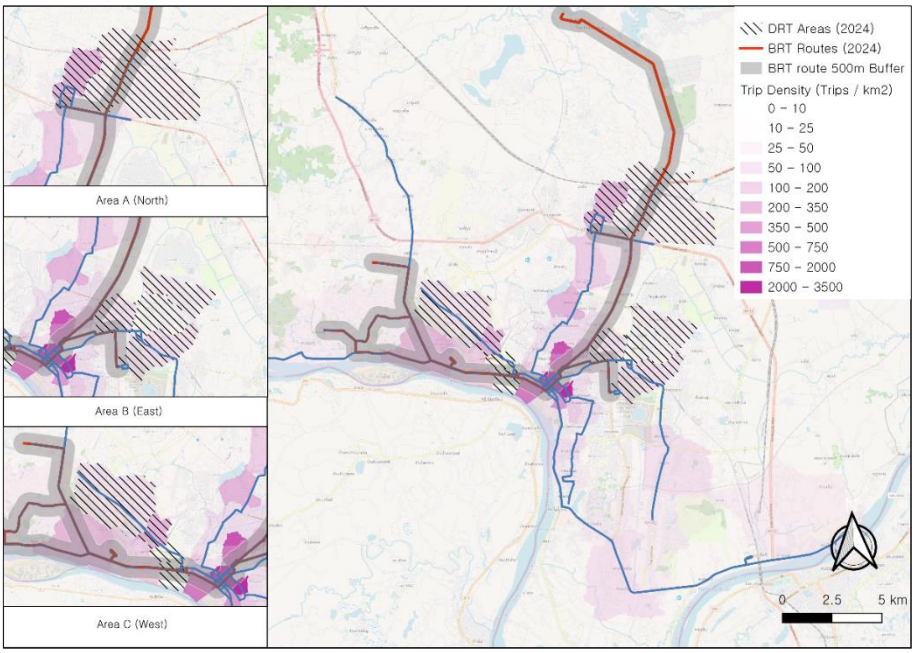
3.34 According to some studies, DRT are appropriate where they can reduce the required subsidy of an existing fixed-route or indeed have a positive economic result from a cost-benefit-analysis (CBA[12]). Previous research has shown that DRT can increase average utilization of transit vehicles and potentially make them economically viable in lower density area (peri-urban areas), but main depends on the demand density. Most of the studies agree that regular

[12] Papanikolaou, A; Basbas, S; Mintsis, G; Taxiltaris, C. A methodological framework for assessing the success of Demand Responsive Transport (DRT) services. Transportation Research Procedia, 2017, 24, 393-400, https://doi.org/10.1016/j.trpro.2017.05.095.

fixed route transit is more efficient at high-demand levels (typically more than 10–50 trips/km^2/h), whereas flexible services are more efficient with lower demand[13].

3.35 In Figure 32 below is illustrated the areas in Vientiane overlaid with trip density (daily trip density). Marked on this map are areas that are therefore most appropriate for potential DRT services.

Figure 32: DRT Areas, Based on Trip Density



3.36 In general, these areas are well within the central urban area of Vientiane and cover a similar area to the existing paratransit within the central city area demand profile (Figure 30). However, paratransit also provides last-mile/first-mile service in the exurban/semi-urban areas generally north of the main urban areas. In the JICA-developed VTMP, songthaew were assumed to be running exclusively in these areas, as feeder-type services, see Figure 33 below.

[13] Dytckov, S.; Persson, J.A.; Lorig, F.; Davidsson, P. Potential Benefits of Demand Responsive Transport in Rural Areas: A Simulation Study in Lolland, Denmark. Sustainability 2022, 14, 3252. https://doi.org/10.3390/su14063252

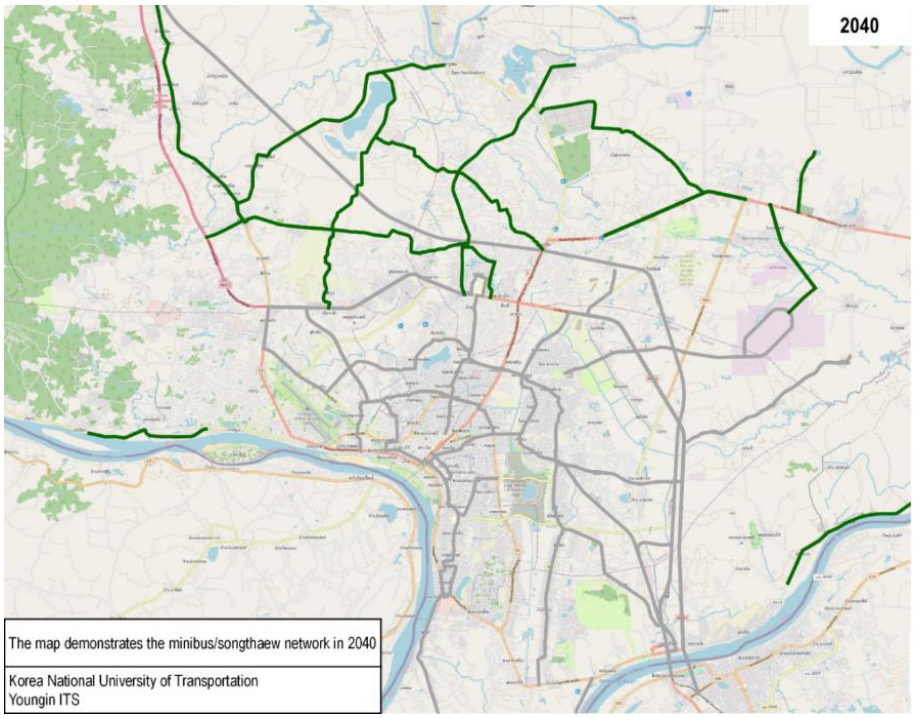
Kim,M.; Schonfeld, P. Conventional, flexible, and variable-type bus services. J. Transp. Eng. 2012, 138, 263–273

Zheng, Y.; Li, W.; Qiu, F. A methodology for choosing between route deviation and point deviation policies for flexible transit services. J. Adv. Transp. 2018, 2018, 6292410:1–6292410:12.

Qiu, F.; Li, W.; Haghani, A. An exploration of the demand limit for flex-route as feeder transit services: A case study in Salt Lake City. Public Transp. 2015, 7, 259–276.

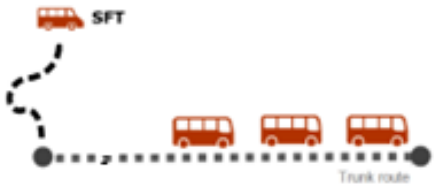
Nourbakhsh, S.M.; Ouyang, Y. A structured flexible transit system for low demand areas. Transp. Res. Part Methodol. 2012, 46, 204–216.

Figure 33: JICA-Described Songthaew/Van Service (By 2040)



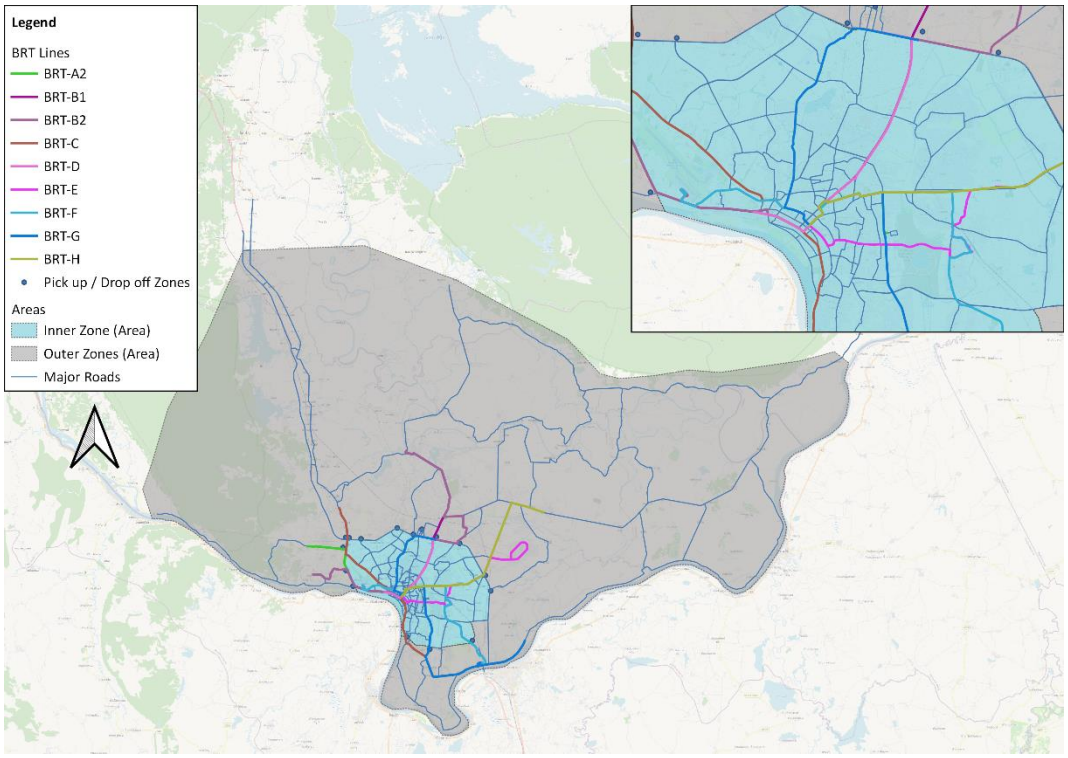
3.37 Finally, two scenarios were created to cover potential use cases for DRT using songthaew-like vehicles in Vientiane:

Outer Scenario – DRT vehicles allow for first mile/last-mile trips that must begin or end at a BRT Station. DRT does not compete with BRT but acts as a feeder. In this scenario, there are 15 designated pick-up/drop-off areas which DRT services must use.



Inner Scenario –, as follows. DRT only competes with BRT for short trips within the city center. The inner area is generally bounded by

Figure 34: DRT Scenario Areas



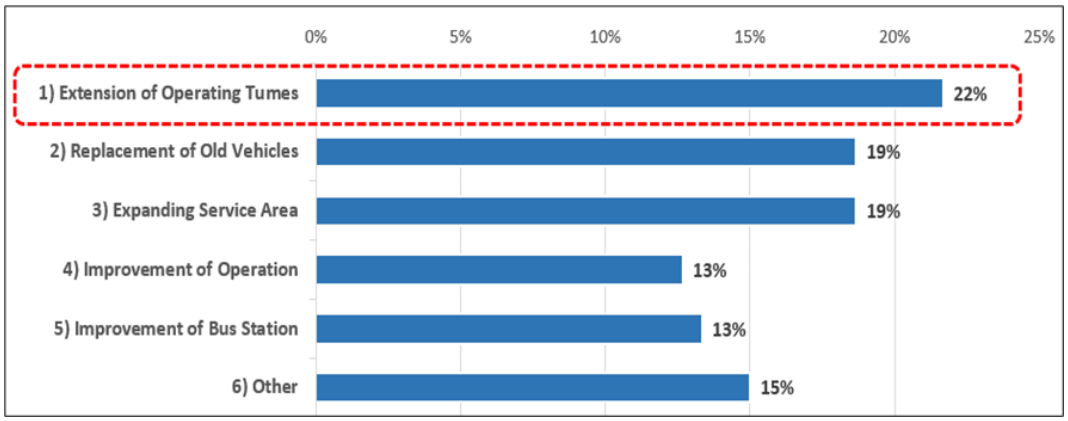
Stated Preference Survey

3.38 In February and March 2023, a Stated Preference survey was given to 300 residents in the Vientiane region. An accompanying report is entitled ***Demand-Responsive Transit (DRT) Stated Preference Survey in Vientiane, Lao PDR (CTCN Technical Assistance)*** from May 2023. Reader should familiarize themselves with this report.

Preferences for Demand-Responsive Transit (DRT)

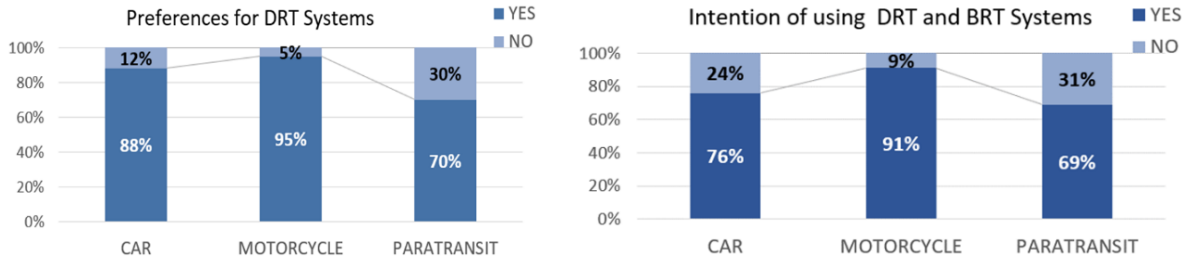
3.39 The highlights of the survey and the resulting analysis are presented here. Respondents were asked to rank their desired improvements to the public transport service in Vientiane. The results of this question are shown below in Figure 35. The most critical improvement, was the extension of operating times, followed by replacement of old vehicles, expanding the service area, improvements of operations, and finally improvement of bus stops.

Figure 35: Ways to Improve Public Transportation Services



3.40 The concept of DRT and benefits was presented to respondents, and they were asked whether they believed that (a) this system was necessary and (b) they would use the system. The response to this question is shown in Figure 36. Despite being a new technology, respondents were generally in favour of both implementing and using DRT. Motorcycle users expressed the most positive opinions towards DRT with 95% saying it was necessary and 91% saying they would use it. Conversely, 76% of car users and 69% of paratransit users said they would use DRT**. Overall, 84% of respondents expressed an intention to use DRT in Vientiane.**

Figure 36: Preference for Introducing a DRT System



3.41 Respondents were also asked what types of routes would be best for DRT, and what types of trips they would use it for. For types of routes, responses were mixed, but the highest portion (34%) indicated that they would be best used as local area circulators. 10% indiciated they thought it would work best for getting to and from bus terminals or railway stations (transport hubs). 36% of respondents said that they would use the DRT to commute, followed by going to school 32% and for business travel at 12%.

Choice Model

3.42 Discrete choice models for transport, based on stated preference, are commonly used to understand and predict individuals' decision-making behavior in transportation-related contexts. These models rely on stated preference surveys, where individuals are presented with hypothetical scenarios and asked to choose their preferred alternative.

3.43 Discrete choice models based on stated preference provide valuable insights into individuals' preferences and the trade-offs they make when selecting transportation alternatives. They are utilized for various applications, such as demand forecasting, evaluating policy interventions, and designing transportation systems that better align with users' needs and preferences.

3.44 In this case, we developed a binary choice model. While several models were developed, the resulting introduced BRT+DRT service was or how many minutes the total travel time was, and whether there was a consciousness to switch means.

Demand Forecasts and Model (Results)

3.45 The above-described choice model makes a up major portion of the model systems used to determine whether a DRT would be feasible in Vientiane. The purpose of the model is to answer the following questions:

- How many people will use the DRT service?
  - Tool: the Emme-based transport model
- How many vehicles will be required to serve the demand, and how long will people be required to wait to use the service?
  - Tool: DRT Simulation Model

Emme-Based Assignment Model

3.46 The Emme assignment model is a transportation modeling tool, developed for this project, which is used for simulating travel patterns, and predicting traffic flows in a transportation network. Network-based models like Emme are often employed in urban planning, traffic engineering, and transportation demand analysis.

DRT Simulation Model

3.47 DRT service have and do use several different algorithms to plan their routes. All these algorithms have the same aim: to optimize their routing and minimize the travel time and waiting time for passengers. In short, a DRT algorithm is an optimization problem, which generally used a heuristic to "solve" the problem. In common parlance, the problems these algorithms are trying to solve are generally referred to as the Vehicle Routing Problem (VRP) or the Travelling Salesman Problem (TSP). The algorithm used here is a Genetic Algorithm which are a type of optimization algorithm that mimics the process of natural selection to find optimal solutions to complex problems. This simulation is coded in Python and is run separately from the Emme model. The Python-based model is used to estimated actual travel time by DRT, including average waiting time, travel times, and the number of vehicles that would be required.

Demand & Modelling Results

3.48 The results of the modelling and simulation summarized in this Section of the report.

Scenario 1a: Outer Scenario

3.49 In this scenario, DRT vehicles act like feeder services that feed into higher-frequency fixed route services. In this case, the higher frequency services are the BRT services as described by the JICA VTMP.

3.50 Based on the modelling system described above, we found the following.

Table 16: BRT & DRT Demand (DRT+BRT Scenario 1)

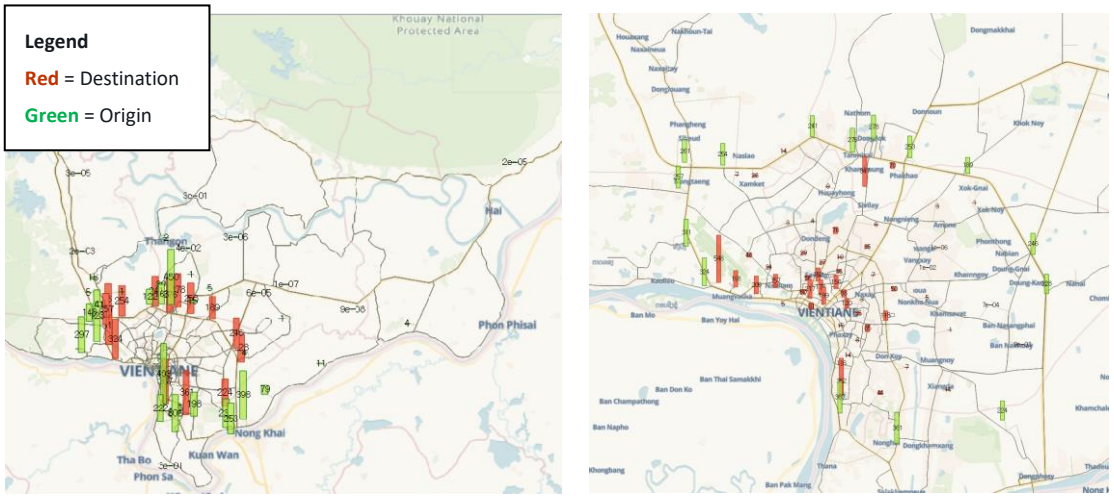
	AM Peak			Daily		
	BRT+DRT	BRT	DRT	BRT+DRT	BRT	DRT
O-D Demand (Trips)	32,300	28,000 (only BRT) 4,000 (DRT+BRT)	4,000	89,000	57,000	11,100
Boardings	32,300	28,000	4,000	90,400	79,000	11,100
Pax-Km	-	114,000	31,900		319,300	89,270

Table 17: BRT Boardings (DRT+BRT Scenario 1)

	Boardings	
BRT	AM Peak	Daily
D	1,100	3,100
E	1,600	4,600
A2	2,000	5,700
C	2,500	7,000
H	3,200	9,000

B1	3,400	9,800
F	4,600	13,100
G	9,800	28,000
Total	**28,200**	**80,400**

Figure 37: O-D Demand (DRT+BRT Scenario 1)



Outer Demand (DRT Leg)

Inner Demand (BRT Leg)

Figure 38: Volumes (DRT+BRT Scenario 1)

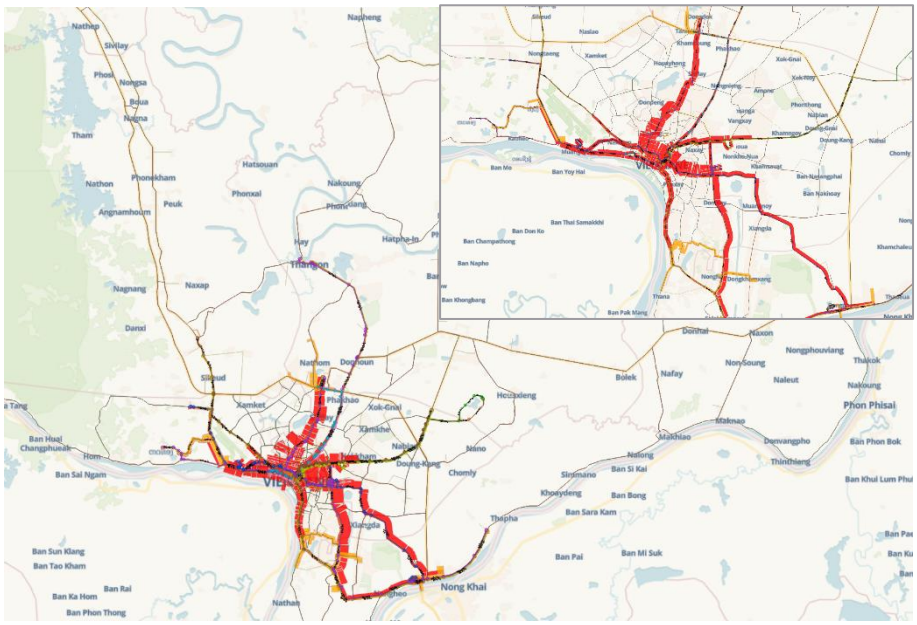


Table 18: Results of DRT Simulations (DRT+BRT Scenario 1)

	Value	Unit
Waiting time	5.56	Mins
Total travel time	9.58	mins

Number of vehicles required	266	vehicles

3.51 We estimate that around 90,000 people would use the combined DRT & BRT transit service every day. Of that, about 13% would use DRT to travel to a BRT station. Generally, DRT would be used for longer distance trips, while BRT would be used for shorter distance trips within the city center and longer distance. In this case, the most-used BRT line would be Line G (serving Dongdok, CBS, and Thanaleng), while the least used is Line D (the first BRT line to be constructed). In this scenario, we found the average waiting time would be around 5.5 minutes, and the average total travel time around 9.5 minutes.

Scenario 1b: Outer Scenario – Modified with Smaller Pick up/Drop off Areas

3.52 In this scenario, DRT vehicles act like feeder services that feed into higher-frequency fixed route services. In this case, the higher frequency services are the BRT services as described by the JICA VTMP. Unlike in Scenario 1, the DRT area was significantly reduced, to cover only a small area adjacent to the pickup/drop off spots.

3.53 Based on the modelling system described above, we found the following.

Table 19: BRT & DRT Demand (DRT+BRT Scenario 1b)

	AM Peak			Daily		
	BRT+DRT	BRT	DRT	BRT+DRT	BRT	DRT
O-D Demand (Trips)	30,500	27,600 (only BRT) 3,500 (DRT+BRT)	3,500	85,100	75,700	9,700
Boardings	31,700	28,200	3,500	88,700	79,000	9,700
Pax-Km	-	100,600	21,800		281,600	60,900

Figure 39: Volumes (DRT+BRT Scenario 1b)

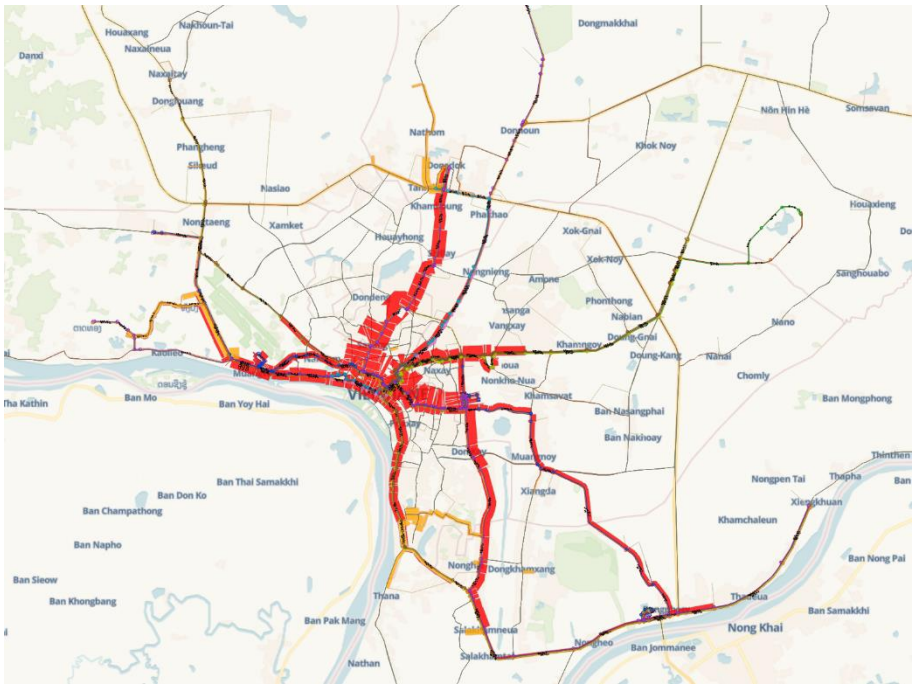


Table 20: Results of DRT Simulations (DRT+BRT Scenario 1)

	Value	Unit
Waiting time	5.56	Mins
Total travel time	9.58	mins
Number of vehicles required	266	vehicles

3.54 We estimate that around 85,100 people would use the combined DRT & BRT transit service every day. Of that, about 9,700 or 11% would use DRT to travel to a BRT station. In this scenario, we found the average waiting time would be around 5.5 minutes, and the average total travel time around 9.5 minutes.

Scenario 2: Inner Scenario

3.55 In this scenario, DRT vehicles may like feeder but also may compete for BRT trips in the inner city, offering point-to-point trips. As with Scenario 1, higher frequency services are the BRT services as described by the JICA VTMP.

3.56 Based on the modelling system described above, we found the following values for demand.

Table 21: BRT & DRT Demand (DRT+BRT Scenario 2)

	AM Peak			Daily		
	BRT+DRT	BRT	DRT	BRT+DRT	BRT	DRT
O-D Demand (Trips)	46,800	20,200	26,600	131,100	56,700	74,400
Boardings	49,300	22,700*	26,600	138,000	63,600	74,400
Pax-Km	-	130,300	113,300		364,900	317,100

Table 22: BRT Boardings (DRT+BRT Scenario 2)

	Boardings	
BRT	AM Peak	Daily
D	800	2,300
E	1,300	3,800
A2	1,400	3,900
C	1,900	5,300
H	1,900	5,500
B1	3,200	9,200
F	4,000	11,500
G	7,100	20,200
Total	**21,700**	**61,800**

Figure 40: O-D Demand (DRT+BRT Scenario 2)

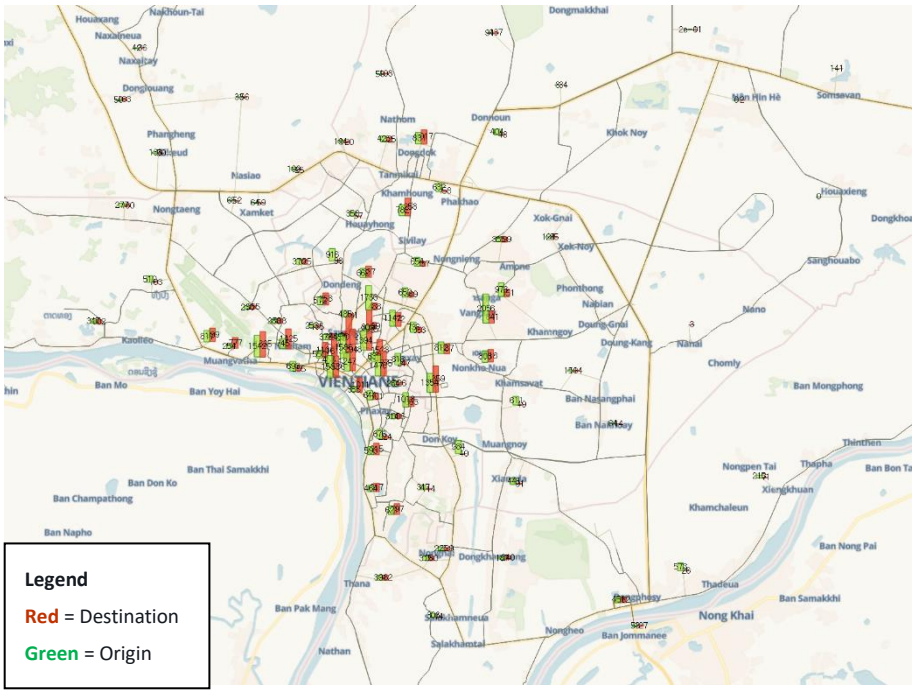


Figure 41: Volumes (DRT+BRT Scenario 2)

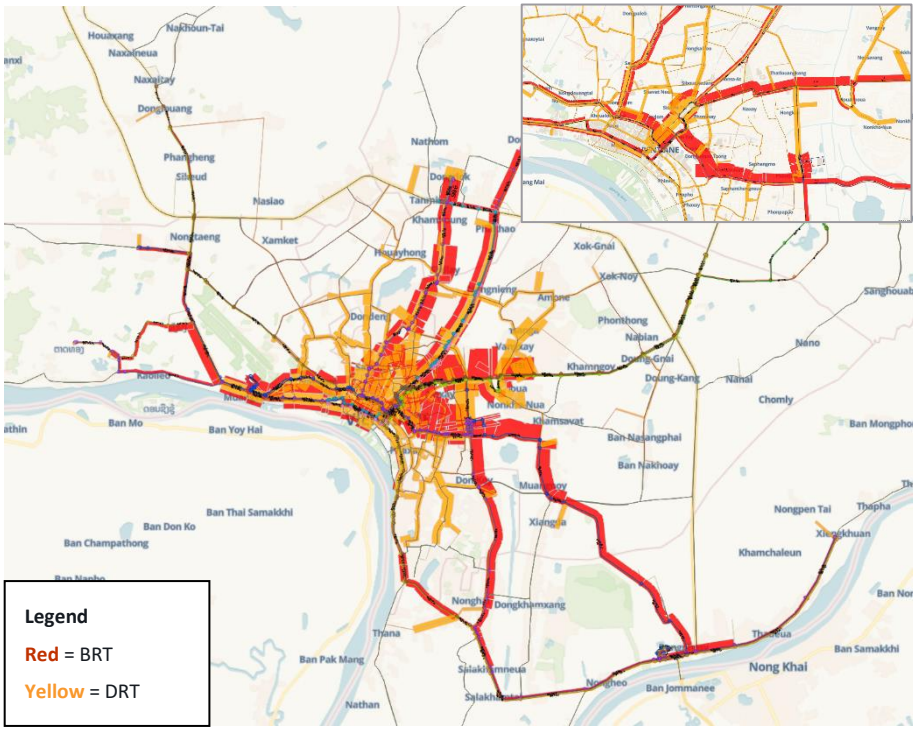


Table 23: Results of DRT Simulations

Item	Value	Unit
Waiting time	low	Mins
Total travel time	3.5	Mins
Number of vehicles required	511	Vehicles

3.57 We estimate that around 130,000 people would use the combined DRT & BRT transit service every day. Of that, about 56% would use DRT over BRT. Generally, BRT would be used for longer distance trips, while DRT would be used for shorter distance trips within the city centre, reflected by the shorter overall pax-km. In this case, the most-used BRT line would be Line G (serving Dongdok, CBS, and Thanaleng), while the least used would be Line D.

3.58 The average waiting time would be low, and the average travel time 3.5 minutes, around 511 vehicles would be required to accomplish this.

GHG Reductions

3.59 The above-described Scenarios may result in a reduction in Greenhouse Gases (GHGs), due to a modal shift, that is, people who previously used fossil fuel powered 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. Assumptions and calculated are shown below and in Table 24 and total estimated GHG reductions are shown below in Table 25.

$$\boldsymbol{\Delta D} = D_{DRT\ Scenario} - D_{BAU}$$

$$\boldsymbol{CO2_e(kg)} = \Delta D \left(\frac{Dist_{,mc} * MC_{mc}}{OCC_{mc}} * \left(\frac{1}{100} \right) * F_{am} * F_{daily} * FE_{mc} + \frac{Dist_{car} * MC_{car}}{OCC_{car}} * \left(\frac{1}{100} \right) * F_{am} * F_{daily} * FE_{car} \right)$$

Table 24: Assumptions for GHG Reductions – DRT Scenarios

Description		Value	Unit	Source
Travel distance, by car or motorcycle (avg. of possible routes) by OD	Distance	Varies	*km, varies by OD*	Emme-based model
Change in demand	ΔD	Varies	*trips, varies by OD*	Emme-based model
Occupancy, motorcycle	OCC_{MC}	1.5	*people*	Assumption based on similar cities
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
Carbon equivalent of gasoline	CE	2.32	*Kg C02 / L gas*	U.S. Energy Information Administration
AM Peak – Daily factor	F_{AM}	~2.80	*unitless, varies by OD*	Calculated from 2021 OD survey
Daily – annual factor	F_{Daily}	300	*unitless*	Assumption
Mode choice car	MC_{Car}	Varies	*%, varies by OD*	2021 OD survey (JICA)

Description		Value	Unit	Source
Mode choice motorcycle	MCmc	Varies	*%, varies by OD*	2021 OD survey (JICA)

3.60 We estimate up to **6,000-20,500 Tonnes of CO2e** could be reduced (15-year total) compared to the Business-as-Usual (BAU) scenarios, see below.

Table 25: GHG Reductions - Proposed DRT

Network Scenario	Tonnes CO2e
Scenario 0	-
Scenario 1	20,500
Scenario 2	18,000
Scenario 1b	6,000

Equipment Requirements

3.61 DRT can be run using conventional vehicles (like songthaews) with some additional equipment installed. In this report, we will use the example from the British company Ioki, which provides DRT equipment and software as part of a Software-as-a-Service package (SaaS) package. Required components are:

Figure 42: Components of the DRT SaaS Ecosystem

Passenger app **Driver app** **Control centre** **Real-time reporting** **Intelligent backend**

- **Passenger Application**: The customer=-facing app which is used by potential customers to book trips by DRT, available for iOS or Android OS
- **Driver Application**: Enables drivers to receive pickup and drop off as well as navigation directions. Best used on an iOS or Android tablet
- **Control Center & Real-Time Reporting**: Browser based (cloud-based) software package to manage and track fleet
- **Intelligent Backend**: Additional smart features to find efficiencies and other insightful items

Cost-Benefit Analysis (Business Case)

Overview

3.62 In this section, we briefly review the expected costs and benefits of the DRT scenarios, under two different operating scenarios for a total of six comparative options. The two operating scenarios are as follows:

- **Type I:** Convert existing Songthaews trucks/gasoline
- **Type II:** Purchase new electric vehicles (vans)

3.63 Cost for the program is calculated based on the following assumptions. For an gasoline vehicle, we assume that a Kia Bongo / Hyundai Porter or equivalent would be used. For an electric vehicle, we assume that the EV version of the Kia Bongo / Hyundai Porter be used, see below.

Table 26: Assumptions Costs for DRT Program

	Item	Unit	Cost ($ USD)
Capital	Software initial set-up	Total	$17,000
	Driver tablet	Per vehicle	$500
	Vehicle	Total	$22,000*
	Management Center	Total	$10,000**
	Sub-Total	**Total**	**$32,000**
Other	Fuel cost, gasoline	$ / L	$1.49
	Fuel economy, gasoline	km / L	8
	Electricity cost, EV	$ / kWh	0.030
	Efficiency, EV	km/ kWh	3.1
	Operation hours	Hours per day	16
	Operation	Days per year	365
	Average speed	km/hr	25
	Normal person-hours per month	Hours/month	128
	Required hours per month per vehicle	Hours/vehicle/month	364
Operational	Insurance/fees	Per vehicle/month	$10.22
	Software license fees	Per vehicle/month	$586
	Driver salary	Per hour	$1.28
	Total labour	Per vehicle/month	$465 (2.85 ppl)
	Maintenance	Per vehicle/month	$383
	Sub-Total	**Per vehicle/month**	**$1,332**
	Total	*Per vehicle/day*	*$43.96*
		Per vehicle/day (non-DRT)	*$24.66*
		Per vehicle-km (gasoline)	*$0.19*
		Per vehicle-km (EV)	*$0.017*

* Price not included because we assume the system will (initially) make use of existing vehicle fleet

* Assuming that space is available in existing government/public building including internet access

Summary of Costs & Profit (Business Case)

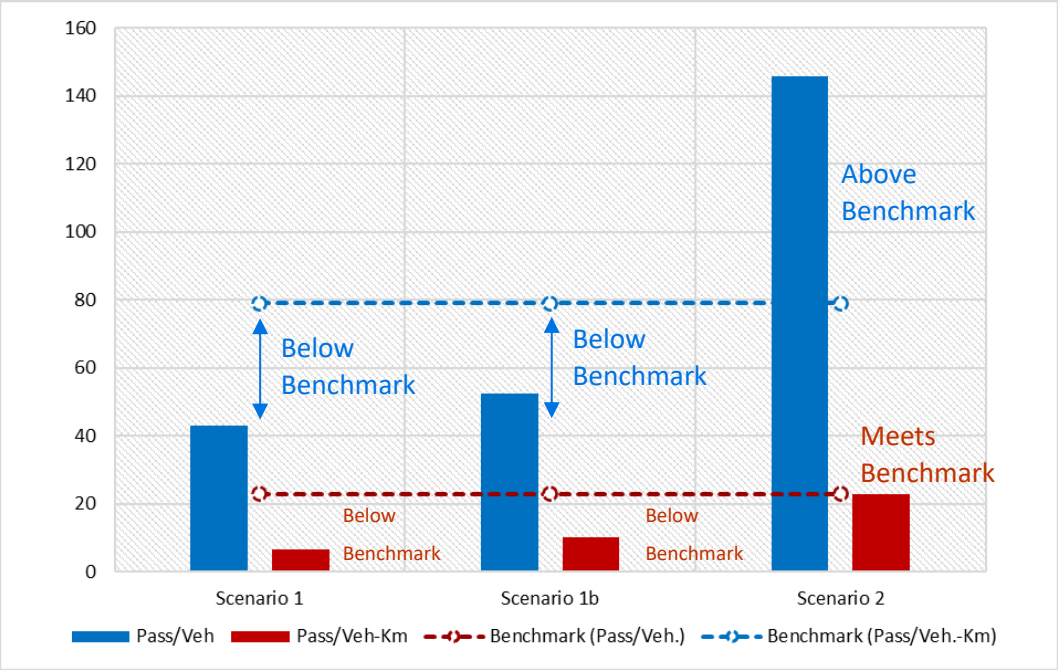
3.64 Average operation cost (per day) amounts to approximately $43.96 + $0.19 (gasoline) or $0.010 (EV) for every kilometre to account for energy. Assuming the vehicles are 80% utilized at 25 km/hr daily fuel costs could amount to approximately $44.70 per vehicle per day, making fuel by far the biggest driver of cost.

3.65 According to our analysis, existing Songthaew operators are profitable, averaging around 5% - 10% profit margins after the driver salary is paid out. Each truck may profit up to ~$200 USD/month. Adding DRT capability to a songthaew is possible with minimal equipment and

would add a cost of around $20 USD/day. Therefore, to remain profitable, the DRT must add 15-20 passengers/vehicle/day versus existing operations to remain profitable.

3.66 The following graphic details two performance metrics for the DRT systems, based on the estimated metric of the existing Songthaew (fixed route) system. Based on our calculations we have found that Songthaews operating in the Vientiane region serve an average of 56 passengers per day per vehicle, assuming 100% utilization of the 136-strong fleet, and serve approximately 23 passengers for every 100 km. Songthaew generally operate outside the urban areas, serving suburban/exurban areas. They operate slowly, generally looking for additional passengers as they travel down their fixed routes. In this metric DRT can easily beat the benchmark since passengers do not have to wait (or walk) as far as they would if taking a fixed-route Songthaew, by a significant margin. DRT users could save an average of 15 – 20 minutes per journey versus existing Songthaew.

Figure 43: Operation Efficiency Metrics (Benchmarked to the Existing Songthaew)



3.67 However, when consideration operator-based metrics (efficiency of operation), the only DRT scenario that meets or exceeds the efficiency operations metrics of the existing songthaew system is Scenario 2, the higher-demand service which would serve the inner urban area of Vientiane.

Business Case

3.68 For the following results are outputs from the modelling system described in the previous section. The following values are NOT capacity constrained, meaning they assume that there is enough supply to meet the potential demand, and therefore they represent demand potential. We have calculated the number of vehicles that would be required to meet the demand, keeping the waiting times for passengers to a reasonable level.

Table 27: Estimated Costs and Profits (Business Case) for DRT

Scenario	Customers (Daily	Number of Vehicles	Daily Pass. /Vehicle	Daily Pass/100 Veh. Km	Fare	OpEx (Daily)	Profit (Daily)
Existing Songthaew (Benchmark)	7,674	136	56	23.0	25,000	$9,400	+5%-10%
Converted Songthaews/TukTuks - Gasoline							
Scenario 1	11,400	266	43	6.5	25,000	$45,000	-$30,000
Scenario 1b	10,000	191	52	10.1	25,000	$90,500	-$14,000
Scenario 2	74,400	511	146	**23.0**	25,000	$28,515	**+$13,700**
EV Vans or Trucks - Electric							
Scenario 1	11,400	266	43	6.5	25,000	$13,400	**+338**
Scenario 1b	10,000	191	52	10.1	25,000	$9,300	**+$3,000**
Scenario 2	74,400	511	146	**23.0**	25,000	$29,500	**+$70,600**

3.69 Results show that it is possible to achieve profitability with a DRT system. However, there must be sufficient demand in a relatively compact area. Scenarios 1 and 1b are only focused on the outer areas, where demand is sparser. To maintain profitability, ideally the DRT would not be exclusively run in these areas (even as feeders for BRT). However, if the vehicles are converted to EV, then all scenarios are profitable due to the significantly reduced cost of fuel (extremely cheap electricity combined with efficient modern electric engines means that the operating cost per km is reduced by ~90% compared to gasoline).

Passenger Considerations

Existing, Songthaew

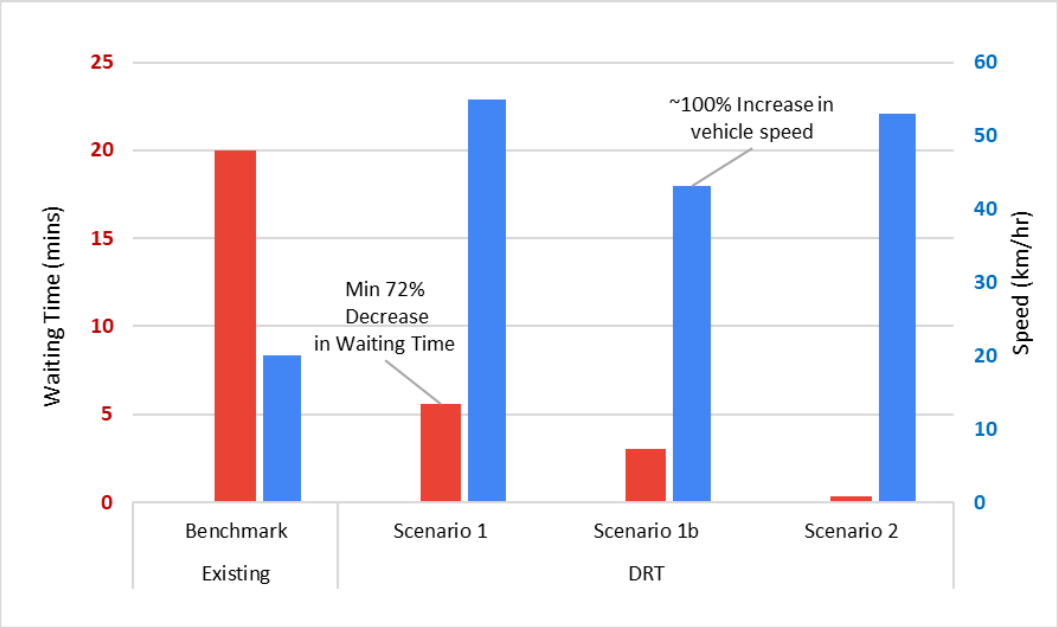
3.70 Under the existing Songthaew system, passengers face inconvenience in many cases. Waiting time for a Songthaew is around ~20 minutes on average, and passengers have no knowledge of where the Songthaew is in many. Passengers must wait on the side of the road and flag the vehicle down from the major route where it is operating.

Future, DRT

3.71 DRT, including in conjunction with BRT, will undoubtedly be more convenient than using the existing songthaew system. That is because passengers will:

- walk less, since the vehicle will pick up the user closer to their home/origin
- wait less since the vehicle will be called on demand,
- increase reliability since users will know exactly where the vehicle is and how long it will take to get to their location through their SmartPhone app, and
- travel faster since their vehicle will no longer need to drive slowly looking for additional passengers.

Figure 44: Waiting Time, Compared to Benchmark



Socioeconomic Cost-Benefit Analysis (SECBA) & GHG Reductions

3.72 The following table presents the results of a simple socioeconomic cost benefit analysis as well as the potential GHG reductions, compared to the Business-as-Usual (BAU) case, which is the existing Songthaew system.

3.73 As mentioned, users of a DRT system can stand to benefit immensely versus the existing Songthaew fixed-route system since their access /egress (walking) times and waiting times are significantly reduced. Users also benefit from increased reliability as well as the ability to see and track the buses (not included in the socioeconomic cost benefit analysis).

3.74 The following table summarizes the results of the SECBA and GHG Reductions (GHG reductions do not count the conversion to electric vehicle, instead only counting the effects from a conversion to a DRT and BRT feeding system).

Table 28: DRT Scenario Results

Scenario	ΔCapEx Millions of USD, discounted	ΔOpEx Millions of USD, discounted	Benefits Millions of USD, discounted	BCR	GHG Reduction Tonnes CO2e
Gasoline Songthaew Conversions					
Scenario 1	$2.69	$96.14	$26.65	0.27	1,800
Scenario 1b	$1.19	$47.81	$18.44	0.38	1,100
Scenario 2	$7.59	$220.52	$68.30	0.30	32,000
EV Vans					
Scenario 1	$14.35	$14.86	$26.65	0.91	1,800
Scenario 1b	$10.31	$1.27	$18.44	**1.59**	1,100
Scenario 2	$27.54	$49.60	$68.30	0.89	32,000
EV Bongo/Trucks					
Scenario 1	$7.95	$14.86	$26.65	**1.17**	1,800

Scenario	ΔCapEx Millions of USD, discounted	ΔOpEx Millions of USD, discounted	Benefits Millions of USD, discounted	BCR	GHG Reduction Tonnes CO2e
Scenario 1b	$5.72	$1.27	$18.44	**2.64**	1,100
Scenario 2	$15.26	$49.60	$68.30	**1.05**	32,000

Conclusions

- According to our analysis, existing Songthaew operators are profitable, averaging around 5% - 10% profit margins after the driver salary is paid out. Each truck may profit up to ~$200 USD/month.
- It is possible to convert the existing Songthaew/informal transit networks to be "smarter" with DRT features and passengers could benefit greatly from this.
- Adding DRT capability to a Songthaew is possible with minimal equipment and would add a cost of around $20 USD/day. Therefore, to remain profitable, the DRT should add 15-20 passengers/vehicle/day versus today to remain profitable.
- **Scenario 2 (the inner scenario with the most demand) offers the best chance for profitability** due to the higher density of potential customers. Especially in the case of EV, it is possible to become profitable, but especially so in Scenario 2.
- In Scenarios 1 and 1b, vehicles travel longer distances for less passenger, thus limiting their potential for profitability, however, Scenario 1b offers the highest socioeconomic cost-benefit analysis, meaning the best overall benefit for passengers (when not considering operator profitability),
- When considering GHG reduction, overall Scenario 2 is the best scenario due to the much higher demand it would receive, however this comes at a cost since many vehicles would need to be purchased.

In this pre-feasibility study we have determined that a DRT conversion of the existing songthaew/informal transport network would be feasible and beneficial. There is an opportunity for operators to remain profitable, especially in the case that electric vehicles are used in higher density areas (like the central urban area of Vientiane) however this will require significant capital expenditures or a potential cost-sharing scheme with drivers.

A scenario-by-scenario comparison is discussed below.

Scenario 1

- This scenario has relatively low usage of DRT, but with long distances driven
- Operating costs and number of vehicles required are very high due to the long distances that must be travelled to pick-up far-flung requests.
- This is the least likely to be profitable.
- This scenario has the most potential for time savings and for GHG reductions due to the longer distances for a small number of trips (that result in significant time savings for those people).
- Overall BCR is only reasonable if relatively inexpensive EVs are used.

Scenario 1b

- A variation of Scenario 1, this scenario has 85% of the demand potential as Scenario 1, while reducing pax-km by 32% and operating costs by 80%.
- Desptite this, profitability for operators will be challenging unless EVs are used.

- Overall, usage is the lowest and therefore reduction of GHG emissions is also the lowest.
- Operating costs and number of vehicles required is low due to the small amount of demand over shorter distances only.
- Overall BCR is reasonable in EV scenarios making it worth the investment.

Scenario 2

- This scenario has highest usage of DRT since it is in the densest area of Vientiane.
- This scenario has the best potential GHG reductions to the large number of short distance trips (that result in small time savings for a lot of people).
- Operating costs and number of vehicles required are high due to the large amount of demand.
- Profitability for operators would be possible in this scenario, or a variation of it.
- Overall BCR is reasonable in EV scenarios making it worth the investment.

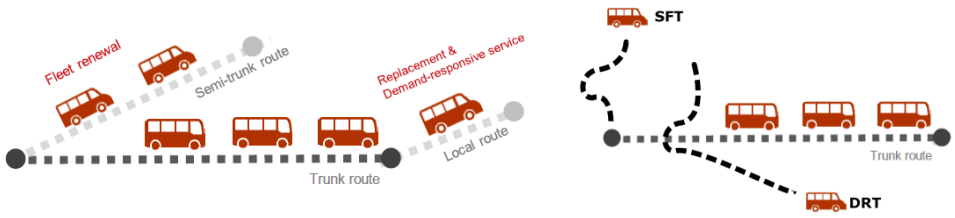
Other Issues with DRT

Songthaew Operators

3.75 In general, our recommendations for DRT assumed that songthaew operations would be replaced by DRT. That is, they would not compete with DRT in any way. However, to accomplish this, proactive cooperation with songthaew operators would be required to expand public transport services through incremental formalization. The VTMP recommended the following three steps for implementation, with a goal of integrating the songthaews into the fixed route operations of the VCSBE:

1. operational cooperation with Songthaew operator including design of fare systems, timetables, bus stops, maps etc.
1. service integration with Songthaew operators using existing Songthaew vehicles; and
2. feet renewal program for Songthaew operator vehicles

Figure 45: Songthaew + DRT Operating Models



Proposed by JICA **Proposed by KNUT**

Social Issues & Public Acceptance

3.76 In Vientiane, people have been familiar with alternative and flexible paratransit options for a long time. However, as in many other developing countries, technology acceptance can be a challenge in Vientiane, the capital city of Laos. Here are some of the key challenges that may affect technology adoption and use in the city:

- **Cost**: The cost of technology, including devices and services, can be prohibitive for many people in Vientiane, particularly those in lower income brackets. While the prices of many technology products have dropped significantly in recent years, they may still be out of reach for many residents.

- **Digital literacy**: Many people in Vientiane may lack the digital literacy skills needed to effectively use and benefit from technology. This can be a particular challenge for older adults, those with limited education, and those who have not had prior exposure to technology. **According to data gathered for this project, only approximately 60% of Lao people had access to a SmartPhone and data, making it dubious whether a service that requires a SmartPhone is feasible in Laos**. **However, this rate is rising fast, and more monitoring is needed.**
- **Language**: The predominant language in Laos is Lao, which may pose a challenge for technology adoption if products and services are not available in the local language, for example, with commercial products and/or SmartPhone applications for operators which may not be available in the Lao language.
- **Cultural attitudes**: Cultural attitudes towards technology and its role in society may also impact technology adoption and acceptance in Vientiane. Some people may view technology as a threat to traditional values or ways of life, while others may be skeptical of new technology or unfamiliar with its potential benefits. In all cases, significant education campaigns would be needed.

3.77 On the other hand, our survey found that respondents would be very much willing to use DRT, if it was available in Vientiane, with 84% responding favourably to the concept.

Pilot Project and Next Steps

3.78 Based on this analysis, we believe it is worth it to take DRT to the next phase of development **with a feasibility study or business case for investment**. Potential funding sources including by the Korean government through a fund like the EDCF, internal Lao, or other source.

3.79 With preparation, a pilot project could be undertaken in 2025/2026 at the earliest. With a full roll out city wide (If justified) starting in around 2028.

Table 29: Potential Timeline

	2024	2025	2026	2027	2028	2029	2030
Preparation	Feasibility Study	Feasibility Study		Business Case			
Pilot Project		**Pilot Project**					
Songthaew Project							

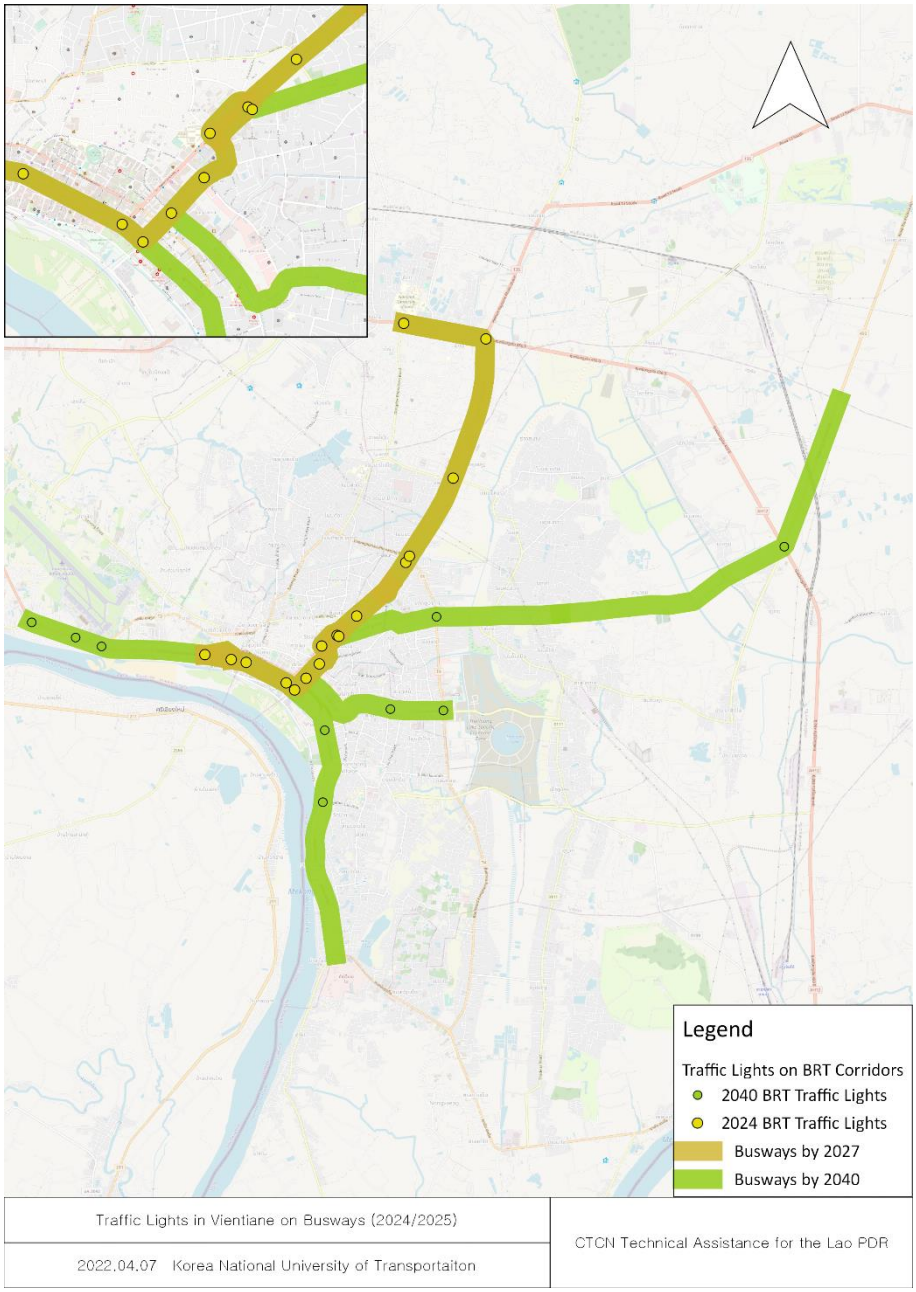
A Additional Information (Chapter 2)

1 Summary of Strategic Benefits and Relative Costs

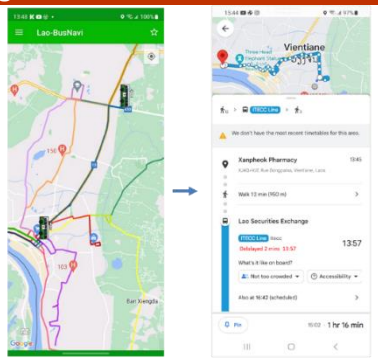
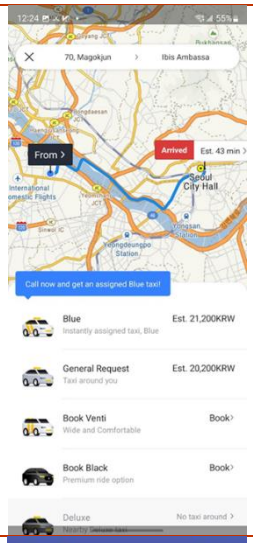
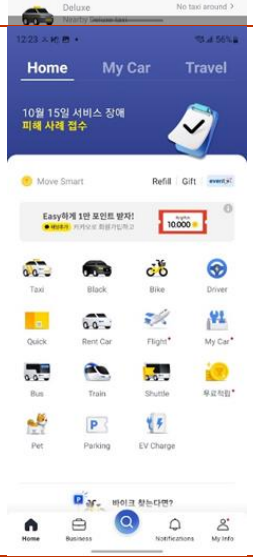
Item	Overall benefit		Cost
Electronic fare collection (EFC) QR-code banking system	Increased convenience, but increases average boarding time, very low cost		
Electronic fare collection (EFC) IC card system	Increased convenience, decreases average boarding time, very high cost		
Bus Management System (BMS) & data management centre	Increases the efficiency of the whole network and allows for real-time information to be provided, very high cost		
Bus Information System (BIS) – online and app-based	Reduces time spent waiting for the bus and increases convenience, but is limited to only those with SmartPhones, overall cost is little if BMS is already paid for		
Bus Information System (BIS) - SMS & ARS	Reduces time spent waiting for the bus and increases convenience, but is limited to customers with mobile phones, overall cost is little if BMS is already paid for		
Next-stop digital signage and announcement on buses	Increases the convenience and decreases anxiety when using public transit, considered essential in most developed countries		
Bus Information Terminals (BITs)	Reduces time spent waiting for the bus and increases convenience with no limitations, medium cost		
Bus Information Terminals (BIT) at CBS	Increases the perceived convenience of the bus passengers with no limitations, low cost		
Transit service priority (TSP) at traffic lights in central Vientiane	Decreases delay at intersections, high cost		
Demand-Responsive Transit (DRT)	Decreases average wait time for low demand transit but is limited to those with SmartPhones, high cost		

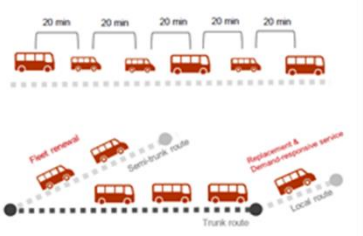
Item	Overall benefit		Cost
Wi-Fi on buses	Increases convenience of public transport, but is limited to those with SmartPhones, medium cost		
Wi-Fi at CBS (bus terminal)	Increases convenience of public transport, but is limited to those with SmartPhones, medium cost		
Closed-Circuit Television Cameras (CCTV) at Central Bus Station (CBS)	Increases perceived safety of public transport, low cost		
CCTV on buses	Increases perceived safety of public transport, low cost		
Demand-responsive taxi-hailing (car, tuktuk, songthaew)	Increases overall network efficiency and redundancy, but is limited to those with SmartPhones, no cost to state		N/A
E-Ticketing for intercity transport	Greatly increases convenience and provide information to passengers about availability of intercity transport.		N/A
Mobility as a Service (Maas)	Greatly increase convenience for customers.		N/A

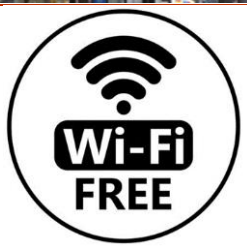
1.1 Corridors for BRT and TSP



B Project Descriptions

Title	Description	Image
1 - Upgrades to Existing Bus Information Systems (BIS)	Maintain, upgrade, and utilize existing BMS. Replace missing OBUs and maintain software and equipment. Abandon application and software, and instead focus on third party data provision based on the GTFS and GTFS-real time. Responsible organization: VCSBE.	 Lao-Developed → Google
2 - Development of policies to legalize ridesharing	Lao PDR government should work quickly to legally support the develop of these services and encourage to be used by other modes like Tuk-Tuk and Jumbos. Develop fair and balanced policies that legalize the already widespread ridesharing that is in place in the Lao PDR as well as in most other developed counties and neighbouring countries. Ensure that the public continues to be served fairly, safely, and efficiently with ridesharing. Responsible organization: MPWT DOT.	
3 - Development of policies to support foreign and local investment in E-Ticketing, micro mobility, & Mobility as a Service (Maas)	MaaS, E-ticketing applications for intercity transport should be allowed to operate, however they are best left to the private sector. Support private sector with grants or other funding opportunities if they become available. Government should support further studies of the benefits of MaaS and explore future private sector partners. Responsible organization: MPWT DOT.	

Title	Description	Image
5 - Upgrades to the Central Bus Station (CBS	The CBS is worth targeting initially because it is by far the busiest station and transfer point on the system and will continue to be in the future. Upgrade real-time monitors to include real-time departures information (in minutes) rather than a geographic display. This information can be displayed in conjunction with the GTFS-real time development. Invest in free public Wi-Fi and in visible CCTV cameras. In 2035, in conjunction with other stations, replacement the monitors at CBS with improved BITs making use of the new BMS system. Responsible organization: Vientiane City.	
6 - Demand-Responsive Transit (DRT) Pilot Project	Invest in DRT program using a few vehicles on outskirts of the city, refer to Chapter 7 of this report. Responsible organization: MPWT DOT	
7a - Full Replacement of the Bus Management System	Invest in new Bus Management System (BMS) using proper On-Board Units with advanced capabilities. Invest in expanded data management centre. This system would replace the, now aging, SmartPhone-based OBU system developed by JICA. Responsible organization: VCSBE.	
7b - Next-stop signs and announcements on buses	Next-stop signs and announcements on buses	
8 - CCTV on Buses	Invest in CCTV cameras for all public buses in Vientiane operated by the VCSBE. Responsible organization: VCSBE.	
9 - Demand-Responsive Transit (DRT) - Project to Enhance Songthaew Capability	Invest in expanded DRT program using many vehicles on outskirts of the city, refer to Chapter 7 of this report. Responsible organization: DOT	

Title	Description	Image
10 - Electronic fare collection (EFC) by IC-card	Invest in an IC-card based electronic fare collection system. The IC-card based system would be far superior to the existing QR-code system as it would significantly increase the speed at which customers can board buses, while also providing accurate real-time data to management companies. Eventually, the QR code system should be phased out as it provides a disutility to passengers as it takes time to use the QR code. Responsible organization: VCSBE.	
11 - Transit service priority (TSP)	Invest in new traffic light systems at all major BRT corridors (expanded from medium-term priorities). Responsible organization: Vientiane City.	
7c - Bus Information Terminals (BITs)	With BMS system in pace, target installation of BIT at selected bus stops, targeting top 10% busiest of all bus stops in Vientiane area.	
12 - Wi-Fi on buses	Invest in free WiFi for all VSBE buses. Responsible organization: VCSBE.	

C Benchmarking

3.80 In order to understand the reasonableness of the recommendations of this report, as well as to develop a future vision for Vientiane, the following benchmarking study was undertaken comparing ITS for public transport that is available in other developed nations (Seoul and Vancouver) and in peer ASEAN capital cities (Manila, Bangkok, Kuala Lumpur, Hanoi, & Phnom Penh), the results of this benchmarking are shown below in Table 30.

3.81 Unsurprisingly, we found the nations with the most advanced economies and largest populations to have the most advanced ITS systems. Bangkok and Kuala Lumpur are the most advanced, with nearly the same level of ITS as Korea. Further Manila and Hanoi also have some advanced ITS features, with Manila edging out Hanoi in most areas. Phnom Penh only has a very basic public transport system and therefore ITS system and is currently the most like Vientiane in terms of its development.

3.82 With the continued strong growth of its economy, and the population expansion of Vientiane, Vientiane may look to its SEA peer cities, especially Hanoi, for a glimpse into of its future.

Table 30: Summary of Benchmarking

ITS Feature	Seoul	Vancouver	Vientiane (2023)	Phnom Penh	Hanoi	Bangkok	Manila	Kuala Lumpur
Population (of city)	*22m*	*2.6m*	*1.1m*	*2.2m*	*5.2m*	*10.7m*	*13.5m*	
GDP per capita	*$35,000*	*$52,000*	*$2,350*	*$1,625*	*$3,756*	*$7,066*	*$3,460*	*$11,110*
ICT usage (SmartPhone %)								
Public transport mode share (%)								
Public transit authority name (private)								
Type of public transport (i.e. metro, bus, paratransit etc.)	*Metro, Regional Metro, Light Metro, BRT, Bus, Taxi-hailing*	*Light Metro, Bus, RHS*	*Bus, TukTuks, Informal Transit*	*Bus, TukTuks Informal Transit*	*Bus, BRT, Metro*	*Bus, Metro, Regional Rail, Light Metro, Informal Transit*	*Metro, Regional Rail, Informal Transit*	*Bus, Metro, Light Metro, Regional Rail*
Electronic fare collection (QR-code)	✗	✗	✓	✗	✗	✓	✓	✗
Electronic fare collection (IC-card)	✓	✓	✗	✗	✗	Some	Some	✓
Bus Management System (BMS)	✓	✓	Limited	Limited	Limited	✓	✓	✓
Bus Information Terminals (BITs)	85%	Some	✗	✗	✗	Some	✗	Some
Bus Information Systems (BIS): Real-time passenger information (RTPI) in navigation apps	✓	✓	✓*	✓*	✓*	✓*	✓*	✓*
In Google Maps (GTFS)	✓	✓			✓	✓	✗	✓
Bus Information Systems (BIS): Real-time bus information by SMS or ARS	✓	✓	✗	✗	✗	✗	✗	
Next-stop signs and announcements on buses	✓	✓	Very Limited	✗	✗	Some	Some	✓
Transit service priority (TSP)	Signficant	Some	✗	✗	Some	Some	✗	Some

ITS Feature	Seoul	Vancouver	Vientiane (2023)	Phnom Penh	Hanoi	Bangkok	Manila	Kuala Lumpur
Demand-Responsive Transit (DRT)	✓	✗	✗	✗	✓	✗	✓	✓
Wi-Fi on buses	✓	✓	Very Limited	✗	✗	Some	✗	Some
Wi-Fi at bus terminals	✓	✓	✗	✗	✗	✗	✗	✓
CCTV on buses	✓	✓	✗	✗	✓	✓	✓	✓
CCTV at bus terminals	✓	✓	✗	✗	✓	✓	✓	✓
Demand-responsive taxi-hailing (Includes cars and Tuk-Tuks etc.)	✓	✓	✗	✓	✓	✓	✓	✓
Autonomous public transport	Some	✗	✗	✗	✗	✗	✗	✗
Mobility as a Service (MaaS)	Emerging	✗	✗	✗	✗	✗	✗	✗
E-Ticketing	✓	Some	✗	✗	✗	✗	✗	✓

* Only available on the agency-developed apps
** Not available on all buses/services
